Submit a comment

Proposed Change 1775

Code Reference(s):	NBC20 Div.B 1.1.3.1. (first printing) NBC20 Div.B Appendix C (first printing)
Subject:	Structural Design (Part 9)
Title:	Seismic Hazard Values for the Design of Part 9 Buildings
Related Proposed Change(s):	PCF 1475

This change could potentially affect the following topic areas:

- [ ] Division A
- [ ] Division C
- [ ] Building operations
- [x] Small Buildings
- [ ] Fire Protection
- [ ] Accessibility
- [ ] Building Envelope
- [ ] Heating, Ventilating and Air Conditioning
- [x] Division B
- [x] Design and Construction
- [x] Housing
- [ ] Large Buildings
- [ ] Occupant safety in use
- [x] Structural Requirements
- [ ] Energy Efficiency
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

The seismic hazard values in existing Table C-3 in Appendix C do not reflect the current knowledge of seismic hazard across the country and may be unconservative. Using these values to design buildings under Part 9 could increase the risk of structural failure or insufficiency beyond the acceptable level established for the NBC 2020 and compromise the safety of Canadians.

Additionally, the current NBC 2020 seismic values in Table C-3 are based on 2015 seismic hazards, which differs from the 2020 seismic hazards used for design of Part 4 buildings, resulting in two seismic hazard data sets used in Canada. This can cause confusion for code users and authorities having jurisdiction.

Justification

The proposed change replaces the 2015 seismic hazard values, $S_a(0.2)$, in Table C-3 of the NBC 2020 with the seismic design parameter, S_{max}. S_{max} is derived from the 2020 seismic hazard values, which are used to design buildings under Part 4 of the NBC 2020. As such, the proposed change will ensure that a single set of seismic hazard values, based on current knowledge of seismic hazards across the country, are used for the design of both Part 4 and Part 9 buildings.

Updating the seismic hazard values in Table C-3 to reflect current knowledge is necessary to establish compatibility with modern seismic hazard maps used in building codes in the United States and other jurisdictions; and to account for:

- new knowledge about active faults near Victoria, BC,
- new data on past Cascadia great earthquakes, which slightly increase the earthquake occurrence rate, and
- current ground motion models (GMMs) developed by large teams of American and Canadian seismologists over the past few years through Next Generation Attenuation (NGA) projects, including suites of GMMs for all four types of tectonic regions in Canada: GMMs for great subduction interface earthquakes, for in-slab earthquakes (deep events), for western crustal earthquakes, and for eastern crustal earthquakes.

Ignoring the effects of this new knowledge and data in the calculation of seismic hazard values could compromise the structural safety and sufficiency of buildings and expose the occupants and buildings to a risk of injury or damage that is higher than the acceptable limit established for the NBC 2020.

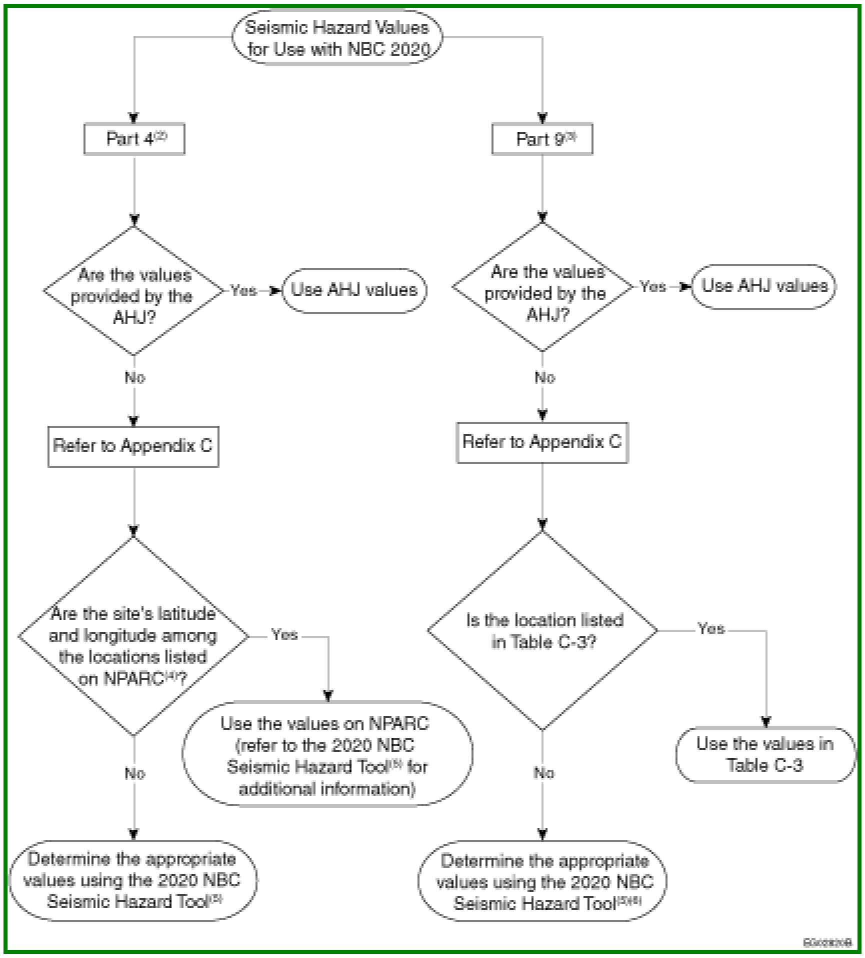
PROPOSED CHANGE

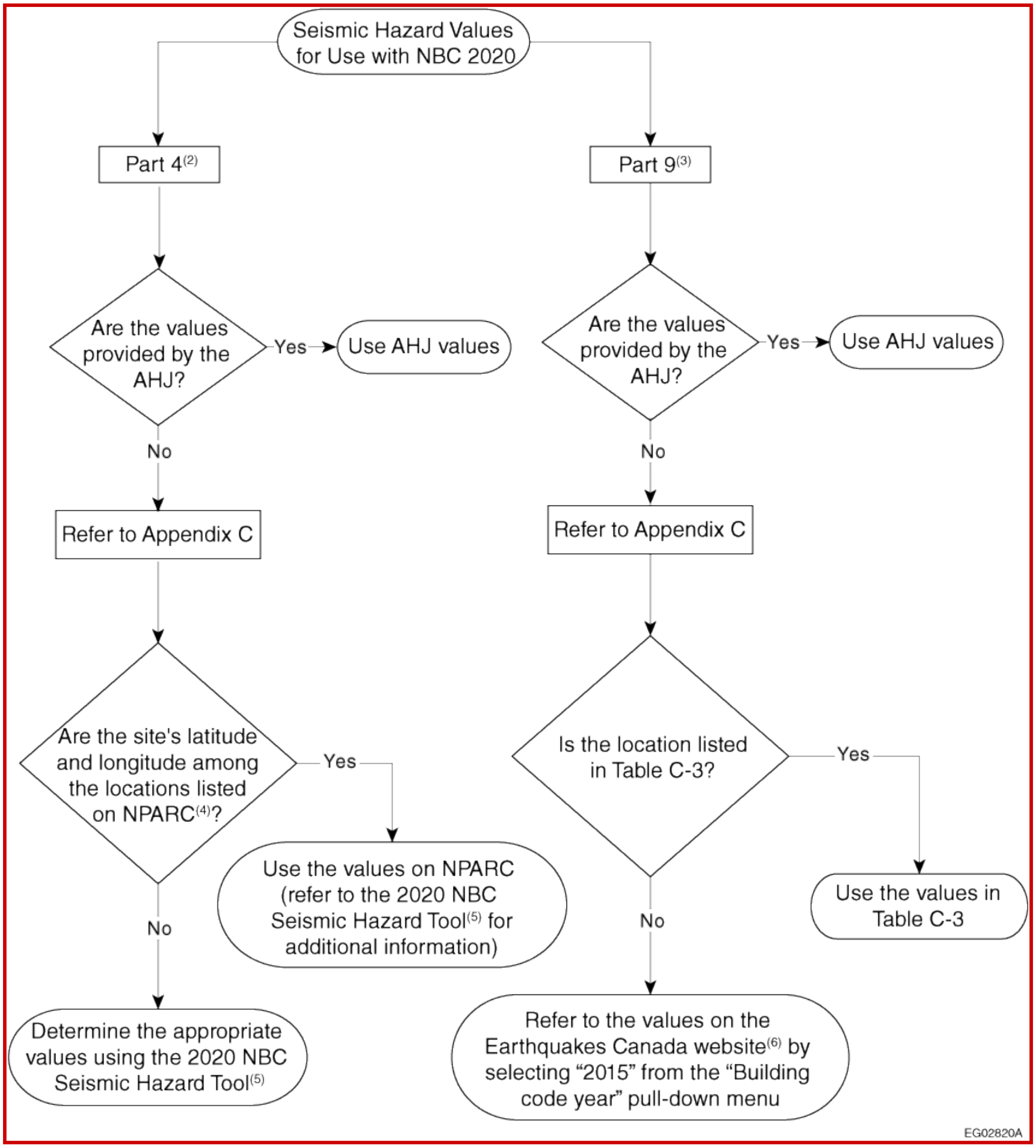
[1.1.3.1.] 1.1.3.1. Climatic and Seismic Values

Note A-1.1.3.1.(4) Seismic Values.

Figure A-1.1.3.1.(4) illustrates how to determine the seismic hazard values to be used in the application of the Part 4 and Part 9 seismic provisions.

Figure [A-1.1.3.1.(4)] A-1.1.3.1.(4)
Determining seismic hazard values for use in Part 4 and Part 9


Seismic Hazard Values for Use with NBC 2020
Part 4(2)
Part 9(3)
Are the values provided by the AHJ?
Yes
Use AHJ values
No
Refer to Appendix C
Are the site's latitude and longitude among the locations listed on NPARC(4)?
Use the values on NPARC (refer to the 2020 NBC Seismic Hazard Tool(5) for additional information)
Determine the appropriate values using the 2020 NBC Seismic Hazard Tool(5)
Is the location listed in Table C-3?
Use the values in Table C-3
Determine the appropriate values using the 2020 NBC Seismic Hazard Tool(5)(6)



Notes to Figure A-1.1.3.1.(4):

(1) The abbreviations used in the figure have the following meanings:
AHJ = authority having jurisdiction
NPARC = NRC Publications Archive

(2) See also the section entitled "Seismic Hazard for Part 4" in Appendix C.

(3) See also the section entitled "Seismic Hazard for Part 9" in Appendix C.

(4) The seismic hazard values available on NPARC at https://doi.org/10.4224/nqzr-dz38 were generated from the 2020 National Building Code of Canada Seismic Hazard Tool. This subset of values on NPARC is provided as a static, archival record for Code users.

(5) The 2020 National Building Code of Canada Seismic Hazard Tool is available at https://doi.org/10.23687/b1bd3cf0-0672-47f4-8bfa-290ae75fde9b.

(6) Refer to the ~~"2015 – 2005 National Building Code of Canada seismic hazard values" page on NRCan's Earthquakes Canada website~~procedure set out in the section entitled "Seismic Hazard for Part 9" in Appendix C.

Appendix C Climatic and Seismic Information for Building Design in Canada

Footnote: This information is included for explanatory purposes only and does not form part of the requirements.

Seismic Hazard for Part 9

Table C-3 lists the seismic hazard values to be used in the application of the prescriptive requirements in Part 9 relating to lateral loads due to earthquake ~~(these values are the same as those listed in Table C-3 of the NBC 2015). Seismic hazard values for localities not listed in Table C-3 can be obtained from the "2015 – 2005 National Building Code of Canada seismic hazard values" page on NRCan's Earthquakes Canada website by selecting "2015" from the "Building code year" pull-down menu~~. For locations not listed in Table C-3, the seismic hazard values to be used can be determined using the 2020 National Building Code of Canada Seismic Hazard Tool (https://doi.org/10.23687/b1bd3cf0-0672-47f4-8bfa-290ae75fde9b).

The Tool provides seismic hazard values for any site in Canada based on the following information:

- Latitude and longitude of the site's location: Seismic hazard values can be appreciably different for localities across a large locale. Therefore, applying the same seismic hazard value to a large geographic area could result in buildings being over-designed or under-designed.
- Site designation in terms of Site Class, X_S, where S is the Site Class (see Sentence 4.1.8.4.(3)).

The procedure to determine the seismic design parameter, S_{max}, for a site is as follows:

1. Go to the 2020 National Building Code of Canada Seismic Hazard Tool (https://doi.org/10.23687/b1bd3cf0-0672-47f4-8bfa-290ae75fde9b).
2. Select "Site Class (X_S)" as the site designation.
3. Select the appropriate Site Class (A, B, C, D or E).
4. Enter the latitude and longitude of the site's location manually, or determine the latitude and longitude from an address or current location.
5. Click "Obtain Seismic Hazard Values." The following values are needed to determine S_{max}: $S_a(0.2,X_S)$ and $S_a(0.5,X_S)$.
6. Determine $S(0.2,X_S)$ in accordance with Sentence 4.1.8.4.(6):
   $S(0.2,X_S) = S_a(0.2,X_S)$ or $S_a(0.5,X_S)$, whichever is greater
7. Determine $S(0.5,X_S)$ in accordance with Sentence 4.1.8.4.(6):
   $S(0.5,X_S) = S_a(0.5,X_S)$

8. Determine S_{max}:

$$S_{max} = (2/3)S(0.2,X_S) \text{ or } S(0.5,X_S)\text{, whichever is greater}$$

9. Round S_{max} to three significant digits.

In cases where the Site Class is determined in accordance with Sentence 4.1.8.4.(3), S_{max} is calculated for the determined Site Class. In cases where the Site Class is unknown, S_{max} must be calculated for each of Site Classes A, B, C, D and E, by repeating Steps 1 to 9, and the highest value of S_{max} among all the Site Classes used for design.

Example

Consider a site in Strathmore, Alberta, a location not listed in Table C-3. The latitude and longitude of Strathmore are 51.040 and −113.402, respectively. In this example, the Site Class is determined by a geotechnical investigation to be Site Class C.

Using the 2020 National Building Code of Canada Seismic Hazard Tool (Step 1), select "Site Class (X_S)" as the site designation (Step 2). Select "C" as the Site Class (Step 3). Under "Location," enter the latitude, 51.040, and longitude, −113.402, and then click "Set coordinates" (Step 4). Click "Obtain Seismic Hazard Values" to obtain the values for $S_a(0.2,X_C)$ and $S_a(0.5,X_C)$, which are 0.191 and 0.125, respectively (Step 5).

Next, determine $S(0.2,X_C)$ as follows (Step 6):

$S(0.2,X_C) = S_a(0.2,X_C)$ or $S_a(0.5,X_C)$, whichever is greater
$S(0.2,X_C) = 0.191$ or 0.125, whichever is greater
$S(0.2,X_C) = 0.191$

Now, determine $S(0.5,X_C)$ as follows (Step 7):

$S(0.5,X_C) = S_a(0.5,X_C)$
$S(0.5,X_C) = 0.125$

Finally, determine S_{max} for Site Class C as follows (Step 8):

$S_{max} = (2/3)S(0.2,X_C)$ or $S(0.5,X_C)$, whichever is greater
$S_{max} = 0.127333$ or 0.125, whichever is greater
$S_{max} = 0.127$ (rounded to three significant digits according to Step 9)

If the Site Class is unknown, this procedure is repeated to determine S_{max} for each of Site Classes A, B, C, D and E. For Strathmore, the resulting values of S_{max} are as follows: 0.071 for Site Class A, 0.097 for Site Class B, 0.127 for Site Class C, 0.213 for Site Class D, and 0.254 for Site Class E. The highest value is selected as S_{max} for unknown Site Class: 0.254.

Table [C-3] C-3
Seismic Design ~~Data~~Parameter, S_{max}, for Selected Locations in Canada ~~for Part 9 Design~~

Province and Location	S_{max} for Unknown Site Class	S_{max} According to Site Class				
		A	B	C	D	E

British Columbia						
100 Mile House	0.283	0.0661	0.084	0.144	0.239	0.283
Abbotsford	1.07	0.381	0.473	0.742	1.01	1.07
Agassiz	0.802	0.25	0.313	0.507	0.729	0.802
Alberni	1.62	0.573	0.74	1.25	1.57	1.62
Ashcroft	0.389	0.098	0.123	0.209	0.335	0.389
Bamfield	2.27	0.919	1.18	1.92	2.23	2.27
Beatton River	0.248	0.074	0.102	0.13	0.211	0.248
Bella Bella	0.585	0.126	0.169	0.312	0.501	0.585
Bella Coola	0.417	0.0887	0.117	0.22	0.355	0.417
Burns Lake	0.214	0.0475	0.0596	0.107	0.179	0.214
Cache Creek	0.381	0.0953	0.12	0.204	0.327	0.381
Campbell River	1.14	0.346	0.452	0.789	1.07	1.14
Carmi	0.298	0.0693	0.0867	0.153	0.251	0.298
Castlegar	0.252	0.0592	0.076	0.124	0.211	0.252
Chetwynd	0.334	0.0867	0.115	0.174	0.286	0.334
Chilliwack	0.887	0.294	0.367	0.583	0.82	0.887
Comox	1.27	0.408	0.53	0.912	1.21	1.27
Courtenay	1.29	0.415	0.538	0.926	1.22	1.29
Cranbrook	0.321	0.0713	0.0933	0.158	0.269	0.321
Crescent Valley	0.252	0.0589	0.076	0.124	0.211	0.252
Crofton	1.75	0.667	0.813	1.32	1.7	1.75
Dawson Creek	0.275	0.0767	0.105	0.14	0.233	0.275
Dease Lake	0.342	0.0648	0.0895	0.173	0.289	0.342
Dog Creek	0.338	0.08	0.101	0.177	0.287	0.338
Duncan	1.86	0.713	0.867	1.42	1.81	1.86
Elko	0.39	0.09	0.117	0.197	0.33	0.39
Fernie	0.404	0.104	0.137	0.21	0.345	0.404

Fort Nelson	0.284	0.0753	0.103	0.144	0.239	0.284
Fort St. John	0.27	0.076	0.104	0.138	0.229	0.27
Glacier	0.356	0.094	0.123	0.184	0.303	0.356
Golden	0.425	0.126	0.164	0.239	0.369	0.425
Gold River	1.73	0.6	0.776	1.31	1.66	1.73
Grand Forks	0.272	0.0641	0.0807	0.138	0.229	0.272
Greenwood	0.283	0.0662	0.0833	0.144	0.238	0.283
Hope	0.672	0.197	0.246	0.405	0.601	0.672
Jordan River	2.31	0.902	1.15	1.90	2.27	2.31
Kamloops	0.304	0.0707	0.0887	0.157	0.257	0.304
Kaslo	0.271	0.0615	0.08	0.132	0.226	0.271
Kelowna	0.302	0.07	0.088	0.155	0.255	0.302
Kimberley	0.311	0.0707	0.0927	0.153	0.261	0.311
Kitimat Plant	0.456	0.091	0.123	0.233	0.385	0.456
Kitimat Townsite	0.456	0.091	0.123	0.233	0.385	0.456
Ladysmith	1.7	0.636	0.773	1.28	1.65	1.7
Langford	2.07	0.887	1.09	1.74	2.06	2.07
Lillooet	0.503	0.147	0.187	0.289	0.442	0.503
Lytton	0.532	0.155	0.196	0.309	0.469	0.532
Mackenzie	0.314	0.0773	0.101	0.162	0.268	0.314
Masset	1.56	0.491	0.605	1.05	1.44	1.56
McBride	0.396	0.116	0.151	0.222	0.343	0.396
McLeod Lake	0.295	0.0707	0.092	0.15	0.251	0.295
Merritt	0.423	0.108	0.136	0.23	0.364	0.423
Mission City	1.01	0.354	0.439	0.692	0.949	1.01
Montrose	0.251	0.059	0.0753	0.124	0.21	0.251
Nakusp	0.259	0.0599	0.0773	0.127	0.216	0.259
Nanaimo	1.55	0.571	0.7	1.15	1.5	1.55

Nelson	0.255	0.0587	0.076	0.124	0.213	0.255
Ocean Falls	0.503	0.106	0.141	0.264	0.428	0.503
Osoyoos	0.365	0.0867	0.109	0.192	0.311	0.365
Parksville	1.46	0.509	0.638	1.08	1.41	1.46
Penticton	0.337	0.078	0.098	0.175	0.285	0.337
Port Alberni	1.66	0.594	0.768	1.29	1.61	1.66
Port Alice	1.86	0.84	1.06	1.64	1.85	1.86
Port Hardy	1.29	0.372	0.486	0.853	1.18	1.29
Port McNeill	1.31	0.385	0.504	0.878	1.21	1.31
Port Renfrew	2.32	0.923	1.18	1.94	2.28	2.32
Powell River	1.08	0.343	0.43	0.75	1.02	1.08
Prince George	0.234	0.0497	0.0644	0.114	0.195	0.234
Prince Rupert	0.684	0.149	0.199	0.367	0.587	0.684
Princeton	0.492	0.135	0.171	0.278	0.43	0.492
Qualicum Beach	1.45	0.496	0.633	1.08	1.39	1.45
Queen Charlotte City	2.52	1.05	1.28	2.03	2.45	2.52
Quesnel	0.225	0.0475	0.0605	0.111	0.188	0.225
Revelstoke	0.275	0.0634	0.082	0.135	0.23	0.275
Salmon Arm	0.264	0.0618	0.0787	0.132	0.222	0.264
Sandspit	2.2	0.833	1.02	1.68	2.11	2.2
Sechelt	1.25	0.455	0.559	0.9	1.2	1.25
Sidney	1.85	0.74	0.907	1.44	1.81	1.85
Smithers	0.236	0.0516	0.0645	0.118	0.197	0.236
Smith River	0.859	0.339	0.439	0.598	0.807	0.859
Sooke	2.21	0.873	1.07	1.78	2.17	2.21
Squamish	0.963	0.334	0.415	0.659	0.903	0.963
Stewart	0.427	0.0828	0.113	0.217	0.361	0.427
Tahsis	1.97	0.807	1	1.62	1.93	1.97

Taylor	0.267	0.0753	0.103	0.137	0.226	0.267
Terrace	0.406	0.08	0.107	0.205	0.342	0.406
Tofino	2.25	0.903	1.16	1.89	2.2	2.25
Trail	0.252	0.0594	0.076	0.125	0.21	0.252
Ucluelet	2.3	0.936	1.21	1.96	2.26	2.3
Vancouver Region						
Burnaby (Simon Fraser Univ.)	1.14	0.416	0.513	0.806	1.08	1.14
Cloverdale	1.18	0.434	0.535	0.839	1.13	1.18
Haney	1.06	0.378	0.467	0.736	1	1.06
Ladner	1.34	0.504	0.618	0.971	1.29	1.34
Langley	1.15	0.419	0.517	0.812	1.09	1.15
New Westminster	1.18	0.433	0.533	0.837	1.12	1.18
North Vancouver	1.17	0.429	0.529	0.831	1.11	1.17
Richmond	1.29	0.479	0.589	0.924	1.23	1.29
Surrey (88 Ave & 156 St.)	1.17	0.427	0.525	0.824	1.11	1.17
Vancouver (City Hall)	1.24	0.458	0.563	0.884	1.18	1.24
Vancouver (Granville St. & 41st Ave)	1.26	0.466	0.573	0.899	1.2	1.26
West Vancouver	1.2	0.441	0.544	0.855	1.14	1.2
Vernon	0.273	0.0639	0.0807	0.138	0.23	0.273
Victoria Region						
Victoria	2.01	0.86	1.06	1.68	2	2.01
Victoria (Gonzales Hts)	1.99	0.853	1.05	1.66	1.98	1.99
Victoria (Mt Tolmie)	1.96	0.82	1.01	1.6	1.94	1.96
Whistler	0.748	0.239	0.301	0.478	0.684	0.748

White Rock	1.27	0.471	0.579	0.907	1.21	1.27
Williams Lake	0.274	0.064	0.0813	0.14	0.231	0.274
Youbou	1.92	0.707	0.9	1.5	1.87	1.92
Alberta						
Athabasca	0.151	0.0407	0.0578	0.074	0.13	0.151
Banff	0.451	0.135	0.177	0.255	0.394	0.451
Barrhead	0.198	0.0611	0.086	0.108	0.169	0.198
Beaverlodge	0.276	0.0753	0.103	0.14	0.234	0.276
Brooks	0.21	0.0631	0.0887	0.111	0.178	0.21
Calgary	0.317	0.0873	0.118	0.164	0.268	0.317
Campsie	0.205	0.0643	0.09	0.113	0.175	0.205
Camrose	0.182	0.0537	0.076	0.096	0.155	0.182
Canmore	0.45	0.135	0.177	0.255	0.392	0.45
Cardston	0.449	0.125	0.166	0.241	0.387	0.449
Claresholm	0.366	0.105	0.141	0.197	0.312	0.366
Cold Lake	0.121	0.0314	0.0445	0.0575	0.104	0.121
Coleman	0.455	0.133	0.174	0.251	0.395	0.455
Coronation	0.159	0.0429	0.0608	0.078	0.136	0.159
Cowley	0.46	0.135	0.177	0.254	0.4	0.46
Drumheller	0.214	0.0654	0.0913	0.115	0.181	0.214
Edmonton	0.189	0.0572	0.0807	0.101	0.161	0.189
Edson	0.286	0.078	0.107	0.144	0.241	0.286
Embarras Portage	0.113	0.0301	0.0424	0.0547	0.0969	0.113
Fairview	0.223	0.0707	0.098	0.123	0.19	0.223
Fort MacLeod	0.381	0.108	0.143	0.203	0.326	0.381
Fort McMurray	0.118	0.0311	0.044	0.0568	0.102	0.118
Fort Saskatchewan	0.173	0.0493	0.0693	0.0887	0.147	0.173
Fort Vermilion	0.135	0.0349	0.0494	0.0642	0.116	0.135

Grande Prairie	0.256	0.072	0.0993	0.13	0.216	0.256
Habay	0.163	0.0429	0.0606	0.078	0.14	0.163
Hardisty	0.148	0.0393	0.0559	0.072	0.127	0.148
High River	0.344	0.098	0.131	0.184	0.292	0.344
Hinton	0.444	0.135	0.177	0.253	0.387	0.444
Jasper	0.456	0.135	0.177	0.256	0.398	0.456
Keg River	0.159	0.0424	0.0601	0.0773	0.137	0.159
Lac La Biche	0.134	0.0354	0.0502	0.0647	0.115	0.134
Lacombe	0.224	0.0673	0.094	0.119	0.189	0.224
Lethbridge	0.294	0.0747	0.102	0.145	0.246	0.294
Manning	0.177	0.0495	0.07	0.0893	0.151	0.177
Medicine Hat	0.178	0.0471	0.0667	0.0853	0.151	0.178
Peace River	0.196	0.0593	0.0833	0.105	0.168	0.196
Pincher Creek	0.464	0.135	0.177	0.255	0.403	0.464
Ranfurly	0.145	0.0387	0.0549	0.0707	0.124	0.145
Red Deer	0.231	0.068	0.0947	0.121	0.196	0.231
Rocky Mountain House	0.301	0.084	0.114	0.156	0.254	0.301
Slave Lake	0.165	0.0455	0.0644	0.082	0.141	0.165
Stettler	0.197	0.0609	0.0853	0.108	0.168	0.197
Stony Plain	0.206	0.0645	0.0907	0.114	0.176	0.206
Suffield	0.194	0.0547	0.0773	0.0973	0.164	0.194
Taber	0.246	0.0667	0.0927	0.12	0.206	0.246
Turner Valley	0.407	0.123	0.163	0.231	0.351	0.407
Valleyview	0.229	0.07	0.098	0.123	0.195	0.229
Vegreville	0.15	0.0404	0.0573	0.0733	0.128	0.15
Vermilion	0.135	0.0353	0.0501	0.0645	0.116	0.135
Wagner	0.167	0.0464	0.0655	0.084	0.143	0.167

Wainwright	0.141	0.0367	0.0523	0.0673	0.121	0.141
Wetaskiwin	0.203	0.0635	0.0893	0.112	0.173	0.203
Whitecourt	0.226	0.0693	0.0967	0.122	0.192	0.226
Wimborne	0.234	0.068	0.0947	0.121	0.197	0.234
Saskatchewan						
Assiniboia	0.253	0.0813	0.115	0.143	0.218	0.253
Battrum	0.157	0.0393	0.0567	0.0738	0.135	0.157
Biggar	0.136	0.0334	0.0479	0.0638	0.117	0.136
Broadview	0.174	0.0473	0.0673	0.086	0.15	0.174
Dafoe	0.146	0.0371	0.0531	0.0687	0.125	0.146
Dundurn	0.143	0.0355	0.0508	0.0671	0.123	0.143
Estevan	0.237	0.0753	0.107	0.133	0.204	0.237
Hudson Bay	0.121	0.0312	0.0443	0.0572	0.104	0.121
Humboldt	0.136	0.0342	0.0489	0.0641	0.117	0.136
Island Falls	0.106	0.0298	0.042	0.0541	0.0911	0.106
Kamsack	0.135	0.0344	0.0492	0.0636	0.116	0.135
Kindersley	0.143	0.0353	0.0505	0.067	0.122	0.143
Lloydminster	0.128	0.0327	0.0465	0.0605	0.111	0.128
Maple Creek	0.161	0.0405	0.0582	0.0755	0.138	0.161
Meadow Lake	0.118	0.0307	0.0435	0.0561	0.101	0.118
Melfort	0.125	0.0318	0.0453	0.0589	0.108	0.125
Melville	0.16	0.042	0.0601	0.0773	0.137	0.16
Moose Jaw	0.206	0.0589	0.084	0.106	0.177	0.206
Nipawin	0.119	0.0308	0.0437	0.0564	0.102	0.119
North Battleford	0.129	0.032	0.0457	0.0607	0.111	0.129
Prince Albert	0.123	0.0312	0.0443	0.0579	0.106	0.123
Qu'Appelle	0.193	0.0549	0.078	0.0993	0.167	0.193
Regina	0.21	0.0613	0.0873	0.11	0.18	0.21

Rosetown	0.143	0.0351	0.0504	0.067	0.123	0.143
Saskatoon	0.137	0.0339	0.0485	0.0644	0.118	0.137
Scott	0.133	0.0329	0.0471	0.0627	0.115	0.133
Strasbourg	0.171	0.0452	0.0647	0.0827	0.146	0.171
Swift Current	0.168	0.0432	0.0621	0.0793	0.145	0.168
Uranium City	0.105	0.0294	0.0414	0.0533	0.0903	0.105
Weyburn	0.285	0.105	0.149	0.181	0.245	0.285
Yorkton	0.147	0.0379	0.0543	0.07	0.126	0.147
Manitoba						
Beausejour	0.109	0.0308	0.0435	0.056	0.0936	0.109
Boissevain	0.133	0.0345	0.0492	0.0633	0.114	0.133
Brandon	0.131	0.0338	0.0483	0.0622	0.113	0.131
Churchill	0.106	0.0298	0.0421	0.0542	0.0913	0.106
Dauphin	0.125	0.0321	0.0458	0.059	0.108	0.125
Flin Flon	0.107	0.0298	0.0421	0.0542	0.092	0.107
Gimli	0.109	0.0305	0.0432	0.0556	0.0937	0.109
Island Lake	0.109	0.0303	0.0427	0.0551	0.0939	0.109
Lac du Bonnet	0.111	0.0314	0.0444	0.0571	0.0955	0.111
Lynn Lake	0.106	0.0298	0.0421	0.0541	0.0912	0.106
Morden	0.111	0.0297	0.042	0.0542	0.0951	0.111
Neepawa	0.124	0.0322	0.0459	0.0591	0.107	0.124
Pine Falls	0.111	0.0313	0.0442	0.0569	0.0956	0.111
Portage la Prairie	0.114	0.0303	0.043	0.0554	0.0981	0.114
Rivers	0.134	0.0345	0.0494	0.0636	0.115	0.134
Sandilands	0.106	0.0304	0.0428	0.0551	0.0911	0.106
Selkirk	0.108	0.0305	0.0431	0.0555	0.0929	0.108
Split Lake	0.106	0.0298	0.0421	0.0541	0.091	0.106
Steinbach	0.106	0.0302	0.0426	0.0549	0.091	0.106

Swan River	0.124	0.0318	0.0453	0.0585	0.107	0.124
The Pas	0.11	0.03	0.0424	0.0546	0.0948	0.11
Thompson	0.106	0.0298	0.0421	0.0542	0.0914	0.106
Virden	0.147	0.0382	0.0547	0.07	0.126	0.147
Winnipeg	0.106	0.0302	0.0425	0.0548	0.0914	0.106
Ontario						
Ailsa Craig	0.247	0.062	0.0893	0.118	0.213	0.247
Ajax	0.374	0.127	0.181	0.219	0.322	0.374
Alexandria	0.671	0.347	0.493	0.561	0.576	0.671
Alliston	0.306	0.076	0.111	0.147	0.264	0.306
Almonte	0.543	0.209	0.301	0.355	0.467	0.543
Armstrong	0.125	0.0358	0.0505	0.0648	0.108	0.125
Arnprior	0.556	0.227	0.325	0.381	0.478	0.556
Atikokan	0.125	0.0389	0.0547	0.07	0.108	0.125
Attawapiskat	0.144	0.042	0.0593	0.076	0.124	0.144
Aurora	0.33	0.0893	0.129	0.163	0.283	0.33
Bancroft	0.411	0.111	0.162	0.207	0.353	0.411
Barrie	0.314	0.076	0.111	0.151	0.27	0.314
Barriefield	0.429	0.119	0.174	0.219	0.368	0.429
Beaverton	0.335	0.0827	0.121	0.162	0.287	0.335
Belleville	0.4	0.115	0.168	0.206	0.344	0.4
Belmont	0.271	0.0733	0.106	0.133	0.233	0.271
Borden (CFB)	0.305	0.0747	0.109	0.146	0.263	0.305
Bracebridge	0.344	0.0847	0.125	0.167	0.295	0.344
Bradford	0.32	0.082	0.119	0.155	0.275	0.32
Brampton	0.335	0.101	0.145	0.178	0.288	0.335
Brantford	0.313	0.0953	0.135	0.167	0.27	0.313
Brighton	0.39	0.117	0.169	0.207	0.336	0.39

Brockville	0.513	0.174	0.252	0.303	0.44	0.513
Burk's Falls	0.37	0.101	0.147	0.186	0.319	0.37
Burlington	0.375	0.151	0.212	0.252	0.323	0.375
Cambridge	0.306	0.088	0.126	0.156	0.264	0.306
Campbellford	0.382	0.102	0.149	0.191	0.33	0.382
Cannington	0.339	0.0853	0.125	0.165	0.291	0.339
Carleton Place	0.532	0.193	0.279	0.333	0.457	0.532
Cavan	0.359	0.096	0.139	0.178	0.309	0.359
Centralia	0.247	0.0607	0.088	0.118	0.213	0.247
Chapleau	0.184	0.0436	0.0627	0.087	0.159	0.184
Chatham	0.248	0.07	0.1	0.125	0.214	0.248
Chesley	0.256	0.0602	0.0847	0.12	0.22	0.256
Clinton	0.24	0.0569	0.082	0.114	0.207	0.24
Coboconk	0.351	0.0873	0.128	0.171	0.302	0.351
Cobourg	0.379	0.115	0.167	0.203	0.327	0.379
Cochrane	0.313	0.124	0.173	0.207	0.27	0.313
Colborne	0.387	0.117	0.169	0.207	0.333	0.387
Collingwood	0.292	0.0695	0.1	0.139	0.251	0.292
Cornwall	0.665	0.345	0.49	0.557	0.571	0.665
Corunna	0.224	0.056	0.0807	0.106	0.192	0.224
Deep River	0.545	0.232	0.331	0.387	0.469	0.545
Deseronto	0.409	0.114	0.167	0.208	0.351	0.409
Dorchester	0.27	0.072	0.103	0.131	0.232	0.27
Dorion	0.117	0.0326	0.0461	0.0593	0.1	0.117
Dresden	0.242	0.0656	0.094	0.119	0.209	0.242
Dryden	0.134	0.0413	0.0581	0.074	0.115	0.134
Dundalk	0.284	0.0677	0.0987	0.136	0.244	0.284
Dunnville	0.36	0.133	0.188	0.225	0.309	0.36

Durham	0.267	0.063	0.09	0.126	0.229	0.267
Dutton	0.262	0.0727	0.104	0.131	0.225	0.262
Earlton	0.369	0.118	0.169	0.206	0.317	0.369
Edison	0.13	0.0399	0.0562	0.072	0.112	0.13
Elliot Lake	0.21	0.0494	0.0687	0.0988	0.181	0.21
Elmvale	0.307	0.0735	0.107	0.147	0.265	0.307
Embro	0.274	0.072	0.104	0.133	0.235	0.274
Englehart	0.36	0.114	0.163	0.199	0.31	0.36
Espanola	0.248	0.0588	0.084	0.118	0.214	0.248
Exeter	0.246	0.0597	0.0867	0.117	0.212	0.246
Fenelon Falls	0.35	0.0873	0.128	0.171	0.301	0.35
Fergus	0.291	0.0753	0.108	0.141	0.251	0.291
Forest	0.232	0.0571	0.0827	0.11	0.2	0.232
Fort Erie	0.402	0.172	0.241	0.285	0.345	0.402
Fort Erie (Ridgeway)	0.397	0.169	0.237	0.28	0.341	0.397
Fort Frances	0.118	0.0365	0.0513	0.0655	0.102	0.118
Gananoque	0.45	0.130	0.190	0.234	0.388	0.450
Geraldton	0.121	0.0321	0.0457	0.0588	0.104	0.121
Glencoe	0.252	0.068	0.0973	0.123	0.217	0.252
Goderich	0.233	0.0549	0.0773	0.11	0.2	0.233
Gore Bay	0.215	0.0503	0.0693	0.101	0.184	0.215
Graham	0.13	0.0402	0.0565	0.072	0.112	0.13
Gravenhurst (Muskoka Airport)	0.337	0.082	0.121	0.162	0.289	0.337
Grimsby	0.394	0.167	0.234	0.277	0.339	0.394
Guelph	0.304	0.0847	0.121	0.151	0.262	0.304
Guthrie	0.319	0.0773	0.113	0.153	0.274	0.319
Haileybury	0.4	0.136	0.195	0.235	0.344	0.4

Haldimand (Caledonia)	0.348	0.124	0.175	0.211	0.299	0.348
Haldimand (Hagersville)	0.324	0.102	0.145	0.178	0.279	0.324
Haliburton	0.379	0.098	0.144	0.188	0.327	0.379
Halton Hills (Georgetown)	0.325	0.0953	0.136	0.168	0.279	0.325
Hamilton	0.37	0.148	0.207	0.247	0.319	0.37
Hanover	0.258	0.0608	0.086	0.122	0.222	0.258
Hastings	0.377	0.1	0.146	0.187	0.325	0.377
Hawkesbury	0.64	0.301	0.431	0.495	0.55	0.64
Hearst	0.169	0.0431	0.0615	0.0799	0.145	0.169
Honey Harbour	0.315	0.0755	0.11	0.151	0.271	0.315
Hornepayne	0.148	0.0367	0.0523	0.0701	0.128	0.148
Huntsville	0.362	0.094	0.137	0.179	0.311	0.362
Ingersoll	0.276	0.074	0.107	0.135	0.238	0.276
Iroquois Falls	0.313	0.113	0.159	0.192	0.27	0.313
Jellicoe	0.12	0.0323	0.0458	0.0589	0.103	0.12
Kapuskasing	0.219	0.0637	0.09	0.113	0.189	0.219
Kemptville	0.582	0.248	0.356	0.415	0.501	0.582
Kenora	0.121	0.036	0.0507	0.0649	0.104	0.121
Killaloe	0.491	0.172	0.249	0.297	0.423	0.491
Kincardine	0.234	0.055	0.076	0.11	0.201	0.234
Kingston	0.428	0.118	0.174	0.219	0.368	0.428
Kinmount	0.361	0.0907	0.133	0.177	0.311	0.361
Kirkland Lake	0.335	0.103	0.147	0.181	0.288	0.335
Kitchener	0.291	0.078	0.113	0.142	0.251	0.291
Kitchenuhmaykoosib / Big Trout Lake	0.111	0.0305	0.0432	0.0556	0.0951	0.111
Lakefield	0.366	0.0933	0.137	0.18	0.315	0.366

Lansdowne House	0.118	0.0318	0.0451	0.058	0.101	0.118
Leamington	0.246	0.0707	0.101	0.127	0.212	0.246
Lindsay	0.349	0.0887	0.13	0.171	0.3	0.349
Lion's Head	0.254	0.0597	0.0827	0.12	0.219	0.254
Listowel	0.264	0.0631	0.0913	0.125	0.226	0.264
London	0.264	0.0693	0.1	0.128	0.227	0.264
Lucan	0.252	0.0632	0.0913	0.12	0.217	0.252
Maitland	0.526	0.187	0.271	0.323	0.451	0.526
Markdale	0.274	0.0647	0.092	0.13	0.235	0.274
Markham	0.354	0.11	0.157	0.192	0.305	0.354
Martin	0.131	0.0407	0.0573	0.0727	0.113	0.131
Matheson	0.309	0.0973	0.139	0.171	0.266	0.309
Mattawa	0.547	0.258	0.365	0.423	0.47	0.547
Midland	0.31	0.0741	0.107	0.148	0.267	0.31
Milton	0.344	0.114	0.162	0.196	0.295	0.344
Milverton	0.267	0.0653	0.0947	0.127	0.229	0.267
Minden	0.364	0.0913	0.135	0.178	0.313	0.364
Mississauga	0.361	0.127	0.18	0.217	0.311	0.361
Mississauga (Lester B. Pearson Int'l Airport)	0.351	0.115	0.163	0.197	0.301	0.351
Mississauga (Port Credit)	0.374	0.141	0.198	0.237	0.322	0.374
Mitchell	0.255	0.062	0.09	0.121	0.22	0.255
Moosonee	0.177	0.0478	0.068	0.0867	0.152	0.177
Morrisburg	0.638	0.321	0.457	0.522	0.548	0.638
Mount Forest	0.271	0.0644	0.0933	0.129	0.233	0.271
Nakina	0.122	0.0322	0.0458	0.0589	0.105	0.122
Nanticoke (Jarvis)	0.314	0.0947	0.135	0.166	0.27	0.314

Nanticoke (Port Dover)	0.303	0.0887	0.126	0.157	0.261	0.303
Napanee	0.412	0.113	0.166	0.209	0.354	0.412
Newcastle	0.373	0.117	0.167	0.203	0.321	0.373
Newcastle (Bowmanville)	0.372	0.117	0.168	0.205	0.321	0.372
New Liskeard	0.393	0.131	0.189	0.228	0.338	0.393
Newmarket	0.327	0.0867	0.125	0.16	0.281	0.327
Niagara Falls	0.41	0.177	0.248	0.292	0.352	0.41
North Bay	0.431	0.149	0.212	0.255	0.371	0.431
Norwood	0.376	0.098	0.143	0.186	0.324	0.376
Oakville	0.377	0.147	0.207	0.247	0.325	0.377
Orangeville	0.3	0.0767	0.111	0.145	0.258	0.3
Orillia	0.327	0.0787	0.116	0.157	0.28	0.327
Oshawa	0.371	0.119	0.171	0.207	0.32	0.371
Ottawa (Metropolitan)						
Ottawa (Barrhaven)	0.589	0.255	0.365	0.425	0.508	0.589
Ottawa (City Hall)	0.6	0.264	0.377	0.439	0.517	0.6
Ottawa (Kanata)	0.576	0.242	0.347	0.406	0.496	0.576
Ottawa (M-C Int'l Airport)	0.602	0.269	0.384	0.445	0.519	0.602
Ottawa (Orléans)	0.616	0.283	0.404	0.466	0.53	0.616
Owen Sound	0.264	0.062	0.0867	0.124	0.226	0.264
Pagwa River	0.137	0.0346	0.0493	0.0646	0.118	0.137
Paris	0.304	0.088	0.126	0.156	0.262	0.304
Parkhill	0.242	0.0601	0.0867	0.115	0.209	0.242
Parry Sound	0.322	0.0787	0.115	0.155	0.277	0.322
Pelham (Fonthill)	0.4	0.171	0.24	0.283	0.344	0.4
Pembroke	0.546	0.227	0.325	0.381	0.469	0.546

Penetanguishene	0.309	0.0738	0.107	0.147	0.266	0.309
Perth	0.491	0.155	0.226	0.273	0.423	0.491
Petawawa	0.542	0.227	0.323	0.379	0.466	0.542
Peterborough	0.363	0.0947	0.138	0.179	0.312	0.363
Petrolia	0.233	0.0595	0.086	0.112	0.201	0.233
Pickering (Dunbarton)	0.375	0.13	0.185	0.223	0.324	0.375
Picton	0.398	0.113	0.164	0.203	0.342	0.398
Plattsville	0.286	0.0767	0.11	0.14	0.246	0.286
Point Alexander	0.545	0.233	0.332	0.388	0.468	0.545
Port Burwell	0.283	0.0813	0.116	0.145	0.244	0.283
Port Colborne	0.391	0.164	0.23	0.273	0.337	0.391
Port Elgin	0.243	0.0571	0.0787	0.114	0.209	0.243
Port Hope	0.377	0.116	0.167	0.203	0.325	0.377
Port Perry	0.347	0.0947	0.137	0.173	0.298	0.347
Port Stanley	0.271	0.076	0.109	0.137	0.233	0.271
Prescott	0.557	0.225	0.323	0.379	0.479	0.557
Princeton	0.293	0.0813	0.117	0.145	0.252	0.293
Raith	0.125	0.0379	0.0533	0.068	0.107	0.125
Rayside-Balfour (Chelmsford)	0.284	0.0707	0.103	0.137	0.245	0.284
Red Lake	0.129	0.0388	0.0547	0.07	0.111	0.129
Renfrew	0.54	0.214	0.307	0.362	0.464	0.54
Richmond Hill	0.341	0.101	0.144	0.177	0.293	0.341
Rockland	0.629	0.299	0.427	0.491	0.54	0.629
Sarnia	0.223	0.0551	0.0793	0.106	0.192	0.223
Sault Ste. Marie	0.16	0.0377	0.0528	0.0753	0.138	0.16
Schreiber	0.118	0.0317	0.0449	0.0578	0.101	0.118
Seaforth	0.246	0.0586	0.0847	0.117	0.212	0.246

Shelburne	0.292	0.0713	0.104	0.14	0.252	0.292
Simcoe	0.3	0.0867	0.124	0.154	0.259	0.3
Sioux Lookout	0.136	0.0419	0.0591	0.0753	0.117	0.136
Smiths Falls	0.512	0.171	0.247	0.298	0.439	0.512
Smithville	0.391	0.165	0.231	0.273	0.336	0.391
Smooth Rock Falls	0.288	0.111	0.154	0.186	0.248	0.288
Southampton	0.244	0.0573	0.0793	0.115	0.21	0.244
South River	0.386	0.111	0.161	0.198	0.333	0.386
St. Catharines	0.408	0.175	0.245	0.289	0.35	0.408
St. Marys	0.262	0.0661	0.0953	0.125	0.225	0.262
St. Thomas	0.269	0.074	0.106	0.133	0.231	0.269
Stirling	0.392	0.107	0.156	0.197	0.338	0.392
Stratford	0.268	0.0673	0.0973	0.128	0.23	0.268
Strathroy	0.249	0.0646	0.0933	0.12	0.215	0.249
Sturgeon Falls	0.381	0.117	0.167	0.204	0.329	0.381
Sudbury	0.297	0.0753	0.109	0.144	0.256	0.297
Sundridge	0.38	0.107	0.156	0.194	0.328	0.38
Tavistock	0.274	0.0707	0.102	0.132	0.236	0.274
Temagami	0.417	0.146	0.208	0.25	0.357	0.417
Thamesford	0.271	0.0713	0.103	0.131	0.233	0.271
Thedford	0.236	0.0581	0.084	0.112	0.203	0.236
Thunder Bay	0.116	0.0339	0.0477	0.0613	0.0999	0.116
Tillsonburg	0.284	0.0787	0.113	0.141	0.244	0.284
Timmins	0.268	0.0767	0.109	0.137	0.23	0.268
Timmins (Porcupine)	0.28	0.0847	0.121	0.149	0.241	0.28
Toronto Metropolitan Region						
Etobicoke	0.352	0.115	0.163	0.198	0.303	0.352

North York	0.357	0.117	0.166	0.201	0.307	0.357
Scarborough	0.37	0.128	0.182	0.22	0.319	0.37
Toronto (City Hall)	0.381	0.144	0.203	0.243	0.328	0.381
Trenton	0.394	0.115	0.167	0.205	0.339	0.394
Trout Creek	0.399	0.121	0.175	0.213	0.343	0.399
Uxbridge	0.341	0.092	0.133	0.169	0.293	0.341
Vaughan (Woodbridge)	0.339	0.102	0.145	0.179	0.291	0.339
Vittoria	0.298	0.086	0.123	0.153	0.257	0.298
Walkerton	0.253	0.0596	0.084	0.119	0.218	0.253
Wallaceburg	0.235	0.0624	0.09	0.113	0.202	0.235
Waterloo	0.288	0.076	0.11	0.14	0.248	0.288
Watford	0.24	0.0613	0.0887	0.115	0.207	0.24
Wawa	0.15	0.0362	0.0517	0.0709	0.129	0.15
Welland	0.398	0.169	0.237	0.28	0.342	0.398
West Lorne	0.261	0.0733	0.105	0.131	0.224	0.261
Whitby	0.374	0.125	0.179	0.216	0.322	0.374
Whitby (Brooklin)	0.361	0.111	0.159	0.193	0.311	0.361
White River	0.142	0.0348	0.0497	0.0668	0.122	0.142
Wiarton	0.256	0.0601	0.0833	0.12	0.22	0.256
Windsor	0.227	0.0615	0.0887	0.112	0.195	0.227
Wingham	0.247	0.0582	0.0827	0.116	0.213	0.247
Woodstock	0.281	0.0753	0.109	0.137	0.242	0.281
Wyoming	0.232	0.0583	0.084	0.111	0.199	0.232
Quebec						
Acton Vale	0.554	0.179	0.261	0.315	0.477	0.554
Alma	0.771	0.459	0.651	0.72	0.699	0.771
Amos	0.324	0.0774	0.112	0.155	0.278	0.324

Asbestos	0.535	0.155	0.229	0.285	0.46	0.535
Aylmer	0.587	0.251	0.36	0.42	0.506	0.587
Baie-Comeau	0.573	0.241	0.345	0.403	0.494	0.573
Baie-Saint-Paul	1.41	0.92	1.31	1.41	1.34	1.12
Beauport	0.693	0.322	0.464	0.533	0.596	0.693
Bedford	0.592	0.238	0.343	0.401	0.51	0.592
Beloeil	0.642	0.303	0.432	0.495	0.551	0.642
Brome	0.539	0.169	0.248	0.299	0.463	0.539
Brossard	0.67	0.343	0.487	0.553	0.575	0.67
Buckingham	0.62	0.291	0.415	0.478	0.533	0.62
Campbell's Bay	0.561	0.234	0.335	0.392	0.483	0.561
Chambly	0.653	0.321	0.457	0.522	0.561	0.653
Coaticook	0.512	0.147	0.218	0.269	0.44	0.512
Contrecoeur	0.63	0.281	0.401	0.463	0.541	0.63
Cowansville	0.556	0.189	0.275	0.329	0.479	0.556
Deux-Montagnes	0.676	0.349	0.495	0.563	0.581	0.676
Dolbeau	0.623	0.289	0.412	0.474	0.536	0.623
Drummondville	0.568	0.192	0.28	0.335	0.489	0.568
Farnham	0.595	0.239	0.343	0.403	0.513	0.595
Fort-Coulonge	0.56	0.234	0.335	0.392	0.481	0.56
Gagnon	0.253	0.0592	0.078	0.118	0.218	0.253
Gaspé	0.368	0.094	0.137	0.181	0.317	0.368
Gatineau	0.603	0.266	0.381	0.443	0.519	0.603
Gracefield	0.582	0.256	0.367	0.427	0.501	0.582
Granby	0.558	0.187	0.273	0.327	0.48	0.558
Harrington Harbour	0.204	0.0487	0.0693	0.0973	0.176	0.204
Havre-Saint-Pierre	0.371	0.135	0.191	0.229	0.319	0.371
Hemmingford	0.658	0.327	0.465	0.531	0.565	0.658

Hull	0.596	0.26	0.371	0.433	0.514	0.596
Iberville	0.645	0.309	0.44	0.504	0.553	0.645
Inukjuak	0.142	0.038	0.054	0.0693	0.122	0.142
Joliette	0.623	0.277	0.395	0.457	0.536	0.623
Kuujjuaq	0.201	0.0471	0.0648	0.0943	0.173	0.201
Kuujjuarapik	0.117	0.0315	0.0446	0.0575	0.1	0.117
Lachute	0.646	0.305	0.437	0.501	0.554	0.646
Lac-Mégantic	0.519	0.148	0.219	0.271	0.445	0.519
La Malbaie	1.53	1	1.43	1.53	1.47	1.2
La Pocatière	1.33	0.86	1.23	1.33	1.27	1.09
La Tuque	0.545	0.157	0.235	0.29	0.468	0.545
Lennoxville	0.518	0.145	0.215	0.27	0.444	0.518
Léry	0.679	0.353	0.502	0.569	0.584	0.679
Loretteville	0.684	0.315	0.454	0.523	0.588	0.684
Louiseville	0.597	0.233	0.335	0.395	0.515	0.597
Magog	0.521	0.149	0.221	0.275	0.446	0.521
Malartic	0.363	0.0947	0.138	0.179	0.312	0.363
Maniwaki	0.58	0.257	0.368	0.428	0.5	0.58
Masson	0.624	0.296	0.422	0.485	0.537	0.624
Matane	0.582	0.258	0.367	0.427	0.502	0.582
Mont-Joli	0.612	0.261	0.374	0.437	0.527	0.612
Mont-Laurier	0.576	0.251	0.359	0.418	0.496	0.576
Montmagny	0.767	0.392	0.565	0.639	0.66	0.767
Montréal Region						
Beaconsfield	0.679	0.353	0.501	0.569	0.584	0.679
Dorval	0.678	0.351	0.499	0.567	0.583	0.678
Laval	0.675	0.347	0.493	0.56	0.58	0.675
Montréal (City Hall)	0.673	0.347	0.492	0.559	0.579	0.673

Montréal-Est	0.669	0.341	0.484	0.551	0.575	0.669
Montréal-Nord	0.673	0.346	0.491	0.557	0.578	0.673
Outremont	0.675	0.348	0.495	0.561	0.58	0.675
Pierrefonds	0.678	0.351	0.499	0.566	0.582	0.678
Sainte-Anne-de-Bellevue	0.679	0.353	0.501	0.569	0.584	0.679
Saint-Lambert	0.671	0.344	0.488	0.555	0.576	0.671
Saint-Laurent	0.676	0.35	0.497	0.564	0.581	0.676
Verdun	0.674	0.348	0.494	0.561	0.579	0.674
Nicolet (Gentilly)	0.608	0.235	0.34	0.399	0.524	0.608
Nitchequon	0.17	0.0396	0.0519	0.0792	0.146	0.17
Noranda	0.337	0.09	0.131	0.166	0.289	0.337
Percé	0.355	0.0864	0.126	0.172	0.305	0.355
Pincourt	0.679	0.353	0.502	0.569	0.584	0.679
Plessisville	0.574	0.185	0.271	0.326	0.494	0.574
Port-Cartier	0.479	0.187	0.267	0.315	0.413	0.479
Puvirnituq	0.195	0.0615	0.0867	0.109	0.168	0.195
Québec City Region						
Ancienne-Lorette	0.676	0.307	0.442	0.509	0.581	0.676
Lévis	0.682	0.31	0.447	0.515	0.586	0.682
Québec	0.682	0.311	0.448	0.516	0.586	0.682
Sainte-Foy	0.678	0.308	0.444	0.511	0.583	0.678
Sillery	0.677	0.306	0.441	0.509	0.582	0.677
Richmond	0.535	0.157	0.232	0.287	0.46	0.535
Rimouski	0.63	0.263	0.381	0.445	0.541	0.63
Rivière-du-Loup	0.987	0.633	0.907	0.987	0.942	0.921
Roberval	0.708	0.397	0.562	0.631	0.609	0.708
Rock Island	0.516	0.15	0.222	0.273	0.442	0.516

Rosemère	0.672	0.344	0.489	0.555	0.578	0.672
Rouyn	0.339	0.0907	0.132	0.168	0.291	0.339
Saguenay	0.794	0.467	0.667	0.74	0.719	0.794
Saguenay (Bagotville)	0.807	0.479	0.687	0.753	0.737	0.807
Saguenay (Jonquière)	0.795	0.472	0.673	0.747	0.725	0.795
Saguenay (Kénogami)	0.795	0.473	0.673	0.747	0.726	0.795
Sainte-Agathe-des-Monts	0.604	0.262	0.375	0.436	0.52	0.604
Saint-Eustache	0.674	0.346	0.492	0.559	0.579	0.674
Saint-Félicien	0.636	0.303	0.431	0.495	0.546	0.636
Saint-Georges-de-Cacouna	0.844	0.498	0.713	0.793	0.782	0.844
Saint-Hubert	0.667	0.339	0.481	0.547	0.573	0.667
Saint-Hubert-de-Rivière-du-Loup	0.696	0.3	0.437	0.506	0.599	0.696
Saint-Hyacinthe	0.595	0.231	0.333	0.391	0.513	0.595
Saint-Jean-sur-Richelieu	0.647	0.313	0.445	0.509	0.556	0.647
Saint-Jérôme	0.651	0.315	0.449	0.514	0.559	0.651
Saint-Jovite	0.599	0.26	0.373	0.434	0.516	0.599
Saint-Lazare / Hudson	0.677	0.351	0.499	0.566	0.582	0.677
Saint-Nicolas	0.664	0.293	0.423	0.489	0.57	0.664
Salaberry-de-Valleyfield	0.679	0.354	0.503	0.571	0.583	0.679
Schefferville	0.136	0.0327	0.0465	0.064	0.117	0.136
Senneterre	0.351	0.0844	0.121	0.169	0.302	0.351
Sept-Îles	0.452	0.171	0.243	0.29	0.389	0.452
Shawinigan	0.585	0.209	0.303	0.361	0.504	0.585
Shawville	0.561	0.233	0.333	0.391	0.482	0.561

Sherbrooke	0.52	0.146	0.217	0.272	0.446	0.52
Sorel	0.609	0.251	0.359	0.42	0.525	0.609
Sutton	0.541	0.173	0.253	0.305	0.464	0.541
Tadoussac	0.798	0.428	0.617	0.693	0.691	0.798
Témiscaming	0.7	0.449	0.631	0.7	0.651	0.676
Terrebonne	0.669	0.341	0.483	0.55	0.575	0.669
Thetford Mines	0.552	0.162	0.24	0.296	0.474	0.552
Thurso	0.624	0.292	0.417	0.48	0.537	0.624
Trois-Rivières	0.603	0.235	0.339	0.398	0.52	0.603
Val-d'Or	0.371	0.0953	0.14	0.183	0.319	0.371
Varennes	0.662	0.333	0.473	0.539	0.569	0.662
Verchères	0.65	0.313	0.445	0.51	0.558	0.65
Victoriaville	0.559	0.174	0.256	0.309	0.481	0.559
Ville-Marie	0.433	0.159	0.226	0.27	0.372	0.433
Wakefield	0.585	0.249	0.357	0.416	0.504	0.585
Waterloo	0.539	0.167	0.245	0.296	0.463	0.539
Windsor	0.527	0.15	0.222	0.278	0.452	0.527
New Brunswick						
Alma	0.383	0.101	0.147	0.19	0.33	0.383
Bathurst	0.453	0.139	0.202	0.246	0.39	0.453
Boiestown	0.482	0.153	0.222	0.269	0.416	0.482
Campbellton	0.49	0.148	0.217	0.265	0.422	0.49
Edmundston	0.571	0.18	0.267	0.323	0.492	0.571
Fredericton	0.468	0.141	0.207	0.251	0.403	0.468
Gagetown	0.446	0.132	0.193	0.235	0.384	0.446
Grand Falls	0.543	0.173	0.253	0.305	0.466	0.543
Miramichi	0.444	0.136	0.197	0.239	0.382	0.444
Moncton	0.39	0.107	0.155	0.196	0.336	0.39

Oromocto	0.46	0.139	0.203	0.247	0.397	0.46
Sackville	0.366	0.0953	0.139	0.182	0.315	0.366
Saint Andrews	0.753	0.489	0.687	0.753	0.7	0.714
Saint John	0.431	0.128	0.185	0.226	0.371	0.431
Shippagan	0.388	0.102	0.149	0.192	0.334	0.388
St. George	0.611	0.331	0.465	0.527	0.526	0.611
St. Stephen	0.673	0.432	0.603	0.673	0.625	0.67
Woodstock	0.497	0.147	0.216	0.263	0.428	0.497
Nova Scotia						
Amherst	0.356	0.0893	0.13	0.174	0.306	0.356
Antigonish	0.317	0.0763	0.103	0.152	0.273	0.317
Bridgewater	0.337	0.0827	0.12	0.165	0.289	0.337
Canso	0.345	0.0846	0.119	0.169	0.296	0.345
Debert	0.33	0.0795	0.111	0.159	0.283	0.33
Digby	0.394	0.11	0.159	0.2	0.339	0.394
Greenwood (CFB)	0.363	0.0913	0.133	0.178	0.312	0.363
Halifax Region						
Dartmouth	0.324	0.079	0.111	0.158	0.278	0.324
Halifax	0.324	0.0791	0.112	0.158	0.279	0.324
Kentville	0.351	0.0858	0.125	0.171	0.301	0.351
Liverpool	0.334	0.084	0.121	0.164	0.286	0.334
Lockeport	0.334	0.0853	0.124	0.165	0.286	0.334
Louisbourg	0.365	0.0898	0.129	0.179	0.314	0.365
Lunenburg	0.333	0.0815	0.118	0.162	0.286	0.333
New Glasgow	0.318	0.0763	0.103	0.152	0.274	0.318
North Sydney	0.342	0.0826	0.115	0.165	0.294	0.342
Pictou	0.318	0.0762	0.102	0.152	0.274	0.318
Port Hawkesbury	0.329	0.0793	0.108	0.158	0.282	0.329

Springhill	0.346	0.084	0.121	0.168	0.297	0.346
Stewiacke	0.326	0.079	0.109	0.158	0.28	0.326
Sydney	0.347	0.0843	0.118	0.168	0.298	0.347
Tatamagouche	0.326	0.0782	0.107	0.156	0.28	0.326
Truro	0.326	0.0786	0.109	0.157	0.28	0.326
Wolfville	0.347	0.0847	0.123	0.169	0.298	0.347
Yarmouth	0.363	0.0953	0.139	0.181	0.312	0.363
Prince Edward Island						
Charlottetown	0.324	0.0774	0.106	0.155	0.278	0.324
Souris	0.308	0.0733	0.0967	0.147	0.266	0.308
Summerside	0.351	0.09	0.131	0.173	0.302	0.351
Tignish	0.359	0.092	0.134	0.177	0.309	0.359
Newfoundland and Labrador						
Argentia	0.342	0.082	0.111	0.164	0.294	0.342
Bonavista	0.278	0.066	0.0853	0.132	0.239	0.278
Buchans	0.261	0.0613	0.0773	0.123	0.224	0.261
Cape Harrison	0.339	0.088	0.127	0.167	0.291	0.339
Cape Race	0.364	0.0887	0.124	0.177	0.313	0.364
Channel-Port aux Basques	0.301	0.0715	0.0947	0.143	0.26	0.301
Corner Brook	0.249	0.0587	0.0747	0.118	0.215	0.249
Gander	0.265	0.0625	0.0793	0.125	0.228	0.265
Grand Bank	0.378	0.0922	0.131	0.184	0.326	0.378
Grand Falls	0.263	0.0618	0.078	0.124	0.226	0.263
Happy Valley-Goose Bay	0.185	0.0437	0.0614	0.0874	0.159	0.185
Labrador City	0.186	0.0437	0.0589	0.0875	0.16	0.186
St. Anthony	0.211	0.0504	0.0707	0.101	0.181	0.211
Stephenville	0.261	0.0615	0.0793	0.123	0.224	0.261

St. John's	0.313	0.0746	0.0987	0.149	0.269	0.313
Twin Falls	0.167	0.0392	0.0547	0.0784	0.143	0.167
Wabana	0.312	0.0744	0.098	0.149	0.269	0.312
Wabush	0.188	0.0441	0.0594	0.0882	0.162	0.188
Yukon						
Aishihik	0.906	0.235	0.303	0.564	0.821	0.906
Dawson	0.787	0.245	0.311	0.513	0.721	0.787
Destruction Bay	2.69	1.47	1.89	2.69	2.69	2.08
Faro	0.515	0.141	0.18	0.294	0.452	0.515
Haines Junction	1.3	0.54	0.693	1.06	1.28	1.3
Snag	1.1	0.329	0.427	0.766	1.03	1.1
Teslin	0.567	0.148	0.19	0.322	0.498	0.567
Watson Lake	0.529	0.147	0.189	0.3	0.463	0.529
Whitehorse	0.701	0.171	0.219	0.404	0.619	0.701
Northwest Territories						
Aklavik	0.709	0.245	0.318	0.453	0.649	0.709
Behchok? / Rae-Edzo	0.116	0.0302	0.0424	0.0551	0.099	0.116
Echo Bay / Port Radium	0.132	0.0331	0.0461	0.0629	0.112	0.132
Fort Good Hope	0.526	0.127	0.165	0.289	0.456	0.526
Fort McPherson	0.753	0.219	0.284	0.459	0.677	0.753
Fort Providence	0.139	0.0324	0.0457	0.0649	0.117	0.139
Fort Resolution	0.11	0.03	0.0422	0.0545	0.0945	0.11
Fort Simpson	0.326	0.0613	0.0825	0.157	0.271	0.326
Fort Smith	0.109	0.0297	0.0418	0.0539	0.0937	0.109
Hay River	0.118	0.0312	0.044	0.0569	0.101	0.118
Inuvik	0.553	0.153	0.199	0.312	0.485	0.553
Mould Bay	0.487	0.137	0.199	0.251	0.42	0.487

Norman Wells	0.889	0.347	0.448	0.624	0.835	0.889
Tungsten	0.55	0.147	0.191	0.306	0.479	0.55
Ulukhaktok / Holman	0.136	0.0333	0.0471	0.0648	0.117	0.136
Wrigley	0.841	0.333	0.431	0.578	0.786	0.841
Yellowknife	0.108	0.0299	0.042	0.0543	0.0928	0.108
Nunavut						
Alert	0.276	0.0867	0.123	0.152	0.237	0.276
Arctic Bay	0.352	0.0838	0.118	0.168	0.303	0.352
Arviat	0.123	0.0311	0.0441	0.0578	0.106	0.123
Baker Lake	0.184	0.0432	0.0624	0.0864	0.158	0.184
Eureka	0.439	0.115	0.168	0.22	0.377	0.439
Igluligaarjuk / Chesterfield Inlet	0.211	0.0523	0.076	0.0994	0.181	0.211
Iqaluit	0.263	0.0616	0.0853	0.123	0.226	0.263
Iqaluktuuttiaq / Cambridge Bay	0.15	0.0351	0.0502	0.0703	0.129	0.15
Isachsen	0.695	0.218	0.325	0.393	0.598	0.695
Kangiqiniq / Rankin Inlet	0.173	0.0407	0.0588	0.0811	0.149	0.173
Kanngiqtugaapik / Clyde River	0.626	0.219	0.322	0.383	0.538	0.626
Kugluktuk / Coppermine	0.119	0.0329	0.046	0.0594	0.103	0.119
Nottingham Island	0.207	0.0634	0.09	0.113	0.178	0.207
Resolute	0.39	0.119	0.172	0.209	0.336	0.39
Resolution Island	0.445	0.138	0.201	0.244	0.383	0.445
Salliq / Coral Harbour	0.237	0.0646	0.0933	0.117	0.204	0.237
~~Province and Location~~	~~$S_a(0.2)$ for Seismic Design in Part 9~~					

~~British Columbia~~	
~~100 Mile House~~	~~0.140~~
~~Abbotsford~~	~~0.701~~
~~Agassiz~~	~~0.457~~
~~Alberni~~	~~0.955~~
~~Ashcroft~~	~~0.198~~
~~Bamfield~~	~~1.44~~
~~Beatton River~~	~~0.132~~
~~Bella Bella~~	~~0.208~~
~~Bella Coola~~	~~0.163~~
~~Burns Lake~~	~~0.095~~
~~Cache Creek~~	~~0.195~~
~~Campbell River~~	~~0.595~~
~~Carmi~~	~~0.141~~
~~Castlegar~~	~~0.129~~
~~Chetwynd~~	~~0.176~~
~~Chilliwack~~	~~0.539~~
~~Comox~~	~~0.685~~
~~Courtenay~~	~~0.692~~
~~Cranbrook~~	~~0.170~~
~~Crescent Valley~~	~~0.130~~
~~Crofton~~	~~1.13~~
~~Dawson Creek~~	~~0.150~~
~~Dease Lake~~	~~0.103~~
~~Dog Creek~~	~~0.172~~
~~Duncan~~	~~1.17~~
~~Elko~~	~~0.217~~
~~Fernie~~	~~0.234~~

~~Fort Nelson~~	~~0.141~~
~~Fort St. John~~	~~0.145~~
~~Glacier~~	~~0.206~~
~~Golden~~	~~0.263~~
~~Gold River~~	~~1.01~~
~~Grand Forks~~	~~0.133~~
~~Greenwood~~	~~0.136~~
~~Hope~~	~~0.363~~
~~Jordan River~~	~~1.40~~
~~Kamloops~~	~~0.146~~
~~Kaslo~~	~~0.142~~
~~Kelowna~~	~~0.143~~
~~Kimberley~~	~~0.165~~
~~Kitimat Plant~~	~~0.161~~
~~Kitimat Townsite~~	~~0.161~~
~~Ladysmith~~	~~1.10~~
~~Langford~~	~~1.32~~
~~Lillooet~~	~~0.285~~
~~Lytton~~	~~0.292~~
~~Mackenzie~~	~~0.165~~
~~Masset~~	~~0.791~~
~~McBride~~	~~0.253~~
~~McLeod Lake~~	~~0.153~~
~~Merritt~~	~~0.211~~
~~Mission City~~	~~0.644~~
~~Montrose~~	~~0.129~~
~~Nakusp~~	~~0.135~~
~~Nanaimo~~	~~1.02~~

~~Nelson~~	~~0.131~~
~~Ocean Falls~~	~~0.180~~
~~Osoyoos~~	~~0.175~~
~~Parksville~~	~~0.917~~
~~Penticton~~	~~0.159~~
~~Port Alberni~~	~~0.987~~
~~Port Alice~~	~~1.60~~
~~Port Hardy~~	~~0.700~~
~~Port McNeill~~	~~0.711~~
~~Port Renfrew~~	~~1.44~~
~~Powell River~~	~~0.595~~
~~Prince George~~	~~0.113~~
~~Prince Rupert~~	~~0.246~~
~~Princeton~~	~~0.259~~
~~Qualicum Beach~~	~~0.888~~
~~Queen Charlotte City~~	~~1.62~~
~~Quesnel~~	~~0.105~~
~~Revelstoke~~	~~0.145~~
~~Salmon Arm~~	~~0.131~~
~~Sandspit~~	~~1.31~~
~~Sechelt~~	~~0.828~~
~~Sidney~~	~~1.23~~
~~Smithers~~	~~0.100~~
~~Smith River~~	~~0.705~~
~~Sooke~~	~~1.34~~
~~Squamish~~	~~0.600~~
~~Stewart~~	~~0.139~~
~~Tahsis~~	~~1.35~~

~~Taylor~~	~~0.143~~
~~Terrace~~	~~0.146~~
~~Tofino~~	~~1.46~~
~~Trail~~	~~0.129~~
~~Ucluelet~~	~~1.48~~
~~Vancouver Region~~	
~~Burnaby (Simon Fraser Univ.)~~	~~0.768~~
~~Cloverdale~~	~~0.800~~
~~Haney~~	~~0.691~~
~~Ladner~~	~~0.924~~
~~Langley~~	~~0.772~~
~~New Westminster~~	~~0.800~~
~~North Vancouver~~	~~0.794~~
~~Richmond~~	~~0.885~~
~~Surrey (88 Ave & 156 St.)~~	~~0.786~~
~~Vancouver (City Hall)~~	~~0.848~~
~~Vancouver (Granville St. & 41st Ave)~~	~~0.863~~
~~West Vancouver~~	~~0.818~~
~~Vernon~~	~~0.133~~
~~Victoria Region~~	
~~Victoria~~	~~1.30~~
~~Victoria (Gonzales Hts)~~	~~1.30~~
~~Victoria (Mt Tolmie)~~	~~1.29~~
~~Whistler~~	~~0.438~~

~~White Rock~~	~~0.868~~
~~Williams Lake~~	~~0.136~~
~~Youbou~~	~~1.20~~
~~Alberta~~	
~~Athabasca~~	~~0.068~~
~~Banff~~	~~0.279~~
~~Barrhead~~	~~0.105~~
~~Beaverlodge~~	~~0.153~~
~~Brooks~~	~~0.116~~
~~Calgary~~	~~0.192~~
~~Campsie~~	~~0.113~~
~~Camrose~~	~~0.095~~
~~Canmore~~	~~0.278~~
~~Cardston~~	~~0.273~~
~~Claresholm~~	~~0.217~~
~~Cold Lake~~	~~0.055~~
~~Coleman~~	~~0.279~~
~~Coronation~~	~~0.075~~
~~Cowley~~	~~0.282~~
~~Drumheller~~	~~0.122~~
~~Edmonton~~	~~0.103~~
~~Edson~~	~~0.165~~
~~Embarras Portage~~	~~0.052~~
~~Fairview~~	~~0.121~~
~~Fort MacLeod~~	~~0.225~~
~~Fort McMurray~~	~~0.053~~
~~Fort Saskatchewan~~	~~0.086~~
~~Fort Vermilion~~	~~0.056~~

~~Grande Prairie~~	~~0.141~~
~~Habay~~	~~0.068~~
~~Hardisty~~	~~0.068~~
~~High River~~	~~0.203~~
~~Hinton~~	~~0.280~~
~~Jasper~~	~~0.287~~
~~Keg River~~	~~0.067~~
~~Lac La Biche~~	~~0.059~~
~~Lacombe~~	~~0.127~~
~~Lethbridge~~	~~0.164~~
~~Manning~~	~~0.081~~
~~Medicine Hat~~	~~0.083~~
~~Peace River~~	~~0.098~~
~~Pincher Creek~~	~~0.284~~
~~Ranfurly~~	~~0.066~~
~~Red Deer~~	~~0.131~~
~~Rocky Mountain House~~	~~0.174~~
~~Slave Lake~~	~~0.075~~
~~Stettler~~	~~0.109~~
~~Stony Plain~~	~~0.115~~
~~Suffield~~	~~0.099~~
~~Taber~~	~~0.134~~
~~Turner Valley~~	~~0.253~~
~~Valleyview~~	~~0.126~~
~~Vegreville~~	~~0.069~~
~~Vermilion~~	~~0.060~~
~~Wagner~~	~~0.077~~

~~Wainwright~~	~~0.062~~
~~Wetaskiwin~~	~~0.115~~
~~Whitecourt~~	~~0.125~~
~~Wimborne~~	~~0.133~~
~~Saskatchewan~~	
~~Assiniboia~~	~~0.136~~
~~Battrum~~	~~0.065~~
~~Biggar~~	~~0.057~~
~~Broadview~~	~~0.077~~
~~Dafoe~~	~~0.062~~
~~Dundurn~~	~~0.059~~
~~Estevan~~	~~0.129~~
~~Hudson Bay~~	~~0.055~~
~~Humboldt~~	~~0.058~~
~~Island Falls~~	~~0.054~~
~~Kamsack~~	~~0.058~~
~~Kindersley~~	~~0.060~~
~~Lloydminster~~	~~0.057~~
~~Maple Creek~~	~~0.069~~
~~Meadow Lake~~	~~0.055~~
~~Melfort~~	~~0.055~~
~~Melville~~	~~0.069~~
~~Moose Jaw~~	~~0.096~~
~~Nipawin~~	~~0.054~~
~~North Battleford~~	~~0.056~~
~~Prince Albert~~	~~0.055~~
~~Qu'Appelle~~	~~0.090~~
~~Regina~~	~~0.101~~

~~Rosetown~~	~~0.059~~
~~Saskatoon~~	~~0.057~~
~~Scott~~	~~0.057~~
~~Strasbourg~~	~~0.074~~
~~Swift Current~~	~~0.070~~
~~Uranium City~~	~~0.053~~
~~Weyburn~~	~~0.186~~
~~Yorkton~~	~~0.063~~
~~**Manitoba**~~	
~~Beausejour~~	~~0.056~~
~~Boissevain~~	~~0.059~~
~~Brandon~~	~~0.054~~
~~Churchill~~	~~0.053~~
~~Dauphin~~	~~0.055~~
~~Flin Flon~~	~~0.054~~
~~Gimli~~	~~0.055~~
~~Island Lake~~	~~0.054~~
~~Lac du Bonnet~~	~~0.056~~
~~Lynn Lake~~	~~0.053~~
~~Morden~~	~~0.053~~
~~Neepawa~~	~~0.054~~
~~Pine Falls~~	~~0.056~~
~~Portage la Prairie~~	~~0.054~~
~~Rivers~~	~~0.058~~
~~Sandilands~~	~~0.055~~
~~Selkirk~~	~~0.055~~
~~Split Lake~~	~~0.053~~
~~Steinbach~~	~~0.055~~

~~Swan River~~	~~0.055~~
~~The Pas~~	~~0.054~~
~~Thompson~~	~~0.053~~
~~Virden~~	~~0.064~~
~~Winnipeg~~	~~0.054~~
~~Ontario~~	
~~Ailsa Craig~~	~~0.095~~
~~Ajax~~	~~0.210~~
~~Alexandria~~	~~0.589~~
~~Alliston~~	~~0.111~~
~~Almonte~~	~~0.337~~
~~Armstrong~~	~~0.064~~
~~Arnprior~~	~~0.371~~
~~Atikokan~~	~~0.069~~
~~Attawapiskat~~	~~0.074~~
~~Aurora~~	~~0.138~~
~~Bancroft~~	~~0.151~~
~~Barrie~~	~~0.108~~
~~Barriefield~~	~~0.162~~
~~Beaverton~~	~~0.117~~
~~Belleville~~	~~0.162~~
~~Belmont~~	~~0.116~~
~~Borden (CFB)~~	~~0.107~~
~~Bracebridge~~	~~0.116~~
~~Bradford~~	~~0.123~~
~~Brampton~~	~~0.168~~
~~Brantford~~	~~0.155~~
~~Brighton~~	~~0.173~~

~~Brockville~~	~~0.259~~
~~Burk's Falls~~	~~0.143~~
~~Burlington~~	~~0.266~~
~~Cambridge~~	~~0.141~~
~~Campbellford~~	~~0.144~~
~~Cannington~~	~~0.122~~
~~Carleton Place~~	~~0.302~~
~~Cavan~~	~~0.140~~
~~Centralia~~	~~0.092~~
~~Chapleau~~	~~0.071~~
~~Chatham~~	~~0.112~~
~~Chesley~~	~~0.083~~
~~Clinton~~	~~0.084~~
~~Coboconk~~	~~0.120~~
~~Cobourg~~	~~0.179~~
~~Cochrane~~	~~0.222~~
~~Colborne~~	~~0.176~~
~~Collingwood~~	~~0.096~~
~~Cornwall~~	~~0.587~~
~~Corunna~~	~~0.087~~
~~Deep River~~	~~0.389~~
~~Deseronto~~	~~0.158~~
~~Dorchester~~	~~0.112~~
~~Dorion~~	~~0.059~~
~~Dresden~~	~~0.104~~
~~Dryden~~	~~0.072~~
~~Dundalk~~	~~0.097~~
~~Dunnville~~	~~0.232~~

~~Durham~~	~~0.088~~
~~Dutton~~	~~0.116~~
~~Earlton~~	~~0.182~~
~~Edison~~	~~0.070~~
~~Elliot Lake~~	~~0.074~~
~~Elmvale~~	~~0.101~~
~~Embro~~	~~0.111~~
~~Englehart~~	~~0.175~~
~~Espanola~~	~~0.086~~
~~Exeter~~	~~0.090~~
~~Fenelon Falls~~	~~0.121~~
~~Fergus~~	~~0.115~~
~~Forest~~	~~0.087~~
~~Fort Erie~~	~~0.312~~
~~Fort Erie (Ridgeway)~~	~~0.307~~
~~Fort Frances~~	~~0.064~~
~~Gananoque~~	~~0.180~~
~~Geraldton~~	~~0.057~~
~~Glencoe~~	~~0.107~~
~~Goderich~~	~~0.079~~
~~Gore Bay~~	~~0.071~~
~~Graham~~	~~0.071~~
~~Gravenhurst (Muskoka Airport)~~	~~0.112~~
~~Grimsby~~	~~0.301~~
~~Guelph~~	~~0.133~~
~~Guthrie~~	~~0.109~~
~~Haileybury~~	~~0.219~~

~~Haldimand (Caledonia)~~	~~0.215~~
~~Haldimand (Hagersville)~~	~~0.172~~
~~Haliburton~~	~~0.133~~
~~Halton Hills (Georgetown)~~	~~0.155~~
~~Hamilton~~	~~0.260~~
~~Hanover~~	~~0.085~~
~~Hastings~~	~~0.141~~
~~Hawkesbury~~	~~0.506~~
~~Hearst~~	~~0.073~~
~~Honey Harbour~~	~~0.103~~
~~Hornepayne~~	~~0.063~~
~~Huntsville~~	~~0.129~~
~~Ingersoll~~	~~0.116~~
~~Iroquois Falls~~	~~0.196~~
~~Jellicoe~~	~~0.057~~
~~Kapuskasing~~	~~0.112~~
~~Kemptville~~	~~0.429~~
~~Kenora~~	~~0.064~~
~~Killaloe~~	~~0.264~~
~~Kincardine~~	~~0.076~~
~~Kingston~~	~~0.161~~
~~Kinmount~~	~~0.123~~
~~Kirkland Lake~~	~~0.159~~
~~Kitchener~~	~~0.122~~
~~Kitchenuhmaykoosib / Big Trout Lake~~	~~0.054~~
~~Lakefield~~	~~0.130~~

~~Lansdowne House~~	~~0.056~~
~~Leamington~~	~~0.114~~
~~Lindsay~~	~~0.126~~
~~Lion's Head~~	~~0.080~~
~~Listowel~~	~~0.093~~
~~London~~	~~0.108~~
~~Lucan~~	~~0.097~~
~~Maitland~~	~~0.282~~
~~Markdale~~	~~0.089~~
~~Markham~~	~~0.182~~
~~Martin~~	~~0.072~~
~~Matheson~~	~~0.160~~
~~Mattawa~~	~~0.446~~
~~Midland~~	~~0.101~~
~~Milton~~	~~0.191~~
~~Milverton~~	~~0.098~~
~~Minden~~	~~0.124~~
~~Mississauga~~	~~0.219~~
~~Mississauga (Lester B. Pearson Int'l Airport)~~	~~0.193~~
~~Mississauga (Port Credit)~~	~~0.247~~
~~Mitchell~~	~~0.093~~
~~Moosonee~~	~~0.081~~
~~Morrisburg~~	~~0.558~~
~~Mount Forest~~	~~0.093~~
~~Nakina~~	~~0.057~~
~~Nanticoke (Jarvis)~~	~~0.156~~

~~Nanticoke (Port Dover)~~	~~0.144~~
~~Napanee~~	~~0.156~~
~~Newcastle~~	~~0.186~~
~~Newcastle (Bowmanville)~~	~~0.188~~
~~New Liskeard~~	~~0.209~~
~~Newmarket~~	~~0.132~~
~~Niagara Falls~~	~~0.321~~
~~North Bay~~	~~0.247~~
~~Norwood~~	~~0.136~~
~~Oakville~~	~~0.260~~
~~Orangeville~~	~~0.115~~
~~Orillia~~	~~0.109~~
~~Oshawa~~	~~0.192~~
~~Ottawa (Metropolitan)~~	
~~Ottawa (Barrhaven)~~	~~0.427~~
~~Ottawa (City Hall)~~	~~0.439~~
~~Ottawa (Kanata)~~	~~0.401~~
~~Ottawa (M-C Int'l Airport)~~	~~0.446~~
~~Ottawa (Orléans)~~	~~0.474~~
~~Owen Sound~~	~~0.083~~
~~Pagwa River~~	~~0.060~~
~~Paris~~	~~0.141~~
~~Parkhill~~	~~0.092~~
~~Parry Sound~~	~~0.110~~
~~Pelham (Fonthill)~~	~~0.311~~
~~Pembroke~~	~~0.379~~

~~Penetanguishene~~	~~0.101~~
~~Perth~~	~~0.225~~
~~Petawawa~~	~~0.379~~
~~Peterborough~~	~~0.135~~
~~Petrolia~~	~~0.092~~
~~Pickering (Dunbarton)~~	~~0.219~~
~~Picton~~	~~0.159~~
~~Plattsville~~	~~0.119~~
~~Point Alexander~~	~~0.391~~
~~Port Burwell~~	~~0.132~~
~~Port Colborne~~	~~0.298~~
~~Port Elgin~~	~~0.077~~
~~Port Hope~~	~~0.181~~
~~Port Perry~~	~~0.144~~
~~Port Stanley~~	~~0.123~~
~~Prescott~~	~~0.350~~
~~Princeton~~	~~0.129~~
~~Raith~~	~~0.067~~
~~Rayside-Balfour (Chelmsford)~~	~~0.104~~
~~Red Lake~~	~~0.068~~
~~Renfrew~~	~~0.352~~
~~Richmond Hill~~	~~0.163~~
~~Rockland~~	~~0.510~~
~~Sarnia~~	~~0.085~~
~~Sault Ste. Marie~~	~~0.062~~
~~Schreiber~~	~~0.057~~
~~Seaforth~~	~~0.087~~

~~Shelburne~~	~~0.104~~
~~Simcoe~~	~~0.141~~
~~Sioux Lookout~~	~~0.073~~
~~Smiths Falls~~	~~0.256~~
~~Smithville~~	~~0.296~~
~~Smooth Rock Falls~~	~~0.200~~
~~Southampton~~	~~0.077~~
~~South River~~	~~0.164~~
~~St. Catharines~~	~~0.319~~
~~St. Marys~~	~~0.101~~
~~St. Thomas~~	~~0.117~~
~~Stirling~~	~~0.149~~
~~Stratford~~	~~0.103~~
~~Strathroy~~	~~0.100~~
~~Sturgeon Falls~~	~~0.183~~
~~Sudbury~~	~~0.110~~
~~Sundridge~~	~~0.157~~
~~Tavistock~~	~~0.108~~
~~Temagami~~	~~0.239~~
~~Thamesford~~	~~0.111~~
~~Thedford~~	~~0.089~~
~~Thunder Bay~~	~~0.061~~
~~Tillsonburg~~	~~0.126~~
~~Timmins~~	~~0.125~~
~~Timmins (Porcupine)~~	~~0.140~~
~~Toronto Metropolitan Region~~	
~~Etobicoke~~	~~0.193~~

~~North York~~	~~0.195~~
~~Scarborough~~	~~0.219~~
~~Toronto (City Hall)~~	~~0.249~~
~~Trenton~~	~~0.167~~
~~Trout Creek~~	~~0.186~~
~~Uxbridge~~	~~0.139~~
~~Vaughan (Woodbridge)~~	~~0.167~~
~~Vittoria~~	~~0.139~~
~~Walkerton~~	~~0.083~~
~~Wallaceburg~~	~~0.098~~
~~Waterloo~~	~~0.118~~
~~Watford~~	~~0.095~~
~~Wawa~~	~~0.062~~
~~Welland~~	~~0.308~~
~~West Lorne~~	~~0.118~~
~~Whitby~~	~~0.203~~
~~Whitby (Brooklin)~~	~~0.176~~
~~White River~~	~~0.060~~
~~Wiarton~~	~~0.080~~
~~Windsor~~	~~0.096~~
~~Wingham~~	~~0.083~~
~~Woodstock~~	~~0.118~~
~~Wyoming~~	~~0.090~~
~~Quebec~~	
~~Acton Vale~~	~~0.254~~
~~Alma~~	~~0.785~~
~~Amos~~	~~0.109~~

~~Asbestos~~	~~0.200~~
~~Aylmer~~	~~0.415~~
~~Baie-Comeau~~	~~0.425~~
~~Baie-Saint-Paul~~	~~1.62~~
~~Beauport~~	~~0.509~~
~~Bedford~~	~~0.358~~
~~Beloeil~~	~~0.522~~
~~Brome~~	~~0.236~~
~~Brossard~~	~~0.587~~
~~Buckingham~~	~~0.491~~
~~Campbell's Bay~~	~~0.387~~
~~Chambly~~	~~0.550~~
~~Coaticook~~	~~0.193~~
~~Contrecoeur~~	~~0.473~~
~~Cowansville~~	~~0.273~~
~~Deux-Montagnes~~	~~0.596~~
~~Dolbeau~~	~~0.484~~
~~Drummondville~~	~~0.273~~
~~Farnham~~	~~0.369~~
~~Fort-Coulonge~~	~~0.391~~
~~Gagnon~~	~~0.078~~
~~Gaspé~~	~~0.128~~
~~Gatineau~~	~~0.442~~
~~Gracefield~~	~~0.426~~
~~Granby~~	~~0.275~~
~~Harrington Harbour~~	~~0.072~~
~~Havre-Saint-Pierre~~	~~0.231~~
~~Hemmingford~~	~~0.546~~

~~Hull~~	~~0.432~~
~~Iberville~~	~~0.520~~
~~Inukjuak~~	~~0.065~~
~~Joliette~~	~~0.457~~
~~Kuujjuaq~~	~~0.074~~
~~Kuujjuarapik~~	~~0.056~~
~~Lachute~~	~~0.518~~
~~Lac-Mégantic~~	~~0.193~~
~~La Malbaie~~	~~1.73~~
~~La Pocatière~~	~~1.51~~
~~La Tuque~~	~~0.196~~
~~Lennoxville~~	~~0.187~~
~~Léry~~	~~0.603~~
~~Loretteville~~	~~0.502~~
~~Louiseville~~	~~0.366~~
~~Magog~~	~~0.196~~
~~Malartic~~	~~0.135~~
~~Maniwaki~~	~~0.430~~
~~Masson~~	~~0.498~~
~~Matane~~	~~0.455~~
~~Mont-Joli~~	~~0.427~~
~~Mont-Laurier~~	~~0.419~~
~~Montmagny~~	~~0.601~~
~~Montréal Region~~	
~~Beaconsfield~~	~~0.602~~
~~Dorval~~	~~0.600~~
~~Laval~~	~~0.595~~
~~Montréal (City Hall)~~	~~0.595~~

~~Montréal-Est~~	~~0.586~~
~~Montréal-Nord~~	~~0.593~~
~~Outremont~~	~~0.597~~
~~Pierrefonds~~	~~0.599~~
~~Sainte-Anne-de-Bellevue~~	~~0.602~~
~~Saint-Lambert~~	~~0.590~~
~~Saint-Laurent~~	~~0.598~~
~~Verdun~~	~~0.596~~
~~Nicolet (Gentilly)~~	~~0.364~~
~~Nitchequon~~	~~0.062~~
~~Noranda~~	~~0.132~~
~~Percé~~	~~0.114~~
~~Pincourt~~	~~0.602~~
~~Plessisville~~	~~0.250~~
~~Port-Cartier~~	~~0.323~~
~~Puvirnituq~~	~~0.108~~
~~Québec City Region~~	
~~Ancienne-Lorette~~	~~0.487~~
~~Lévis~~	~~0.493~~
~~Québec~~	~~0.493~~
~~Sainte-Foy~~	~~0.488~~
~~Sillery~~	~~0.486~~
~~Richmond~~	~~0.208~~
~~Rimouski~~	~~0.408~~
~~Rivière-du-Loup~~	~~1.16~~
~~Roberval~~	~~0.688~~
~~Rock Island~~	~~0.199~~

~~Rosemère~~	~~0.591~~
~~Rouyn~~	~~0.134~~
~~Saguenay~~	~~0.791~~
~~Saguenay (Bagotville)~~	~~0.801~~
~~Saguenay (Jonquière)~~	~~0.798~~
~~Saguenay (Kénogami)~~	~~0.799~~
~~Sainte-Agathe-des-Monts~~	~~0.431~~
~~Saint-Eustache~~	~~0.593~~
~~Saint-Félicien~~	~~0.488~~
~~Saint-Georges-de-Cacouna~~	~~0.857~~
~~Saint-Hubert~~	~~0.581~~
~~Saint-Hubert-de-Rivière-du-Loup~~	~~0.468~~
~~Saint-Hyacinthe~~	~~0.369~~
~~Saint-Jean-sur-Richelieu~~	~~0.522~~
~~Saint-Jérôme~~	~~0.539~~
~~Saint-Jovite~~	~~0.428~~
~~Saint-Lazare / Hudson~~	~~0.597~~
~~Saint-Nicolas~~	~~0.466~~
~~Salaberry-de-Valleyfield~~	~~0.602~~
~~Schefferville~~	~~0.059~~
~~Senneterre~~	~~0.114~~
~~Sept-Îles~~	~~0.295~~
~~Shawinigan~~	~~0.306~~
~~Shawville~~	~~0.386~~

~~Sherbrooke~~	~~0.187~~
~~Sorel~~	~~0.406~~
~~Sutton~~	~~0.243~~
~~Tadoussac~~	~~0.694~~
~~Témiscaming~~	~~0.820~~
~~Terrebonne~~	~~0.584~~
~~Thetford Mines~~	~~0.207~~
~~Thurso~~	~~0.492~~
~~Trois-Rivières~~	~~0.366~~
~~Val-d'Or~~	~~0.135~~
~~Varennes~~	~~0.571~~
~~Verchères~~	~~0.537~~
~~Victoriaville~~	~~0.233~~
~~Ville-Marie~~	~~0.262~~
~~Wakefield~~	~~0.409~~
~~Waterloo~~	~~0.232~~
~~Windsor~~	~~0.194~~
~~New Brunswick~~	
~~Alma~~	~~0.144~~
~~Bathurst~~	~~0.217~~
~~Campbellton~~	~~0.210~~
~~Edmundston~~	~~0.231~~
~~Fredericton~~	~~0.210~~
~~Gagetown~~	~~0.195~~
~~Grand Falls~~	~~0.254~~
~~Miramichi~~	~~0.214~~
~~Moncton~~	~~0.158~~
~~Oromocto~~	~~0.209~~

~~Sackville~~	~~0.140~~
~~Saint Andrews~~	~~0.874~~
~~Saint John~~	~~0.199~~
~~Shippagan~~	~~0.143~~
~~St. George~~	~~0.578~~
~~St. Stephen~~	~~0.781~~
~~Woodstock~~	~~0.206~~
~~Nova Scotia~~	
~~Amherst~~	~~0.130~~
~~Antigonish~~	~~0.098~~
~~Bridgewater~~	~~0.117~~
~~Canso~~	~~0.114~~
~~Debert~~	~~0.107~~
~~Digby~~	~~0.164~~
~~Greenwood (CFB)~~	~~0.128~~
~~Halifax Region~~	
~~Dartmouth~~	~~0.110~~
~~Halifax~~	~~0.110~~
~~Kentville~~	~~0.120~~
~~Liverpool~~	~~0.120~~
~~Lockeport~~	~~0.123~~
~~Louisbourg~~	~~0.119~~
~~Lunenburg~~	~~0.115~~
~~New Glasgow~~	~~0.099~~
~~North Sydney~~	~~0.105~~
~~Pictou~~	~~0.098~~
~~Port Hawkesbury~~	~~0.102~~
~~Springhill~~	~~0.118~~

~~Stewiacke~~	~~0.107~~
~~Sydney~~	~~0.108~~
~~Tatamagouche~~	~~0.103~~
~~Truro~~	~~0.105~~
~~Wolfville~~	~~0.118~~
~~Yarmouth~~	~~0.137~~
~~Prince Edward Island~~	
~~Charlottetown~~	~~0.103~~
~~Souris~~	~~0.091~~
~~Summerside~~	~~0.133~~
~~Tignish~~	~~0.135~~
~~Newfoundland and Labrador~~	
~~Argentia~~	~~0.098~~
~~Bonavista~~	~~0.083~~
~~Buchans~~	~~0.077~~
~~Cape Harrison~~	~~0.125~~
~~Cape Race~~	~~0.108~~
~~Channel-Port aux Basques~~	~~0.088~~
~~Corner Brook~~	~~0.074~~
~~Gander~~	~~0.077~~
~~Grand Bank~~	~~0.115~~
~~Grand Falls~~	~~0.076~~
~~Happy Valley-Goose Bay~~	~~0.067~~
~~Labrador City~~	~~0.067~~
~~St. Anthony~~	~~0.073~~
~~Stephenville~~	~~0.077~~

~~St. John's~~	~~0.090~~
~~Twin Falls~~	~~0.064~~
~~Wabana~~	~~0.089~~
~~Wabush~~	~~0.067~~
~~Yukon~~	
~~Aishihik~~	~~0.446~~
~~Dawson~~	~~0.396~~
~~Destruction Bay~~	~~1.54~~
~~Faro~~	~~0.271~~
~~Haines Junction~~	~~0.973~~
~~Snag~~	~~0.502~~
~~Teslin~~	~~0.284~~
~~Watson Lake~~	~~0.304~~
~~Whitehorse~~	~~0.334~~
~~Northwest Territories~~	
~~Aklavik~~	~~0.475~~
~~Behchok? / Rae-Edzo~~	~~0.052~~
~~Echo Bay / Port Radium~~	~~0.052~~
~~Fort Good Hope~~	~~0.257~~
~~Fort McPherson~~	~~0.476~~
~~Fort Providence~~	~~0.055~~
~~Fort Resolution~~	~~0.052~~
~~Fort Simpson~~	~~0.154~~
~~Fort Smith~~	~~0.052~~
~~Hay River~~	~~0.053~~
~~Inuvik~~	~~0.308~~
~~Mould Bay~~	~~0.21~~

~~Norman Wells~~	~~0.688~~	
~~Tungsten~~	~~0.325~~	
~~Ulukhaktok / Holman~~	~~0.057~~	
~~Wrigley~~	~~0.653~~	
~~Yellowknife~~	~~0.052~~	
~~Nunavut~~		
~~Alert~~	~~0.145~~	
~~Arctic Bay~~	~~0.111~~	
~~Arviat~~	~~0.054~~	
~~Baker Lake~~	~~0.068~~	
~~Eureka~~	~~0.173~~	
~~Igluligaarjuk / Chesterfield Inlet~~	~~0.081~~	
~~Iqaluit~~	~~0.087~~	
~~Iqaluktuuttiaq / Cambridge Bay~~	~~0.059~~	
~~Isachsen~~	~~0.256~~	
~~Kangiqiniq / Rankin Inlet~~	~~0.064~~	
~~Kanngiqtugaapik / Clyde River~~	~~0.306~~	
~~Kugluktuk / Coppermine~~	~~0.053~~	
~~Nottingham Island~~	~~0.109~~	
~~Resolute~~	~~0.194~~	
~~Resolution Island~~	~~0.203~~	
~~Salliq / Coral Harbour~~	~~0.103~~	

Impact analysis

Since PCFs 1775 and 1475 are interdependent, a combined impact analysis is provided; refer to the supporting document titled, “PCFs 1475 and 1775 on Lateral Loads: Combined Impact Analysis.” This document includes a general impact analysis, which describes how all locations are impacted by these PCFs, and a detailed impact analysis, which for some locations demonstrates how the cost impact of applying the updated seismic hazard values in PCF 1775 is reduced by applying the new proposed prescriptive requirements for lateral loads in PCF 1475.

Enforcement implications

Awareness of the updated seismic hazard values will need to be raised, but no difficulty is expected to be encountered in checking compliance, and no special testing is anticipated to be necessary.

Who is affected

Building officials, consultants, contractors and building owners.

Supporting Document(s)

PCFs 1475 and 1775 on Lateral Loads: Combined Impact Analysis (nbc20_pcfs_1475_and_1775_combined_impact_analysis.pdf)

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

N/A

N/A

PCFs 1475 and 1775 on Lateral Loads
Combined Impact Analysis

Table of Contents

Background

PCFs 1475 and 1775 were developed by the Joint Task Group on Lateral Loads to update the seismic hazard values and the prescriptive provisions for lateral loads resistance for Part 9 construction.

The proposed seismic hazard parameters (S_{max} – derived from the 2020 seismic data referenced in Part 4) and the current hourly wind pressure (HWP) values in Table C-2 of Appendix C of the NBC 2020 are used in the application of the requirements for the fastening of sheathing, anchorage of building frames, joints in top plates, and in the design of bracing to resist lateral loads (i.e., wind and earthquake loads).

Subsection 9.23.13., Bracing to Resist Lateral Loads Due to Wind and Earthquake, lists three articles that broadly categorize lateral loads as "Low to Moderate", "High", and "Extremely High". Lateral load hazard values are then more exactly applied to the requirements for braced wall length and construction.

Whereas the article for "Extremely High" directs code users to Part 4, the articles for "Low to Moderate" and "High" direct code users to the same set of requirements for the construction and length of braced walls. The only differences between the articles for "Low to Moderate" and "High" are with respect to the number of storeys of various types of construction that are permitted to be supported by the lowest exterior frame wall.

General Impacts

While the Cost Analysis section below and Appendix D evaluates the impact of the PCFs on three archetypes representative of common Part 9 construction in seven locations across Canada, this General Impacts section describes how all locations in Canada are generally impacted by the PCFs. To further supplement the general impacts, a visual representation of the impacts is available in **Figure 1** - Graph of impacts on all locations. There will be a steep learning curve for designers and buildings in the locations that are currently exempt from lateral load bracing requirements. The prescriptive requirements in PCF 1475 were created because buildings in these locations are subject to wind or seismic loads that are sufficiently high that some lateral bracing is deemed necessary. Once an AHJ, and local designers assess requirements for their jurisdiction, they can apply these requirements in a streamlined manner.

Locations that maintain a Low to Moderate Wind and Seismic Forces Category

There are 520 locations that are currently exempt (in the NBC 2020) from lateral load bracing requirements (refer to **Appendix A** and **Figure 1**, blue shading), but now would not be and would apply the new prescriptive requirements in PCF 1475, which are proportionate to the severity of the expected local wind and seismic hazards.

Locations from the cost analysis (refer to the Cost Analysis section and Appendix D for details) included in this category are:

- Ottawa, ON
- Whitehorse, YT
- Winnipeg, MB

Locations that move into the High Wind and Seismic Forces Category

There are 96 locations that are currently exempt (in the NBC 2020) from lateral loads bracing requirements (refer to **Appendix B** and **Figure 1**, orange shading), but now would not be and would apply the new prescriptive requirements according to the severity of their local wind and seismic hazards. As well, the lowest exterior framed walls for buildings in these locations are limited from supporting more than one floor of heavy weight construction.

For 71 of the 96 locations, the new limit for lowest exterior framed walls supporting heavy weight construction is due to the increase in seismic hazard values that are presented in PCF 1775.

For 25 of the 96 locations, the new limit for lowest exterior framed walls supporting heavy weight construction is due to the lowering of the hourly wind pressure threshold (from 0.8 kPa to 0.6 kPa in PCF 1475).

Locations from the cost analysis (refer to the Cost Analysis section and Appendix D for details) included in this category are:

- Montreal, QC
- Lethbridge, AB
- St. John’s, NL

Locations that maintain a High Wind and Seismic Forces Category

In the NBC 2020, there are 63 locations that apply the requirements for high wind and seismic forces, and 62 of these locations remain in this category (refer to **Appendix C** and **Figure 1**, green shading) with no change to the limit of how many floors of heavy weight construction are permitted to be supported by the lowest exterior framed wall. The other location (refer to **Figure 1**, red shading) is bumped to Part 4 because of the seismic hazard update in PCF 1775.

PCF 1475 expands the application of Part 9 and keeps 16 locations (refer to **Figure 1**, green shading) from being bumped into Part 4 by the seismic hazard update in PCF 1775.

One location whose wind loads are beyond Part 9 application in the NBC 2020 remains beyond Part 9 application despite changes to thresholds in PCF 1475 (refer to **Figure 1**, red shading).

Although these locations are not impacted by the seismic hazard update in PCF 1775 or any of the trigger threshold changes in PCF 1475, they will be impacted by the new prescriptive requirements for lateral loads, which are more clearly laid out in the Cost Analysis section and **Appendix D**.

A location from the cost analysis (refer to the Cost Analysis section and **Appendix D** for details) included in this category is:

- Victoria, BC

Figure 1: Graph of impacts on all locations

Cost Analysis

Approach

The cost analysis looks at the cost difference between a base scenario (NBC 2020 provisions with Seismic Values in Table C-3 of the NBC 2020) and two other scenarios (Scenario A: NBC 2020 lateral loads provisions with updated seismic hazard values; and Scenario B: proposed lateral loads provisions with updated seismic hazard values).

Several iterations of the impact analysis were completed using the seismic design parameters and hourly wind pressures for 7 locations (Victoria, BC; Lethbridge AB, Ottawa, ON; , Winnipeg, Montréal, QC; St. John's, NL; and Whitehorse, YT). For each of these locations a duplex, stacked-town, and bungalow archetype were used. The cost for various wall assemblies representing braced wall panels from the NBC 2020 and braced wall framing types included in the proposed change were costed using RS Means Software. The cost analysis does not determine the overall wall costs or building cost; instead it compares the difference in cost between the above noted scenarios.

Results

The cost analysis found that, in general, there will be an increased cost in each of the locations analyzed ranging from -0.01% to 0.45% ($ -43.60 to $863.05) of the average building cost of a home (obtained from Altus Group – 2022 Canadian Construction Cost Guide).

The cost analysis shows how the two types of changes within PCF 1475 affect the cost increase in different ways. Scenario A evaluates how the increase in seismic hazards impacts construction costs, which is seen in locations like Victoria, BC, which sees a construction cost increase ranging from 0.24% to 1.15% ($1,242.73 to $2,955.67) (across the three archetypes). The increase in seismic hazard values also push some locations like Montreal above the existing trigger which is why Montreal sees a construction cost increase ranging from 0.4% to 0.76% ($1,095.89 to $1,525.99) across the archetypes. The other five cities that were analyzed were not pushed above the existing lateral loads design triggers and therefore do not see an increase in construction cost as a result of the updated seismic hazard values.

PCF 1475 introduces new lateral loads design provisions which are more precise and therefore less conservative than the existing provisions, so when Scenario B evaluates the construction cost increase of updating the seismic hazard values in conjunction with the new lateral loads provisions we see a softening of the increased construction cost for locations that required lateral loads design when subjected to the updated seismic hazard values. Victoria goes from a cost increase range of 0.24% to 1.15% ($1,242.73 to $2,955.67) in Scenario A to -0.01% to 0.25% ($-43.60 to $633.35) in Scenario B. Montreal sees a similar softening of the cost increase when comparing Scenario A with Scenario B. The other five cities that were analyzed saw an increase in construction cost ranging from 0.05% to 0.45% ($165.10 to $863.05).

PCF 1475 also includes a Simplified Approach for lateral loads design, which provides conservative minimum braced wall lengths which is evidenced by the resulting construction cost increase of 0.62% ($1,230.03) compared to the 0.41% ($800.81) cost increase for that same location using the normal lateral loads design approach.

Finally, for construction of exterior walls where rigid insulation is used as exterior sheathing in low wind and seismic zones, the impact is greater than typical exterior wall construction, with a difference in construction cost increase range of 0.11% to 0.55% ($352.25 to $1,088.17) compared to that location's cost increase range of 0.05% to 0.41% ($165.10 to $800.81) when using typical exterior wall construction.

A full summary of cost analysis results, including detailed code analysis and costing calculations can be found in **Appendix D**.

Assumptions

- Where Part 4 design is required, it is assumed that the wall lengths would be increased by 10% and the cost of hiring a professional engineer was represented as a 1% additional to the construction cost of the home.
- Where a city that was analyzed had several options for which braced wall panel assembly type could be used, the weakest assembly was selected, unless other portions of that wall façade required another thickness of exterior sheathing, in which case the sheathing thickness dictated the assembly selection.
- The Altus Group housing construction data did not include average prices for energy efficient homes, so the analysis for an energy efficient home compares with the cost of normal construction.
- Labour to nail exterior sheathing to the studs represents 25% of the overall labour cost to install sheathing (used when data from RS Means needed to be interpolated).

Limitations

- This is a small subset of all the locations in Canada, so that same general conclusions above will not necessarily apply everywhere.
- Three archetypes were analyzed and the Duplex and Townhome were selected because they included an analysis of a party wall situation which is meant to represent how a Row House could be impacted by PCF 1475.
- The analysis is limited to normal weight construction.
- The analysis does not examine the benefits of finding a Site Class of A, B, C or D.
- National averages material costs are used.
- To be consistent with the CCBFC Appendix G guidelines on impact analysis, this impact analysis does not account for escalation costs (e.g., fluctuations in direct costs for wood materials).

List of Benefits

1. More Flexibility – The existing NBC provisions set minimum braced wall panel length requirements as a percentage of the total length of a wall that is designed as a braced wall band. This means that builders can run into situations where the architectural layout of interior walls does not leave enough wall length to accommodate the minimum braced wall panel percentage length. PCF 1475 replaces the percentage approach with a variety of braced wall panel types representing a range of strength values. This gives builders the flexibility to choose a strong braced wall panel type if they have limited available interior wall length, and they can choose a less strong panel type if there is a lot of available interior wall length.
2. More Flexibility – PCF 1475 introduces an appendix table that lists the strength factors for each of the braced wall panel compliance options, which make a simple and clear reference point for the alternative solutions.
3. More Flexibility – PCF 1475 gives builders the opportunity to use the actual building site's soil class when determining the design seismic conditions, which may allow them to use construction details that are more cost effective.
4. Reduced Undue Conservatism – The existing NBC provisions for lateral loads lists one set of minimum percentage lengths for braced wall panels that applies to the entire range of applicable seismic and wind hazard values, meaning locations with a hazard value near the low-end of the range will have overly conservative construction requirements. PCF 1475 divides the seismic and wind ranges into eight and six segments respectively and lists minimum braced wall panel length requirements for each of them, meaning the requirements are specific to the hazard level thereby reducing the undue conservatism. PCF 1475 also introduces the consideration for the factors that affect lateral loads on a building (i.e. weight, shape, snow load, wind exposure, etc.), which contributes to a prescriptive solution that more specifically reflects the expected loads.
5. Reduced Undue Conservatism – The existing NBC provisions require higher seismic and wind locations to have braced wall bands spaced not more than 7.6 m apart which means if the building is 9 m deep then it must have three braced wall bands constructed of braced wall panels. PCF 1475 expands the maximum distance between braced wall bands to 10.6 m for all locations, which means that a 9 m deep building will now only require two braced wall bands and save the costs from the additional braced wall band.
6. Increased Inclusivity – PCF 1475 introduces provisions that are specific to the application of cripple walls, as well as partially clad and fully clad masonry and stone veneers.
7. Increased Inclusivity – 16 locations have updated seismic hazard values that direct them to the application of Part 4 and the usage of a professional engineer, but PCF 1475 expands the prescriptive provisions to keep these locations within Part 9 application.

8. New Knowledge – Updating the seismic hazard values means Part 9 construction will be built to reflect the industry's new understanding of the hazard levels, and aligns Part 9 hazard levels with those that are used in Part 4 designs.
9. Safety – The existing NBC exempts locations with a 1-in-50 year Hourly Wind Pressure of 0.8 kPa which is equivalent to an EF2 Tornado (~190km/h wind), and exempts locations with a seismic hazard of Sa(0.2) of 0.7 which corresponds to "very strong" and "severe" earthquakes. PCF 1475 requires all locations to have construction reflective of the expected local lateral loads.
10. Safety – The existing NBC provisions were developed assuming that homes have some inherent lateral loads resistance but this redundancy has dissipated over the years with home design trends moving more to open plans, with larger openings in exterior walls (i.e. fenestration), and the use of non-structural sheathing (i.e. rigid insulation) in exterior walls for energy efficiency purposes. PCF 1475 introduces the consideration of these factors in its prescriptive solutions.

APPENDIX A

Locations that maintain a Low to Moderate Wind and Seismic Forces Category

Bella Bella, BC
Hope, BC
Lillooet, BC
Lytton, BC
Ocean Falls, BC
Prince Rupert, BC
Princeton, BC
100 Mile House, BC
Ashcroft, BC
Beatton River, BC
Bella Coola, BC
Burns Lake, BC
Cache Creek, BC
Carmi, BC
Castlegar, BC
Chetwynd, BC
Cranbrook, BC
Crescent Valley, BC
Dawson Creek, BC
Dease Lake, BC
Dog Creek, BC
Elko, BC
Fernie, BC
Fort Nelson, BC
Fort St. John, BC
Glacier, BC
Golden, BC
Grand Forks, BC
Greenwood, BC
Kamloops, BC
Kaslo, BC
Kelowna, BC
Kimberley, BC
Kitimat Plant, BC
Kitimat Townsite, BC
Mackenzie, BC
McBride, BC
McLeod Lake, BC
Merritt, BC
Montrose, BC
Nakusp, BC
Nelson, BC
Osoyoos, BC
Penticton, BC
Prince George, BC
Quesnel, BC
Revelstoke, BC
Salmon Arm, BC
Smithers, BC
Stewart, BC
Taylor, BC
Terrace, BC
Trail, BC
Vernon, BC
Williams Lake, BC
Athabasca, AB
Banff, AB
Barrhead, AB
Beaverlodge, AB
Brooks, AB
Calgary, AB
Campsie, AB
Camrose, AB
Canmore, AB
Claresholm, AB
Cold Lake, AB
Coronation, AB
Drumheller, AB
Edmonton, AB
Edson, AB
Embarras Portage, AB
Fairview, AB
Fort McMurray, AB
Fort Saskatchewan, AB
Fort Vermilion, AB
Grande Prairie, AB
Habay, AB
Hardisty, AB
Hinton, AB
Jasper, AB
Keg River, AB
Lac la Biche, AB
Lacombe, AB
Manning, AB
Medicine Hat, AB
Peace River, AB
Ranfurly, AB
Red Deer, AB
Rocky Mountain House, AB
Slave Lake, AB
Stettler, AB
Stony Plain, AB
Suffield, AB
Valleyview, AB
Vegreville, AB
Vermilion, AB
Wagner, AB
Wainwright, AB
Wetaskiwin, AB
Whitecourt, AB
Wimborne, AB
Assiniboia, SK
Battrum, SK
Biggar, SK
Broadview, SK
Dafoe, SK
Dundurn, SK
Estevan, SK
Hudson Bay, SK
Humboldt, SK
Island Falls, SK
Kamsack, SK
Kindersley, SK
Lloydminster, SK
Maple Creek, SK
Meadow Lake, SK
Melfort, SK
Melville, SK
Moose Jaw, SK
Nipawin, SK
North Battleford, SK
Prince Albert, SK
Qu'Appelle, SK
Regina, SK
Rosetown, SK
Saskatoon, SK
Scott, SK
Strasbourg, SK
Swift Current, SK
Uranium City, SK
Weyburn, SK
Yorkton, SK

Locations that maintain a Low to Moderate Wind and Seismic Forces Category

Beausejour, MB
Boissevain, MB
Brandon, MB
Churchill, MB
Dauphin, MB
Flin Flon, MB
Gimli, MB
Island Lake, MB
Lac du Bonnet, MB
Lynn Lake, MB
Morden, MB
Neepawa, MB
Pine Falls, MB
Portage la Prairie, MB
Rivers, MB
Sandilands, MB
Selkirk, MB
Split Lake, MB
Steinbach, MB
Swan River, MB
The Pas, MB
Thompson, MB
Virden, MB
Winnipeg, MB
Ailsa Craig, ON
Ajax, ON
Alliston, ON
Armstrong, ON
Atikokan, ON
Attawapiskat, ON
Aurora, ON
Bancroft, ON
Barrie, ON
Barriefield, ON
Beaverton, ON
Belleville, ON
Belmont, ON
Bowmanville, ON
Bracebridge, ON
Bradford, ON
Brampton, ON
Brantford, ON
Brighton, ON
Burk's Falls, ON
Burlington, ON
Cambridge, ON
Campbellford, ON
Cannington, ON
Cavan, ON
Centralia, ON
CFB Borden, ON
Chapleau, ON
Chatham, ON
Chesley, ON
Clinton, ON
Coboconk, ON
Cobourg, ON
Cochrane, ON
Colborne, ON
Collingwood, ON
Corunna, ON
Deseronto, ON
Dorchester, ON
Dorion, ON
Dresden, ON
Dryden, ON
Dundalk, ON
Dunnville, ON
Durham, ON
Dutton, ON
Earlton, ON
Edison, ON
Elliot Lake, ON
Elmvale, ON
Embro, ON
Englehart, ON
Espanola, ON
Exeter, ON
Fenelon Falls, ON
Fergus, ON
Forest, ON
Fort Erie, ON
Fort Erie (Ridgeway), ON
Fort Frances, ON
Gananoque, ON
Geraldton, ON
Glencoe, ON
Goderich, ON
Gore Bay, ON
Graham, ON
Gravenhurst (Muskoka Airport), ON
Grimsby, ON
Guelph, ON
Guthrie, ON
Haileybury, ON
Haldimand (Caledonia), ON
Haldimand (Hagersville), ON
Haliburton, ON
Halton Hills (Georgetown), ON
Hamilton, ON
Hanover, ON
Hastings, ON
Hearst, ON
Honey Harbour, ON
Hornepayne, ON
Huntsville, ON
Ingersoll, ON
Iroquois Falls, ON
Jellicoe, ON
Kapuskasing, ON
Kenora, ON
Kincardine, ON
Kingston, ON
Kinmount, ON
Kirkland Lake, ON
Kitchener, ON
Kitchenuhmaykoosib, ON
Lakefield, ON
Lansdowne House, ON
Leamington, ON
Lindsay, ON
Lion's Head, ON
Listowel, ON
London, ON
Lucan, ON
Markdale, ON
Markham, ON
Martin, ON
Matheson, ON
Midland, ON
Milton, ON
Milverton, ON
Minden, ON

Locations that maintain a Low to Moderate Wind and Seismic Forces Category

Mississauga, ON
Mississauga Port Credit, ON
Mitchell, ON
Moosonee, ON
Mount Forest, ON
Nakina, ON
Nanticoke (Jarvis), ON
Nanticoke (Port Dover), ON
Napanee, ON
New Liskeard, ON
Newcastle, ON
Newmarket, ON
Niagara Falls, ON
North Bay, ON
Norwood, ON
Oakville, ON
Orangeville, ON
Orillia, ON
Oshawa, ON
Owen Sound, ON
Pagwa River, ON
Paris, ON
Parkhill, ON
Parry Sound, ON
Pelham (Fonthill), ON
Penetanguishene, ON
Peterborough, ON
Petrolia, ON
Pickering (Dunbarton), ON
Picton, ON
Plattsville, ON
Port Burwell, ON
Port Colborne, ON
Port Elgin, ON
Port Hope, ON
Port Perry, ON
Port Stanley, ON
Princeton, ON
Raith, ON
Rayside-Balfour (Chelmsford), ON
Red Lake, ON
Richmond Hill, ON
Sarnia, ON
Sault Ste. Marie, ON
Schreiber, ON
Seaforth, ON
Shelburne, ON
Simcoe, ON
Sioux Lookout, ON
Smithville, ON
Smooth Rock Falls, ON
South River, ON
Southampton, ON
St. Catharines, ON
St. Mary's, ON
St. Thomas, ON
Stirling, ON
Stratford, ON
Strathroy, ON
Sturgeon Falls, ON
Sudbury, ON
Sundridge, ON
Tavistock, ON
Temagami, ON
Thamesford, ON
Thedford, ON
Thunder Bay, ON
Tillsonburg, ON
Timmins, ON
Timmins (Porcupine), ON
Etobicoke, ON
North York, ON
Scarborough, ON
Toronto (city hall), ON
Toronto (LBP Int'l Airport), ON
Trenton, ON
Trout Creek, ON
Uxbridge, ON
Vaughan (Woodbridge), ON
Vittoria, ON
Walkerton, ON
Wallaceburg, ON
Waterloo, ON
Watford, ON
Wawa, ON
Welland, ON
West Lorne, ON
Whitby, ON
Whitby (Brooklin), ON
White River, ON
Wiarton, ON
Windsor, ON
Wingham, ON
Woodstock, ON
Wyoming, ON
Almonte, ON
Arnprior, ON
Brockville, ON
Carleton Place, ON
Deep River, ON
Kemptville, ON
Killaloe, ON
Maitland, ON
Mattawa, ON
Ottawa (Barrhaven), ON
Ottawa (city hall), ON
Ottawa (Kanata), ON
Ottawa (M-C Int'l Airport), ON
Ottawa (Orleans), ON
Pembroke, ON
Perth, ON
Petawawa, ON
Point Alexander, ON
Prescott, ON
Renfrew, ON
Smiths Falls, ON
Amos, QC
Gagnon, QC
Gaspé, QC
Inukjuak, QC
Kuujjuaq, QC
Kuujjuarapik, QC
Malartic, QC
Nitchequon, QC
Noranda, QC
Puvinrituq, QC
Rouyn, QC
Schefferville, QC
Senneterre, QC
Sept-Îles, QC
Val-d'Or, QC
Ville-Marie, QC

Locations that maintain a Low to Moderate Wind and Seismic Forces Category

Acton-Vale, QC
Asbestos, QC
Aylmer, QC
Baie-Comeau, QC
Bedford, QC
Brome, QC
Campbell's Bay, QC
Coaticook, QC
Contrecoeur, QC
Cowansville, QC
Drummondville, QC
Farnham, QC
Fort-Coulonge, QC
Gatineau, QC
Gracefield, QC
Granby, QC
Hull, QC
Joliette, QC
Lac-Mégantic, QC
La-Tuque, QC
Lennoxville, QC
Louiseville, QC
Magog, QC
Maniwaki, QC
Matane, QC
Mont-Joli, QC
Mont-Laurier, QC
Nicolet (Gentilly), QC
Plessisville, QC
Port-Cartier, QC
Richmond, QC
Rimouski, QC
Rock-Island, QC
Shawinigan, QC
Shawville, QC
Sherbrooke, QC
Sorel, QC
Ste-Agathe-des-Monts, QC
St-Hyacinthe, QC
St-Jovite, QC
Sutton, QC
Thetford Mines, QC
Trois-Rivières, QC
Victoriaville, QC
Wakefield, QC
Waterloo, QC
Windsor, QC
Alma, NB
Bathurst, NB
Fredericton, NB
Gagetown, NB
Miramichi, NB
Moncton, NB
Oromocto, NB
Sackville, NB
Saint John, NB
Boisetown, NB
Campbellton, NB
Edmundston, NB
Grand Falls, NB
Woodstock, NB
Amherst, NS
Antigonish, NS
Bridgewater, NS
Dartmouth, NS
Debert, NS
Digby, NS
Greenwood (CFB), NS
Halifax, NS
Kentville, NS
Lockeport, NS
New Glasgow, NS
North Sydney, NS
Pictou, NS
Springhill, NS
Stewiacke, NS
Sydney, NS
Tatamagouche, NS
Truro, NS
Wolfville, NS
Yarmouth, NS
Charlottetown, PE
Souris, PE
Summerside, PE
Buchans, NL
Cape Harrison, NL
Corner Brook, NL
Gander, NL
Grand Falls, NL
Happy Valley-Goose Bay, NL
Labrador City, NL
Stephenville, NL
Twin Falls, NL
Wabush, NL
Echo Bay / Port Radium, NT
Fort Providence, NT
Fort Resolution, NT
Fort Simpson, NT
Fort Smith, NT
Hay River, NT
Rae-Edzo, NT
Yellowknife, NT
Aklavik, NT
Fort Good Hope, NT
Fort McPherson, NT
Inuvik, NT
Mould Bay, NT
Tungsten, NT
Arctic Bay, NU
Arviat, NU
Baker Lake, NU
Eureka, NU
Igluligaarjuk / Chesterfield Inlet, NU
Iqaluktuuttiaq / Cambridge Bay, NU
Kangiqiniq / Rankin Inlet, NU
Kugluktuk, NU
Resolute, NU
Salliq / Coral Harbour, NU
Isachsen, NU
Kanngiqtugaapik / Clyde River, NU
Faro, YT
Teslin, YT
Watson Lake, YT
Whitehorse, YT

APPENDIX B

Locations that move into the High Wind and Seismic Forces Category

Agassiz, BC
Campbell River, BC
Chilliwack, BC
Comox, BC
Courtenay, BC
Mission City, BC
Port Hardy, BC
Powell River, BC
Squamish, BC
Haney, BC
Whistler, BC
Hope, BC
Cardston, AB
Coleman, AB
Fort MacLeod, AB
High River, AB
Lethbridge, AB
Taber, AB
Turner Valley, AB
Alexandria, ON
Cornwall, ON
Hawkesbury, ON
Morrisburg, ON
Rockland, ON
Harrington-Harbour, QC
Havre-St-Pierre, QC
Percé, QC
Beauport, QC
Beloeil, QC
Brossard, QC
Buckingham, QC
Chambly, QC
Deux-Montagnes, QC
Dolbeau, QC
Hemmingford, QC
Iberville, QC
Lachute, QC
Léry, QC
Loretteville, QC
Masson, QC
Montmagny, QC
Beaconsfield, QC
Dorval, QC
Laval, QC
Montréal (city hall), QC
Montréal-Est, QC
Montréal-Nord, QC
Outremont, QC
Pierrefonds, QC
St-Lambert, QC
St-Laurent, QC
Ste-Anne-de-Bellevue, QC
Verdun, QC
Pincourt, QC
Ancienne-Lorette, QC
Lévis, QC
Québec, QC
Sillery, QC
Ste-Foy, QC
Roberval, QC
Rosemère, QC
Saint-Eustache, QC
Saint-Jean-sur-Richelieu, QC
Salaberry-de-Valleyfield, QC
St-Félicien, QC
St-Hubert, QC
St-Hubert-de-Rivière-du-Loup, QC
St-Jérôme, QC
St-Lazare-Hudson, QC
St-Nicolas, QC
Tadoussac, QC
Terrebonne, QC
Thurso, QC
Varennes, QC
Verchères, QC
Saint George, NB
Shippagan, NB
Canso, NS
Liverpool, NS
Louisburg, NS
Lunenburg, NS
Port Hawkesbury, NS
Argentia, NL
Channel-Port aux Basques, NL
Grand Bank, NL
St. John's, NL
Wabana, NL
Tignish, PE
Alert, NU
Iqaluit, NU
Nottingham Island, NU
Aishihik, YT
Dawson, YT
Destruction Bay, YT
Snag, YT
Norman Wells, NT
Wrigley, NT

APPENDIX C

Locations that maintain a High Wind and Seismic Hazard Forces Catergory

Abbotsford, BC
Alberni, BC
Crofton, BC
Duncan, BC
Gold River, BC
Ladysmith, BC
Masset, BC
Nanaimo, BC
Parksville, BC
Port Alberni, BC
Port McNeill, BC
Qualicum Beach, BC
Sechelt, BC
Sidney, BC
Smith River, BC
Tahsis, BC
Burnaby (Simon Fraser Univ.), BC
Cloverdale, BC
Ladner, BC
Langley, BC
New Westminster, BC
North Vancouver, BC
Richmond, BC
Surrey (88 Ave & 156 St.), BC
Vancouver (city hall), BC
Vancouver (Granville & 41 Ave), BC
West Vancouver, BC
White Rock, BC
Youbou, BC
Bamfield, BC
Jordan River, BC
Langford, BC
Port Alice, BC
Port Renfrew, BC
Queen Charlotte City, BC
Sandspit, BC
Sooke, BC
Tofino, BC
Ucluelet, BC
Victoria, BC
Victoria Gonzales Height, BC
Victoria Mt Tolmie, BC
Cowley, AB
Pincher Creek, AB
Baie-Saint-Paul, QC
La Pocatière, QC
La-Malbaie, QC
Alma, QC
Rivière-du-Loup, QC
Saguenay, QC
Saguenay (Bagotville), QC
Saguenay (Jonquière), QC
Saguenay (Kénogami), QC
St-Georges-de-Cacouna, QC
Témiscaming, QC
Saint Andrews, NB
St. Stephen, NB
Bonavista, NL
Cape Race, NL
St. Anthony, NL
Ulukhaqtuuq / Holman, NT
Haines Junction, YT

APPENDIX D

PCFs 1475 and 1775 - Impact Analysis for Duplex Archetype

Summary of Results

Summary of 2015 NBC and 2020 NBC Seismic Hazard Values and the Seismic Parameter, Smax

		Existing for Part 9					Proposed for Part 9							
Location	Prov.	2020 Sa(0.2)	2020 Sa(0.5)	2020 HWP (kPa)	2020 Ss (kPa)	2020 Sr (kPa)	Updated S(0.2, C)	Updated S(0.5, C)	2020 A S_{max}	2020 B S_{max}	2020 C S_{max}	2020 D S_{max}	2020 E S_{max}	Unknown Site Class S_{max}
Victoria	BC	1.300	1.160	0.57	1.10	0.20	1.910	1.68	0.87	1.07	1.68	2.01	2.02	2.02
Lethbridge	AB	0.164	0.125	0.66	1.20	0.10	0.210	0.15	0.08	0.10	0.15	0.25	0.29	0.29
Winnipeg	MB	0.054	0.032	0.45	1.90	0.20	0.082	0.050	0.03	0.04	0.06	0.09	0.11	0.11
Ottawa (City Hall)	ON	0.439	0.237	0.41	2.40	0.40	0.660	0.39	0.26	0.38	0.44	0.51	0.60	0.60
Montréal (City Hall)	QC	0.595	0.311	0.42	2.60	0.40	0.840	0.49	0.35	0.49	0.56	0.58	0.67	0.67
St. John's	NL	0.090	0.073	0.78	2.90	0.70	0.190	0.15	0.07	0.10	0.15	0.27	0.31	0.31
Whitehorse	YK	0.334	0.258	0.38	2.00	0.10	0.470	0.40	0.17	0.22	0.41	0.62	0.70	0.70

Summary of the Change in Cost due to PCFs 1475 and 1775

				Scenario A		Scenario B	
Location	Prov.	House Construction Cost		NBC 2020 Provisions		PCF Provisions	
		Avg. $/Sq.ft.	House Cost	Updated Seismic Hazard		Updated Seismic Hazard	
				Cost Diff.	% Change	Cost Diff.	% Change
Victoria	BC	$ 186.30	$ 257,653	$ 2,955.67	1.15%	$ 633.35	0.25%
Whitehorse	YT	$ 200.00	$ 276,600	$ -	0.00%	$ 607.08	0.22%
Lethbridge	AB	$ 150.00	$ 207,450	$ -	0.00%	$ 863.05	0.42%
Ottawa (City Hall)	ON	$ 142.50	$ 197,078	$ -	0.00%	$ 800.81	0.41%
Ottawa Simple Approach	ON	$ 142.50	$ 197,078	$ -	0.00%	$ 1,230.03	0.62%
Ottawa Energy Efficient	ON	$ 142.50	$ 197,078	$ -	0.00%	$ 1,088.17	0.55%
Montréal (City Hall)	QC	$ 145.00	$ 200,535	$ 1,525.99	0.76%	$ 607.08	0.30%
St. John's	NL	$ 140.00	$ 193,620	$ -	0.00%	$ 863.05	0.45%
Winnipeg	MB	$ 135.00	$ 186,705	$ -	0.00%	$ 786.30	0.42%

Notes:

1. The cost differences and % change in the above table represents the change relative to the base scenario, which is the NBC 2020 provisions with the NBC 2020 seismic hazard values.

2. The house cost is based on the square footage cost and the square footage of the archetype used in the impact analysis (1,383 sq.ft.). Square footage construction costs were obtained from Altus Group - 2022 Canadian Construction Cost Guide which reflects costs of 2021. Without information for Victoria or Lethbridge, factors were applied to the 2021 data to reflect previous years' cost variations.

3. The cost differences between the basement components were negligeable and for this reason were excluded from the data presented.

Comments and Disussion of Results

Location	Prov.	Comments and Discussion
Victoria	BC	With the updated Seismic Hazard values Victoria is moved into using Part 4 for lateral loads resistance design. The PCF would keep Victoria from being pushed into Part 4 for many cases which is why Scenario B represents a cost reduction compared to Scenario A.
Whitehorse	YT	Whitehorse is currently not required to design for lateral loads resistance which is reflected by the cost increase. This archetype was governed by the seismic hazard value because the worst case maximum value was selected, assuming the designer did not have a geotechnical evaluation conducted.
Lethbridge	AB	The lateral loads design cost values for St. John's were applied to the construction cost information for Lethbridge because the two cities fall into the same seismic and wind hazard categories. The lateral loads resistance for this archetype was governed by the expected wind loads.
Winnipeg	MB	The large difference between Wind and Seismic hazards for Winnipeg would likely mean that regardless of the building dimensions, Wind will govern the design to resist lateral loads.
Ottawa (City Hall)	ON	Following the PCF's proposed provisions, Ottawa's wind and seismic hazard values result in similar minimum lengths for braced wall panels depending on the dimensions of the building. For this archetype, Seismic governed over Wind.
Montréal (City Hall)	QC	The Base Scenario vs Scenario B, and Scenario A vs Scenario B are compared separately because Montreal does not require any braced wall panels in the Base Scenario. This means all braced wall panel lengths from Scenario B are compared against the same length of non-braced walls that would be built to current code. When comparing Scenario A to Scenario B, Scenario A does have requirements for braced wall panel lengths and where these lengths differ from those in Scenario B, the cost of non-braced wall must be applied. So because Scenario B accounts for additional non-braced wall costs where Scenario A has longer braced wall panels, this version of Scenario B cannot be compared directly to the Base Scenario.
St. John's	NL	The large difference between Wind and Seismic hazards for St. John's would likely mean that regardless of the building dimensions, wind will govern the design to resist lateral loads.

Cost Differences - Victoria

Archetype	Duplex Arch. G
No. Storeys =	2
Construction =	Light
w =	12.6 m
l =	14.2 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	1.82 m

Braced Wall Panel Difference

Scenario A, with updated Seismic data, requires homes in Victoria to be designed according to Part 4, which has been represented as a 10% increase in braced panel lengths.

		Base Scenario: Existing NBC 2020				Scenario A: Updated Seismic Values				Difference b/w Base and Scenario A
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	600	2015 WSP-3a	$ 163.94 /m	$ 98.37	660	2015 WSP-4a	$ 173.60 /m	$ 114.57	$ 16.21
		1365	EXT-W26600	$ 155.18 /m	$ 211.82	1305	EXT-W26600	$ 155.18 /m	$ 202.51	$ (9.31)
	BWP2	407	2015 WSP-3a	$ 163.94 /m	$ 66.73	447.7	2015 WSP-4a	$ 173.60 /m	$ 77.72	$ 10.99
	BWP3	407	2015 WSP-3a	$ 163.94 /m	$ 66.73	447.7	2015 WSP-4a	$ 173.60 /m	$ 77.72	$ 10.99
	BWP4	600	2015 WSP-3a	$ 163.94 /m	$ 98.37	660	2015 WSP-4a	$ 173.60 /m	$ 114.57	$ 16.21
		920	EXT-W26600	$ 155.18 /m	$ 142.76	860	EXT-W26600	$ 155.18 /m	$ 133.45	$ (9.31)
	BWP5	1800	2015 WSP-3a	$ 163.94 /m	$ 295.10	1980	2015 WSP-4a	$ 173.60 /m	$ 343.72	$ 48.62
		920	EXT-W26600	$ 155.18 /m	$ 142.76	740	EXT-W26600	$ 155.18 /m	$ 114.83	$ (27.93)
	BWP6	750	2015 WSP-3a	$ 163.94 /m	$ 122.96	825	2015 WSP-4a	$ 173.60 /m	$ 143.22	$ 20.26
		920	EXT-W26600	$ 155.18 /m	$ 142.76	845	EXT-W26600	$ 155.18 /m	$ 131.12	$ (11.64)
	BWP7	750	2015 WSP-3a	$ 163.94 /m	$ 122.96	825	2015 WSP-4a	$ 173.60 /m	$ 143.22	$ 20.26
	BWP8	750	2015 WSP-3a	$ 163.94 /m	$ 122.96	825	2015 WSP-4a	$ 173.60 /m	$ 143.22	$ 20.26
		1010	EXT-W26600	$ 155.18 /m	$ 156.73	935	EXT-W26600	$ 155.18 /m	$ 145.09	$ (11.64)
	BWP9	600	2015 WSP-3a	$ 163.94 /m	$ 98.37	660	2015 WSP-4a	$ 173.60 /m	$ 114.57	$ 16.21
	BWP10	1030	2015 WSP-3a-Interior	$ 157.62 /m	$ 162.35	1133	2015 WSP-4a-Interior	$ 167.28 /m	$ 189.52	$ 27.17
		4440	INT-W26600-B	$ 124.87 /m	$ 554.44	4337	INT-W26600-B	$ 124.87 /m	$ 541.57	$ (12.86)
	BWP11	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57	660	2015 WSP-4a-Interior	$ 167.28 /m	$ 110.40	$ 15.83
	BWP12	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57	660	2015 WSP-4a-Interior	$ 167.28 /m	$ 110.40	$ 15.83
	BWP13	1030	2015 WSP-3a-Interior	$ 157.62 /m	$ 162.35	1133	2015 WSP-4a-Interior	$ 167.28 /m	$ 189.52	$ 27.17
	BWP14	600	2015 WSP-3a	$ 163.94 /m	$ 98.37	660	2015 WSP-4a	$ 173.60 /m	$ 114.57	$ 16.21
		1020	EXT-W26600	$ 155.18 /m	$ 158.28	960	EXT-W26600	$ 155.18 /m	$ 148.97	$ (9.31)
	BWP15	600	2015 WSP-3a	$ 163.94 /m	$ 98.37	660	2015 WSP-4a	$ 173.60 /m	$ 114.57	$ 16.21
		0	EXT-W26600	$ 155.18 /m	$ -					
	BWP16	600	2015 WSP-3a	$ 163.94 /m	$ 98.37	660	2015 WSP-4a	$ 173.60 /m	$ 114.57	$ 16.21
	BWP17	750	2015 WSP-3a	$ 163.94 /m	$ 122.96	825	2015 WSP-4a	$ 173.60 /m	$ 143.22	$ 20.26
		1750	EXT-W26600	$ 155.18 /m	$ 271.56	1675	EXT-W26600	$ 155.18 /m	$ 259.92	$ (11.64)
	BWP18	1670	2015 WSP-3a	$ 163.94 /m	$ 273.79	1837	2015 WSP-4a	$ 173.60 /m	$ 318.90	$ 45.11
		840	EXT-W26600	$ 155.18 /m	$ 130.35	673	EXT-W26600	$ 155.18 /m	$ 104.43	$ (25.91)
2nd Flr	BWP19	600	2015 WSP-3a	$ 163.94 /m	$ 98.37	660	2015 WSP-4a	$ 173.60 /m	$ 114.57	$ 16.21
	BWP20	600	2015 WSP-3a	$ 163.94 /m	$ 98.37	660	2015 WSP-4a	$ 173.60 /m	$ 114.57	$ 16.21
	BWP21	1310	2015 WSP-3a	$ 163.94 /m	$ 214.77	1441	2015 WSP-4a	$ 173.60 /m	$ 250.15	$ 35.39
					$ -					$ -
	BWP22	750	2015 WSP-3a	$ 163.94 /m	$ 122.96	825	2015 WSP-4a	$ 173.60 /m	$ 143.22	$ 20.26
		250	2015 WSP-3a	$ 163.94 /m	$ 40.99	175	EXT-W26600	$ 155.18 /m	$ 27.16	$ (13.83)
	BWP23	750	2015 WSP-3a	$ 163.94 /m	$ 122.96	825	2015 WSP-4a	$ 173.60 /m	$ 143.22	$ 20.26
	BWP23b	750	2015 WSP-3a	$ 163.94 /m	$ 122.96	825	2015 WSP-4a	$ 173.60 /m	$ 143.22	$ 20.26
				/m	$ -					
	BWP24	600	2015 WSP-3a	$ 163.94 /m	$ 98.37	660	2015 WSP-4a	$ 173.60 /m	$ 114.57	$ 16.21
	BWP25	1030	2015 WSP-3a-Interior	$ 157.62 /m	$ 162.35	1133	2015 WSP-4a-Interior	$ 167.28 /m	$ 189.52	$ 27.17
		3610	INT-W26600	$ 116.08 /m	$ 419.06	3507	INT-W26600	$ 116.08 /m	$ 407.10	$ (11.96)
	BWP26	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57	660	2015 WSP-4a-Interior	$ 167.28 /m	$ 110.40	$ 15.83
	BWP27	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57	660	2015 WSP-4a-Interior	$ 167.28 /m	$ 110.40	$ 15.83
		600	INT-W26600	$ 116.08 /m	$ 69.65					
	BWP28	1030	2015 WSP-3a-Interior	$ 157.62 /m	$ 162.35	1133	2015 WSP-4a-Interior	$ 167.28 /m	$ 189.52	$ 27.17
					$ -					
	BWP29	600	2015 WSP-3a	$ 163.94 /m	$ 98.37	660	2015 WSP-4a	$ 173.60 /m	$ 114.57	$ 16.21
	BWP30	600	2015 WSP-3a	$ 163.94 /m	$ 98.37	660	2015 WSP-4a	$ 173.60 /m	$ 114.57	$ 16.21
		1200	EXT-W26600	$ 155.18 /m	$ 186.21	1140	EXT-W26600	$ 155.18 /m	$ 176.90	$ (9.31)
	BWP31	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57	660	2015 WSP-4a-Interior	$ 167.28 /m	$ 110.40	$ 15.83
	BWP32	750	2015 WSP-3a-Interior	$ 157.62 /m	$ 118.22	825	2015 WSP-4a-Interior	$ 167.28 /m	$ 138.00	$ 19.78
		77	INT-W26600	$ 116.08 /m	$ 8.94	2	INT-W26600	$ 116.08 /m	$ 0.23	$ (8.71)
	BWP33	1170	2015 WSP-3a-Interior	$ 157.62 /m	$ 184.42	1287	2015 WSP-4a-Interior	$ 167.28 /m	$ 215.28	$ 30.86
		1320	INT-W26600	$ 116.08 /m	$ 153.23	1203	INT-W26600	$ 116.08 /m	$ 139.65	$ (13.58)
1st Flr	Extra 11 mm OSB	9552	Extra 11 mm OSB	$ 30.70 /m	$ 293.22	8596.8	Extra 11 mm OSB	$ 30.70 /m	$ 263.90	$ (29.32)
2nd Flr	Extra 11 mm OSB	12388	Extra 11 mm OSB	$ 30.70 /m	$ 380.28	11149.2	Extra 11 mm OSB	$ 30.70 /m	$ 342.25	$ (38.03)
All Flrs	Extra 12.7 Gypsum	-8930	Extra Gypsum Board	$ 34.92 /m	$ (311.82)	-9359	Extra Gypsum Board	$ 34.92 /m	$ (326.80)	$ (14.98)
					$ 7,435.97				**$ 7,806.72**	**$ 440.40**

Cost Increase of Scenario A relative to Base Scenario	$ 370.75
Percent Cost Increase of Scenario A relative to Base Scenario	5.0%

		Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	1965	2020 WSP-C	$ 168.01 /m	$ 330.14	$231.78
					$ -	-$211.82
	BWP2	407	2020 WSP-B	$ 161.84 /m	$ 65.87	-$0.85
	BWP3	407	2020 WSP-B	$ 161.84 /m	$ 65.87	-$0.85
	BWP4	1520	2020 WSP-B	$ 161.84 /m	$ 246.00	$147.64
					$ -	-$142.76
	BWP5	2720	2020 WSP-B	$ 161.84 /m	$ 440.22	$145.12
					$ -	-$142.76
	BWP6	1670	2020 WSP-B	$ 161.84 /m	$ 270.28	$147.32
					$ -	-$142.76
	BWP7	750	2020 WSP-B	$ 161.84 /m	$ 121.38	-$1.57
	BWP8	1760	2020 WSP-B	$ 161.84 /m	$ 284.85	$161.89
					$ -	-$156.73
	BWP9	600	2020 WSP-B	$ 161.84 /m	$ 97.11	-$1.26
	BWP10	5470	2020 WSP-B-Interior	$ 155.52 /m	$ 850.72	$688.37
					$ -	-$554.44
	BWP11	600	2020 WSP-B-Interior	$ 155.52 /m	$ 93.31	-$1.26
	BWP12	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	-$1.22
	BWP13	1030	2020 WSP-B-Interior	$ 155.52 /m	$ 160.19	-$2.16
	BWP14	1620	2020 WSP-F	$ 190.58 /m	$ 308.73	$210.37
					$ -	-$158.28
	BWP15	600	2020 WSP-F	$ 190.58 /m	$ 114.35	$15.98
					$ -	$0.00
	BWP16	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$2.44
	BWP17	2500	2020 WSP-C	$ 168.01 /m	$ 420.03	$297.07
					$ -	-$271.56
	BWP18	2510	2020 WSP-A	$ 149.69 /m	$ 375.71	$101.93
					$ -	-$130.35
2nd Flr	BWP19	600	2020 WSP-F	$ 190.58 /m	$ 114.35	$15.98
	BWP20	600	2020 WSP-B	$ 161.84 /m	$ 97.11	-$1.26
	BWP21	600	2020 WSP-B	$ 161.84 /m	$ 97.11	-$117.66
		710	EXT-W26600	$ 155.18 /m	$ 110.18	$110.18
	BWP22	1000	2020 WSP-B	$ 161.84 /m	$ 161.84	$38.89
					$ -	-$40.99
	BWP23	750	2020 WSP-B	$ 161.84 /m	$ 121.38	-$1.57
	BWP23b	0			$ -	-$122.96
		750	EXT-W26600	$ 155.18 /m	$ 116.38	$116.38
	BWP24	600	2020 WSP-B	$ 161.84 /m	$ 97.11	-$1.26
	BWP25	4640	2020 WSP-A-Interior	$ 163.91 /m	$ 760.56	$598.21
				/m	$ -	-$419.06
	BWP26	600	2020 WSP-A-Interior	$ 163.91 /m	$ 98.35	$3.77
	BWP27	1200	GWB-B Interior	$ 95.82 /m	$ 114.98	$20.41
	BWP28	600	2020 WSP-A-Interior	$ 163.91 /m	$ 98.35	-$64.00
		430	INT-W26600	$ 116.08 /m	$ 49.92	$49.92
	BWP29	600	2020 WSP-F	$ 190.58 /m	$ 114.35	$15.98
	BWP30	1800	2020 WSP-F	$ 190.58 /m	$ 343.04	$244.67
					$ -	-$186.21
	BWP31	750	2020 WSP-F-Interior	$ 184.26 /m	$ 138.19	$43.62
	BWP32	827	2020 WSP-F-Interior	$ 184.26 /m	$ 152.38	$34.16
					$ -	-$8.94
	BWP33	2490	GWB-B Interior	$ 95.82 /m	$ 238.59	$54.17
					$ -	-$153.23
1st Flr	Extra 11 mm OSB	4868	Extra 11 mm OSB	$ 30.70 /m	$ 149.44	-$143.79
2nd Flr	Extra 11 mm OSB	8032	Extra 11 mm OSB	$ 30.70 /m	$ 246.56	-$133.72
All Flrs	Extra 12.7 Gypsum	2490	Extra Gypsum Board	$ 34.92 /m	$ 86.95	$398.77
					$ 7,946.04	**$ 579.72**

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 510.07
Percent Cost Increase of Scenario B relative to Base Scenario	6.9%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020				Scenario A: Updated Seismic Values				Difference b/w Base and Scenario A
	Spacing (mm)	Number	Unit Cost	Cost	Spacing (mm)	Number	Unit Cost	Cost	
1/2" dia. Anchor	2400	28	$ 6.13 Ea.	$ 171.64	2400	28	$ 6.13 Ea.	$ 171.64	$ -
									0%

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
500/800/1400/	44	$ 6.13 Ea.	$ 269.72	**$ 98.08**
				57%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020					Scenario A: Updated Seismic Values					Difference b/w Base and Scenario A
	No. Locations	No. Fasteners	Total	Cost per	Total Cost	No. Locations	No. Fasteners	Total	Cost per	Total Cost	
1st Floor Framing	14	16	224	$ 0.10	$ 22.40	14	18	252	$ 0.10	$ 25.20	$ 2.80
2nd Floor Framing	14	6	84	$ 0.10	$ 8.40	14	10	140	$ 0.10	$ 14.00	$ 5.60
			308		**$ 30.80**			**392**		**$ 39.20**	**$ 8.40**
											27%

	Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
1st Floor Framing	14	20	280	$ 0.10	$ 28.00	$ 5.60
2nd Floor Framing	14	20	280	$ 0.10	$ 28.00	$ 19.60
			560		**$ 56.00**	**$ 25.20**
						82%

% Professional Fees =	1%
Professional Fees =	$ 2,576.53

Base Scenario Total Cost	$ 7,638.41

Average Cost of Housing Construction in Victoria
$ 257,652.90 CAD
Based on Altus Group - 2022 Canadian Cost Guide and applying a 1.08 Factor to the cost for Vancouver (as has been the average)

Scenario A Total Cost	$ 10,594.09
Total Percent Increase Relative to Base Scenario (Existing Code)	39%
Scenario A Percent Increase from Base Case Home Construction Cost	1.15%

Scenario B Total Cost	$ 8,271.76
Total Percent Increase Relative to Base Scenario (Existing Code)	8%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	-22%
Scenario B Percent Increase from Base Case Home Construction Cost	0.25%

Code Analysis - Victoria

Archetype	Duplex Arch. G	
No. Storeys =	2	
Construction =	Light	
w =	12.6	m
l =	14.2	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	1.82	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	1.30	
HWP =	0.57	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		Design to 9.23.13.4. to 9.23.13.7.
	Does the Article apply?	Yes	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		Yes
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		0.25
	% braced walls - 1st Floor		0.25
	% braced walls - bsmt		0.40
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		7.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		750 mm
9.23.13.6.	**Materials in Braced Wall Panels**		Use OSB wall sheathing
	Is Sa(0.2) less than or equal to 0.9?	No	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	N/A	N/A	mm
Plywood	11	12.5	mm
Diagonal lumber	N/A	N/A	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**					
	Does Table 9.23.3.5.-A govern design?				No	
	Does Table 9.23.3.5.-B govern design?				No	
	Does Table 9.23.3.5.-C govern design?				Yes	
	Braced Wall Panel Type				**2015 WSP-4**	**2015 WSP-4a**
9.23.6.1.	**Anchorage of Building Frames**					
	1.2 < Sa(0.2) ≤ 1.3					
	Anchor bolt size	12.7	mm		Use Table 9.23.6.1.	
	Anchor bolt spacing	1.9	m		Use Table 9.23.6.1.	
9.23.11.4.	**Joints in Top Plates**					
	1.2 < Sa(0.2) ≤ 1.3					
	Top Plate Connections					
	1st Floor	8	nails	Supporting 1 floor	Using Table 9.23.11.4.-2015	
	2nd Floor	3	nails	Supporting 0 floors	Using Table 9.23.11.4.-2015	

Scenario A:
2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 1.91
HWP = 0.45 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**	
	Does the Article apply? No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	**Design to Part 4**
	Does the Article apply? Yes	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	0.25
	% braced walls - 1st Floor	0.25
	% braced walls - bsmt	0.40
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	7.6 m **Design to Part 4**
	Maximum distance between required braced wall panels measured from the edges of the panels	6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
9.23.13.6.	**Materials in Braced Wall Panels**	
	Is Sa(0.2) less than or equal to 0.9? No	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	n/a	n/a	mm
Plywood	11	12.5	mm
Diagonal lumber	n/a	n/a	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	No
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**Design to Part 4**
9.23.6.1.	**Anchorage of Building Frames**	
	Sa(0.2) > 1.8	**Design to Part 4**
	Anchor bolt size 12.7 mm	
	Anchor bolt spacing 1.8 m	**Use at least the highest from Table 9.23.6.1.**

9.23.11.4.	**Joints in Top Plates** Sa(0.2) > 1.8 Top Plate Connections	Design to Part 4
	1st Floor **9** nails Supporting 1 floor	
	2nd Floor **5** nails Supporting 0 floors	**Use at least the highest from Table 9.23.11.4.**

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

				First Storey		Second Storey	
Smax =	2.02	Worst Case	w =	14.2	m	14.2	m
Smax =	1.68	Site Class C	l =	12.6	m	10.8	m
HWP =	0.57	kPa	Stud spacing =	600	mm		
S =	0.70	kPa	Stud Height =	2.4	m		
Construction =	Normal		Eave-to-Ridge height =	1.82	m		

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	No	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A

9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	10.6	m
	Maximum distance between required braced wall panels measured from the edges of the panels	6.4	m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	2.4	m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600	mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750	mm
	Minimum length of individual gypsum board-sheathed braced wall panels:		
	• gypsum board installed on both faces of braced wall panel	1.2	m
	• gypsum board installed on one face of braced wall panel	2.4	m

Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(4) **SEISMIC**

$L_s = L_{us} \times [K_{weight} \times K_{snow}] \times [K_{Sspacing} \times K_{Snumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Walls)

L_{us} =	6.47	m	**WSP-B**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**5.90**	**m**	

Front to Back Direction (Interior Party Walls)

L_{us} =	4.62	m	**WSP-E**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1.2	walls are blocked but not sheathed on the opposing side of the wood sheathing	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**5.06**	**m**	

Front to Back Direction (Interior Garage Walls)

L_{us} =	4.62	m	**WSP-C**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1.2	walls are blocked but not sheathed on the opposing side of the wood sheathing	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**5.06**	**m**	

Left to Right Direction (Exterior Back Wall)

L_{us} =	6.47	m	**WSP-B**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.64	space between braced walls approx. 4.2 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**6.21**	**m**	

Left to Right Direction (Interior Wall)

L_{us} =	6.47 m	**WSP-B**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.64	space between braced walls approx. 4.2 m (average)
$K_{Snumber}$ =	1.5	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**6.21 m**	

Left to Right Direction (Exterior Front Wall - Front Door)

L_{us} =	4.62 m	**WSP-F**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.64	space between braced walls approx. 4.2 m (average)
$K_{Snumber}$ =	1.5	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**4.44 m**	

Second Storey

Front to Back Direction (Exterior) 10.8m

L_{us} =	2.4 m	**WSP-B**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m (average)
$K_{Snumber}$ =	1.6	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**2.19 m**	

Front to Back Direction (Interior Party Wall) 10.8m

L_{us} =	4.57 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m (average)
$K_{Snumber}$ =	1.6	5 braced wall bands
K_{gyp} =	1.4	walls are not blocked and not sheathed on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**5.83 m**	

Front to Back Direction (Interior @ bedroom) 10.8m

L_{us} =	1.72 m	**WSP-F**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m (average)
$K_{Snumber}$ =	1.6	5 braced wall bands

K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**1.57 m**	

Left to Right Direction (Exterior Back Wall)

L_{us} =	2.95 m	**WSP-B**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.64	space between braced walls approx. 5.3 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**2.51 m**	

Left to Right Direction (Exterior Front Wall)

L_{us} =	2.11 m	**WSP-F**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.64	space between braced walls approx. 5.3 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**1.80 m**	

Left to Right Direction (Interior Bedroom Wall)

L_{us} =	7.525 m	**GWB-B**	15.05/2
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.64	space between braced walls approx. 5.3 m (average)	
$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**6.41 m**		

9.23.6.1.	**Anchorage of Building Frames**		
	Is HWP between 0.6 kPa and 1.2 kPa	No	
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	Yes	Use Table 9.23.6.1.

<u>From Table 9.23.6.1.</u>

Framing Type Selected	**WSP-B**
Anchor bolt size	12.7 mm
Anchor bolt spacing	0.6 m

<u>From Table 9.23.6.1.</u>

Framing Type Selected	**WSP-B**
Anchor bolt size	12.7 mm
Anchor bolt spacing	0.5 m

9.23.11.4.	**Joints in Top Plates**		
	Is HWP between 0.6 kPa and 1.2 kPa	No	N/A
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A
	Table 9.23.11.4.-A <u>1.2 < and ≤ 1.6</u> Normal Weight All floors 19 nails For BWB Spacing of 10.6m **10 nails** For BWB Spacing of ≤ 7.6m		
	Table 9.23.11.4.-B <u>1.2 < and ≤ 1.6</u> 1st Floor 13 nails For BWB Spacing of 10.6m **7 nails** For BWB Spacing of ≤ 7.6m 2nd Floor 7 nails For BWB Spacing of 10.6m **4 nails** For BWB Spacing of ≤ 7.6m		

Cost Differences - Whitehorse

Archetype	Duplex Arch. G
No. Storeys =	2
Construction =	Light
w =	12.6 m
l =	14.2 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	1.82 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020			
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP2	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP3	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP4	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP5	1800	EXT-W26400-9.5OSB	$ 149.69 /m	$ 269.43
	BWP6	1060	EXT-W26400-9.5OSB	$ 149.69 /m	$ 158.67
	BWP7	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP8	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP9	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP10	2525	INT-W26600-B	$ 124.87 /m	$ 315.30
	BWP11	600	INT-W26600-B	$ 124.87 /m	$ 74.92
	BWP12	600	INT-W26600-B	$ 124.87 /m	$ 74.92
	BWP13	1030	INT-W26600-B	$ 124.87 /m	$ 128.62
	BWP14	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP15	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP16	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP17	2125	EXT-W26400-9.5OSB	$ 149.69 /m	$ 318.08
	BWP18	1670	EXT-W26400-9.5OSB	$ 149.69 /m	$ 249.98
2nd Flr	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP21	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP22	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP23	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP24	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP25	1500	INT-W26600	$ 116.08 /m	$ 174.13
	BWP26	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP27	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP28	2800	INT-W26600	$ 116.08 /m	$ 325.03
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP31	600	INT-W26600	$ 116.08 /m	$ 69.65
	BWP32	700	INT-W26600	$ 116.08 /m	$ 81.26
	BWP33	1200	INT-W26600	$ 116.08 /m	$ 139.30
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
2nd Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
All Flrs	Extra 12.7 Gypsum	-9655	Extra Gypsum Board	$ 34.92 /m	$ (337.14)
					$ 3,969.40

		Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP2	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP3	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP4	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP5	1800	2020 WSP-A	$ 149.69 /m	$ 269.43	$0.00
	BWP6	1060	2020 WSP-A	$ 149.69 /m	$ 158.67	$0.00
	BWP7	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP8	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP9	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP10	2525	GWB-D Interior	$ 97.75 /m	$ 246.82	-$68.48
	BWP11	600	GWB-D Interior	$ 97.75 /m	$ 58.65	-$16.27
	BWP12	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$18.43
	BWP13	1030	GWB-D Interior	$ 97.75 /m	$ 100.68	-$27.94
	BWP14	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP15	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$9.12
	BWP16	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP17	2125	2020 WSP-A	$ 149.69 /m	$ 318.08	$0.00
	BWP18	1670	2020 WSP-A	$ 149.69 /m	$ 249.98	$0.00
2nd Flr	BWP19	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP21	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP23	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP24	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP25	1500	GWB-A Interior	$ 81.17 /m	$ 121.75	-$52.38
	BWP26	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP27	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP28	2800	GWB-A Interior	$ 81.17 /m	$ 227.26	-$97.77
	BWP29	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP30	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP31	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$23.71
	BWP32	700	2020 WSP-A-Interior	$ 155.59 /m	$ 108.92	$27.66
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
1st Flr	Extra 11 mm OSB	8423	Extra 11 mm OSB	$ 30.70 /m	$ 258.57	$258.57
2nd Flr	Extra 11 mm OSB	1659	Extra 11 mm OSB	$ 30.70 /m	$ 50.93	$50.93
All Flrs	Extra 12.7 Gypsum	3700	Extra Gypsum Board	$ 34.92 /m	$ 129.20	$466.33
					$ 4,464.78	$ 495.38

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 495.38
Percent Cost Increase of Scenario B relative to Base Scenario	12.5%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020			
	Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	28	$ 6.13 Ea.	$ 171.64

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
800/2400	38	$ 6.13 Ea.	$ 232.94	$ 61.30
				36%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020				
	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	16	224	$ 0.10	$ 22.40
2nd Floor Framing	14	6	84	$ 0.10	$ 8.40
			308		$ 30.80

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
14	38	532	$ 0.10	$ 53.20	$ 30.80
14	20	280	$ 0.10	$ 28.00	$ 19.60
		812		$ 81.20	$ 50.40
					164%

Base Scenario Total Cost	$ 4,171.84

Scenario B Total Cost	$ 4,778.92
Total Percent Increase Relative to Base Scenario (Existing Code)	14.55%

Scenario B Percent Increase from Base Case Home Construction Cost	0.22%

Average Cost of Housing Construction in Whitehorse
$ 276,600.00 CAD
Based on the Industry Rule of Thumb for Yukon, proposed by a JTG Member.

Code Analysis - Whitehorse

Archetype	Duplex Arch. G	
No. Storeys =	2	
Construction =	Light	
w =	12.6	m
l =	14.2	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	1.82	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.334	
HWP =	0.38	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		Use OSB wall sheathing
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**			
	Does Table 9.23.3.5.-A govern design?			Yes
	Does Table 9.23.3.5.-B govern design?			No
	Does Table 9.23.3.5.-C govern design?			No
	Braced Wall Panel Type			**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**			
	Anchor bolt size	12.7	mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing	2.4	m	
9.23.11.4.	**Joints in Top Plates**			
	Top Plate Connections			
	1st Floor	1 nails	Supporting 1 floor	
	2nd Floor	1 nails	Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.47

HWP = 0.38 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm

Use OSB wall sheathing

Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**		
	Does Table 9.23.3.5.-A govern design?		Yes
	Does Table 9.23.3.5.-B govern design?		No
	Does Table 9.23.3.5.-C govern design?		No
	Braced Wall Panel Type		**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**		
	Anchor bolt size	12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing	2.4 m	
9.23.11.4.	**Joints in Top Plates**		
	Top Plate Connections		
	1st Floor 1 nail	Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail	Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

				First Storey	Second Storey
Smax =	0.70 Worst Case	w =		12.6 m	12.6 m
Smax =	0.41 Site Class C	l =		14.2 m	10.84 m
HWP =	0.38 kPa	Stud spacing =		600 mm	
S =	1.00 kPa	Stud Height =		2.4 m	
Construction =	Normal	Eave-to-Ridge height =		1.82 m	

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply? Yes		
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		750 mm

	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(4) **SEISMIC**

$L_s = L_{us} \times [K_{weight} \times K_{snow}] \times [K_{Sspacing} \times K_{Snumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Walls)

	3.79	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**3.46**	**m**	

Front to Back Direction (Interior Garage Walls)

	3.79	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**3.46**	**m**	

Front to Back Direction (Interior Party Wall)

L_{us} =	3.79	m	**GWB-D**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1.2	walls are blocked but no gypsum sheathing on interior	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**4.15**	**m**	

Left to Right Direction (Exterior Back Wall and Interior Wall)

L_{us} =	3.79	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.64	space between braced walls approx. 4.2 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	

K_{sheath} = 1 walls are continuously wood sheathed

L_s = 3.64 m

Left to Right Direction (Exterior Front Wall - Front Door)

L_{us} = 1.99 m **WSP-B**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.64 space between braced walls approx. 4.2 m (average)
$K_{Snumber}$ = 1.5 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 1.91 m

Second Storey

Front to Back Direction (Exterior Walls)

1.41 m **WSP-A**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.57 space between braced walls approx. 3.55 m
$K_{Snumber}$ = 1.6 5 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 1.29 m

Front to Back Direction (Interior Bedroom Walls)

1.41 m **WSP-A**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.57 space between braced walls approx. 3.55 m
$K_{Snumber}$ = 1.6 5 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 1.29 m

Front to Back Direction (Interior Party Wall)

6.02 m **GWB-A**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.57 space between braced walls approx. 3.55 m
$K_{Snumber}$ = 1.6 5 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 5.49 m

Left to Right Direction (Exterior Back Wall)

L_{us} = 1.72 m **WSP-A**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.64 space between braced walls approx. 5.3 m (average)
$K_{Snumber}$ = 1.33 3 braced wall bands

K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 1.46 m

Left to Right Direction (Exterior Front Wall)

L_{us} =	1.72 m	**WSP-B**	
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.64	space between braced walls approx. 5.3 m (average)	
$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_s = 1.46 m

Left to Right Direction (Interior Walls)

L_{us} =	3.625 m	**GWB-A**	7.25/2
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.64	space between braced walls approx. 5.3 m (average)	
$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_s = 3.09 m

9.23.6.1. **Anchorage of Building Frames**

Is HWP greater than 1.2 kPa	No	If "No" to both then use Table 9.23.6.1.
Is Smax greater than 2.6?	No	Use 9.23.6.1.(2)(b)

From Table 9.23.6.1.
Framing Type Selected **WSP-A**
Anchor bolt size 12.7 mm
Anchor bolt spacing 0.8 m

From Table 9.23.6.1.
Framing Type Selected **WSP-A**
Anchor bolt size 12.7 mm
Anchor bolt spacing 0.7 m

9.23.11.4. **Joints in Top Plates**

Is HWP less than or equal to 1.2 kPa	Yes	Use Table 9.23.11.4.-B
Is Smax for Site Class C less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A

Table 9.23.11.4.-A

≤ 0.6		Normal Weight
All floors	6 nails	For BWB Spacing of 10.6m
	3 nails	For BWB Spacing of ≤ 7.6m

Table 9.23.11.4.-B

0.3 < and ≤ 0.4		Normal Weight
1st Floor	9 nails	For BWB Spacing of 10.6m
	5 nails	For BWB Spacing of ≤ 7.6m

	2nd Floor	5 nails	For BWB Spacing of 10.6m	
		3 nails	For BWB Spacing of ≤ 7.6m	

Cost Differences - Lethbridge

Archetype	Duplex Arch. G
No. Storeys =	2
Construction =	Light
w =	12.6 m
l =	14.2 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	1.82 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020			
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	1965	EXT-W26400-9.5OSB	$ 149.69 /m	$ 294.13
	BWP2	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP3	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP4	1502	EXT-W26400-9.5OSB	$ 149.69 /m	$ 224.83
	BWP5	840	EXT-W26400-9.5OSB	$ 149.69 /m	$ 125.74
	BWP6	1670	EXT-W26400-9.5OSB	$ 149.69 /m	$ 249.98
	BWP7	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP8	915	EXT-W26400-9.5OSB	$ 149.69 /m	$ 136.96
	BWP9	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP10	3200	INT-W26600-B	$ 124.87 /m	$ 399.59
	BWP11	600	INT-W26600-B	$ 124.87 /m	$ 74.92
	BWP12	600	INT-W26600-B	$ 124.87 /m	$ 74.92
	BWP13	1030	INT-W26600-B	$ 124.87 /m	$ 128.62
	BWP14	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP15	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP16	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP17	1470	EXT-W26400-9.5OSB	$ 149.69 /m	$ 220.04
	BWP18	1670	EXT-W26400-9.5OSB	$ 149.69 /m	$ 249.98
2nd Flr	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP21	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP22	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP23	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP24	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP25	1800	INT-W26600	$ 116.08 /m	$ 208.95
	BWP26	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP27	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP28	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP31	600	INT-W26600	$ 116.08 /m	$ 69.65
	BWP32	900	INT-W26600	$ 116.08 /m	$ 104.48
	BWP33	1200	INT-W26600	$ 116.08 /m	$ 139.30
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
2nd Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
All Flrs	Extra 12.7 Gypsum	-9030	Extra Gypsum Board	$ 34.92 /m	$ (315.31)
					$ 4,138.97

		Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	1965	2020 WSP-A	$ 149.69 /m	$ 294.13	$0.00
	BWP2	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP3	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP4	1502	2020 WSP-A	$ 149.69 /m	$ 224.83	$0.00
	BWP5	840	2020 WSP-A	$ 149.69 /m	$ 125.74	$0.00
	BWP6	1670	2020 WSP-A	$ 149.69 /m	$ 249.98	$0.00
	BWP7	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP8	915	2020 WSP-A	$ 149.69 /m	$ 136.96	$0.00
	BWP9	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP10	3200	GWB-D Interior	$ 97.75 /m	$ 312.80	-$86.79
	BWP11	600	GWB-D Interior	$ 97.75 /m	$ 58.65	-$16.27
	BWP12	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$18.43
	BWP13	1030	GWB-D Interior	$ 97.75 /m	$ 100.68	-$27.94
	BWP14	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP15	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP16	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP17	1470	2020 WSP-A	$ 149.69 /m	$ 220.04	$0.00
	BWP18	1670	2020 WSP-A	$ 149.69 /m	$ 249.98	$0.00
2nd Flr	BWP19	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP21	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP23	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP24	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP25	1800	GWB-A Interior	$ 81.17 /m	$ 146.10	-$62.85
	BWP26	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP27	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP28	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP29	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP30	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP31	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$23.71
	BWP32	900	2020 WSP-A-Interior	$ 155.59 /m	$ 140.03	$35.56
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
1st Flr	Extra 11 mm OSB	7548	Extra 11 mm OSB	$ 30.70 /m	$ 231.70	$231.70
2nd Flr	Extra 11 mm OSB	10675	Extra 11 mm OSB	$ 30.70 /m	$ 327.70	$327.70
All Flrs	Extra 12.7 Gypsum	3900	Extra Gypsum Board	$ 34.92 /m	$ 136.18	$451.49
					$ 4,902.58	$ 763.61

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 763.61
Percent Cost Increase of Scenario B relative to Base Scenario	18.4%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020			
	Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	28	$ 6.13 Ea.	$ 171.64

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
1400/2400	36	$ 6.13 Ea.	$ 220.68	$ 49.04
				29%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020				
	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	16	224	$ 0.10	$ 22.40
2nd Floor Framing	14	6	84	$ 0.10	$ 8.40
			308		$ 30.80

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
14	38	532	$ 0.10	$ 53.20	$ 30.80
14	20	280	$ 0.10	$ 28.00	$ 19.60
		812		$ 81.20	$ 50.40
					164%

Base Scenario Total Cost	$ 4,341.41

Scenario B Total Cost	$ 5,204.46
Total Percent Increase Relative to Base Scenario (Existing Code)	19.88%

Average Cost of Duplex Construction in Lethbridge
$ **207,450.00** CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Percent Increase from Base Case Home Construction Cost	0.42%

Code Analysis - Lethbridge

Archetype	Duplex Arch. G	
No. Storeys =	2	
Construction =	Light	
w =	12.6	m
l =	14.2	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	1.82	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.09	
HWP =	0.78	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		Use OSB wall sheathing
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**		
	Does Table 9.23.3.5.-A govern design?		Yes
	Does Table 9.23.3.5.-B govern design?		No
	Does Table 9.23.3.5.-C govern design?		No
	Braced Wall Panel Type		**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**		
	Anchor bolt size	12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing	2.4 m	
9.23.11.4.	**Joints in Top Plates**		
	Top Plate Connections		
	1st Floor — 1 nails	Supporting 1 floor	
	2nd Floor — 1 nails	Supporting 0 floors	

Scenario A:
2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.19
HWP = 0.78 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm

Use OSB wall sheathing

Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

					First Storey		Second Storey	
Smax =	0.31	Worst Case	w =		14.2	m	14.2	m
Smax =	0.15	Site Class C	l =		12.6	m	10.8	m
HWP =	0.78	kPa	Stud spacing =		600	mm		
S =	2.01	kPa	Stud Height =		2.4	m		
Construction =	Normal		Eave-to-Ridge height =		1.82	m		

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750	mm
	Minimum length of individual gypsum board-sheathed braced wall panels:		
	• gypsum board installed on both faces of braced wall panel	1.2	m
	• gypsum board installed on one face of braced wall panel	2.4	m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2	m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.	

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	7.06 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m
$K_{Wnumber}$ =	1.43	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**4.02 m**	

Front to Back Direction (Interior Garage Walls)

L_{uw} =	7.06 m	**GWB-D**
K_{exp} =	1	for suburban
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m
$K_{Wnumber}$ =	1.43	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**4.02 m**	

Front to Back Direction (Party Walls)

L_{uw} =	7.06 m	**WSP-A**	
K_{exp} =	1	for suburban	
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m	
$K_{Wnumber}$ =	1.43	5 braced wall bands	
K_{gyp} =	1.2	walls are blocked but not sheathed on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**4.83 m**		

Left to Right Direction (Exterior Back Wall and Interior Wall)

L_{uw} =	7.06 m	**WSP-A**	
K_{exp} =	1	for suburban	
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.56	space between braced walls approx. 4.2 m (averaged)	
$K_{Wnumber}$ =	1.38	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**4.53 m**		

Left to Right Direction (Exterior Front Wall - Front Door)

L_{uw} =	3.71 m	**WSP-B**	
K_{exp} =	1	for suburban	
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.56	space between braced walls approx. 4.2 m (averaged)	
$K_{Wnumber}$ =	1.38	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.38 m**		

Second Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	3.43 m	**WSP-A**	
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m	
$K_{Wnumber}$ =	1.43	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**1.46 m**		

Front to Back Direction (Interior Bedroom Walls)

L_{uw} =	3.43 m	**WSP-A**	7.01/2
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m	
$K_{Wnumber}$ =	1.43	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **1.46 m**

Front to Back Direction (Interior Party Wall)

L_{uw} =	9.86 m	**GWB-A**	
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m	
$K_{Wnumber}$ =	1.43	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **4.20 m**

Left to Right Direction (Exterior Back)

L_{uw} =	3.43 m	**WSP-A**	
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.72	space between braced walls approx. 5.4 m (average)	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **1.96 m**

Left to Right Direction (Exterior Back)

L_{uw} =	1.8 m	**WSP-B**	
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.72	space between braced walls approx. 5.4 m (average)	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **1.03 m**

Left to Right Direction (Interior Bedroom)

L_{uw} =	4.93 m	**GWB-A**	9.86/2
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.72	space between braced walls approx. 5.4 m (average)	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **2.82 m**

9.23.6.1.	**Anchorage of Building Frames**		
	Is HWP between 0.6 kPa and 1.2 kPa	Yes	
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	No	Use Table 9.23.6.1.
	From Table 9.23.6.1.		
	Framing Type Selected **WSP-A**		
	Anchor bolt size 12.7 mm		

	Anchor bolt spacing 0.8 m From Table 9.23.6.1. Framing Type Selected **WSP-B** Anchor bolt size 12.7 mm Anchor bolt spacing 0.7 m		
9.23.11.4.	**Joints in Top Plates**		
	Is HWP between 0.6 kPa and 1.2 kPa	Yes	Use Table 9.23.11.4.-B
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	No	N/A
	Table 9.23.11.4.-A 0.6 < and ≤ 0.8 — Normal Weight All floors — 4 nails — For BWB Spacing of 10.6m 2 — For BWB Spacing of ≤ 7.6m Table 9.23.11.4.-B 0.6 < and ≤ 0.9 — Normal Weight 1st Floor — 20 nails — For BWB Spacing of 10.6m **10 nails** — For BWB Spacing of ≤ 7.6m 2nd Floor — 13 nails — For BWB Spacing of 10.6m **7 nails** — For BWB Spacing of ≤ 7.6m		

Cost Differences - Ottawa

Archetype	Duplex Arch. G
No. Storeys =	2
Construction =	Light
w =	12.6 m
l =	14.2 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	1.82 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020			
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP2	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP3	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP4	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP5	1240	EXT-W26400-9.5OSB	$ 149.69 /m	$ 185.61
	BWP6	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP7	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP8	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP9	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP10	3710	INT-W26600-B	$ 124.87 /m	$ 463.28
	BWP11	1200	INT-W26600-B	$ 124.87 /m	$ 149.85
	BWP12	600	INT-W26600-B	$ 124.87 /m	$ 74.92
	BWP13	1420	INT-W26600-B	$ 124.87 /m	$ 177.32
	BWP14	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP15	800	EXT-W26400-9.5OSB	$ 149.69 /m	$ 119.75
	BWP16	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP17	1260	EXT-W26400-9.5OSB	$ 149.69 /m	$ 188.60
	BWP18	1670	EXT-W26400-9.5OSB	$ 149.69 /m	$ 249.98
2nd Flr	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP21	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP22	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP23	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP24	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP25	1715	INT-W26600	$ 116.08 /m	$ 199.08
	BWP26	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP27	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP28	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP31	600	INT-W26600	$ 116.08 /m	$ 69.65
	BWP32	750	INT-W26600	$ 116.08 /m	$ 87.06
	BWP33	1200	INT-W26600	$ 116.08 /m	$ 139.30
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
2nd Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
All Flrs	Extra 12.7 Gypsum	-10445	Extra Gypsum Board	$ 34.92 /m	$ (364.72)
					$ 3,806.22

		Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP2	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP3	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP4	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP5	1240	2020 WSP-A	$ 149.69 /m	$ 185.61	$0.00
	BWP6	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP7	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP8	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP9	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP10	3710	GWB-B Interior	$ 95.53 /m	$ 354.43	-$108.85
	BWP11	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	-$35.21
	BWP12	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$18.43
	BWP13	1420	GWB-B Interior	$ 95.53 /m	$ 135.66	-$41.66
	BWP14	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP15	800	2020 WSP-A	$ 149.69 /m	$ 119.75	$0.00
	BWP16	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP17	1260	2020 WSP-A	$ 149.69 /m	$ 188.60	$0.00
	BWP18	1670	2020 WSP-A	$ 149.69 /m	$ 249.98	$0.00
2nd Flr	BWP19	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP21	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP23	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP24	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP25	1715	GWB-A Interior	$ 81.17 /m	$ 139.20	-$59.88
	BWP26	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP27	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP28	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP29	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP30	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP31	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$23.71
	BWP32	750	2020 WSP-A-Interior	$ 155.59 /m	$ 116.70	$29.63
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
1st Flr	Extra 11 mm OSB	7548	Extra 11 mm OSB	$ 30.70 /m	$ 231.70	$231.70
2nd Flr	Extra 11 mm OSB	10675	Extra 11 mm OSB	$ 30.70 /m	$ 327.70	$327.70
All Flrs	Extra 12.7 Gypsum	3750	Extra Gypsum Board	$ 34.92 /m	$ 130.94	$495.67
					$ 4,519.85	$ 713.63

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 713.63
Percent Cost Increase of Scenario B relative to Base Scenario	18.7%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020			
	Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	28	$ 6.13 Ea.	$ 171.64

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
1400/2400	34	$ 6.13 Ea.	$ 208.42	$ 36.78
				21%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020				
	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	16	224	$ 0.10	$ 22.40
2nd Floor Framing	14	6	84	$ 0.10	$ 8.40
			308		$ 30.80

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
14	38	532	$ 0.10	$ 53.20	$ 30.80
14	20	280	$ 0.10	$ 28.00	$ 19.60
		812		$ 81.20	$ 50.40
					164%

Base Scenario Total Cost	$ 4,008.66

Scenario B Total Cost	$ 4,809.47
Total Percent Increase Relative to Base Scenario (Existing Code)	19.98%

Scenario B Percent Increase from Base Case Home Construction Cost	0.41%

Average Cost of Housing Construction in Ottawa
$ 197,077.50 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Cost Differences - Ottawa (Simplified Approach)

Archetype	Duplex Arch. G
No. Storeys =	2
Construction =	Light
w =	12.6 m
l =	14.2 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	1.82 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020			
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	1815	EXT-W26400-9.5OSB	$ 149.69 /m	$ 271.68
	BWP2	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP3	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP4	2670	EXT-W26400-9.5OSB	$ 149.69 /m	$ 399.66
	BWP5	1800	EXT-W26400-9.5OSB	$ 149.69 /m	$ 269.43
	BWP6	3710	EXT-W26400-9.5OSB	$ 149.69 /m	$ 555.33
	BWP7	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP8	820	EXT-W26400-9.5OSB	$ 149.69 /m	$ 122.74
	BWP9	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP10	4550	INT-W26600-B	$ 124.87 /m	$ 568.17
	BWP11	600	INT-W26600-B	$ 124.87 /m	$ 74.92
	BWP12	1030	INT-W26600-B	$ 124.87 /m	$ 128.62
	BWP13	3030	INT-W26600-B	$ 124.87 /m	$ 378.36
	BWP14	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP15	955	EXT-W26400-9.5OSB	$ 149.69 /m	$ 142.95
	BWP16	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP17	1780	EXT-W26400-9.5OSB	$ 149.69 /m	$ 266.44
	BWP18	3060	EXT-W26400-9.5OSB	$ 149.69 /m	$ 458.04
2nd Flr	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP21	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP22	2780	EXT-W26400-9.5OSB	$ 149.69 /m	$ 416.13
	BWP23	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP24	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP25	2290	INT-W26600	$ 116.08 /m	$ 265.83
	BWP26	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP27	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP28	3110	INT-W26600	$ 116.08 /m	$ 361.02
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP31	600	INT-W26600	$ 116.08 /m	$ 69.65
	BWP32	1070	INT-W26600	$ 116.08 /m	$ 124.21
	BWP33	1640	INT-W26600	$ 116.08 /m	$ 190.38
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
2nd Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
All Flrs	Extra 12.7 Gypsum	-14780	Extra Gypsum Board	$ 34.92 /m	$ (516.09)
					$ 5,980.75

		Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	1815	2020 WSP-B	$ 161.84 /m	$ 293.75	$22.07
	BWP2	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP3	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP4	2670	2020 WSP-A	$ 149.69 /m	$ 399.66	$0.00
	BWP5	1800	2020 WSP-A	$ 149.69 /m	$ 269.43	$0.00
	BWP6	3710	2020 WSP-A	$ 149.69 /m	$ 555.33	$0.00
	BWP7	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$9.12
	BWP8	820	2020 WSP-B	$ 161.84 /m	$ 132.71	$9.97
	BWP9	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP10	4550	GWB-D Interior	$ 97.75 /m	$ 444.77	-$123.40
	BWP11	600	GWB-D Interior	$ 97.75 /m	$ 58.65	-$16.27
	BWP12	1030	2020 WSP-A-Interior	$ 155.59 /m	$ 160.26	$31.64
	BWP13	3030	GWB-D Interior	$ 97.75 /m	$ 296.19	-$82.18
	BWP14	600	2020 WSP-F	$ 190.58 /m	$ 114.35	$24.53
	BWP15	955	2020 WSP-F	$ 190.58 /m	$ 182.00	$39.05
	BWP16	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$9.12
	BWP17	1780	2020 WSP-B	$ 161.84 /m	$ 288.08	$21.64
	BWP18	3060	2020 WSP-A	$ 149.69 /m	$ 458.04	$0.00
2nd Flr	BWP19	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$11.00
	BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP21	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP22	2780	2020 WSP-A	$ 149.69 /m	$ 416.13	$0.00
	BWP23	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP24	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP25	2290	GWB-B Interior	$ 95.53 /m	$ 218.77	-$47.06
	BWP26	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	-$24.66
	BWP27	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP28	3110	GWB-B Interior	$ 95.53 /m	$ 297.11	-$63.91
	BWP29	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$11.00
	BWP30	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$11.00
	BWP31	600	2020 WSP-F-Interior	$ 184.26 /m	$ 110.55	$40.90
	BWP32	1070	2020 WSP-F-Interior	$ 184.26 /m	$ 197.15	$72.95
	BWP33	1640	GWB-A Interior	$ 81.17 /m	$ 133.11	-$57.27
1st Flr	Extra 11 mm OSB	7548	Extra 11 mm OSB	$ 30.70 /m	$ 231.70	$231.70
2nd Flr	Extra 11 mm OSB	10675	Extra 11 mm OSB	$ 30.70 /m	$ 327.70	$327.70
All Flrs	Extra 12.7 Gypsum	4510	Extra Gypsum Board	$ 34.92 /m	$ 157.48	$673.58
					$ 7,092.95	$ 1,112.20

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 1,112.20
Percent Cost Increase of Scenario B relative to Base Scenario	18.6%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020			
	Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	28	$ 6.13 Ea.	$ 171.64

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
1400/2400	39	$ 6.13 Ea.	$ 239.07	$ 67.43
				39%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020				
	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	16	224	$ 0.10	$ 22.40
2nd Floor Framing	14	6	84	$ 0.10	$ 8.40
			308		$ 30.80

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
14	38	532	$ 0.10	$ 53.20	$ 30.80
14	20	280	$ 0.10	$ 28.00	$ 19.60
		812		$ 81.20	$ 50.40
					164%

Base Scenario Total Cost	$ 6,183.19

Scenario B Total Cost	$ 7,413.22
Total Percent Increase Relative to Base Scenario (Existing Code)	19.89%

Average Cost of Housing Construction in Ottawa
$ 197,077.50 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Percent Increase from Base Case Home Construction Cost	0.62%

Code Analysis - Ottawa

Archetype	Duplex Arch. G
No. Storeys =	2
Construction =	Light
w =	12.6 m
l =	14.2 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	1.82 m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) = 0.439

HWP = 0.41 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		Use OSB wall sheathing
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**				
	Does Table 9.23.3.5.-A govern design?				Yes
	Does Table 9.23.3.5.-B govern design?				No
	Does Table 9.23.3.5.-C govern design?				No
	Braced Wall Panel Type				**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**				
	Anchor bolt size		12.7	mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing		2.4	m	
9.23.11.4.	**Joints in Top Plates**				
	Top Plate Connections				
	1st Floor	1 nails	Supporting 1 floor		
	2nd Floor	1 nails	Supporting 0 floors		

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.66

HWP = 0.41 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Does the Article apply?	No	-
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Does the Article apply?	No	-
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm

Use OSB wall sheathing

Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**		
	Does Table 9.23.3.5.-A govern design?		Yes
	Does Table 9.23.3.5.-B govern design?		No
	Does Table 9.23.3.5.-C govern design?		No
	Braced Wall Panel Type		**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**		
	Anchor bolt size	12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing	2.4 m	
9.23.11.4.	**Joints in Top Plates**		
	Top Plate Connections		
	1st Floor 1 nail	Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail	Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

					First Storey	Second Storey	
Smax =	0.60	Worst Case	w =		14.2 m	14.2 m	LtR
Smax =	0.44	Site Class C	l =		12.6 m	10.6 m	FtB
HWP =	0.41	kPa	Stud spacing =		600 mm		
S =	1.48	kPa	Stud Height =		2.4 m		
Construction =	Normal		Eave-to-Ridge height =		1.82 m		

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply? Yes		
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750	mm
	Minimum length of individual gypsum board-sheathed braced wall panels:		
	• gypsum board installed on both faces of braced wall panel	1.2	m
	• gypsum board installed on one face of braced wall panel	2.4	m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2	m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.	

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(4) **SEISMIC**

$L_s = L_{us} \times [K_{weight} \times K_{snow}] \times [K_{Sspacing} \times K_{Snumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Walls)

	2.84	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**2.59**	**m**	

Front to Back Direction (Interior Garage Walls)

	2.84	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**2.59**	**m**	

Front to Back Direction (Interior Party Wall)

L_{us} =	6.94	m	**GWB-B**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**6.33**	**m**	

Left to Right Direction (Exterior Back Wall and Interior Wall)

L_{us} =	2.84	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	

$K_{Sspacing}$ =	0.64	space between braced walls approx. 4.2 m (average)
$K_{Snumber}$ =	1.5	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**2.73 m**	

Left to Right Direction (Exterior Front Wall - Front Door)

L_{us} =	2.84 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.64	space between braced walls approx. 4.2 m (average)
$K_{Snumber}$ =	1.5	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**2.73 m**	

Second Storey

Front to Back Direction (Exterior Walls)

L_{us} =	1.05 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m (average)
$K_{Snumber}$ =	1.6	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**0.96 m**	

Front to Back Direction (Interior Bedroom Walls)

L_{us} =	1.05 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m (average)
$K_{Snumber}$ =	1.6	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**0.96 m**	

Front to Back Direction (Interior Party Wall)

L_{us} =	4.51 m	**GWB-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m (average)
$K_{Snumber}$ =	1.6	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**4.11 m**	

Left to Right Direction (Exterior Walls)

L_{us} = 1.29 m **WSP-A**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.64 space between braced walls approx. 5.3 m (average)
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 1.10 m

Left to Right Direction (Interior Walls)
L_{us} = 5.44 m **GWB-A**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.64 space between braced walls approx. 5.3 m (average)
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 4.63 m

Simplified Approach

Ottawa fits the criteria to use Table 9.23.13.11.-B

First Storey

Front to Back Direction (Exterior Wall and Party Wall)
WSP-A 8.18 m

Front to Back Direction (Interior Garage Wall)
WSP-B 4.34 m

Left to Right Direction (Exterior back Wall)
WSP-B 4.34 m

Left to Right Direction (Exterior Front Wall)
WSP-F 3.11 m

Left to Right Direction (Interior Walls)
WSP-A 8.18 m

Second Storey

Front to Back Direction (Exterior Wall)
WSP-A 3.98 m

Front to Back Direction (Party Wall)
GWB-B 6.60 m

Front to Back Direction (Interior Walls)
WSP-D 1.67 m

Left to Right Direction (Exterior back Wall)
WSP-B 2.11 m

Left to Right Direction (Exterior Front Wall)
WSP-F 1.51 m

	Left to Right Direction (Interior Walls) **GWB-A 5.68 m**		
9.23.6.1.	**Anchorage of Building Frames**		
	Is HWP greater than 1.2 kPa	No	If "No" to both then use Table 9.23.6.1.
	Is Smax greater than 2.6?	No	Use 9.23.6.1.(2)(b)
	From Table 9.23.6.1. Framing Type Selected **WSP-A** Anchor bolt size 12.7 mm Anchor bolt spacing 0.8 m		
	From Table 9.23.6.1. Framing Type Selected **WSP-A** Anchor bolt size 12.7 mm Anchor bolt spacing 0.7 m		
9.23.11.4.	**Joints in Top Plates**		
	Is HWP less than or equal to 1.2 kPa	Yes	Use Table 9.23.11.4.-B
	Is Smax for Site Class C less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A
	Table 9.23.11.4.-A ≤ 0.6 — Normal Weight All floors 4 nails For BWB Spacing of 10.6m 2 For BWB Spacing of ≤ 7.6m		
	Table 9.23.11.4.-B 0.4 < and ≤ 0.5 — Normal Weight 1st Floor 11 nails For BWB Spacing of 10.6m **6 nails** For BWB Spacing of ≤ 7.6m 2nd Floor 6 nails For BWB Spacing of 10.6m **3 nails** For BWB Spacing of ≤ 7.6m		

Cost Differences - Ottawa - Energy Efficient Home (Intermittent Wood Sheathing)

Archetype	Duplex Arch. G
No. Storeys =	2
Construction =	Light
w =	12.6 m
l =	14.2 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	1.82 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020			
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP2	407	EXT-W26400-Energy	$ 182.01 /m	$ 74.08
	BWP3	407	EXT-W26400-Energy	$ 182.01 /m	$ 74.08
	BWP4	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP5	1240	EXT-W26400-Energy	$ 182.01 /m	$ 225.69
	BWP6	1150	EXT-W26400-Energy	$ 182.01 /m	$ 209.31
	BWP7	750	EXT-W26400-Energy	$ 182.01 /m	$ 136.51
	BWP8	750	EXT-W26400-Energy	$ 182.01 /m	$ 136.51
	BWP9	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP10	3710	INT-W26600-B	$ 124.87 /m	$ 463.28
	BWP11	1200	INT-W26600-B	$ 124.87 /m	$ 149.85
	BWP12	600	INT-W26600-B	$ 124.87 /m	$ 74.92
	BWP13	1420	INT-W26600-B	$ 124.87 /m	$ 177.32
	BWP14	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP15	800	EXT-W26400-Energy	$ 182.01 /m	$ 145.61
	BWP16	750	EXT-W26400-Energy	$ 182.01 /m	$ 136.51
	BWP17	1260	EXT-W26400-Energy	$ 182.01 /m	$ 229.33
	BWP18	1670	EXT-W26400-Energy	$ 182.01 /m	$ 303.95
2nd Flr	BWP19	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP20	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP21	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP22	1300	EXT-W26400-Energy	$ 182.01 /m	$ 236.61
	BWP23	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP24	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP25	1715	INT-W26600	$ 116.08 /m	$ 199.08
	BWP26	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP27	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP28	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP29	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP30	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP31	600	INT-W26600	$ 116.08 /m	$ 69.65
	BWP32	750	INT-W26600	$ 116.08 /m	$ 87.06
	BWP33	1200	INT-W26600	$ 116.08 /m	$ 139.30
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
2nd Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
All Flrs	Extra 12.7 Gypsum	-10445	Extra Gypsum Board	$ 34.92 /m	$ (364.72)
					$ 4,523.05

		Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$9.49
	BWP2	407	2020 WSP-A-Energy	$ 197.83 /m	$ 80.52	$6.44
	BWP3	407	2020 WSP-A-Energy	$ 197.83 /m	$ 80.52	$6.44
	BWP4	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$9.49
	BWP5	1240	2020 WSP-A-Energy	$ 197.83 /m	$ 245.31	$19.62
	BWP6	1150	2020 WSP-A-Energy	$ 197.83 /m	$ 227.51	$18.20
	BWP7	750	2020 WSP-A-Energy	$ 197.83 /m	$ 148.37	$11.87
	BWP8	750	2020 WSP-A-Energy	$ 197.83 /m	$ 148.37	$11.87
	BWP9	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$9.49
	BWP10	3710	GWB-B Interior	$ 95.53 /m	$ 354.43	-$108.85
	BWP11	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	-$35.21
	BWP12	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$18.43
	BWP13	1420	GWB-B Interior	$ 95.53 /m	$ 135.66	-$41.66
	BWP14	600	2020 WSP-B-Energy	$ 209.99 /m	$ 125.99	$16.79
	BWP15	800	2020 WSP-B-Energy	$ 209.99 /m	$ 167.99	$22.39
	BWP16	750	2020 WSP-A-Energy	$ 197.83 /m	$ 148.37	$11.87
	BWP17	1260	2020 WSP-A-Energy	$ 197.83 /m	$ 249.27	$19.94
	BWP18	1670	2020 WSP-A-Energy	$ 197.83 /m	$ 330.38	$26.43
2nd Flr	BWP19	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$9.49
	BWP20	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$9.49
	BWP21	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$9.49
	BWP22	1300	2020 WSP-A-Energy	$ 197.83 /m	$ 257.18	$20.57
	BWP23	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$9.49
	BWP24	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$9.49
	BWP25	1715	GWB-A Interior	$ 81.17 /m	$ 139.20	-$59.88
	BWP26	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP27	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP28	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP29	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$9.49
	BWP30	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$9.49
	BWP31	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$23.71
	BWP32	750	2020 WSP-A-Interior	$ 155.59 /m	$ 116.70	$29.63
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
1st Flr	Extra 11 mm OSB	7548	Extra 11 mm OSB	$ 30.70 /m	$ 231.70	$231.70
2nd Flr	Extra 11 mm OSB	10675	Extra 11 mm OSB	$ 30.70 /m	$ 327.70	$327.70
All Flrs	Extra 12.7 Gypsum	3750	Extra Gypsum Board	$ 34.92 /m	$ 130.94	$495.67
					$ 5,524.04	$ 1,000.99

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 1,000.99
Percent Cost Increase of Scenario B relative to Base Scenario	22.1%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020			
	Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	28	$ 6.13 Ea.	$ 171.64

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
1400/2400	34	$ 6.13 Ea.	$ 208.42	$ 36.78
				21%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020				
	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	16	224	$ 0.10	$ 22.40
2nd Floor Framing	14	6	84	$ 0.10	$ 8.40
			308		$ 30.80

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
14	38	532	$ 0.10	$ 53.20	$ 30.80
14	20	280	$ 0.10	$ 28.00	$ 19.60
		812		$ 81.20	$ 50.40
					164%

Base Scenario Total Cost	$ 4,725.49

Scenario B Total Cost	$ 5,813.66
Total Percent Increase Relative to Base Scenario (Existing Code)	23.03%

Average Cost of Housing Construction in Ottawa	
$ 197,077.50 CAD	
Based on Altus Group - 2022 Canadian Cost Guide	

Scenario B Percent Increase from Base Case Home Construction Cost	0.55%

Code Analysis - Ottawa - Energy Efficient Construction (Intermittent Wood Sheathing)

Archetype	Duplex Arch. G	
No. Storeys =	2	
Construction =	Light	
w =	12.6	m
l =	14.2	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	1.82	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.439	
HWP =	0.41	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		Use OSB wall sheathing
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nails Supporting 1 floor	
	2nd Floor 1 nails Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.66

HWP = 0.41 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**	
	Does the Article apply? Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	-
	% braced walls - 1st Floor	-
	% braced walls - bsmt	-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	- m
	Maximum distance between required braced wall panels measured from the edges of the panels	- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	- mm
9.23.13.6.	**Materials in Braced Wall Panels**	
	Is Sa(0.2) less than or equal to 0.9? Yes	

Stud spacing?	400	600	

GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

Use OSB wall sheathing

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

				First Storey	Second Storey	
Smax =	0.60 Worst Case		w =	14.2 m	14.2 m	LtR
Smax =	0.44 Site Class C		l =	12.6 m	10.6 m	FtB
HWP =	0.41 kPa		Stud spacing =	600 mm		
S =	1.48 kPa		Stud Height =	2.4 m		
Construction =	Normal		Eave-to-Ridge height =	1.82 m		

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m

	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(4) **SEISMIC**

$L_s = L_{us} \times [K_{weight} \times K_{snow}] \times [K_{Sspacing} \times K_{Snumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Walls)

	2.84 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m
$K_{Snumber}$ =	1.6	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1.15	walls are not continuously wood sheathed
L_s =	**2.98 m**	

Front to Back Direction (Interior Garage Walls)

	2.84 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m
$K_{Snumber}$ =	1.6	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**2.59 m**	

Front to Back Direction (Interior Party Wall)

L_{us} =	6.94 m	**GWB-B**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m
$K_{Snumber}$ =	1.6	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**6.33 m**	

Left to Right Direction (Exterior Back Wall and Interior Wall)

L_{us} =	2.84 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.64	space between braced walls approx. 4.2 m (average)
$K_{Snumber}$ =	1.5	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1.15	walls are not continuously wood sheathed
L_s =	**3.14 m**	

Left to Right Direction (Exterior Front Wall - Front Door)

L_{us} =	1.49 m	**WSP-B**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.64	space between braced walls approx. 4.2 m (average)
$K_{Snumber}$ =	1.5	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1.15	walls are not continuously wood sheathed
L_s =	**1.64 m**	

Second Storey

Front to Back Direction (Exterior Walls)

L_{us} =	1.05 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m (average)
$K_{Snumber}$ =	1.6	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1.15	walls are not continuously wood sheathed
L_s =	**1.10 m**	

Front to Back Direction (Interior Bedroom Walls)

L_{us} =	1.05 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m (average)
$K_{Snumber}$ =	1.6	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**0.96 m**	

Front to Back Direction (Interior Party Wall)

L_{us} =	4.51 m	**GWB-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m (average)
$K_{Snumber}$ =	1.6	5 braced wall bands

K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 4.11 m

Left to Right Direction (Exterior Walls)

L_{us} =	1.29 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.64	space between braced walls approx. 5.3 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1.15	walls are not continuously wood sheathed

L_s = 1.26 m

Left to Right Direction (Interior Walls)

L_{us} =	5.44 m	**GWB-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.64	space between braced walls approx. 5.3 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 4.63 m

9.23.6.1. **Anchorage of Building Frames**

Is HWP greater than 1.2 kPa	No	If "No" to both then use Table 9.23.6.1.
Is Smax greater than 2.6?	No	Use 9.23.6.1.(2)(b)

From Table 9.23.6.1.

Framing Type Selected	**WSP-A**	
Anchor bolt size	12.7	mm
Anchor bolt spacing	0.8	m

From Table 9.23.6.1.

Framing Type Selected	**WSP-A**	
Anchor bolt size	12.7	mm
Anchor bolt spacing	0.7	m

9.23.11.4. **Joints in Top Plates**

Is HWP less than or equal to 1.2 kPa	Yes	Use Table 9.23.11.4.-B
Is Smax for Site Class C less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A

Table 9.23.11.4.-A

≤ 0.6		Normal Weight
All floors	4 nails	For BWB Spacing of 10.6m
	2	For BWB Spacing of ≤ 7.6m

Table 9.23.11.4.-B

0.4 < and ≤ 0.5 Normal Weight

1st Floor	11 nails	For BWB Spacing of 10.6m	
	6 nails	For BWB Spacing of ≤ 7.6m	
2nd Floor	6 nails	For BWB Spacing of 10.6m	
	3 nails	For BWB Spacing of ≤ 7.6m	

Cost Differences - Montreal Scenario B compared with Base Scenario

Archetype	Duplex Arch. G
No. Storeys =	2
Construction =	Light
w =	12.6 m
l =	14.2 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	1.82 m

Braced Wall Panel Difference

		Base Scenario: Existing NBC 2020			
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP2	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP3	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP4	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP5	1800	EXT-W26400-9.5OSB	$ 149.69 /m	$ 269.43
	BWP6	1060	EXT-W26400-9.5OSB	$ 149.69 /m	$ 158.67
	BWP7	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP8	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP9	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP10	2525	INT-W26600-B	$ 124.87 /m	$ 315.30
	BWP11	600	INT-W26600-B	$ 124.87 /m	$ 74.92
	BWP12	600	INT-W26600-B	$ 124.87 /m	$ 74.92
	BWP13	1030	INT-W26600-B	$ 124.87 /m	$ 128.62
	BWP14	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP15	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP16	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP17	2125	EXT-W26400-9.5OSB	$ 149.69 /m	$ 318.08
	BWP18	1670	EXT-W26400-9.5OSB	$ 149.69 /m	$ 249.98
2nd Flr	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP21	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP22	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP23	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP24	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP25	1500	INT-W26600	$ 116.08 /m	$ 174.13
	BWP26	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP27	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP28	2800	INT-W26600	$ 116.08 /m	$ 325.03
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP31	600	INT-W26600	$ 116.08 /m	$ 69.65
	BWP32	700	INT-W26600	$ 116.08 /m	$ 81.26
	BWP33	1200	INT-W26600	$ 116.08 /m	$ 139.30
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
2nd Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
All Flrs	Extra 12.7 Gypsum	-9655	Extra Gypsum Board	$ 34.92 /m	$ (337.14)
					$ 3,969.40

		Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP2	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP3	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP4	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP5	1800	2020 WSP-A	$ 149.69 /m	$ 269.43	$0.00
	BWP6	1060	2020 WSP-A	$ 149.69 /m	$ 158.67	$0.00
	BWP7	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP8	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP9	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP10	2525	GWB-D Interior	$ 97.75 /m	$ 246.82	-$68.48
	BWP11	600	GWB-D Interior	$ 97.75 /m	$ 58.65	-$16.27
	BWP12	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$18.43
	BWP13	1030	GWB-D Interior	$ 97.75 /m	$ 100.68	-$27.94
	BWP14	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP15	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$9.12
	BWP16	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP17	2125	2020 WSP-A	$ 149.69 /m	$ 318.08	$0.00
	BWP18	1670	2020 WSP-A	$ 149.69 /m	$ 249.98	$0.00
2nd Flr	BWP19	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP21	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP23	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP24	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP25	1500	GWB-A Interior	$ 81.17 /m	$ 121.75	-$52.38
	BWP26	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP27	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP28	2800	GWB-A Interior	$ 81.17 /m	$ 227.26	-$97.77
	BWP29	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP30	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP31	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$23.71
	BWP32	700	2020 WSP-A-Interior	$ 155.59 /m	$ 108.92	$27.66
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
1st Flr	Extra 11 mm OSB	8423	Extra 11 mm OSB	$ 30.70 /m	$ 258.57	$258.57
2nd Flr	Extra 11 mm OSB	1659	Extra 11 mm OSB	$ 30.70 /m	$ 50.93	$50.93
All Flrs	Extra 12.7 Gypsum	3700	Extra Gypsum Board	$ 34.92 /m	$ 129.20	$466.33
					$ 4,464.78	$ 495.38

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 495.38
Percent Cost Increase of Scenario B relative to Base Scenario	12.5%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020			
	Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	28	$ 6.13 Ea.	$ 171.64

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
800/2400	38	$ 6.13 Ea.	$ 232.94	$ 61.30
				36%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020				
	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	16	224	$ 0.10	$ 22.40
2nd Floor Framing	14	6	84	$ 0.10	$ 8.40
			308		$ 30.80

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
14	38	532	$ 0.10	$ 53.20	$ 30.80
14	20	280	$ 0.10	$ 28.00	$ 19.60
		812		$ 81.20	$ 50.40
					164%

Base Scenario Total Cost	$ 4,171.84

Scenario B Total Cost	$ 4,778.92
Total Percent Increase Relative to Base Scenario (Existing Code)	14.55%

Average Cost of Housing Construction in Montreal
$ 200,535.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Percent Increase from Base Case Home Construction Cost	0.30%

Cost Differences - Montreal Scenario B compared with Scenario A

Archetype Duplex Arch. G

No. Storeys =	2	
Construction =	Light	
w =	12.6	m
l =	14.2	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	1.82	m

Braced Wall Panel Difference

Floor Level	Braced Wall Panel	Scenario A: Updated Seismic Values Length	BWP Type	BWP Unit Cost	BWP Cost
	BWP1	600	2015 WSP-3a	$ 163.94 /m	$ 98.37
	BWP2	407	2015 WSP-3a	$ 163.94 /m	$ 66.73
	BWP3	407	2015 WSP-3a	$ 163.94 /m	$ 66.73
	BWP4	600	2015 WSP-3a	$ 163.94 /m	$ 98.37
	BWP5	1800	2015 WSP-3a	$ 163.94 /m	$ 295.10
	BWP6	750	2015 WSP-3a	$ 163.94 /m	$ 122.96
		310	EXT-W26600	$ 155.18 /m	$ 48.10
	BWP7	750	2015 WSP-3a	$ 163.94 /m	$ 122.96
	BWP8	750	2015 WSP-3a	$ 163.94 /m	$ 122.96
	BWP9	600	2015 WSP-3a	$ 163.94 /m	$ 98.37
	BWP10	1030	2015 WSP-3a-Interior	$ 157.62 /m	$ 162.35
1st Flr		1495	INT-W26600-B	$ 124.87 /m	$ 186.68
	BWP11	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57
	BWP12	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57
	BWP13	1030	2015 WSP-3a-Interior	$ 157.62 /m	$ 162.35
	BWP14	600	2015 WSP-3a	$ 163.94 /m	$ 98.37
	BWP15	600	2015 WSP-3a	$ 163.94 /m	$ 98.37
		150	EXT-W26600	$ 155.18 /m	$ 23.28
	BWP16	600	2015 WSP-3a	$ 163.94 /m	$ 98.37
		150	EXT-W26600	$ 155.18 /m	$ 23.28
	BWP17	750	2015 WSP-3a	$ 163.94 /m	$ 122.96
		1375	EXT-W26600	$ 155.18 /m	$ 213.37
	BWP18	1670	2015 WSP-3a	$ 163.94 /m	$ 273.79
	BWP19	600	2015 WSP-3a	$ 163.94 /m	$ 98.37
	BWP20	600	2015 WSP-3a	$ 163.94 /m	$ 98.37
	BWP21	1310	2015 WSP-3a	$ 163.94 /m	$ 214.77
					$ -
	BWP22	750	2015 WSP-3a	$ 163.94 /m	$ 122.96
					$ -
	BWP23	750	2015 WSP-3a	$ 163.94 /m	$ 122.96
	BWP23b	750	2015 WSP-3a	$ 163.94 /m	$ 122.96
				/m	$ -
	BWP24	600	2015 WSP-3a	$ 163.94 /m	$ 98.37
	BWP25	1030	2015 WSP-3a-Interior	$ 157.62 /m	$ 162.35
2nd Flr		470	INT-W26600	$ 116.08 /m	$ 54.56
	BWP26	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57
		600	INT-W26600	$ 116.08 /m	$ 69.65
	BWP27	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57
	BWP28	1030	2015 WSP-3a-Interior	$ 157.62 /m	$ 162.35
		1770	INT-W26600	$ 116.08 /m	$ 205.47
	BWP29	600	2015 WSP-3a	$ 163.94 /m	$ 98.37
	BWP30	600	2015 WSP-3a	$ 163.94 /m	$ 98.37
	BWP31	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57
		0	INT-W26600	$ 116.08 /m	$ -
	BWP32	750	2015 WSP-3a-Interior	$ 157.62 /m	$ 118.22
		-50	INT-W26600	$ 116.08 /m	$ (5.80)
	BWP33	1170	2015 WSP-3a-Interior	$ 157.62 /m	$ 184.42
		30	INT-W26600	$ 116.08 /m	$ 3.48
1st Flr	Extra 11 mm OSB	9552	Extra 11 mm OSB	$ 30.70 /m	$ 293.22
2nd Flr	Extra 11 mm OSB	12388	Extra 11 mm OSB	$ 30.70 /m	$ 380.28
All Flrs	Extra 12.7 Gypsum	-8160	Extra Gypsum Board	$ 34.92 /m	$ (284.93)
					$ 5,495.39

Floor Level	Braced Wall Panel	Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions Length	BWP Type	BWP Unit Cost	BWP Cost	Difference b/w Base and Scenario B
	BWP1	600	2020 WSP-A	$ 149.69 /m	$ 89.81	-$8.55
	BWP2	407	2020 WSP-A	$ 149.69 /m	$ 60.92	-$5.80
	BWP3	407	2020 WSP-A	$ 149.69 /m	$ 60.92	-$5.80
	BWP4	600	2020 WSP-A	$ 149.69 /m	$ 89.81	-$8.55
	BWP5	1800	2020 WSP-A	$ 149.69 /m	$ 269.43	-$25.66
	BWP6	1060	2020 WSP-A	$ 149.69 /m	$ 158.67	$35.71
					$ -	-$48.10
	BWP7	750	2020 WSP-A	$ 149.69 /m	$ 112.26	-$10.69
	BWP8	750	2020 WSP-A	$ 149.69 /m	$ 112.26	-$10.69
	BWP9	600	2020 WSP-A	$ 149.69 /m	$ 89.81	-$8.55
	BWP10	2525	GWB-D Interior	$ 97.75 /m	$ 246.82	$84.47
1st Flr					$ -	-$186.68
	BWP11	600	GWB-D Interior	$ 97.75 /m	$ 58.65	-$35.92
	BWP12	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	-$1.22
	BWP13	1030	GWB-D Interior	$ 97.75 /m	$ 100.68	-$61.67
	BWP14	600	2020 WSP-B	$ 161.84 /m	$ 97.11	-$1.26
	BWP15	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$23.02
					$ -	-$23.28
	BWP16	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$13.90
						-$23.28
	BWP17	2125	2020 WSP-A	$ 149.69 /m	$ 318.08	$195.12
					$ -	-$213.37
	BWP18	1670	2020 WSP-A	$ 149.69 /m	$ 249.98	-$23.81
	BWP19	600	2020 WSP-B	$ 161.84 /m	$ 97.11	-$1.26
	BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	-$8.55
	BWP21	600	2020 WSP-A	$ 149.69 /m	$ 89.81	-$124.95
		710	EXT-W26600	$ 155.18 /m	$ 110.18	$110.18
	BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	-$33.15
		150	EXT-W26600	$ 155.18	$ 23.28	$23.28
	BWP23	600	2020 WSP-A	$ 149.69 /m	$ 89.81	-$33.15
		150	EXT-W26600	$ 155.18	$ 23.28	$23.28
	BWP23b	0			$ -	-$122.96
		750	EXT-W26600	$ 155.18 /m	$ 116.38	$116.38
	BWP24	600	2020 WSP-A	$ 149.69 /m	$ 89.81	-$8.55
	BWP25	1500	GWB-A Interior	$ 81.17 /m	$ 121.75	-$40.60
2nd Flr				/m	$ -	-$54.56
	BWP26	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$2.82
						-$69.65
	BWP27	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$2.82
	BWP28	2800	GWB-A Interior	$ 81.17 /m	$ 227.26	$64.91
				/m	$ -	-$205.47
	BWP29	600	2020 WSP-B	$ 161.84 /m	$ 97.11	-$1.26
	BWP30	600	2020 WSP-B	$ 161.84 /m	$ 97.11	-$1.26
	BWP31	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	-$1.22
						$0.00
	BWP32	700	2020 WSP-A-Interior	$ 155.59 /m	$ 108.92	-$9.30
					$ -	$5.80
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$87.02
					$ -	-$3.48
1st Flr	Extra 11 mm OSB	4868	Extra 11 mm OSB	$ 30.70 /m	$ 149.44	-$143.79
2nd Flr	Extra 11 mm OSB	8032	Extra 11 mm OSB	$ 30.70 /m	$ 246.56	-$133.72
All Flrs	Extra 12.7 Gypsum	3700	Extra Gypsum Board	$ 34.92 /m	$ 129.20	$414.13
					$ 4,824.39	**$ (670.99)**
	Cost Increase of Scenario B (PCF 1475) relative to Scenario A (Updated Seismic)				-$ 670.99	
	Percent Cost Increase of Scenario B relative to Scenario A (Updated Seismic)				-12.2%	

Anchor Bolts Difference

	Scenario A: Updated Seismic Values Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	28	$ 6.13 Ea.	$ 171.64

Scenario B: Updated Seismic Values and Lateral Loads Provisions Spacing (mm)	Number	Unit Cost	Cost	Difference b/w Base and Scenario B
500/800/1400/	38	$ 6.13 Ea.	$ 232.94	**$ 61.30**
				36%

Top Plate Splice Fasteners

	Scenario A: Updated Seismic Values No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	16	224	$ 0.10	$ 22.40
2nd Floor Framing	14	6	84	$ 0.10	$ 8.40
			308		**$ 30.80**

	Scenario B: Updated Seismic Values and Lateral Loads Provisions No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	Difference b/w Base and Scenario B
1st Floor Framing	14	20	280	$ 0.10	$ 28.00	$ 5.60
2nd Floor Framing	14	20	280	$ 0.10	$ 28.00	$ 19.60
			560		**$ 56.00**	**$ 25.20**
						82%

Scenario A Total Cost	$ 5,697.83

Scenario B Total Cost	$ 5,113.33
Total Percent Increase Relative to Scenario A (Updated Seismic)	-10%

Code Analysis - Montreal

Archetype	Duplex Arch. G	
No. Storeys =	2	
Construction =	Light	
w =	12.6	m
l =	14.2	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	1.82	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.595	
HWP =	0.42	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply? Yes		
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	-	
	Does the Article apply? No		
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	-	
	Does the Article apply? No		
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No	
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No	
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No	
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor	-	
	% braced walls - 2nd Floor	-	
	% braced walls - 1st Floor	-	
	% braced walls - bsmt	-	
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	-	m
	Maximum distance between required braced wall panels measured from the edges of the panels	-	m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	-	m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	-	mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	-	mm
9.23.13.6.	**Materials in Braced Wall Panels**	Use OSB wall sheathing	
	Is Sa(0.2) less than or equal to 0.9? Yes		

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**			
	Does Table 9.23.3.5.-A govern design?			Yes
	Does Table 9.23.3.5.-B govern design?			No
	Does Table 9.23.3.5.-C govern design?			No
	Braced Wall Panel Type			**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**			
	Sa(0.2) ≤ 0.7			
	Anchor bolt size	12.7 mm		Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing	2.4 m		
9.23.11.4.	**Joints in Top Plates**			
	Sa(0.2) ≤ 0.7			
	Top Plate Connections			
	1st Floor	1 nails	Supporting 1 floor	
	2nd Floor	1 nails	Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.840

HWP = 0.42 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		Design to 9.23.13.4. to 9.23.13.7.
	Does the Article apply?	Yes	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		Yes
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		0.25
	% braced walls - 1st Floor		0.25
	% braced walls - bsmt		0.40
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		750 mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2, C) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	

GWB interior finish	12.7	15.9	mm	
CSA O325 sheathing	W16	W24		Use OSB wall sheathing
OSB O-1 and O-2 grades	11	12.5	mm	
Waferboard R-1 grade	9.5	12.5	mm	
Plywood	11	12.5	mm	
Diagonal lumber	17	17	mm	

9.23.3.5.	**Fasteners for Sheathing or Subflooring**		
	Does Table 9.23.3.5.-A govern design?	No	
	Does Table 9.23.3.5.-B govern design?	Yes	
	Does Table 9.23.3.5.-C govern design?	No	
	Braced Wall Panel Type	**2015 WSP-3**	**2015 WSP-3a**

9.23.6.1.	**Anchorage of Building Frames**				
	0.8 ≤ S(0.2, C) ≤ 0.9, HWP ≤ 1.2 kPa				
	Anchor bolt size	12.7	mm		Using Table 9.23.6.1.
	Anchor bolt spacing	2.3	m		Using Table 9.23.6.1.
9.23.11.4.	**Joints in Top Plates**				
	0.80 ≤ S(0.2, C) ≤ 0.90				
	Top Plate Connections				
	1st Floor	5	nails	Supporting 1 floor	
	2nd Floor	2	nails	Supporting 0 floors	

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

				First Storey		Second Storey	
Smax =	0.67	Worst Case	w =	14.2	m	14.2	m
Smax =	0.56	Site Class C	l =	12.6	m	10.8	m
HWP =	0.42	kPa	Stud spacing =	600	mm		
S =	1.57	kPa	Stud Height =	2.4	m		
Construction =	Normal		Eave-to-Ridge height =	1.82	m		

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m

	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	2.4	m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600	mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750	mm
	Minimum length of individual gypsum board-sheathed braced wall panels:		
	• gypsum board installed on both faces of braced wall panel	1.2	m
	• gypsum board installed on one face of braced wall panel	1.2	m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2	m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.	

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(4) **SEISMIC**

$L_s = L_{us} \times [K_{weight} \times K_{snow}] \times [K_{Sspacing} \times K_{Snumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Walls)

L_{us} =	3.79	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**3.46**	**m**	

Front to Back Direction (Interior Garage Walls)

L_{us} =	3.79	m	**GWB-D**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**3.46**	**m**	

Front to Back Direction (Interior Party Wall)

L_{us} =	3.79	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	

K_{gyp} = 1.2 walls are blocked but no gypsum sheathing on interior
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 4.15 m

Left to Right Direction (Exterior Back Wall and Interior Wall)

L_{us} =	3.79	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.64	space between braced walls approx. 4.2 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_s = 3.64 m

Left to Right Direction (Exterior Front Wall - Front Door)

L_{us} =	1.99	m	**WSP-B**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.64	space between braced walls approx. 4.2 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_s = 1.91 m

Second Storey

Front to Back Direction (Exterior Walls)

L_{us} =	1.41	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_s = 1.29 m

Front to Back Direction (Interior Bedroom Walls)

L_{us} =	1.41	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m	
$K_{Snumber}$ =	1.6	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_s = 1.29 m

Front to Back Direction (Interior Party Wall)

L_{us} = 6.02 m **GWB-A**

K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.57	space between braced walls approx. 3.55 m
$K_{Snumber}$ =	1.6	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 5.49 m

Left to Right Direction (Exterior Back Wall)

L_{us} =	1.72 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.64	space between braced walls approx. 5.3 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 1.46 m

Left to Right Direction (Exterior Front Wall)

L_{us} =	1.72 m	**WSP-B**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.64	space between braced walls approx. 5.3 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 1.46 m

Left to Right Direction (Interior Walls)

L_{us} =	3.625 m	**GWB-A** 7.25/2
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.64	space between braced walls approx. 5.3 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 3.09 m

9.23.6.1.	**Anchorage of Building Frames**		
	Is HWP between 0.6 kPa and 1.2 kPa	No	
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	Yes	Use Table 9.23.6.1.
	From Table 9.23.6.1.		
	Framing Type Selected **WSP-A**		
	Anchor bolt size 12.7 mm		
	Anchor bolt spacing 1.4 m		

9.23.11.4.	**Joints in Top Plates**			
	Is HWP between 0.6 kPa and 1.2 kPa		No	N/A
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6		Yes	Use Table 9.23.11.4.-A
	Table 9.23.11.4.-A			
	0.6 < and ≤ 0.8		Normal Weight	
	All floors	6 nails	For BWB Spacing of 10.6m	
		3 nails	For BWB Spacing of ≤ 7.6m	
	Table 9.23.11.4.-B			
	0.6 < and ≤ 0.9			
	1st Floor	11 nails	For BWB Spacing of 10.6m	
		6 nails	For BWB Spacing of ≤ 7.6m	
	2nd Floor	6 nails	For BWB Spacing of 10.6m	
		3 nails	For BWB Spacing of ≤ 7.6m	

Cost Differences - St. John's

Archetype	Duplex Arch. G
No. Storeys =	2
Construction =	Light
w =	12.6 m
l =	14.2 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	1.82 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020			
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	1965	EXT-W26400-9.5OSB	$ 149.69 /m	$ 294.13
	BWP2	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP3	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP4	1502	EXT-W26400-9.5OSB	$ 149.69 /m	$ 224.83
	BWP5	840	EXT-W26400-9.5OSB	$ 149.69 /m	$ 125.74
	BWP6	1670	EXT-W26400-9.5OSB	$ 149.69 /m	$ 249.98
	BWP7	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP8	915	EXT-W26400-9.5OSB	$ 149.69 /m	$ 136.96
	BWP9	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP10	3200	INT-W26600-B	$ 124.87 /m	$ 399.59
	BWP11	600	INT-W26600-B	$ 124.87 /m	$ 74.92
	BWP12	600	INT-W26600-B	$ 124.87 /m	$ 74.92
	BWP13	1030	INT-W26600-B	$ 124.87 /m	$ 128.62
	BWP14	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP15	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP16	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP17	1470	EXT-W26400-9.5OSB	$ 149.69 /m	$ 220.04
	BWP18	1670	EXT-W26400-9.5OSB	$ 149.69 /m	$ 249.98
2nd Flr	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP21	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP22	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP23	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP24	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP25	1800	INT-W26600	$ 116.08 /m	$ 208.95
	BWP26	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP27	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP28	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP31	600	INT-W26600	$ 116.08 /m	$ 69.65
	BWP32	900	INT-W26600	$ 116.08 /m	$ 104.48
	BWP33	1200	INT-W26600	$ 116.08 /m	$ 139.30
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
2nd Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
All Flrs	Extra 12.7 Gypsum	-9030	Extra Gypsum Board	$ 34.92 /m	$ (315.31)
					$ 4,138.97

		Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	1965	2020 WSP-A	$ 149.69 /m	$ 294.13	$0.00
	BWP2	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP3	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP4	1502	2020 WSP-A	$ 149.69 /m	$ 224.83	$0.00
	BWP5	840	2020 WSP-A	$ 149.69 /m	$ 125.74	$0.00
	BWP6	1670	2020 WSP-A	$ 149.69 /m	$ 249.98	$0.00
	BWP7	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP8	915	2020 WSP-A	$ 149.69 /m	$ 136.96	$0.00
	BWP9	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP10	3200	GWB-D Interior	$ 97.75 /m	$ 312.80	-$86.79
	BWP11	600	GWB-D Interior	$ 97.75 /m	$ 58.65	-$16.27
	BWP12	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$18.43
	BWP13	1030	GWB-D Interior	$ 97.75 /m	$ 100.68	-$27.94
	BWP14	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP15	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP16	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP17	1470	2020 WSP-A	$ 149.69 /m	$ 220.04	$0.00
	BWP18	1670	2020 WSP-A	$ 149.69 /m	$ 249.98	$0.00
2nd Flr	BWP19	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP21	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP23	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP24	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP25	1800	GWB-A Interior	$ 81.17 /m	$ 146.10	-$62.85
	BWP26	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP27	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP28	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP29	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP30	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$7.30
	BWP31	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$23.71
	BWP32	900	2020 WSP-A-Interior	$ 155.59 /m	$ 140.03	$35.56
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
1st Flr	Extra 11 mm OSB	7548	Extra 11 mm OSB	$ 30.70 /m	$ 231.70	$231.70
2nd Flr	Extra 11 mm OSB	10675	Extra 11 mm OSB	$ 30.70 /m	$ 327.70	$327.70
All Flrs	Extra 12.7 Gypsum	3900	Extra Gypsum Board	$ 34.92 /m	$ 136.18	$451.49
					$ 4,902.58	$ 763.61

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 763.61
Percent Cost Increase of Scenario B relative to Base Scenario	18.4%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020			
	Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	28	$ 6.13 Ea.	$ 171.64

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
1400/2400	36	$ 6.13 Ea.	$ 220.68	$ 49.04
				29%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020				
	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	16	224	$ 0.10	$ 22.40
2nd Floor Framing	14	6	84	$ 0.10	$ 8.40
			308		$ 30.80

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
14	38	532	$ 0.10	$ 53.20	$ 30.80
14	20	280	$ 0.10	$ 28.00	$ 19.60
		812		$ 81.20	$ 50.40
					164%

Base Scenario Total Cost	$ 4,341.41

Scenario B Total Cost	$ 5,204.46
Total Percent Increase Relative to Base Scenario (Existing Code)	19.88%

Average Cost of Housing Construction in St. John's
$ 193,620.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Percent Increase from Base Case Home Construction Cost	0.45%

Code Analysis - St. John's

Archetype	Duplex Arch. G	
No. Storeys =	2	
Construction =	Light	
w =	12.6	m
l =	14.2	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	1.82	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.09	
HWP =	0.78	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		Use OSB wall sheathing
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**		
	Does Table 9.23.3.5.-A govern design?		Yes
	Does Table 9.23.3.5.-B govern design?		No
	Does Table 9.23.3.5.-C govern design?		No
	Braced Wall Panel Type		**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**		
	Anchor bolt size	12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing	2.4 m	
9.23.11.4.	**Joints in Top Plates**		
	Top Plate Connections		
	1st Floor 1 nails	Supporting 1 floor	
	2nd Floor 1 nails	Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.19

HWP = 0.78 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm

Use OSB wall sheathing

Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

					First Storey	Second Storey
Smax =	0.31	Worst Case		w =	14.2 m	14.2 m
Smax =	0.15	Site Class C		l =	12.6 m	10.8 m
HWP =	0.78	kPa		Stud spacing =	600 mm	
S =	2.01	kPa		Stud Height =	2.4 m	
Construction =	Normal			Eave-to-Ridge height =	1.82 m	

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750	mm
	Minimum length of individual gypsum board-sheathed braced wall panels:		
	• gypsum board installed on both faces of braced wall panel	1.2	m
	• gypsum board installed on one face of braced wall panel	2.4	m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2	m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.	

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	7.06	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m	
$K_{Wnumber}$ =	1.43	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**4.02**	**m**	

Front to Back Direction (Interior Garage Walls)

L_{uw} =	7.06	m	**GWB-D**
K_{exp} =	1	for suburban	
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m	
$K_{Wnumber}$ =	1.43	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**4.02**	**m**	

Front to Back Direction (Party Walls)

L_{uw} =	7.06 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m
$K_{Wnumber}$ =	1.43	5 braced wall bands
K_{gyp} =	1.2	walls are blocked but not sheathed on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**4.83 m**	

Left to Right Direction (Exterior Back Wall and Interior Wall)

L_{uw} =	7.06 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m
$K_{Wspacing}$ =	0.56	space between braced walls approx. 4.2 m (averaged)
$K_{Wnumber}$ =	1.38	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**4.53 m**	

Left to Right Direction (Exterior Front Wall - Front Door)

L_{uw} =	3.71 m	**WSP-B**
K_{exp} =	1	for suburban
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m
$K_{Wspacing}$ =	0.56	space between braced walls approx. 4.2 m (averaged)
$K_{Wnumber}$ =	1.38	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**2.38 m**	

Second Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	3.43 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m
$K_{Wnumber}$ =	1.43	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**1.46 m**	

Front to Back Direction (Interior Bedroom Walls)

L_{uw} =	3.43 m	**WSP-A**	7.01/2
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m	
$K_{Wnumber}$ =	1.43	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **1.46 m**

Front to Back Direction (Interior Party Wall)

L_{uw} =	9.86 m	**GWB-A**	
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m	
$K_{Wnumber}$ =	1.43	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **4.20 m**

Left to Right Direction (Exterior Back)

L_{uw} =	3.43 m	**WSP-A**	
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.72	space between braced walls approx. 5.4 m (average)	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **1.96 m**

Left to Right Direction (Exterior Back)

L_{uw} =	1.8 m	**WSP-B**	
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.72	space between braced walls approx. 5.4 m (average)	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **1.03 m**

Left to Right Direction (Interior Bedroom)

L_{uw} =	4.93 m	**GWB-A**	9.86/2
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.72	space between braced walls approx. 5.4 m (average)	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **2.82 m**

9.23.6.1.	**Anchorage of Building Frames**		
	Is HWP between 0.6 kPa and 1.2 kPa	Yes	
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	No	Use Table 9.23.6.1.
	From Table 9.23.6.1.		
	Framing Type Selected **WSP-A**		
	Anchor bolt size 12.7 mm		

	Anchor bolt spacing 0.8 m <u>From Table 9.23.6.1.</u> Framing Type Selected **WSP-B** Anchor bolt size 12.7 mm Anchor bolt spacing 0.7 m		
9.23.11.4.	**Joints in Top Plates**		
	Is HWP between 0.6 kPa and 1.2 kPa	Yes	Use Table 9.23.11.4.-B
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	No	N/A
	Table 9.23.11.4.-A <u>0.6 < and ≤ 0.8</u> Normal Weight All floors 4 nails For BWB Spacing of 10.6m 2 For BWB Spacing of ≤ 7.6m Table 9.23.11.4.-B <u>0.6 < and ≤ 0.9</u> Normal Weight 1st Floor 20 nails For BWB Spacing of 10.6m **10 nails** For BWB Spacing of ≤ 7.6m 2nd Floor 13 nails For BWB Spacing of 10.6m **7 nails** For BWB Spacing of ≤ 7.6m		

Cost Differences - Winnipeg

Archetype Duplex Arch. G

No. Storeys =	2	
Construction =	Light	
w =	12.6	m
l =	14.2	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	1.82	m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

Floor Level	Braced Wall Panel	Base Scenario: Existing NBC 2020 Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP2	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP3	407	EXT-W26400-9.5OSB	$ 149.69 /m	$ 60.92
	BWP4	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP5	975	EXT-W26400-9.5OSB	$ 149.69 /m	$ 145.94
	BWP6	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP7	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP8	0	EXT-W26400-9.5OSB	$ 149.69 /m	$ -
	BWP9	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP10	1330	INT-W26600-B	$ 124.87 /m	$ 166.08
	BWP11	1200	INT-W26600-B	$ 124.87 /m	$ 149.85
	BWP12	600	INT-W26600-B	$ 124.87 /m	$ 74.92
	BWP13	1200	INT-W26600-B	$ 124.87 /m	$ 149.85
	BWP14	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP15	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP16	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP17	1040	EXT-W26400-9.5OSB	$ 149.69 /m	$ 155.67
	BWP18	1670	EXT-W26400-9.5OSB	$ 149.69 /m	$ 249.98
2nd Flr	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP21	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP22	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP23	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP24	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP25	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP26	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP27	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP28	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP31	600	INT-W26600	$ 116.08 /m	$ 69.65
	BWP32	750	INT-W26600	$ 116.08 /m	$ 87.06
	BWP33	1200	INT-W26600	$ 116.08 /m	$ 139.30
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
2nd Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
All Flrs	Extra 12.7 Gypsum	-7330	Extra Gypsum Board	$ 34.92 /m	$ (255.95)
					$ 3,315.74

Floor Level	Braced Wall Panel	Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions Length	BWP Type	BWP Unit Cost	BWP Cost	Difference b/w Base and Scenario B
1st Flr	BWP1	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP2	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP3	407	2020 WSP-A	$ 149.69 /m	$ 60.92	$0.00
	BWP4	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP5	975	2020 WSP-A	$ 149.69 /m	$ 145.94	$0.00
	BWP6	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP7	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP8	0	2020 WSP-A	$ 149.69 /m	$ -	$0.00
	BWP9	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP10	1330	GWB-B Interior	$ 95.53 /m	$ 127.06	-$39.02
	BWP11	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	-$35.21
	BWP12	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$18.43
	BWP13	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	-$35.21
	BWP14	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP15	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$0.00
	BWP16	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP17	1040	2020 WSP-A	$ 149.69 /m	$ 155.67	$0.00
	BWP18	1670	2020 WSP-A	$ 149.69 /m	$ 249.98	$0.00
2nd Flr	BWP19	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP21	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP23	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP24	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP25	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP26	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP27	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP28	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
	BWP29	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP30	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$0.00
	BWP31	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$23.71
	BWP32	750	2020 WSP-A-Interior	$ 155.59 /m	$ 116.70	$29.63
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	-$41.90
1st Flr	Extra 11 mm OSB	7548	Extra 11 mm OSB	$ 30.70 /m	$ 231.70	$231.70
2nd Flr	Extra 11 mm OSB	10675	Extra 11 mm OSB	$ 30.70 /m	$ 327.70	$327.70
All Flrs	Extra 12.7 Gypsum	3750	Extra Gypsum Board	$ 34.92 /m	$ 130.94	$386.90
					$ 4,014.86	**$ 699.12**

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 699.12
Percent Cost Increase of Scenario B relative to Base Scenario	21.1%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020 Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	28	$ 6.13 Ea.	$ 171.64

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions Spacing (mm)	Number	Unit Cost	Cost	Difference b/w Base and Scenario B
1400/2400	34	$ 6.13 Ea.	$ 208.42	**$ 36.78**
				21%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020 No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	16	224	$ 0.10	$ 22.40
2nd Floor Framing	14	6	84	$ 0.10	$ 8.40
			308		**$ 30.80**

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	Difference b/w Base and Scenario B
14	38	532	$ 0.10	$ 53.20	$ 30.80
14	20	280	$ 0.10	$ 28.00	$ 19.60
		812		**$ 81.20**	**$ 50.40**
					164%

Base Scenario Total Cost	**$ 3,518.18**

Scenario B Total Cost	**$ 4,304.48**
Total Percent Increase Relative to Base Scenario (Existing Code)	22.35%

Average Cost of Housing Construction in Winnipeg
$ 186,705.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Percent Increase from Base Case Home Construction Cost	0.42%

Code Analysis - Winnipeg

Archetype	Duplex Arch. G	
No. Storeys =	2	
Construction =	Light	
w =	12.6	m
l =	14.2	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	1.82	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.054	
HWP =	0.45	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		Use OSB wall sheathing
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**		
	Does Table 9.23.3.5.-A govern design?		Yes
	Does Table 9.23.3.5.-B govern design?		No
	Does Table 9.23.3.5.-C govern design?		No
	Braced Wall Panel Type		**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**		
	Anchor bolt size	12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing	2.4 m	
9.23.11.4.	**Joints in Top Plates**		
	Top Plate Connections		
	1st Floor 1 nails	Supporting 1 floor	
	2nd Floor 1 nails	Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.08

HWP = 0.45 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9?	Yes	
			Use OSB wall sheathing

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm

Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

					First Storey		Second Storey	
Smax =	0.11	Worst Case	w =		14.2	m	14.2	m
Smax =	0.06	Site Class C	l =		12.6	m	10.8	m
HWP =	0.45	kPa	Stud spacing =		600	mm		
S =	1.06	kPa	Stud Height =		2.4	m		
Construction =	Normal		Eave-to-Ridge height =		1.82	m		

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		750 mm

	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$$

First Storey

Front to Back Direction (Exterior Walls and Interior Garage Walls)

L_{uw} =	3.92	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m	
$K_{Wnumber}$ =	1.43	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.23**	**m**	

Front to Back Direction (Interior Party Wall)

L_{uw} =	6.54	m	**GWB-B**
K_{exp} =	1	for suburban	
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m	
$K_{Wnumber}$ =	1.43	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**3.73**	**m**	

Left to Right Direction (Exterior Back Wall)

L_{uw} =	3.92 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m
$K_{Wspacing}$ =	0.56	space between braced walls approx. 4.2 m (averaged)
$K_{Wnumber}$ =	1.38	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**2.51 m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} =	3.92 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m
$K_{Wspacing}$ =	0.56	space between braced walls approx. 4.2 m (averaged)
$K_{Wnumber}$ =	1.38	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**2.51 m**	

Left to Right Direction (Interior Walls)

L_{uw} =	3.92 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.83	for roof eave to ridge of 1.82 m < 3 m
$K_{Wspacing}$ =	0.56	space between braced walls approx. 4.2 m (averaged)
$K_{Wnumber}$ =	1.38	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**2.51 m**	

Second Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	1.9 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m
$K_{Wnumber}$ =	1.43	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**0.81 m**	

Front to Back Direction (Interior Bedroom Walls)

L_{uw} =	3.42 m	**GWB-A**
K_{exp} =	1	for suburban
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m
$K_{Wnumber}$ =	1.43	5 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_w = **1.46 m**

Front to Back Direction (Interior Party Wall)

L_{uw} =	5.84	m	**GWB-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.48	space between braced walls approx. 3.55 m	
$K_{Wnumber}$ =	1.43	5 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **2.49 m**

Left to Right Direction (Exterior Back Walls)

L_{uw} =	1.9	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.72	space between braced walls approx. 5.4 m (average)	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **1.09 m**

Left to Right Direction (Exterior Front Walls)

L_{uw} =	1	m	**WSP-B**
K_{exp} =	1	for suburban	
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m	
$K_{Wspacing}$ =	0.72	space between braced walls approx. 5.4 m (average)	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **0.57 m**

Left to Right Direction (Interior Walls)

L_{uw} =	2.92	m	**GWB-A**	5.84/2
K_{exp} =	1	for suburban		
K_{roof} =	0.62	for roof eave to ridge of 1.82 m < 3 m		
$K_{Wspacing}$ =	0.72	space between braced walls approx. 5.4 m (average)		
$K_{Wnumber}$ =	1.28	3 braced wall bands		
K_{gyp} =	1	walls are sheathing on the interior with gypsum		
K_{sheath} =	1	walls are continuously wood sheathed		

L_w = **1.67 m**

9.23.6.1. **Anchorage of Building Frames**

Is HWP greater than 1.2 kPa	No	If "No" to both then use Table 9.23.6.1.
Is Smax greater than 2.6?	No	Use 9.23.6.1.(2)(b)

From Table 9.23.6.1.

Framing Type Selected **WSP-A**

Anchor bolt size 12.7 mm

	Anchor bolt spacing 0.8 m From Table 9.23.6.1. Framing Type Selected **WSP-A** Anchor bolt size 12.7 mm Anchor bolt spacing 0.7 m		
9.23.11.4.	**Joints in Top Plates**		
	Is HWP less than or equal to 1.2 kPa	Yes	Use Table 9.23.11.4.-B
	Is Smax for Site Class C less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A

Table 9.23.11.4.-A

<= 0.6		Normal Weight
All floors	4 nails	For BWB Spacing of 10.6m
	2 nails	For BWB Spacing of ≤ 7.6m

Table 9.23.11.4.-B

0.4 < and ≤ 0.5		Normal Weight
1st Floor	11 nails	For BWB Spacing of 10.6m
	6 nails	For BWB Spacing of ≤ 7.6m
2nd Floor	7 nails	For BWB Spacing of 10.6m
	4 nails	For BWB Spacing of ≤ 7.6m

PCFs 1475 and 1775 - Impact Analysis for Bungalow Archetype

Summary of Results

Summary of NBC 2020 Seismic Hazard Values and Updated Seismic Hazard Values and the Seismic Parameter, Smax

Location	Prov.	Existing for Part 9					Proposed for Part 9								
		2020 Sa(0.2)	2020 Sa(0.5)	2020 HWP (kPa)	2020 Ss (kPa)	2020 Sr (kPa)	Updated S(0.2, C)	Updated S(0.5, C)	2020 A S_{max}	2020 B S_{max}	2020 C S_{max}	2020 D S_{max}	2020 E S_{max}	Unknown Site Class S_{max}
Victoria	BC	1.300	1.160	0.57	1.10	0.20	1.91	1.68	0.87	1.07	1.68	2.01	2.02	2.02
Lethbridge	AB	0.164	0.125	0.66	1.20	0.10	0.21	0.15	0.08	0.10	0.15	0.25	0.29	0.29
Winnipeg	MB	0.054	0.032	0.45	1.90	0.20	0.082	0.050	0.03	0.04	0.06	0.09	0.11	0.11
Ottawa (City Hall)	ON	0.439	0.237	0.41	2.40	0.40	0.66	0.39	0.26	0.38	0.44	0.51	0.60	0.60
Montréal (City Hall)	QC	0.595	0.311	0.42	2.60	0.40	0.84	0.49	0.35	0.49	0.56	0.58	0.67	0.67
St. John's	NL	0.090	0.073	0.78	2.90	0.70	0.19	0.15	0.07	0.10	0.15	0.27	0.31	0.31
Whitehorse	YK	0.334	0.258	0.38	2.00	0.10	0.47	0.40	0.17	0.22	0.41	0.62	0.70	0.70

Summary of the Change in Cost due to PCFs 1475 and 1775

Location	Prov.	Housing Construction Cost		Scenario A 2020 NBC Provisions Updated Seismic Values		Scenario B PCF Provisions Updated Seismic Values	
		Avg. $/Sq.ft.	House Cost	Cost. Diff	% Change	Cost. Diff	% Change
Victoria	BC	$ 229.50	$ 433,984.50	$ 4,429.45	1.0%	$ (43.60)	-0.01%
Whitehorse	YT	$ 200.00	$ 378,200.00	$ -	0%	$ 257.39	0.07%
Letbridge	AB	$ 162.50	$ 307,287.50	$ -	0%	$ 181.14	0.06%
Ottawa	ON	$ 165.00	$ 312,015.00	$ -	0%	$ 165.10	0.05%
Ottawa Energy	ON	$ 165.00	$ 312,015.00	$ -	0%	$ 352.25	0.11%
Montréal (City Hall)	QC	$ 160.00	$ 302,560.00	$ 1,095.89	0.4%	$ 242.18	0.08%
St. John's	NL	$ 137.50	$ 260,012.50	$ -	0%	$ 181.14	0.07%
Winnipeg	MB	$ 155.00	$ 293,105.00	$ -	0%	$ 165.10	0.06%

Notes:

1. The cost differences and % change in the above table presents the cost differences when comparing Scenarios A and B to the Base Scenario, which is the existing NBC 2020.

2. The house cost is based on the square footage cost and the square footage of the archetype used in the impact analysis (1,981 sq.ft.). Square footage construction costs were obtained from Altus Group - 2022 Canadian Construction Cost Guide which reflects costs of 2021. Without information for Victoria or Lethbridge, factors were applied to the 2021 data to reflect previous years' cost variations.

3. The cost per metre of the half-height framed wall that sits on the foundation for most of the perimeter is represented as 44% of the cost per metre for the same wall type at full-height.

Comments and Disussion of Results

Location	Prov.	Comments and Discussion
Victoria	BC	With the updated Seismic Hazard values Victoria is moved into using Part 4 for lateral loads resistance design. The PCF would keep Victoria from being pushed into Part 4 for many cases which is why Scenario B represents a cost reduction compared to Scenario A. The PCF also introduces less conservative design requirements for lateral loads which is why Scenario B presents a cost reduction relative to the Base Case.
Whitehorse	YK	Whitehorse is currently not required to design for lateral loads resistance which is reflected by the cost increase. This archetype was governed by the seismic hazard value because the worst case maximum value was selected, assuming the designer did not have a geotechnical evaluation conducted.
Lethbridge	AB	The lateral loads design cost values for St. John's were applied to the construction cost information for Lethbridge because the two cities fall into the same seismic and wind hazard categories. The lateral loads resistance for this archetype was governed by the expected wind loads.
Winnipeg	MB	The large difference between Wind and Seismic hazards for Winnipeg would likely mean that regardless of the building dimensions, Wind will govern the design to resist lateral loads.
Ottawa (City Hall)	ON	Following the PCF's provisions, Ottawa's wind and seismic hazard values result in similar minimum lengths for braced wall panels depending on the dimensions of the building. For this archetype, Wind governed over Seismic.
Montréal (City Hall)	QC	Montreal does not currently require lateral loads resistance but with the updated seismic values it would be shifted into where the current NBC 2020 does require braced wall panels. The proposed lateral loads design provisions reduce the cost of bracing for the proposed updated seismic hazard values.
St. John's	NL	The large difference between Wind and Seismic hazards for St. John's would likely mean that regardless of the building dimensions, wind will govern the design to resist lateral loads.

Cost Differences - Victoria

Archetype	Bungalow
No. Storeys =	1.5
Construction =	Light
w =	12.2 m
l =	13 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.2 m

Braced Wall Panel Difference

		Base Scenario: Existing NBC 2020				NBC 2020 Provisions with Updated Seismic Hazard Values				Difference b/w Base and Scenario A			Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	Length	BWP Type	BWP Unit Cost	BWP Cost		Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
	BWP1	750	2015 WSP-3a	$ 72.14 /m	$ 54.10	825	2015 WSP-3a	$ 72.14 /m	$ 59.51	$ 5.41		BWP1	750	2020 WSP-F	$ 83.85 /m	$ 62.89	$ 8.79
	BWP2	600	2015 WSP-3a	$ 72.14 /m	$ 43.28	660	2015 WSP-3a	$ 72.14 /m	$ 47.61	$ 4.33		BWP2	3211	2020 WSP-F	$ 83.85 /m	$ 269.25	$ 225.97
		2611	EXT-W26600	$ 68.28 /m	$ 178.27	2551	EXT-W26600	$ 68.28 /m	$ 174.18	$ (4.10)						$ -	$ (178.27)
	BWP3	600	2015 WSP-3a	$ 72.14 /m	$ 43.28	660	2015 WSP-3a	$ 72.14 /m	$ 47.61	$ 4.33		BWP3	3275	2020 WSP-C	$ 73.93 /m	$ 242.10	$ 198.82
		2675	EXT-W26600	$ 68.28 /m	$ 182.64	2615	EXT-W26600	$ 68.28 /m	$ 178.55	$ (4.10)						$ -	$ (182.64)
	BWP4	950	2015 WSP-3a	$ 72.14 /m	$ 68.53	1045	2015 WSP-3a	$ 72.14 /m	$ 75.38	$ 6.85		BWP4	950	2020 WSP-C	$ 73.93 /m	$ 70.23	$ 1.70
	BWP5	600	2015 WSP-3a	$ 72.14 /m	$ 43.28	660	2015 WSP-3a	$ 72.14 /m	$ 47.61	$ 4.33		BWP5	2375	2020 WSP-C	$ 73.93 /m	$ 175.57	$ 132.29
		1775	EXT-W26600	$ 68.28 /m	$ 121.19	1715	EXT-W26600	$ 68.28 /m	$ 117.10	$ (4.10)						$ -	$ (121.19)
	BWP6	600	2015 WSP-3a	$ 72.14 /m	$ 43.28	660	2015 WSP-3a	$ 72.14 /m	$ 47.61	$ 4.33		BWP6	600	2020 WSP-B	$ 71.21 /m	$ 42.73	$ (0.55)
	BWP6b	900	2015 WSP-3a	$ 72.14 /m	$ 64.92	990	2015 WSP-3a	$ 72.14 /m	$ 71.41	$ 6.49		BWP6b	900	2020 WSP-B	$ 71.21 /m	$ 64.09	$ (0.83)
	BWP7	2075	2015 WSP-3a	$ 72.14 /m	$ 149.68	2282.5	2015 WSP-3a	$ 72.14 /m	$ 164.65	$ 14.97		BWP7	2075	2020 WSP-B	$ 71.21 /m	$ 147.76	$ (1.92)
	BWP7b	1850	2015 WSP-3a	$ 72.14 /m	$ 133.45	2035	2015 WSP-3a	$ 72.14 /m	$ 146.80	$ 13.35		BWP7b	1850	2020 WSP-B	$ 71.21 /m	$ 131.74	$ (1.71)
Basement	BWP8	600	2015 WSP-3a	$ 72.14 /m	$ 43.28	660	2015 WSP-3a	$ 72.14 /m	$ 47.61	$ 4.33	Basement	BWP8	600	2020 WSP-B	$ 71.21 /m	$ 42.73	$ (0.55)
	BWP9	975	2015 WSP-3a	$ 72.14 /m	$ 70.33	1072.5	2015 WSP-3a	$ 72.14 /m	$ 77.37	$ 7.03		BWP9	3450	2020 WSP-B	$ 71.21 /m	$ 245.68	$ 175.35
		2475	EXT-W26600	$ 68.28 /m	$ 168.99	2377.5	EXT-W26600	$ 68.28 /m	$ 162.33	$ (6.66)						$ -	$ (168.99)
	BWP10	600	2015 WSP-3a	$ 72.14 /m	$ 43.28	660	2015 WSP-3a	$ 72.14 /m	$ 47.61	$ 4.33		BWP10	600	2020 WSP-B	$ 71.21 /m	$ 42.73	$ (0.55)
	BWP11	2250	2015 WSP-3a	$ 72.14 /m	$ 162.30	2475	2015 WSP-3a	$ 72.14 /m	$ 178.53	$ 16.23		BWP11	2250	2020 WSP-B	$ 71.21 /m	$ 160.23	$ (2.08)
	BWP12	950	2015 WSP-3a	$ 72.14 /m	$ 68.53	1045	2015 WSP-3a	$ 72.14 /m	$ 75.38	$ 6.85		BWP12	3775	2020 WSP-B	$ 71.21 /m	$ 268.82	$ 200.30
		2825	EXT-W26600	$ 68.28 /m	$ 192.89	2730	EXT-W26600	$ 68.28 /m	$ 186.40	$ (6.49)						$ -	$ (192.89)
	BWP13	840	2015 WSP-3a-Interior	$ 157.62 /m	$ 132.40	924	2015 WSP-3a-Interior	$ 157.62 /m	$ 145.64	$ 13.24		BWP13	1840	2020 WSP-B-Interior	$ 155.52 /m	$ 286.17	$ 153.76
		1000	INT-W24600-B	$ 113.33 /m	$ 113.33	916	INT-W24600-B	$ 113.33 /m	$ 103.81	$ (9.52)						$ -	$ (113.33)
	BWP14	750	2015 WSP-3a-Interior	$ 157.62 /m	$ 118.22	825	2015 WSP-3a-Interior	$ 157.62 /m	$ 130.04	$ 11.82		BWP14	750	INT-W24600-B	$ 113.33 /m	$ 85.00	$ (33.22)
	BWP15	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57	660	2015 WSP-3a-Interior	$ 157.62 /m	$ 104.03	$ 9.46		BWP15	1740	2020 WSP-B-Interior	$ 155.52 /m	$ 270.61	$ 176.04
		1140	INT-W24600-B	$ 113.33 /m	$ 129.20	1080	INT-W24600-B	$ 113.33 /m	$ 122.40	$ (6.80)						$ -	$ (129.20)
	BWP16	750	2015 WSP-3a-Interior	$ 157.62 /m	$ 118.22	825	2015 WSP-3a-Interior	$ 157.62 /m	$ 130.04	$ 11.82		BWP16	0	N/A	/m	$ -	$ (118.22)
	BWP17	750	2015 WSP-3	$ 155.15 /m	$ 116.37	825	2015 WSP-3	$ 155.15 /m	$ 128.00	$ 11.64		BWP17	750	2020 WSP-F	$ 190.58 /m	$ 142.93	$ 26.57
	BWP18	750	2015 WSP-3	$ 155.15 /m	$ 116.37	825	2015 WSP-3	$ 155.15 /m	$ 128.00	$ 11.64		BWP18	750	2020 WSP-F	$ 190.58 /m	$ 142.93	$ 26.57
	BWP19	600	2015 WSP-3	$ 155.15 /m	$ 93.09	660	2015 WSP-3	$ 155.15 /m	$ 102.40	$ 9.31		BWP19	600	2020 WSP-F	$ 190.58 /m	$ 114.35	$ 21.25
	BWP20	600	2015 WSP-3	$ 155.15 /m	$ 93.09	660	2015 WSP-3	$ 155.15 /m	$ 102.40	$ 9.31		BWP20	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 7.71
	BWP21	950	2015 WSP-3	$ 155.15 /m	$ 147.40	1045	2015 WSP-3	$ 155.15 /m	$ 162.14	$ 14.74		BWP21	950	2020 WSP-C	$ 168.01 /m	$ 159.61	$ 12.21
	BWP22	600	2015 WSP-3	$ 155.15 /m	$ 93.09	660	2015 WSP-3	$ 155.15 /m	$ 102.40	$ 9.31		BWP22	1450	2020 WSP-C	$ 168.01 /m	$ 243.62	$ 150.52
		850	EXT-W26600	$ 155.18 /m	$ 131.90	790	EXT-W26600	$ 155.18 /m	$ 122.59	$ (9.31)						$ -	$ (131.90)
	BWP23	600	2015 WSP-3	$ 155.15 /m	$ 93.09	660	2015 WSP-3	$ 155.15 /m	$ 102.40	$ 9.31		BWP23	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 4.01
	BWP24	2075	2015 WSP-3	$ 155.15 /m	$ 321.95	2282.5	2015 WSP-3	$ 155.15 /m	$ 354.14	$ 32.19		BWP24	1545	2020 WSP-B	$ 161.84 /m	$ 250.05	$ (71.90)
			EXT-W26600	$ 155.18 /m	$ -	-737.5	EXT-W26600	$ 155.18 /m	$ (114.44)	$ (114.44)			530			$ -	$ -
	BWP25	600	2015 WSP-3	$ 155.15 /m	$ 93.09	660	2015 WSP-3	$ 155.15 /m	$ 102.40	$ 9.31		BWP25	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 4.01
	BWP26	1530	2015 WSP-3	$ 155.15 /m	$ 237.39	1683	2015 WSP-3	$ 155.15 /m	$ 261.12	$ 23.74		BWP26	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ (140.28)
			EXT-W26600	$ 155.18 /m	$ -	-1083	EXT-W26600	$ 155.18 /m	$ (168.06)	$ (168.06)			930			$ -	$ -
	BWP27	600	2015 WSP-3	$ 155.15 /m	$ 93.09	660	2015 WSP-3	$ 155.15 /m	$ 102.40	$ 9.31		BWP27	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 4.01
1st Floor	BWP28	940	2015 WSP-3	$ 155.15 /m	$ 145.85	1034	2015 WSP-3	$ 155.15 /m	$ 160.43	$ 14.58	1st Floor	BWP28	2940	2020 WSP-B	$ 161.84 /m	$ 475.82	$ 329.98
		2000	EXT-W26600	$ 155.18 /m	$ 310.35	1906	EXT-W26600	$ 155.18 /m	$ 295.77	$ (14.59)						$ -	$ (310.35)
	BWP29	600	2015 WSP-3	$ 155.15 /m	$ 93.09	660	2015 WSP-3	$ 155.15 /m	$ 102.40	$ 9.31		BWP29	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 4.01
	BWP30	600	2015 WSP-3	$ 155.15 /m	$ 93.09	660	2015 WSP-3	$ 155.15 /m	$ 102.40	$ 9.31		BWP30	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 4.01
	BWP31	940	2015 WSP-3	$ 155.15 /m	$ 145.85	1034	2015 WSP-3	$ 155.15 /m	$ 160.43	$ 14.58		BWP31	3415	2020 WSP-B	$ 161.84 /m	$ 552.70	$ 406.85
		2475	EXT-W26600	$ 155.18 /m	$ 384.06	2381	EXT-W26600	$ 155.18 /m	$ 369.48	$ (14.59)						$ -	$ (384.06)
	BWP32	600	2015 WSP-3	$ 155.15 /m	$ 93.09	660	2015 WSP-3	$ 155.15 /m	$ 102.40	$ 9.31		BWP32	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 4.01
	BWP33	2420	2015 WSP-3	$ 155.15 /m	$ 375.47	2662	2015 WSP-3	$ 155.15 /m	$ 413.02	$ 37.55		BWP33	2420	2020 WSP-A	$ 149.69 /m	$ 362.24	$ (13.23)
	BWP34	775	2015 WSP-3	$ 155.15 /m	$ 120.24	852.5	2015 WSP-3	$ 155.15 /m	$ 132.27	$ 12.02		BWP34	2790	2020 WSP-A	$ 149.69 /m	$ 417.62	$ 297.38
		2015	EXT-W26600	$ 155.18 /m	$ 312.68	1937.5	EXT-W26600	$ 155.18 /m	$ 300.66	$ (12.03)						$ -	$ (312.68)
	BWP35	890	2015 WSP-3a-Interior	$ 157.62 /m	$ 140.28	979	2015 WSP-3a-Interior	$ 157.62 /m	$ 154.31	$ 14.03		BWP35	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ (25.64)
	BWP36	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57	660	2015 WSP-3a-Interior	$ 157.62 /m	$ 104.03	$ 9.46		BWP36	2800	GWB-B Interior	$ 95.53 /m	$ 267.50	$ 172.92
		2200	INT-W24600	$ 106.44 /m	$ 234.18	2140	INT-W24600	$ 106.44 /m	$ 227.79	$ (6.39)						$ -	$ (234.18)
	BWP37	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57	660	2015 WSP-3a-Interior	$ 157.62 /m	$ 104.03	$ 9.46		BWP37	600	INT-W24600	$ 106.44	$ 63.87	$ (30.71)
	BWP38	850	2015 WSP-3a-Interior	$ 157.62 /m	$ 133.98	935	2015 WSP-3a-Interior	$ 157.62 /m	$ 147.38	$ 13.40		BWP38	850	INT-W24600	$ 106.44	$ 90.48	$ (43.50)
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	0	Extra 11 mm OSB	$ 30.70 /m	$ -	$ -	1st Flr	Extra 11 mm OSB	2466	Extra 11 mm OSB	$ 30.70 /m	$ 75.70	$ 75.70
Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	0	Extra 11 mm OSB	$ 30.70 /m	$ -	$ -	Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	$ -
All Flrs	Extra 12.7 Gypsum	2940	Extra Gypsum Board	$ 34.92 /m	$ 102.66	2646	Extra Gypsum Board	$ 34.92 /m	$ 92.39	$ (10.27)	All Flrs	Extra 12.7 Gypsum	0	Extra Gypsum Board	$ 34.92 /m	$ -	$ (102.66)
					$ 7,085.41				**$ 7,146.30**	**$ 60.89**						**$ 6,862.95**	**$ (222.47)**

Percent Increase Relative to Base Case (Existing Code)	**0.9%**

Percent Increase Relative to Base Case (Existing Code)	**-3.1%**
Percent Increase Relative to Scenario A (Updated Seismic Values)	**-4.0%**

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020				NBC 2020 Provisions with Updated Seismic Hazard Values				Difference b/w Base and Scenario A	Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
	Spacing (mm)	Number	Unit Cost	Cost	Spacing (mm)	Number	Unit Cost	Cost		Spacing (mm)	Number	Unit Cost	Cost	
1/2" dia. Anchor	2400	38	$ 6.13 Ea.	$ 232.94	2400	42	$ 6.13 Ea.	$ 257.46	**$ 24.52**	500	57	$ 6.13 Ea.	$ 349.41	**$ 116.47**
									11%					**50%**

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020					NBC 2020 Provisions with Updated Seismic Hazard Values					Difference b/w Base and Scenario A	Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
	No. Locations	No. Fasteners	Total	Cost per	Total Cost	No. Locations	No. Fasteners	Total	Cost per	Total Cost		No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
1st Floor Framing	15	16	240	$ 0.10	$ 24.00	15	16	240	$ 0.10	$ 24.00	$ -	15	38	570	$ 0.10	$ 57.00	$ 33.00
2nd Floor Framing	21	6	126	$ 0.10	$ 12.60	21	8	168	$ 0.10	$ 16.80	$ 4.20	21	20	420	$ 0.10	$ 42.00	$ 29.40
			366		**$ 36.60**			**408**		**$ 40.80**	**$ 4.20**			**990**		**$ 99.00**	**$ 62.40**
											11%						**170%**

% Professional Fees =	1%
Professional Fees =	$ 4,339.85

Base Scenario Total Cost	$ 7,354.95

Scenario A Total Cost	$ 11,784.41
Total Percent Increase Relative to Base Scenario (Existing Code)	60%
Scenario A Percent Increase from Base Case Home Construction Cost	1.02%

Scenario B Total Cost	$ 7,311.36
Total Percent Increase Relative to Base Scenario (Existing Code)	-1%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	-38%
Scenario B Percent Increase from Base Case Home Construction Cost	-0.01%

Average Cost of Housing Construction in Victoria
$ 433,984.50 CAD
Based on Altus Group - 2022 Canadian Cost Guide and applying a 1.08 Factor to the cost for Vancouver (as has been the average)

Code Analysis - Victoria

Archetype	Bungalow	
No. Storeys =	1.5	
Construction =	Light	
w =	12.2	m
l =	13	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.2	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	1.30	
HWP =	0.57	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		Design to 9.23.13.4. to 9.23.13.7.
	Does the Article apply?	Yes	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		Yes
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		7.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		750 mm
9.23.13.6.	**Materials in Braced Wall Panels**		Use OSB wall sheathing
	Is Sa(0.2) less than or equal to 0.9?	No	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	N/A	N/A	mm
Plywood	11	12.5	mm
Diagonal lumber	N/A	N/A	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**			
	Does Table 9.23.3.5.-A govern design?		No	
	Does Table 9.23.3.5.-B govern design?		No	
	Does Table 9.23.3.5.-C govern design?		Yes	
	Braced Wall Panel Type		**2015 WSP-4**	**2015 WSP-4a**
9.23.6.1.	**Anchorage of Building Frames**			
	1.2 < Sa(0.2) ≤ 1.3			
	Anchor bolt size	12.7 mm	Use Table 9.23.6.1.	
	Anchor bolt spacing	1.9 m	Use Table 9.23.6.1.	
9.23.11.4.	**Joints in Top Plates**			
	1.2 < Sa(0.2) ≤ 1.3			
	Top Plate Connections			
	1st Floor 8 nails	Supporting 1 floor	Using Table 9.23.11.4.-2015	
	2nd Floor 3 nails	Supporting 0 floors	Using Table 9.23.11.4.-2015	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 1.91

HWP = 0.57 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**			
	Does the Article apply?	No		
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-	
	Does the Article apply?	No		
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		**Design to Part 4**	
	Does the Article apply?	Yes		
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**			
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No	
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No	
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No	
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**			
	% braced walls - 3rd Floor		-	
	% braced walls - 2nd Floor		-	
	% braced walls - 1st Floor		-	
	% braced walls - bsmt		-	
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		7.6	m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4	m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4	m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600	mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		750	mm
9.23.13.6.	**Materials in Braced Wall Panels**			
	Is Sa(0.2) less than or equal to 0.9?	No		

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm

Waferboard R-1 grade	n/a	n/a	mm
Plywood	11	12.5	mm
Diagonal lumber	n/a	n/a	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	No
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**Design to Part 4**
9.23.6.1.	**Anchorage of Building Frames**	
	Sa(0.2) > 1.8	**Design to Part 4**
	Anchor bolt size 12.7 mm	
	Anchor bolt spacing 1.8 m	**Use at least the highest from Table 9.23.6.1.**
9.23.11.4.	**Joints in Top Plates**	
	Sa(0.2) > 1.8	
	Top Plate Connections	**Design to Part 4**
	1st Floor **8** nails Supporting 1 floor	
	2nd Floor **4** nails Supporting 0 floors	**Use at least the highest from Table 9.23.11.4.**

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	2.02	Worst Case	w =	12.2	m
Smax =	1.68	Site Class C	l =	13	m
HWP =	0.57	kPa	Stud spacing =	600	mm
S =	0.70	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.2	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	No	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m

	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(4) **SEISMIC**

$L_s = L_{us} \times [K_{weight} \times K_{snow}] \times [K_{Sspacing} \times K_{Snumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Wall Left Side)

L_{us} =	2.56 m	**WSP-C**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**3.00 m**	

Front to Back Direction (Exterior Wall Right Side)

L_{us} =	2.95 m	**WSP-B**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**3.45 m**	

Front to Back Direction (Interior Wall)

L_{us} =	6.845 m	**GWB-B** 13.69/2
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**8.01 m**	

Left to Right Direction (Exterior Back Wall)

L_{us} =	2.95	m	**WSP-B**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**2.74**	**m**	

Left to Right Direction (Exterior Front Wall)

L_{us} =	2.11	m	**WSP-F**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**1.96**	**m**	

Left to Right Direction (Interior Garage Wall)

L_{us} =	5.6	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**5.21**	**m**	

Basement Framed Wall above Foundation

Front to Back Direction (Exterior Wall Left Side)

L_{us} =	5.63	m	**WSP-C**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m	
$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**6.59**	**m**	

Front to Back Direction (Exterior Wall Right Side)

L_{us} =	6.47	m	**WSP-B**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m	
$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**7.57**	**m**	

Front to Back Direction (Interior Wall extending through Garage Wall)

L_{us} =	6.47	m	**WSP-B**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m	
$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**7.57**	**m**	

Left to Right Direction (Exterior Back Wall)

L_{us} =	6.47	m	**WSP-B**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**6.02**	**m**	

Left to Right Direction (Exterior Front Wall)

L_{us} =	4.62	m	**WSP-F**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**4.30**	**m**	The archetype cannot fit 340mm of what is needed for this WSP-F

Left to Right Direction (Interior Garage Wall)

L_{us} =	6.47	m	**WSP-B**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**6.02**	**m**	

9.23.6.1.	**Anchorage of Building Frames**		
	Is HWP between 0.6 kPa and 1.2 kPa	No	
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	Yes	Use Table 9.23.6.1.

From Table 9.23.6.1.

Framing Type Selected	**WSP-C**	
Anchor bolt size	12.7	mm
Anchor bolt spacing	0.6	m

From Table 9.23.6.1.

Framing Type Selected	**WSP-C**	
Anchor bolt size	12.7	mm
Anchor bolt spacing	0.5	m

9.23.11.4.	**Joints in Top Plates**		
	Is HWP between 0.6 kPa and 1.2 kPa	No	N/A
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A
	Table 9.23.11.4.-A		
	<u>1.2 < and ≤ 1.6</u> — Normal Weight		
	All floors — 19 nails — For BWB Spacing of 10.6m		
	10 nails — For BWB Spacing of ≤ 7.6m		
	Table 9.23.11.4.-B		
	<u>1.2 < and ≤ 1.6</u>		
	1st Floor — 13 nails — For BWB Spacing of 10.6m		
	7 nails — For BWB Spacing of ≤ 7.6m		
	2nd Floor — 7 nails — For BWB Spacing of 10.6m		
	4 nails — For BWB Spacing of ≤ 7.6m		

Cost Differences - Whitehorse

Archetype Bungalow

No. Storeys =	1.5	
Construction =	Light	
w =	12.2	m
l =	13	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.2	m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020			
Floor Level	**Braced Wall Panel**	**Length**	**BWP Type**	**BWP Unit Cost**	**BWP Cost**
	BWP1	750	EXT-W26400-9.5OSB	$ 65.86 /m	$ 49.40
	BWP2	875	EXT-W26400-9.5OSB	$ 65.86 /m	$ 57.63
	BWP3	875	EXT-W26400-9.5OSB	$ 65.86 /m	$ 57.63
	BWP4	950	EXT-W26400-9.5OSB	$ 65.86 /m	$ 62.57
	BWP5	2625	EXT-W26400-9.5OSB	$ 65.86 /m	$ 172.89
	BWP6	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52
Basement	BWP7	2075	EXT-W26400-9.5OSB	$ 65.86 /m	$ 136.66
	BWP8	850	EXT-W26400-9.5OSB	$ 65.86 /m	$ 55.98
	BWP9	975	EXT-W26400-9.5OSB	$ 65.86 /m	$ 64.22
	BWP10	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52
	BWP11	2250	EXT-W26400-9.5OSB	$ 65.86 /m	$ 148.19
	BWP12	1275	EXT-W26400-9.5OSB	$ 65.86 /m	$ 83.97
	BWP13	1840	INT-W26600-B	$ 124.87 /m	$ 229.77
	BWP15	1740	INT-W26600-B	$ 124.87 /m	$ 217.28
	BWP17	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP21	820	EXT-W26400-9.5OSB	$ 149.69 /m	$ 122.74
	BWP22	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP23	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP24	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP25	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP26	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
1st Floor	BWP27	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP28	2265	EXT-W26400-9.5OSB	$ 149.69 /m	$ 339.04
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP31	2615	EXT-W26400-9.5OSB	$ 149.69 /m	$ 391.43
	BWP32	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP33	2420	EXT-W26400-9.5OSB	$ 149.69 /m	$ 362.24
	BWP34	775	EXT-W26400-9.5OSB	$ 149.69 /m	$ 116.01
	BWP35	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP36	1200	INT-W26600	$ 116.08 /m	$ 139.30
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
All Flrs	Extra 12.7 Gypsum	0	Extra Gypsum Board	$ 34.92 /m	$ -
					$ 4,125.46

		Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	**Braced Wall Panel**	**Length**	**BWP Type**	**BWP Unit Cost**	**BWP Cost**	
	BWP1	750	2020 WSP-C	$ 73.93 /m	$ 55.44	$ 6.05
	BWP2	875	2020 WSP-C	$ 73.93 /m	$ 64.68	$ 7.06
	BWP3	875	2020 WSP-A	$ 65.86 /m	$ 57.63	$ -
	BWP4	950	2020 WSP-A	$ 65.86 /m	$ 62.57	$ -
	BWP5	2625	2020 WSP-A	$ 65.86 /m	$ 172.89	$ -
	BWP6	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
Basement	BWP7	2075	2020 WSP-A	$ 65.86 /m	$ 136.66	$ -
	BWP8	850	2020 WSP-A	$ 65.86 /m	$ 55.98	$ -
	BWP9	975	2020 WSP-A	$ 65.86 /m	$ 64.22	$ -
	BWP10	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP11	2250	2020 WSP-A	$ 65.86 /m	$ 148.19	$ -
	BWP12	1275	2020 WSP-A	$ 65.86 /m	$ 83.97	$ -
	BWP13	1840	GWB-B Interior	$ 95.53 /m	$ 175.78	$ (53.98)
	BWP15	1740	GWB-B Interior	$ 95.53 /m	$ 166.23	$ (51.05)
	BWP17	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP19	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP21	820	2020 WSP-A	$ 149.69 /m	$ 122.74	$ -
	BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP23	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP24	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP25	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP26	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
1st Floor	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP28	2265	2020 WSP-A	$ 149.69 /m	$ 339.04	$ -
	BWP29	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP30	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP31	2615	2020 WSP-A	$ 149.69 /m	$ 391.43	$ -
	BWP32	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP33	2420	2020 WSP-A	$ 149.69 /m	$ 362.24	$ -
	BWP34	775	2020 WSP-A	$ 149.69 /m	$ 116.01	$ -
	BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP36	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
1st Flr	Extra 11 mm OSB	2776	Extra 11 mm OSB	$ 30.70 /m	$ 85.22	$ 85.22
Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	$ -
All Flrs	Extra 12.7 Gypsum	5980	Extra Gypsum Board	$ 34.92 /m	$ 208.81	$ 208.81
					$ 4,260.17	**$ 134.71**

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 134.71
Percent Cost Increase of Scenario B relative to Base Scenario	3.3%

Anchor Bolts Difference

	Base Scenario: 2015 NBC and 2015 NBC Sa(0.2)			
	Spacing (mm)	**Number**	**Unit Cost**	**Cost**
1/2" dia. Anchor	2400	38	$ 6.13 Ea.	$ 232.94

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Spacing (mm)	**Number**	**Unit Cost**	**Cost**	
500	54	$ 6.13 Ea.	$ 331.02	**$ 98.08**
				42%

Top Plate Splice Fasteners L

	Base Scenario: 2015 NBC and 2015 NBC Sa(0.2)				
	No. Locations	**No. Fasteners**	**Total**	**Cost per**	**Total Cost**
1st Floor Framing	15	2	30	$ 0.10	$ 3.00
2nd Floor Framing	21	2	42	$ 0.10	$ 4.20
			72		**$ 7.20**

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
No. Locations	**No. Fasteners**	**Total Fasteners**	**Cost per**	**Total Cost**	
15	10	150	$ 0.10	$ 15.00	$ 12.00
21	8	168	$ 0.10	$ 16.80	$ 12.60
		318		**$ 31.80**	**$ 24.60**
					342%

Base Case Total Cost	$ 4,365.60

Average Cost of Bungalow Construction in Whitehorse
$ 378,200.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Total Cost	$ 4,622.99
Total Percent Increase Relative to Base Case (Existing Code)	5.9%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	5.9%
Percent Increase from Base Case Home Construction	0.07%

Code Analysis - Whitehorse

Archetype	Bungalow	
No. Storeys =	1.5	
Construction =	Light	
w =	12.2	m
l =	13	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.2	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.334	
HWP =	0.38	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**			
	Does the Article apply?	Yes		
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-	
	Does the Article apply?	No		
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-	
	Does the Article apply?	No		
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**			
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No	
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No	
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No	
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**			
	% braced walls - 3rd Floor		-	
	% braced walls - 2nd Floor		-	
	% braced walls - 1st Floor		-	
	% braced walls - bsmt		-	
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		-	m
	Maximum distance between required braced wall panels measured from the edges of the panels		-	m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		-	m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		-	mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		-	mm
9.23.13.6.	**Materials in Braced Wall Panels**			
	Is Sa(0.2) less than or equal to 0.9?	Yes	Use OSB wall sheathing	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**		
	Does Table 9.23.3.5.-A govern design?		Yes
	Does Table 9.23.3.5.-B govern design?		No
	Does Table 9.23.3.5.-C govern design?		No
	Braced Wall Panel Type		**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**		
	Anchor bolt size	12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing	2.4 m	
9.23.11.4.	**Joints in Top Plates**		
	Top Plate Connections		
	1st Floor — 1 nails	Supporting 1 floor	
	2nd Floor — 1 nails	Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.47

HWP = 0.38 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm

Use OSB wall sheathing

Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	0.70	Worst Case	w =	12.2	m
Smax =	0.41	Site Class C	l =	13	m
HWP =	0.38	kPa	Stud spacing =	600	mm
S =	1.00	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.2	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(4) **SEISMIC**

$L_s = L_{us} \times [K_{weight} \times K_{snow}] \times [K_{Sspacing} \times K_{Snumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Wall Left Side)

L_{us} =	1.72 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**2.01 m**	

Front to Back Direction (Exterior Wall Right Side)

L_{us} =	1.72 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**2.01 m**	

Front to Back Direction (Interior Wall)

L_{us} =	3.625 m	**GWB-A** 7.25/2
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**4.24 m**	

Left to Right Direction (Exterior Back Wall)

L_{us} =	1.72 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)

$K_{Snumber}$ = 1.5 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 1.60 m

Left to Right Direction (Exterior Front Wall)

L_{us} = 0.91 m **WSP-B**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.62 space between braced walls approx. 4 m (average)
$K_{Snumber}$ = 1.5 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 0.85 m

Left to Right Direction (Interior Garage Wall)

L_{us} = 1.72 m **WSP-A**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.62 space between braced walls approx. 4 m (average)
$K_{Snumber}$ = 1.5 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 1.60 m

Basement Framed Wall above Foundation

Front to Back Direction (Exterior Wall Left Side)

L_{us} = 3.79 m **WSP-A**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.88 space between braced walls approx. 6.5 m
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 4.44 m

Front to Back Direction (Exterior Wall Right Side)

L_{us} = 3.79 m **WSP-A**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.88 space between braced walls approx. 6.5 m
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 4.44 m

Front to Back Direction (Interior Wall)

L_{us} = 4.63 m **GWB-B** 9.26/2
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.88 space between braced walls approx. 6.5 m

$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**5.42 m**		Garage portion of BWB is WSP-A

Left to Right Direction (Exterior Back Wall)

L_{us} =	3.79 m		**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**3.52 m**		

Left to Right Direction (Exterior Front Wall)

L_{us} =	1.73 m		**WSP-C**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**1.61 m**		

Left to Right Direction (Interior Garage Wall)

L_{us} =	3.79 m		**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**3.52 m**		

9.23.6.1.	**Anchorage of Building Frames**		
	Is HWP greater than 1.2 kPa	No	If "No" to both then use Table 9.23.6.1.
	Is Smax greater than 2.6?	No	Use 9.23.6.1.(2)(b)
	<u>From Table 9.23.6.1.</u>		
	Framing Type Selected **WSP-A**		
	Anchor bolt size 12.7 mm		
	Anchor bolt spacing 0.8 m		
	<u>From Table 9.23.6.1.</u>		
	Framing Type Selected **WSP-A**		
	Anchor bolt size 12.7 mm		
	Anchor bolt spacing 0.7 m		
9.23.11.4.	**Joints in Top Plates**		
	Is HWP less than or equal to 1.2 kPa	Yes	Use Table 9.23.11.4.-B
	Is Smax for Site Class C less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A

Table 9.23.11.4.-A			
≤ 0.6		Normal Weight	
All floors	6 nails	For BWB Spacing of 10.6m	
	3 nails	For BWB Spacing of ≤ 7.6m	
Table 9.23.11.4.-B			
0.3 < and ≤ 0.4		Normal Weight	
1st Floor	9 nails	For BWB Spacing of 10.6m	Wind Governs
	5 nails	For BWB Spacing of ≤ 7.6m	
2nd Floor	5 nails	For BWB Spacing of 10.6m	
	3 nails	For BWB Spacing of ≤ 7.6m	

Cost Differences - Lethbridge

Archetype	Bungalow
No. Storeys =	1.5
Construction =	Light
w =	12.2 m
l =	13 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.2 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020						Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
	BWP1	750	EXT-W26400-9.5OSB	$ 65.86 /m	$ 49.40		BWP1	750	2020 WSP-F	$ 83.85 /m	$ 62.89	$ 13.49
	BWP2	1025	EXT-W26400-9.5OSB	$ 65.86 /m	$ 67.51		BWP2	1025	2020 WSP-F	$ 83.85 /m	$ 85.95	$ 18.44
	BWP3	3350	EXT-W26400-9.5OSB	$ 65.86 /m	$ 220.64		BWP3	3350	2020 WSP-A	$ 65.86 /m	$ 220.64	$ -
	BWP4	950	EXT-W26400-9.5OSB	$ 65.86 /m	$ 62.57		BWP4	950	2020 WSP-A	$ 65.86 /m	$ 62.57	$ -
	BWP5	2625	EXT-W26400-9.5OSB	$ 65.86 /m	$ 172.89		BWP5	2625	2020 WSP-A	$ 65.86 /m	$ 172.89	$ -
	BWP6	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52		BWP6	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
Basement	BWP7	2075	EXT-W26400-9.5OSB	$ 65.86 /m	$ 136.66	Basement	BWP7	2075	2020 WSP-A	$ 65.86 /m	$ 136.66	$ -
	BWP8	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52		BWP8	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP9	2800	EXT-W26400-9.5OSB	$ 65.86 /m	$ 184.41		BWP9	2800	2020 WSP-A	$ 65.86 /m	$ 184.41	$ -
	BWP10	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52		BWP10	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP11	2250	EXT-W26400-9.5OSB	$ 65.86 /m	$ 148.19		BWP11	2250	2020 WSP-A	$ 65.86 /m	$ 148.19	$ -
	BWP12	2450	EXT-W26400-9.5OSB	$ 65.86 /m	$ 161.36		BWP12	2450	2020 WSP-A	$ 65.86 /m	$ 161.36	$ -
	BWP13	1200	INT-W26600-B	$ 124.87 /m	$ 149.85		BWP13	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ (35.21)
	BWP15	1200	INT-W26600-B	$ 124.87 /m	$ 149.85		BWP15	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ (35.21)
	BWP17	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26		BWP17	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP19	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP21	950	EXT-W26400-9.5OSB	$ 149.69 /m	$ 142.20		BWP21	950	2020 WSP-A	$ 149.69 /m	$ 142.20	$ -
	BWP22	1250	EXT-W26400-9.5OSB	$ 149.69 /m	$ 187.11		BWP22	1250	2020 WSP-A	$ 149.69 /m	$ 187.11	$ -
	BWP23	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP23	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP24	700	EXT-W26400-9.5OSB	$ 149.69 /m	$ 104.78		BWP24	700	2020 WSP-A	$ 149.69 /m	$ 104.78	$ -
	BWP25	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP25	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP26	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP26	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
1st Floor	BWP27	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81	1st Floor	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP28	2940	EXT-W26400-9.5OSB	$ 149.69 /m	$ 440.08		BWP28	2940	2020 WSP-A	$ 149.69 /m	$ 440.08	$ -
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP29	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP30	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP31	2890	EXT-W26400-9.5OSB	$ 149.69 /m	$ 432.59		BWP31	2890	2020 WSP-A	$ 149.69 /m	$ 432.59	$ -
	BWP32	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP32	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP33	2420	EXT-W26400-9.5OSB	$ 149.69 /m	$ 362.24		BWP33	2420	2020 WSP-A	$ 149.69 /m	$ 362.24	$ -
	BWP34	775	EXT-W26400-9.5OSB	$ 149.69 /m	$ 116.01		BWP34	775	2020 WSP-A	$ 149.69 /m	$ 116.01	$ -
	BWP35	1200	INT-W26600	$ 116.08 /m	$ 139.30		BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP36	3125	INT-W26600	$ 116.08 /m	$ 362.76		BWP36	3125	GWB-A Interior	$ 81.17 /m	$ 253.64	$ (109.12)
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	1st Flr	Extra 11 mm OSB	991	Extra 11 mm OSB	$ 30.70 /m	$ 30.42	$ 30.42
Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	$ -
All Flrs	Extra 12.7 Gypsum	0	Extra Gypsum Board	$ 34.92 /m	$ -	All Flrs	Extra 12.7 Gypsum	6725	Extra Gypsum Board	$ 34.92 /m	$ 234.83	$ 234.83
					$ 4,829.50						**$ 4,921.66**	**$ 92.16**

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 92.16
Percent Cost Increase of Scenario B relative to Base Scenario	1.9%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020				Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
	Spacing (mm)	Number	Unit Cost	Cost	Spacing (mm)	Number	Unit Cost	Cost	
1/2" dia. Anchor	2400	38	$ 6.13 Ea.	$ 232.94	500/1400/2400	44	$ 6.13 Ea.	$ 269.72	**$ 36.78**
									16%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020					Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
	No. Locations	No. Fasteners	Total	Cost per	Total Cost	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
1st Floor Framing	15	2	30	$ 0.10	$ 3.00	15	20	300	$ 0.10	$ 30.00	$ 27.00
2nd Floor Framing	21	2	42	$ 0.10	$ 4.20	21	14	294	$ 0.10	$ 29.40	$ 25.20
			72		**$ 7.20**			**594**		**$ 59.40**	**$ 52.20**
											725%

Base Case Total Cost	$ 5,069.64

Cost of Bungalow Construction in Lethbridge	
$ 307,287.50	CAD
Based on Altus Group - 2022 Canadian Cost Guide	

Scenario B Total Cost	$ 5,250.78
Total Percent Increase Relative to Base Case (Existing Code)	4%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	4%

Percent Increase from Base Case Home Construction	0.1%

Code Analysis - Lethbridge

Archetype	Bungalow	
No. Storeys =	1.5	
Construction =	Light	
w =	12.2	m
l =	13	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.2	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.09	
HWP =	0.78	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9?	Yes	Use OSB wall sheathing

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nails Supporting 1 floor	
	2nd Floor 1 nails Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.19

HWP = 0.78 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**	
	Does the Article apply? Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	-
	% braced walls - 1st Floor	-
	% braced walls - bsmt	-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	- m
	Maximum distance between required braced wall panels measured from the edges of the panels	- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	- mm
9.23.13.6.	**Materials in Braced Wall Panels**	
	Is Sa(0.2) less than or equal to 0.9? Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

Use OSB wall sheathing

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	0.31	Worst Case	w =	12.2	m
Smax =	0.15	Site Class C	l =	13	m
HWP =	0.78	kPa	Stud spacing =	600	mm
S =	2.01	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.2	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m

	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Left Side and Right Side)

L_{uw} =	3.43	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m	
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.79**	**m**	

Front to Back Direction (Interior Walls)

L_{uw} =	4.93	m	**GWB-A**	9.86/2
K_{exp} =	1	for suburban		
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m		
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m		
$K_{Wnumber}$ =	1.28	3 braced wall bands		
K_{gyp} =	1	walls are sheathing on the interior with gypsum		
K_{sheath} =	1	walls are continuously wood sheathed		
L_w =	**4.02**	**m**	Garage portion is WSP-A	

Left to Right Direction (Exterior Back Wall)

L_{uw} =	3.43	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m	
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)	
$K_{Wnumber}$ =	1.38	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**1.89**	**m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} =	1.29 m		**WSP-F**
K_{exp} =	1	for suburban	
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m	
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)	
$K_{Wnumber}$ =	1.38	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**0.71 m**		

Left to Right Direction (Interior Garage Wall)

L_{uw} =	3.43 m		**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m	
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)	
$K_{Wnumber}$ =	1.38	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**1.89 m**		Can't be shrunk to this size because of 9.23.13.10.(4)

Basement Framed Walls

Front to Back Direction (Exterior Left Side and Right Side)

L_{uw} =	7.06 m		**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.89	for roof eave to ridge of 2.2 m < 3 m	
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**6.92 m**		

Front to Back Direction (Interior Walls)

L_{uw} =	5.88 m		**GWB-B** 11.76/2
K_{exp} =	1	for suburban	
K_{roof} =	0.89	for roof eave to ridge of 2.2 m < 3 m	
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**5.76 m**		The garage portion is constructed as a WSP-A

Left to Right Direction (Exterior Back Wall)

L_{uw} =	7.06 m		**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.89	for roof eave to ridge of 2.2 m < 3 m	
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)	
$K_{Wnumber}$ =	1.38	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **4.68 m**

Left to Right Direction (Exterior Front Wall)

L_{uw} =	2.65 m		**WSP-F**
K_{exp} =	1	for suburban	
K_{roof} =	0.89	for roof eave to ridge of 2.2 m < 3 m	
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)	
$K_{Wnumber}$ =	1.38	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **1.76 m**

Left to Right Direction (Interior Garage Wall)

L_{uw} =	7.06 m		**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.89	for roof eave to ridge of 2.2 m < 3 m	
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)	
$K_{Wnumber}$ =	1.38	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w = **4.68 m**

9.23.6.1. **Anchorage of Building Frames**

Is HWP between 0.6 kPa and 1.2 kPa	Yes	
Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	No	Use Table 9.23.6.1.

From Table 9.23.6.1.

Framing Type Selected	**WSP-A**	
Anchor bolt size		12.7 mm
Anchor bolt spacing		0.8 m

From Table 9.23.6.1.

Framing Type Selected	**WSP-A**	
Anchor bolt size		12.7 mm
Anchor bolt spacing		0.7 m

9.23.11.4. **Joints in Top Plates**

Is HWP between 0.6 kPa and 1.2 kPa	Yes	Use Table 9.23.11.4.-B
Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	No	N/A

Table 9.23.11.4.-A

0.6 < and ≤ 0.8		Normal Weight	
All floors	4 nails	For BWB Spacing of 10.6m	
	2	For BWB Spacing of ≤ 7.6m	

Table 9.23.11.4.-B

0.6 < and ≤ 0.9		Normal Weight	
1st Floor	20 nails	For BWB Spacing of 10.6m	Wind governs
	10 nails	For BWB Spacing of ≤ 7.6m	
2nd Floor	10 nails	For BWB Spacing of 10.6m	

	5 nails	For BWB Spacing of ≤ 7.6m	

Cost Differences - Ottawa

Archetype	Bungalow
No. Storeys =	1.5
Construction =	Light
w =	12.2 m
l =	13 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.2 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

Base Scenario: Existing NBC 2020

Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
Basement	BWP1	750	EXT-W26400-9.5OSB	$ 65.86 /m	$ 49.40
	BWP2	625	EXT-W26400-9.5OSB	$ 65.86 /m	$ 41.16
	BWP3	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52
	BWP4	950	EXT-W26400-9.5OSB	$ 65.86 /m	$ 62.57
	BWP5	2300	EXT-W26400-9.5OSB	$ 65.86 /m	$ 151.48
	BWP6	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52
	BWP7	1400	EXT-W26400-9.5OSB	$ 65.86 /m	$ 92.21
	BWP8	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52
	BWP9	1725	EXT-W26400-9.5OSB	$ 65.86 /m	$ 113.61
	BWP10	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52
	BWP11	2250	EXT-W26400-9.5OSB	$ 65.86 /m	$ 148.19
	BWP12	950	EXT-W26400-9.5OSB	$ 65.86 /m	$ 62.57
	BWP13	1200	INT-W26600-B	$ 124.87 /m	$ 149.85
	BWP15	1200	INT-W26600-B	$ 124.87 /m	$ 149.85
1st Floor	BWP17	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP21	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP22	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP23	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP24	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP25	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP26	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP27	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP28	940	EXT-W26400-9.5OSB	$ 149.69 /m	$ 140.70
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP31	2740	EXT-W26400-9.5OSB	$ 149.69 /m	$ 410.14
	BWP32	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP33	2420	EXT-W26400-9.5OSB	$ 149.69 /m	$ 362.24
	BWP34	775	EXT-W26400-9.5OSB	$ 149.69 /m	$ 116.01
	BWP35	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP36	1200	INT-W26600	$ 116.08 /m	$ 139.30
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
All Flrs	Extra 12.7 Gypsum	0	Extra Gypsum Board	$ 34.92 /m	$ -
					$ 3,699.09

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions

Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	Difference b/w Base and Scenario B
Basement	BWP1	750	2020 WSP-B	$ 71.21 /m	$ 53.41	$ 4.01
	BWP2	625	2020 WSP-B	$ 71.21 /m	$ 44.51	$ 3.34
	BWP3	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP4	950	2020 WSP-A	$ 65.86 /m	$ 62.57	$ -
	BWP5	2300	2020 WSP-A	$ 65.86 /m	$ 151.48	$ -
	BWP6	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP7	1400	2020 WSP-A	$ 65.86 /m	$ 92.21	$ -
	BWP8	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP9	1725	2020 WSP-A	$ 65.86 /m	$ 113.61	$ -
	BWP10	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP11	2250	2020 WSP-A	$ 65.86 /m	$ 148.19	$ -
	BWP12	950	2020 WSP-A	$ 65.86 /m	$ 62.57	$ -
	BWP13	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (52.45)
	BWP15	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (52.45)
1st Floor	BWP17	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP19	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP21	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$ -
	BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP23	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP24	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP25	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP26	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP28	940	2020 WSP-A	$ 149.69 /m	$ 140.70	$ -
	BWP29	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP30	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP31	2740	2020 WSP-A	$ 149.69 /m	$ 410.14	$ -
	BWP32	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP33	2420	2020 WSP-A	$ 149.69 /m	$ 362.24	$ -
	BWP34	775	2020 WSP-A	$ 149.69 /m	$ 116.01	$ -
	BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP36	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	$ -
Basement	Extra 11 mm OSB	3656	Extra 11 mm OSB	$ 30.70 /m	$ 112.23	$ 112.23
All Flrs	Extra 12.7 Gypsum	4800	Extra Gypsum Board	$ 34.92 /m	$ 167.61	$ 167.61
					$ 3,814.00	**$ 114.91**

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 114.91
Percent Cost Increase of Scenario B relative to Base Scenario	3.1%

Anchor Bolts Difference

	Base Scenario: 2015 NBC and 2015 NBC Sa(0.2) Spacing (mm)	Number	Unit Cost	Cost	Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions Spacing (mm)	Number	Unit Cost	Cost	Difference b/w Base and Scenario B
1/2" dia. Anchor	2400	38	$ 6.13 Ea.	$ 232.94	500	41	$ 6.13 Ea.	$ 251.33	**$ 18.39**
									8%

Top Plate Splice Fasteners

	Base Scenario: 2015 NBC and 2015 NBC Sa(0.2) No. Locations	No. Fasteners	Total	Cost per	Total Cost	Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	Difference b/w Base and Scenario B
1st Floor Framing	15	2	30	$ 0.10	$ 3.00	15	12	180	$ 0.10	$ 18.00	$ 15.00
2nd Floor Framing	21	2	42	$ 0.10	$ 4.20	21	10	210	$ 0.10	$ 21.00	
			72		**$ 7.20**			**390**		**$ 39.00**	**$ 31.80**
											442%

Base Case Total Cost	$ 3,939.23

Average Cost of Bungalow Construction in Ottawa
$ 312,015.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Total Cost	$ 4,104.33
Total Percent Increase Relative to Base Case (Existing Code)	4.2%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	4.2%

Percent Increase from Base Case Home Construction	0.05%

Code Analysis - Ottawa

Archetype	Bungalow	
No. Storeys =	1.5	
Construction =	Light	
w =	12.2	m
l =	13	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.2	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) = 0.439

HWP = 0.41 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces** Does the Article apply? Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces** Does the Article apply? No	-
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces** Does the Article apply? No	-
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	-
	% braced walls - 1st Floor	-
	% braced walls - bsmt	-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	- m
	Maximum distance between required braced wall panels measured from the edges of the panels	- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	- mm
9.23.13.6.	**Materials in Braced Wall Panels** Is Sa(0.2) less than or equal to 0.9? Yes	Use OSB wall sheathing

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nails Supporting 1 floor	
	2nd Floor 1 nails Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.66

HWP = 0.41 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**	
	Does the Article apply? Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	
	Does the Article apply? No	-
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	
	Does the Article apply? No	-
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	-
	% braced walls - 1st Floor	-
	% braced walls - bsmt	-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	- m
	Maximum distance between required braced wall panels measured from the edges of the panels	- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	- mm
9.23.13.6.	**Materials in Braced Wall Panels**	
	Is Sa(0.2) less than or equal to 0.9? Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	

OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

Use OSB wall sheathing

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	0.60	Worst Case	w =	12.2	m
Smax =	0.44	Site Class C	l =	13	m
HWP =	0.41	kPa	Stud spacing =	600	mm
S =	1.48	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.2	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750	mm
	Minimum length of individual gypsum board-sheathed braced wall panels:		
	• gypsum board installed on both faces of braced wall panel	1.2	m
	• gypsum board installed on one face of braced wall panel	2.4	m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2	m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.	

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Left Side and Right Side)

L_{uw} =	1.9	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m	
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**1.55**	**m**	

Front to Back Direction (Interior Walls)

L_{uw} =	2.92	m	**GWB-A**	5.84/2
K_{exp} =	1	for suburban		
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m		
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m		
$K_{Wnumber}$ =	1.28	3 braced wall bands		
K_{gyp} =	1	walls are sheathing on the interior with gypsum		
K_{sheath} =	1	walls are continuously wood sheathed		
L_w =	**2.38**	**m**	Garage portion is WSP-A	

Left to Right Direction (Exterior Back Wall)

L_{uw} =	1.9	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m	
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)	
$K_{Wnumber}$ =	1.38	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**1.05**	**m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} =	1	m	**WSP-B**
K_{exp} =	1	for suburban	
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m	

$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)		
$K_{Wnumber}$ =	1.38	4 braced wall bands		
K_{gyp} =	1	walls are sheathing on the interior with gypsum		
K_{sheath} =	1	walls are continuously wood sheathed		
L_w =	**0.55 m**			

Left to Right Direction (Interior Garage Wall)

L_{uw} =	1.9 m		**WSP-A**	
K_{exp} =	1	for suburban		
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m		
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)		
$K_{Wnumber}$ =	1.38	4 braced wall bands		
K_{gyp} =	1	walls are sheathing on the interior with gypsum		
K_{sheath} =	1	walls are continuously wood sheathed		
L_w =	**1.05 m**		Can't be shrunk to this size because of 9.23.13.10.(4)	

Basement Framed Walls

Front to Back Direction (Exterior Left Side and Right Side)

L_{uw} =	3.92 m		**WSP-A**	
K_{exp} =	1	for suburban		
K_{roof} =	0.89	for roof eave to ridge of 2.2 m < 3 m		
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m		
$K_{Wnumber}$ =	1.28	3 braced wall bands		
K_{gyp} =	1	walls are sheathing on the interior with gypsum		
K_{sheath} =	1	walls are continuously wood sheathed		
L_w =	**3.84 m**			

Front to Back Direction (Interior Walls)

L_{uw} =	5.625 m		**GWB-A**	11.25/2
K_{exp} =	1	for suburban		
K_{roof} =	0.89	for roof eave to ridge of 2.2 m < 3 m		
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m		
$K_{Wnumber}$ =	1.28	3 braced wall bands		
K_{gyp} =	1	walls are sheathing on the interior with gypsum		
K_{sheath} =	1	walls are continuously wood sheathed		
L_w =	**5.51 m**		The garage portion is constructed as a WSP-A	

Left to Right Direction (Exterior Back Wall)

L_{uw} =	3.92 m		**WSP-A**	
K_{exp} =	1	for suburban		
K_{roof} =	0.89	for roof eave to ridge of 2.2 m < 3 m		
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)		
$K_{Wnumber}$ =	1.38	4 braced wall bands		
K_{gyp} =	1	walls are sheathing on the interior with gypsum		
K_{sheath} =	1	walls are continuously wood sheathed		
L_w =	**2.60 m**			

Left to Right Direction (Exterior Front Wall)

L_{uw} =	2.06 m		**WSP-B**	
K_{exp} =	1	for suburban		

	K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m		
	$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)		
	$K_{Wnumber}$ = 1.38 4 braced wall bands		
	K_{gyp} = 1 walls are sheathing on the interior with gypsum		
	K_{sheath} = 1 walls are continuously wood sheathed		
	L_w = 1.37 m		
	Left to Right Direction (Interior Garage Wall)		
	L_{uw} = 3.92 m **WSP-A**		
	K_{exp} = 1 for suburban		
	K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m		
	$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)		
	$K_{Wnumber}$ = 1.38 4 braced wall bands		
	K_{gyp} = 1 walls are sheathing on the interior with gypsum		
	K_{sheath} = 1 walls are continuously wood sheathed		
	L_w = 2.60 m Can't be shrunk to this size because of 9.23.13.10.(4)		
9.23.6.1.	**Anchorage of Building Frames**		
	Is HWP greater than 1.2 kPa	No	If "No" to both then use Table 9.23.6.1.
	Is Smax greater than 2.6?	No	Use 9.23.6.1.(2)(b)
	<u>From Table 9.23.6.1.</u>		
	Framing Type Selected **WSP-A**		
	Anchor bolt size 12.7 mm		
	Anchor bolt spacing 0.8 m	This Table was updated since PR	
	<u>From Table 9.23.6.1.</u>		
	Framing Type Selected **WSP-A**		
	Anchor bolt size 12.7 mm		
	Anchor bolt spacing 0.7 m		
9.23.11.4.	**Joints in Top Plates**		
	Is HWP less than or equal to 1.2 kPa	Yes	Use Table 9.23.11.4.-B
	Is Smax for Site Class C less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A
	Table 9.23.11.4.-A		
	<= 0.6	Normal Weight	
	All floors 4 nails	For BWB Spacing of 10.6m	
	2 nails	For BWB Spacing of ≤ 7.6m	min. number of nails on each side of top plate splice for BWB
	Table 9.23.11.4.-B		
	0.4 < and ≤ 0.5	Normal Weight	
	1st Floor 11 nails	For BWB Spacing of 10.6m	Wind Governs
	6 nails	For BWB Spacing of ≤ 7.6m	
	2nd Floor 9 nails	For BWB Spacing of 10.6m	
	5 nails	For BWB Spacing of ≤ 7.6m	

Cost Differences - Ottawa - Energy Efficient Home (Intermittent Wood Sheathing)

Archetype	Bungalow	
No. Storeys =	1.5	
Construction =	Light	
w =	12.2	m
l =	13	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.2	m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020			
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
	BWP1	750	EXT-W26400-Energy	$ 80.08 /m	$ 60.06
	BWP2	825	EXT-W26400-Energy	$ 80.08 /m	$ 66.07
	BWP3	1170	EXT-W26400-Energy	$ 80.08 /m	$ 93.70
	BWP4	950	EXT-W26400-Energy	$ 80.08 /m	$ 76.08
	BWP5	2300	EXT-W26400-Energy	$ 80.08 /m	$ 184.19
	BWP6	600	EXT-W26400-Energy	$ 80.08 /m	$ 48.05
Basement	BWP7	1800	EXT-W26400-Energy	$ 80.08 /m	$ 144.15
	BWP8	600	EXT-W26400-Energy	$ 80.08 /m	$ 48.05
	BWP9	2300	EXT-W26400-Energy	$ 80.08 /m	$ 184.19
	BWP10	600	EXT-W26400-Energy	$ 80.08 /m	$ 48.05
	BWP11	2250	EXT-W26400-Energy	$ 80.08 /m	$ 180.19
	BWP12	950	EXT-W26400-Energy	$ 80.08 /m	$ 76.08
	BWP13	1200	INT-W26600-B	$ 124.87 /m	$ 149.85
	BWP15	1200	INT-W26600-B	$ 124.87 /m	$ 149.85
	BWP17	750	EXT-W26400-Energy	$ 182.01 /m	$ 136.51
	BWP19	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP20	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP21	750	EXT-W26400-Energy	$ 182.01 /m	$ 136.51
	BWP22	775	EXT-W26400-Energy	$ 182.01 /m	$ 141.06
	BWP23	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP24	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP25	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP26	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
1st Floor	BWP27	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP28	940	EXT-W26400-Energy	$ 182.01 /m	$ 171.09
	BWP29	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP30	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP31	2740	EXT-W26400-Energy	$ 182.01 /m	$ 498.70
	BWP32	600	EXT-W26400-Energy	$ 182.01 /m	$ 109.20
	BWP33	2420	EXT-W26400-Energy	$ 182.01 /m	$ 440.46
	BWP34	775	EXT-W26400-Energy	$ 182.01 /m	$ 141.06
	BWP35	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP36	1200	INT-W26600	$ 116.08 /m	$ 139.30
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
All Flrs	Extra 12.7 Gypsum	0	Extra Gypsum Board	$ 34.92 /m	$ -
					$ 4,544.55

		Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
	BWP1	750	2020 WSP-B-Energy	$ 92.40 /m	$ 69.30	$ 9.23
	BWP2	825	2020 WSP-B-Energy	$ 92.40 /m	$ 76.23	$ 10.16
	BWP3	1170	2020 WSP-A-Energy	$ 87.05 /m	$ 101.84	$ 8.15
	BWP4	950	2020 WSP-A-Energy	$ 87.05 /m	$ 82.69	$ 6.61
	BWP5	2300	2020 WSP-A-Energy	$ 87.05 /m	$ 200.20	$ 16.01
	BWP6	600	2020 WSP-A-Energy	$ 87.05 /m	$ 52.23	$ 4.18
Basement	BWP7	1800	2020 WSP-A-Energy	$ 87.05 /m	$ 156.68	$ 12.53
	BWP8	600	2020 WSP-A-Energy	$ 87.05 /m	$ 52.23	$ 4.18
	BWP9	2300	2020 WSP-A-Energy	$ 87.05 /m	$ 200.20	$ 16.01
	BWP10	600	2020 WSP-A-Energy	$ 87.05 /m	$ 52.23	$ 4.18
	BWP11	2250	2020 WSP-A-Energy	$ 87.05 /m	$ 195.85	$ 15.67
	BWP12	950	2020 WSP-A-Energy	$ 87.05 /m	$ 82.69	$ 6.61
	BWP13	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (52.45)
	BWP15	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (52.45)
	BWP17	750	2020 WSP-B-Energy	$ 92.40 /m	$ 69.30	$ (67.21)
	BWP19	600	2020 WSP-B-Energy	$ 92.40 /m	$ 55.44	$ (53.77)
	BWP20	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$ 9.49
	BWP21	750	2020 WSP-A-Energy	$ 197.83 /m	$ 148.37	$ 11.87
	BWP22	775	2020 WSP-A-Energy	$ 197.83 /m	$ 153.32	$ 12.26
	BWP23	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$ 9.49
	BWP24	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$ 9.49
	BWP25	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$ 9.49
	BWP26	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$ 9.49
1st Floor	BWP27	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$ 9.49
	BWP28	940	2020 WSP-A-Energy	$ 197.83 /m	$ 185.96	$ 14.87
	BWP29	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$ 9.49
	BWP30	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$ 9.49
	BWP31	2740	2020 WSP-A-Energy	$ 197.83 /m	$ 542.06	$ 43.36
	BWP32	600	2020 WSP-A-Energy	$ 197.83 /m	$ 118.70	$ 9.49
	BWP33	2420	2020 WSP-A-Energy	$ 197.83 /m	$ 478.75	$ 38.29
	BWP34	775	2020 WSP-A-Energy	$ 197.83 /m	$ 153.32	$ 12.26
	BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP36	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	$ -
Basement	Extra 11 mm OSB	3656	Extra 11 mm OSB	$ 30.70 /m	$ 112.23	$ 112.23
All Flrs	Extra 12.7 Gypsum	4800	Extra Gypsum Board	$ 34.92 /m	$ 167.61	$ 167.61
					$ 4,846.61	**$ 302.06**

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 302.06
Percent Cost Increase of Scenario B relative to Base Scenario	6.6%

Anchor Bolts Difference

	Base Scenario: 2015 NBC and 2015 NBC Sa(0.2)			
	Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	38	$ 6.13 Ea.	$ 232.94

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
500	41	$ 6.13 Ea.	$ 251.33	**$ 18.39**
				8%

Top Plate Splice Fasteners

	Base Scenario: 2015 NBC and 2015 NBC Sa(0.2)				
	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	15	2	30	$ 0.10	$ 3.00
2nd Floor Framing	21	2	42	$ 0.10	$ 4.20
			72		**$ 7.20**

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
15	12	180	$ 0.10	$ 18.00	$ 15.00
21	10	210	$ 0.10	$ 21.00	
		390		**$ 39.00**	**$ 31.80**
					442%

Base Case Total Cost	$ 4,784.69

Average Cost of Bungalow Construction in Ottawa
$ 312,015.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Total Cost	$ 5,136.94
Total Percent Increase Relative to Base Case (Existing Code)	7.4%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	7.4%
Percent Increase from Base Case Home Construction	0.11%

Code Analysis - Ottawa - Energy Efficient Home (Intermittent Wood Sheathing)

Archetype	Bungalow	
No. Storeys =	1.5	
Construction =	Light	
w =	12.2	m
l =	13	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.2	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.439	
HWP =	0.41	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9?	Yes	Use OSB wall sheathing

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**				
	Does Table 9.23.3.5.-A govern design?				Yes
	Does Table 9.23.3.5.-B govern design?				No
	Does Table 9.23.3.5.-C govern design?				No
	Braced Wall Panel Type				**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**				
	Anchor bolt size	12.7	mm		Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing	2.4	m		
9.23.11.4.	**Joints in Top Plates**				
	Top Plate Connections				
	1st Floor	1	nails	Supporting 1 floor	
	2nd Floor	1	nails	Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.66

HWP = 0.41 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm

Use OSB wall sheathing

Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	0.60	Worst Case	w =	12.2	m
Smax =	0.44	Site Class C	l =	13	m
HWP =	0.41	kPa	Stud spacing =	600	mm
S =	1.48	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.2	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Left Side and Right Side)

L_{uw} =	1.9 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1.15	walls are not continuously wood sheathed
L_w =	**1.78 m**	

Front to Back Direction (Interior Walls)

L_{uw} =	2.92 m	**GWB-A** 5.84/2
K_{exp} =	1	for suburban
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**2.38 m**	Garage portion is WSP-A

Left to Right Direction (Exterior Back Wall)

L_{uw} =	1.9 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)
$K_{Wnumber}$ =	1.38	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1.15	walls are not continuously wood sheathed
L_w =	**1.20 m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} =	1 m	**WSP-B**
K_{exp} =	1	for suburban
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)

$K_{Wnumber}$ = 1.38 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1.15 walls are not continuously wood sheathed

L_w = 0.63 m

Left to Right Direction (Interior Garage Wall)
L_{uw} = 1.9 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.74 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)
$K_{Wnumber}$ = 1.38 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 1.05 m Can't be shrunk to this size because of 9.23.13.10.(4)

Basement Framed Walls

Front to Back Direction (Exterior Left Side and Right Side)
L_{uw} = 3.92 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.86 space between braced walls approx. 6.5 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1.15 walls are not continuously wood sheathed

L_w = 4.42 m

Front to Back Direction (Interior Walls)
L_{uw} = 5.625 m **GWB-A** 11.25/2
K_{exp} = 1 for suburban
K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.86 space between braced walls approx. 6.5 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 5.51 m The garage portion is constructed as a WSP-A

Left to Right Direction (Exterior Back Wall)
L_{uw} = 3.92 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)
$K_{Wnumber}$ = 1.38 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1.15 walls are not continuously wood sheathed

L_w = 2.99 m

Left to Right Direction (Exterior Front Wall)
L_{uw} = 2.06 m **WSP-B**
K_{exp} = 1 for suburban
K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)

	$K_{Wnumber}$ = 1.38 4 braced wall bands		
	K_{gyp} = 1 walls are sheathing on the interior with gypsum		
	K_{sheath} = 1.15 walls are not continuously wood sheathed		
	L_w = 1.57 m		
	Left to Right Direction (Interior Garage Wall)		
	L_{uw} = 3.92 m **WSP-A**		
	K_{exp} = 1 for suburban		
	K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m		
	$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)		
	$K_{Wnumber}$ = 1.38 4 braced wall bands		
	K_{gyp} = 1 walls are sheathing on the interior with gypsum		
	K_{sheath} = 1 walls are continuously wood sheathed		
	L_w = 2.60 m Can't be shrunk to this size because of 9.23.13.10.(4)		
9.23.6.1.	**Anchorage of Building Frames**		
	Is HWP greater than 1.2 kPa	No	If "No" to both then use Table 9.23.6.1.
	Is Smax greater than 2.6?	No	Use 9.23.6.1.(2)(b)
	From Table 9.23.6.1.		
	Framing Type Selected **WSP-A**		
	Anchor bolt size 12.7 mm		
	Anchor bolt spacing 0.8 m	This Table was updated since PR	
	From Table 9.23.6.1.		
	Framing Type Selected **WSP-A**		
	Anchor bolt size 12.7 mm		
	Anchor bolt spacing 0.7 m		
9.23.11.4.	**Joints in Top Plates**		
	Is HWP less than or equal to 1.2 kPa	Yes	Use Table 9.23.11.4.-B
	Is Smax for Site Class C less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A
	Table 9.23.11.4.-A		
	<= 0.6 Normal Weight		
	All floors 4 nails For BWB Spacing of 10.6m		min. number of nails on each side of top plate splice for BWB
	2 nails For BWB Spacing of ≤ 7.6m		
	Table 9.23.11.4.-B		
	0.4 < and ≤ 0.5 Normal Weight		
	1st Floor 11 nails For BWB Spacing of 10.6m		Wind Governs
	6 nails For BWB Spacing of ≤ 7.6m		
	2nd Floor 9 nails For BWB Spacing of 10.6m		
	5 nails For BWB Spacing of ≤ 7.6m		

Cost Differences - Montreal comparing to Base Case

Archetype	Bungalow	
No. Storeys =	1.5	
Construction =	Light	
w =	12.2	m
l =	13	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.2	m

Braced Wall Panel Difference

		Base Scenario: Existing NBC 2020						Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
	BWP1	750	EXT-W26400-9.5OSB	$ 65.86 /m	$ 49.40		BWP1	750	2020 WSP-C	$ 73.93 /m	$ 55.44	$ 6.05
	BWP2	875	EXT-W26400-9.5OSB	$ 65.86 /m	$ 57.63		BWP2	875	2020 WSP-C	$ 73.93 /m	$ 64.68	$ 7.06
	BWP3	875	EXT-W26400-9.5OSB	$ 65.86 /m	$ 57.63		BWP3	875	2020 WSP-A	$ 65.86 /m	$ 57.63	$ -
	BWP4	950	EXT-W26400-9.5OSB	$ 65.86 /m	$ 62.57		BWP4	950	2020 WSP-A	$ 65.86 /m	$ 62.57	$ -
	BWP5	2625	EXT-W26400-9.5OSB	$ 65.86 /m	$ 172.89		BWP5	2625	2020 WSP-A	$ 65.86 /m	$ 172.89	$ -
	BWP6	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52		BWP6	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
Basement	BWP7	2075	EXT-W26400-9.5OSB	$ 65.86 /m	$ 136.66	Basement	BWP7	2075	2020 WSP-A	$ 65.86 /m	$ 136.66	$ -
	BWP8	850	EXT-W26400-9.5OSB	$ 65.86 /m	$ 55.98		BWP8	850	2020 WSP-A	$ 65.86 /m	$ 55.98	$ -
	BWP9	975	EXT-W26400-9.5OSB	$ 65.86 /m	$ 64.22		BWP9	975	2020 WSP-A	$ 65.86 /m	$ 64.22	$ -
	BWP10	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52		BWP10	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP11	2250	EXT-W26400-9.5OSB	$ 65.86 /m	$ 148.19		BWP11	2250	2020 WSP-A	$ 65.86 /m	$ 148.19	$ -
	BWP12	1275	EXT-W26400-9.5OSB	$ 65.86 /m	$ 83.97		BWP12	1275	2020 WSP-A	$ 65.86 /m	$ 83.97	$ -
	BWP13	1200	INT-W26600-B	$ 124.87 /m	$ 149.85		BWP13	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ (35.21)
	BWP15	1200	INT-W26600-B	$ 124.87 /m	$ 149.85		BWP15	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ (35.21)
	BWP17	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26		BWP17	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP19	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP21	820	EXT-W26400-9.5OSB	$ 149.69 /m	$ 122.74		BWP21	820	2020 WSP-A	$ 149.69 /m	$ 122.74	$ -
	BWP22	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP23	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP23	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP24	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP24	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP25	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP25	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP26	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP26	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
1st Floor	BWP27	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81	1st Floor	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP28	2265	EXT-W26400-9.5OSB	$ 149.69 /m	$ 339.04		BWP28	2265	2020 WSP-A	$ 149.69 /m	$ 339.04	$ -
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP29	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP30	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP31	2615	EXT-W26400-9.5OSB	$ 149.69 /m	$ 391.43		BWP31	2615	2020 WSP-A	$ 149.69 /m	$ 391.43	$ -
	BWP32	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP32	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP33	2420	EXT-W26400-9.5OSB	$ 149.69 /m	$ 362.24		BWP33	2420	2020 WSP-A	$ 149.69 /m	$ 362.24	$ -
	BWP34	775	EXT-W26400-9.5OSB	$ 149.69 /m	$ 116.01		BWP34	775	2020 WSP-A	$ 149.69 /m	$ 116.01	$ -
	BWP35	1200	INT-W26600	$ 116.08 /m	$ 139.30		BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP36	1200	INT-W26600	$ 116.08 /m	$ 139.30		BWP36	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	1st Flr	Extra 11 mm OSB	2495	Extra 11 mm OSB	$ 30.70 /m	$ 76.59	$ 76.59
Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	$ -
All Flrs	Extra 12.7 Gypsum	0	Extra Gypsum Board	$ 34.92 /m	$ -	All Flrs	Extra 12.7 Gypsum	4800	Extra Gypsum Board	$ 34.92 /m	$ 167.61	$ 167.61
					$ 3,978.11						**$ 4,097.61**	**$ 119.50**

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 119.50
Percent Cost Increase of Scenario B relative to Base Scenario	3.0%

Anchor Bolts Difference

	Base Scenario: 2015 NBC and 2015 NBC Sa(0.2)				Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
	Spacing (mm)	Number	Unit Cost	Cost	Spacing (mm)	Number	Unit Cost	Cost	
1/2" dia. Anchor	2400	38	$ 6.13 Ea.	$ 232.94	500	54	$ 6.13 Ea.	$ 331.02	**$ 98.08**
									42%

Top Plate Splice Fasteners

	Base Scenario: 2015 NBC and 2015 NBC Sa(0.2)					Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
	No. Locations	No. Fasteners	Total	Cost per	Total Cost	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
1st Floor Framing	15	2	30	$ 0.10	$ 3.00	15	10	150	$ 0.10	$ 15.00	$ 12.00
2nd Floor Framing	21	2	42	$ 0.10	$ 4.20	21	8	168	$ 0.10	$ 16.80	$ 12.60
			72		**$ 7.20**			**318**		**$ 31.80**	**$ 24.60**
											342%

Base Case Total Cost	$ 4,218.25	**Scenario B Total Cost**	$ 4,460.43
		Total Percent Increase Relative to Base Case (Existing Code)	5.7%

Cost of Housing Construction in Montreal
$ 302,560.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Percent Increase from Base Case Home Construction	0.08%

Cost Differences - Montreal comparing to Scenario A

Archetype	Bungalow	
No. Storeys =	1.5	
Construction =	Light	
w =	12.2	m
l =	13	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.2	m

Braced Wall Panel Difference

		Scenario A: NBC 2020 Provisions with Updated Seismic Hazard Values						Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Scenario A and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
	BWP1	750	2015 WSP-2	$ 71.36 /m	$ 53.52		BWP1	750	2020 WSP-C	$ 73.93 /m	$ 55.44	$ 1.93
	BWP2	600	2015 WSP-2	$ 71.36 /m	$ 42.81		BWP2	875	2020 WSP-C	$ 73.93 /m	$ 64.68	$ 21.87
		275	EXT-W26400-9.5OSB	$ 65.86 /m	$ 18.11						$ -	$ (18.11)
	BWP3	600	2015 WSP-2	$ 71.36 /m	$ 42.81		BWP3	875	2020 WSP-A	$ 65.86 /m	$ 57.63	$ 14.81
		275	EXT-W26400-9.5OSB	$ 65.86 /m	$ 18.11						$ -	$ (18.11)
	BWP4	950	2015 WSP-2	$ 71.36 /m	$ 67.79		BWP4	950	2020 WSP-A	$ 65.86 /m	$ 62.57	$ (5.22)
	BWP5	600	2015 WSP-2	$ 71.36 /m	$ 42.81		BWP5	2625	2020 WSP-A	$ 65.86 /m	$ 172.89	$ 130.07
		2025	EXT-W26400-9.5OSB	$ 65.86 /m	$ 133.37						$ -	$ (133.37)
	BWP6	600	2015 WSP-2	$ 71.36 /m	$ 42.81		BWP6	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ (3.30)
	BWP7	2075	2015 WSP-2	$ 71.36 /m	$ 148.07		BWP7	2075	2020 WSP-A	$ 65.86 /m	$ 136.66	$ (11.40)
Basement	BWP8	600	2015 WSP-2	$ 71.36 /m	$ 42.81	Basement	BWP8	850	2020 WSP-A	$ 65.86 /m	$ 55.98	$ 13.17
		250	EXT-W26400-9.5OSB	$ 65.86 /m	$ 16.47						$ -	$ (16.47)
	BWP9	975	2015 WSP-2	$ 71.36 /m	$ 69.57		BWP9	975	2020 WSP-A	$ 65.86 /m	$ 64.22	$ (5.36)
	BWP10	600	2015 WSP-2	$ 71.36 /m	$ 42.81		BWP10	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ (3.30)
	BWP11	2250	2015 WSP-2	$ 71.36 /m	$ 160.55		BWP11	2250	2020 WSP-A	$ 65.86 /m	$ 148.19	$ (12.36)
	BWP12	950	2015 WSP-2	$ 71.36 /m	$ 67.79		BWP12	1275	2020 WSP-A	$ 65.86 /m	$ 83.97	$ 16.18
		325	EXT-W26400-9.5OSB	$ 65.86 /m	$ 21.41						$ -	$ (21.41)
	BWP13	840	2015 WSP-3a-Interior	$ 157.62 /m	$ 132.40		BWP13	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ (17.76)
		360	INT-W26600	$ 116.08 /m	$ 41.79						$ -	$ (41.79)
	BWP15	600	2015 WSP-3a-Interior	$ 157.62 /m	$ 94.57		BWP15	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ 20.07
		600	INT-W26600	$ 116.08 /m	$ 69.65						$ -	$ (69.65)
	BWP17	750	2015 WSP-2	$ 162.18 /m	$ 121.63		BWP17	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ (0.25)
	BWP18	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26		BWP18	0			$ -	$ (112.26)
					$ -			750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26	$ 112.26
	BWP19	600	2015 WSP-2	$ 162.18 /m	$ 97.31		BWP19	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ (0.20)
	BWP20	600	2015 WSP-2	$ 162.18 /m	$ 97.31		BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP21	950	2015 WSP-2	$ 162.18 /m	$ 154.07		BWP21	820	2020 WSP-A	$ 149.69 /m	$ 122.74	$ (31.32)
					$ -			130	EXT-W26400-9.5OSB	$ 149.69 /m	$ 19.46	$ 19.46
	BWP22	600	2015 WSP-2	$ 162.18 /m	$ 97.31		BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP23	600	2015 WSP-2	$ 162.18 /m	$ 97.31		BWP23	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP24	2075	2015 WSP-2	$ 162.18 /m	$ 336.51		BWP24	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (246.70)
					$ -			1475	EXT-W26400-9.5OSB	$ 149.69 /m	$ 220.79	$ 220.79
	BWP25	600	2015 WSP-2	$ 162.18 /m	$ 97.31		BWP25	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP26	1530	2015 WSP-2	$ 162.18 /m	$ 248.13		BWP26	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (158.32)
1st Floor					$ -	1st Floor		930	EXT-W26400-9.5OSB	$ 149.69 /m	$ 139.21	$ 139.21
	BWP27	600	2015 WSP-2	$ 162.18 /m	$ 97.31		BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP28	940	2015 WSP-2	$ 162.18 /m	$ 152.44		BWP28	2265	2020 WSP-A	$ 149.69 /m	$ 339.04	$ 186.59
		1325	EXT-W26400-9.5OSB	$ 149.69 /m	$ 198.33						$ -	$ (198.33)
	BWP29	600	2015 WSP-2	$ 162.18 /m	$ 97.31		BWP29	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP30	600	2015 WSP-2	$ 162.18 /m	$ 97.31		BWP30	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP31	940	2015 WSP-2	$ 162.18 /m	$ 152.44		BWP31	2615	2020 WSP-A	$ 149.69 /m	$ 391.43	$ 238.98
		1675	EXT-W26400-9.5OSB	$ 149.69 /m	$ 250.72						$ -	$ (250.72)
	BWP32	600	2015 WSP-2	$ 162.18 /m	$ 97.31		BWP32	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP33	2420	2015 WSP-2	$ 162.18 /m	$ 392.46		BWP33	2420	2020 WSP-A	$ 149.69 /m	$ 362.24	$ (30.22)
	BWP34	775	2015 WSP-2	$ 162.18 /m	$ 125.69		BWP34	775	2020 WSP-A	$ 149.69 /m	$ 116.01	$ (9.68)
	BWP35	1200	2015 WSP-3a-Interior	$ 157.62 /m	$ 189.15		BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (91.75)
	BWP36	1340	2015 WSP-3a-Interior	$ 157.62 /m	$ 211.22		BWP36	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (113.82)
								140	INT-W26400	$ 128.63 /m	$ 18.01	$ 18.01
1st Flr	Extra 11 mm OSB	1922	Extra 11 mm OSB	$ 30.70 /m	$ 59.00	1st Flr	Extra 11 mm OSB	2495	Extra 11 mm OSB	$ 30.70 /m	$ 76.59	$ 17.59
Basement	Extra 11 mm OSB	3516	Extra 11 mm OSB	$ 30.70 /m	$ 107.93	Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	$ (107.93)
All Flrs	Extra 12.7 Gypsum	0	Extra Gypsum Board	$ 34.92 /m	$ -	All Flrs	Extra 12.7 Gypsum	4800	Extra Gypsum Board	$ 34.92 /m	$ 167.61	$ 167.61
					$ 5,057.80						**$ 4,607.33**	**$ (450.47)**

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	-$ 450.47
Percent Cost Increase of Scenario B relative to Base Scenario	-8.9%

Anchor Bolts Difference

	Scenario A: NBC 2020 Provisions with Updated Seismic Hazard Values				Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Scenario A and Scenario B
	Spacing (mm)	Number	Unit Cost	Cost	Spacing (mm)	Number	Unit Cost	Cost	
1/2" dia. Anchor	2400	38	$ 6.13 Ea.	$ 232.94	500	54	$ 6.13 Ea.	$ 331.02	**$ 98.08**
									42%

Top Plate Splice Fasteners

L

	Scenario A: NBC 2020 Provisions with Updated Seismic Hazard Values					Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Scenario A and Scenario B
	No. Locations	No. Fasteners	Total	Cost per	Total Cost	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
1st Floor Framing	15	10	150	$ 0.10	$ 15.00	15	10	150	$ 0.10	$ 15.00	$ -
2nd Floor Framing	21	4	84	$ 0.10	$ 8.40	21	8	168	$ 0.10	$ 16.80	$ 8.40
			234		**$ 23.40**			**318**		**$ 31.80**	**$ 8.40**
											36%

Base Case Total Cost	$ 5,314.14

Cost of Housing Construction in Montreal
$ **302,560.00** CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Total Cost	$ 4,970.15
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	-6.5%

Percent Cost Increase from Scenario A Constructed Home	-0.11%

Code Analysis - Montreal

Archetype	Bungalow
No. Storeys =	1.5
Construction =	Light
w =	12.2 m
l =	13 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.2 m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) = 0.595

HWP = 0.42 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply? Yes		
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Does the Article apply? No	-	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Does the Article apply? No	-	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No	
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No	
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No	
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor	-	
	% braced walls - 2nd Floor	-	
	% braced walls - 1st Floor	-	
	% braced walls - bsmt	-	
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	-	m
	Maximum distance between required braced wall panels measured from the edges of the panels	-	m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	-	m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	-	mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	-	mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9? Yes	Use OSB wall sheathing	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Sa(0.2) ≤ 0.7	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	

	Sa(0.2) ≤ 0.7 Top Plate Connections 1st Floor 1 nails Supporting 1 floor 2nd Floor 1 nails Supporting 0 floors	

Scenario A:
2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.840
HWP = 0.42 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces** Does the Article apply? No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces** Does the Article apply? Yes	Design to 9.23.13.4. to 9.23.13.7.
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces** Does the Article apply? No	-
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	Yes
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	-
	% braced walls - 1st Floor	-
	% braced walls - bsmt	-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels	6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
9.23.13.6.	**Materials in Braced Wall Panels** Is Sa(0.2, C) less than or equal to 0.9? Yes	Use OSB wall sheathing

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**		
	Does Table 9.23.3.5.-A govern design?	No	
	Does Table 9.23.3.5.-B govern design?	Yes	
	Does Table 9.23.3.5.-C govern design?	No	
	Braced Wall Panel Type	**2015 WSP-3**	**2015 WSP-3a**
9.23.6.1.	**Anchorage of Building Frames** 0.8 ≤ S(0.2, C) ≤ 0.9, HWP ≤ 1.2 kPa		
	Anchor bolt size 12.7 mm	Using Table 9.23.6.1.	
	Anchor bolt spacing 2.3 m	Using Table 9.23.6.1.	
9.23.11.4.	**Joints in Top Plates** 0.80 ≤ S(0.2, C) ≤ 0.90 Top Plate Connections		
	1st Floor 5 nails Supporting 1 floor		
	2nd Floor 2 nails Supporting 0 floors		

Scenario B - Post Public Review
2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	0.67 Worst Case	w =	12.2 m
Smax =	0.56 Site Class C	l =	13 m

HWP =	0.42 kPa	Stud spacing =	600 mm
S =	1.57 kPa	Stud Height =	2.4 m
Construction =	Normal	Eave-to-Ridge height =	2.2 m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:		
	• gypsum board installed on both faces of braced wall panel		1.2 m
	• gypsum board installed on one face of braced wall panel		1.2 m
	Minimum length of individual lumber-sheathed braced wall panels:		1.2 m
	Minimum total length of all braced wall panels in a braced wall band		Per Article 9.23.13.7.
9.23.13.7.	**Braced Wall Panel Length**		
9.23.13.7.(2)			
	Is HWP greater than 0.6 kPa but not greater than 1.2 kPa and is Smax for Site Class C greater than 0.47 but not greater than 2.6?	No	
	Is HWP greater than 0.6 kPa but not greater than 1.2 kPa and is Smax for Site Class C less than or equal to 0.47?	No	
	Is Smax for Site Class C greater than 0.47 but not greater 2.6, and is HWP less than or equal to 0.6 kPa?	Yes	Calculate braced wall length based on the equation for L_s (seismic)

9.23.13.7.(4) **SEISMIC**

$L_s = L_{us} \times [K_{weight} \times K_{snow}] \times [K_{Sspacing} \times K_{Snumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Wall Left Side)

L_{us} =	1.72	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m	
$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**2.01**	**m**	

Front to Back Direction (Exterior Wall Right Side)

L_{us} =	1.72	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m	
$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**2.01**	**m**	

Front to Back Direction (Interior Wall)

L_{us} =	3.625	m	**GWB-A**	7.25/2
K_{weight} =	1	normal weight		
K_{snow} =	1	roof snow load less than 2 kPa		
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m		
$K_{Snumber}$ =	1.33	3 braced wall bands		
K_{gyp} =	1	walls are sheathing on the interior with gypsum		
K_{sheath} =	1	walls are continuously wood sheathed		
L_s =	**4.24**	**m**		

Left to Right Direction (Exterior Back Wall)

L_{us} =	1.72	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**1.60**	**m**	

Left to Right Direction (Exterior Front Wall)

L_{us} =	0.91	m	**WSP-B**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**0.85**	**m**	

Left to Right Direction (Interior Garage Wall)

L_{us} =	1.72	m	**WSP-A**
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	

K_{sheath} = 1 walls are continuously wood sheathed

L_s = 1.60 m

Basement Framed Wall above Foundation

Front to Back Direction (Exterior Wall Left Side)

L_{us} =	3.79 m	**WSP-A**	
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m	
$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**4.44 m**		

Front to Back Direction (Exterior Wall Right Side)

L_{us} =	3.79 m	**WSP-A**	
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m	
$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**4.44 m**		

Front to Back Direction (Interior Wall)

L_{us} =	4.63 m	**GWB-B**	9.26/2
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.88	space between braced walls approx. 6.5 m	
$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**5.42 m**	Garage portion of BWB is WSP-A	

Left to Right Direction (Exterior Back Wall)

L_{us} =	3.79 m	**WSP-A**	
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**3.52 m**		

Left to Right Direction (Exterior Front Wall)

L_{us} =	1.73 m	**WSP-C**	
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**1.61 m**		

Left to Right Direction (Interior Garage Wall)

L_{us} =	3.79 m	**WSP-A**	
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.62	space between braced walls approx. 4 m (average)	
$K_{Snumber}$ =	1.5	4 braced wall bands	

	K_{gyp} =	1 walls are sheathing on the interior with gypsum	
	K_{sheath} =	1 walls are continuously wood sheathed	
	L_s =	**3.52 m**	
9.23.6.1.	**Anchorage of Building Frames**		
	Is HWP between 0.6 kPa and 1.2 kPa	No	
	Is Smax for Site Class C greater than 0.47	Yes	Use Table 9.23.6.1.
	and is Smax less than or equal to 2.6		
	From Table 9.23.6.1.		
	Framing Type Selected **0**		
	Anchor bolt size 12.7 mm		
	Anchor bolt spacing 0.8 m		

9.23.11.4.	**Joints in Top Plates**		
	Is HWP between 0.6 kPa and 1.2 kPa	No	N/A
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A
	Table 9.23.11.4.-A		
	<u>0.6 < and ≤ 0.8</u> — Normal Weight		
	All floors — 6 nails — For BWB Spacing of 10.6m		
	3 nails — For BWB Spacing of ≤ 7.6m		
	Table 9.23.11.4.-B		
	<u>0.6 < and ≤ 0.9</u>		
	1st Floor — 11 nails — For BWB Spacing of 10.6m		
	6 nails — For BWB Spacing of ≤ 7.6m		
	2nd Floor — 6 nails — For BWB Spacing of 10.6m		
	3 nails — For BWB Spacing of ≤ 7.6m		

Cost Differences - St. John's

Archetype	Bungalow
No. Storeys =	1.5
Construction =	Light
w =	12.2 m
l =	13 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.2 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

Base Scenario: Existing NBC 2020					
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
Basement	BWP1	750	EXT-W26400-9.5OSB	$ 65.86 /m	$ 49.40
	BWP2	1025	EXT-W26400-9.5OSB	$ 65.86 /m	$ 67.51
	BWP3	3350	EXT-W26400-9.5OSB	$ 65.86 /m	$ 220.64
	BWP4	950	EXT-W26400-9.5OSB	$ 65.86 /m	$ 62.57
	BWP5	2625	EXT-W26400-9.5OSB	$ 65.86 /m	$ 172.89
	BWP6	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52
	BWP7	2075	EXT-W26400-9.5OSB	$ 65.86 /m	$ 136.66
	BWP8	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52
	BWP9	2800	EXT-W26400-9.5OSB	$ 65.86 /m	$ 184.41
	BWP10	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52
	BWP11	2250	EXT-W26400-9.5OSB	$ 65.86 /m	$ 148.19
	BWP12	2450	EXT-W26400-9.5OSB	$ 65.86 /m	$ 161.36
	BWP13	1200	INT-W26600-B	$ 124.87 /m	$ 149.85
	BWP15	1200	INT-W26600-B	$ 124.87 /m	$ 149.85
1st Floor	BWP17	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26
	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP21	950	EXT-W26400-9.5OSB	$ 149.69 /m	$ 142.20
	BWP22	1250	EXT-W26400-9.5OSB	$ 149.69 /m	$ 187.11
	BWP23	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP24	700	EXT-W26400-9.5OSB	$ 149.69 /m	$ 104.78
	BWP25	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP26	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP27	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP28	2940	EXT-W26400-9.5OSB	$ 149.69 /m	$ 440.08
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP31	2890	EXT-W26400-9.5OSB	$ 149.69 /m	$ 432.59
	BWP32	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81
	BWP33	2420	EXT-W26400-9.5OSB	$ 149.69 /m	$ 362.24
	BWP34	775	EXT-W26400-9.5OSB	$ 149.69 /m	$ 116.01
	BWP35	1200	INT-W26600	$ 116.08 /m	$ 139.30
	BWP36	3125	INT-W26600	$ 116.08 /m	$ 362.76
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -
All Flrs	Extra 12.7 Gypsum	0	Extra Gypsum Board	$ 34.92 /m	$ -
					$ 4,829.50

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions						Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
Basement	BWP1	750	2020 WSP-F	$ 83.85 /m	$ 62.89	$ 13.49
	BWP2	1025	2020 WSP-F	$ 83.85 /m	$ 85.95	$ 18.44
	BWP3	3350	2020 WSP-A	$ 65.86 /m	$ 220.64	$ -
	BWP4	950	2020 WSP-A	$ 65.86 /m	$ 62.57	$ -
	BWP5	2625	2020 WSP-A	$ 65.86 /m	$ 172.89	$ -
	BWP6	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP7	2075	2020 WSP-A	$ 65.86 /m	$ 136.66	$ -
	BWP8	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP9	2800	2020 WSP-A	$ 65.86 /m	$ 184.41	$ -
	BWP10	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP11	2250	2020 WSP-A	$ 65.86 /m	$ 148.19	$ -
	BWP12	2450	2020 WSP-A	$ 65.86 /m	$ 161.36	$ -
	BWP13	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ (35.21)
	BWP15	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ (35.21)
1st Floor	BWP17	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP19	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP21	950	2020 WSP-A	$ 149.69 /m	$ 142.20	$ -
	BWP22	1250	2020 WSP-A	$ 149.69 /m	$ 187.11	$ -
	BWP23	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP24	700	2020 WSP-A	$ 149.69 /m	$ 104.78	$ -
	BWP25	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP26	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP28	2940	2020 WSP-A	$ 149.69 /m	$ 440.08	$ -
	BWP29	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP30	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP31	2890	2020 WSP-A	$ 149.69 /m	$ 432.59	$ -
	BWP32	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP33	2420	2020 WSP-A	$ 149.69 /m	$ 362.24	$ -
	BWP34	775	2020 WSP-A	$ 149.69 /m	$ 116.01	$ -
	BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP36	3125	GWB-A Interior	$ 81.17 /m	$ 253.64	$ (109.12)
1st Flr	Extra 11 mm OSB	991	Extra 11 mm OSB	$ 30.70 /m	$ 30.42	$ 30.42
Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	$ -
All Flrs	Extra 12.7 Gypsum	6725	Extra Gypsum Board	$ 34.92 /m	$ 234.83	$ 234.83
					$ 4,921.66	**$ 92.16**

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 92.16
Percent Cost Increase of Scenario B relative to Base Scenario	1.9%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020			
	Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	38	$ 6.13 Ea.	$ 232.94

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
500/1400/2400	44	$ 6.13 Ea.	$ 269.72	**$ 36.78**
				16%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020				
	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	15	2	30	$ 0.10	$ 3.00
2nd Floor Framing	21	2	42	$ 0.10	$ 4.20
			72		**$ 7.20**

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
15	20	300	$ 0.10	$ 30.00	$ 27.00
21	14	294	$ 0.10	$ 29.40	$ 25.20
		594		**$ 59.40**	**$ 52.20**
					725%

Base Case Total Cost	$ 5,069.64

Cost of Bungalow Construction in St. John's
$ 260,012.50 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Total Cost	$ 5,250.78
Total Percent Increase Relative to Base Case (Existing Code)	4%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	4%

Percent Increase from Base Case Home Construction	0.1%

Code Analysis - St. John's

Archetype	Bungalow	
No. Storeys =	1.5	
Construction =	Light	
w =	12.2	m
l =	13	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.2	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.09	
HWP =	0.78	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		Use OSB wall sheathing
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nails Supporting 1 floor	
	2nd Floor 1 nails Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.19

HWP = 0.78 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**	
	Does the Article apply? Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	-
	% braced walls - 1st Floor	-
	% braced walls - bsmt	-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	- m
	Maximum distance between required braced wall panels measured from the edges of the panels	- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	- mm
9.23.13.6.	**Materials in Braced Wall Panels**	
	Is Sa(0.2) less than or equal to 0.9? Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

Use OSB wall sheathing

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	0.31	Worst Case	w =	12.2	m
Smax =	0.15	Site Class C	l =	13	m
HWP =	0.78	kPa	Stud spacing =	600	mm
S =	2.01	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.2	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m

	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Left Side and Right Side)

L_{uw} =	3.43 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**2.79 m**	

Front to Back Direction (Interior Walls)

L_{uw} =	4.93 m	**GWB-A** 9.86/2
K_{exp} =	1	for suburban
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**4.02 m**	Garage portion is WSP-A

Left to Right Direction (Exterior Back Wall)

L_{uw} =	3.43 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)
$K_{Wnumber}$ =	1.38	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**1.89 m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} = 1.29 m **WSP-F**
K_{exp} = 1 for suburban
K_{roof} = 0.74 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)
$K_{Wnumber}$ = 1.38 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 0.71 m

Left to Right Direction (Interior Garage Wall)

L_{uw} = 3.43 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.74 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)
$K_{Wnumber}$ = 1.38 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 1.89 m Can't be shrunk to this size because of 9.23.13.10.(4)

Basement Framed Walls

Front to Back Direction (Exterior Left Side and Right Side)

L_{uw} = 7.06 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.86 space between braced walls approx. 6.5 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 6.92 m

Front to Back Direction (Interior Walls)

L_{uw} = 5.88 m **GWB-B** 11.76/2
K_{exp} = 1 for suburban
K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.86 space between braced walls approx. 6.5 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 5.76 m The garage portion is constructed as a WSP-A

Left to Right Direction (Exterior Back Wall)

L_{uw} = 7.06 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)
$K_{Wnumber}$ = 1.38 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

	L_w =	**4.68 m**		
	Left to Right Direction (Exterior Front Wall)			
	L_{uw} =	2.65 m	**WSP-F**	
	K_{exp} =	1	for suburban	
	K_{roof} =	0.89	for roof eave to ridge of 2.2 m < 3 m	
	$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)	
	$K_{Wnumber}$ =	1.38	4 braced wall bands	
	K_{gyp} =	1	walls are sheathing on the interior with gypsum	
	K_{sheath} =	1	walls are continuously wood sheathed	
	L_w =	**1.76 m**		
	Left to Right Direction (Interior Garage Wall)			
	L_{uw} =	7.06 m	**WSP-A**	
	K_{exp} =	1	for suburban	
	K_{roof} =	0.89	for roof eave to ridge of 2.2 m < 3 m	
	$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)	
	$K_{Wnumber}$ =	1.38	4 braced wall bands	
	K_{gyp} =	1	walls are sheathing on the interior with gypsum	
	K_{sheath} =	1	walls are continuously wood sheathed	
	L_w =	**4.68 m**		
9.23.6.1.	**Anchorage of Building Frames**			
	Is HWP between 0.6 kPa and 1.2 kPa		Yes	
	Is Smax for Site Class C greater than 0.47		No	Use Table 9.23.6.1.
	and is Smax less than or equal to 2.6			
	From Table 9.23.6.1.			
	Framing Type Selected	**WSP-A**		
	Anchor bolt size	12.7 mm		
	Anchor bolt spacing	0.8 m		
	From Table 9.23.6.1.			
	Framing Type Selected	**WSP-A**		
	Anchor bolt size	12.7 mm		
	Anchor bolt spacing	0.7 m		
9.23.11.4.	**Joints in Top Plates**			
	Is HWP between 0.6 kPa and 1.2 kPa		Yes	Use Table 9.23.11.4.-B
	Is Smax for Site Class C greater than 0.47		No	N/A
	and is Smax less than or equal to 2.6			
	Table 9.23.11.4.-A			
	0.6 < and ≤ 0.8		Normal Weight	
	All floors	4 nails	For BWB Spacing of 10.6m	
		2	For BWB Spacing of ≤ 7.6m	
	Table 9.23.11.4.-B			
	0.6 < and ≤ 0.9		Normal Weight	
	1st Floor	20 nails	For BWB Spacing of 10.6m	Wind governs
		10 nails	For BWB Spacing of ≤ 7.6m	
	2nd Floor	10 nails	For BWB Spacing of 10.6m	

	5 nails	For BWB Spacing of ≤ 7.6m	

Cost Differences - Winnipeg

Archetype	Bungalow
No. Storeys =	1.5
Construction =	Light
w =	12.2 m
l =	13 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.2 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020						Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
	BWP1	750	EXT-W26400-9.5OSB	$ 65.86 /m	$ 49.40		BWP1	750	2020 WSP-B	$ 71.21 /m	$ 53.41	$ 4.01
	BWP2	625	EXT-W26400-9.5OSB	$ 65.86 /m	$ 41.16		BWP2	625	2020 WSP-B	$ 71.21 /m	$ 44.51	$ 3.34
	BWP3	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52		BWP3	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP4	950	EXT-W26400-9.5OSB	$ 65.86 /m	$ 62.57		BWP4	950	2020 WSP-A	$ 65.86 /m	$ 62.57	$ -
	BWP5	2300	EXT-W26400-9.5OSB	$ 65.86 /m	$ 151.48		BWP5	2300	2020 WSP-A	$ 65.86 /m	$ 151.48	$ -
	BWP6	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52		BWP6	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
Basement	BWP7	1400	EXT-W26400-9.5OSB	$ 65.86 /m	$ 92.21	Basement	BWP7	1400	2020 WSP-A	$ 65.86 /m	$ 92.21	$ -
	BWP8	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52		BWP8	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP9	1725	EXT-W26400-9.5OSB	$ 65.86 /m	$ 113.61		BWP9	1725	2020 WSP-A	$ 65.86 /m	$ 113.61	$ -
	BWP10	600	EXT-W26400-9.5OSB	$ 65.86 /m	$ 39.52		BWP10	600	2020 WSP-A	$ 65.86 /m	$ 39.52	$ -
	BWP11	2250	EXT-W26400-9.5OSB	$ 65.86 /m	$ 148.19		BWP11	2250	2020 WSP-A	$ 65.86 /m	$ 148.19	$ -
	BWP12	950	EXT-W26400-9.5OSB	$ 65.86 /m	$ 62.57		BWP12	950	2020 WSP-A	$ 65.86 /m	$ 62.57	$ -
	BWP13	1200	INT-W26600-B	$ 124.87 /m	$ 149.85		BWP13	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (52.45)
	BWP15	1200	INT-W26600-B	$ 124.87 /m	$ 149.85		BWP15	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (52.45)
	BWP17	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26		BWP17	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP19	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP19	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP20	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP20	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP21	750	EXT-W26400-9.5OSB	$ 149.69 /m	$ 112.26		BWP21	750	2020 WSP-A	$ 149.69 /m	$ 112.26	$ -
	BWP22	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP23	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP23	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP24	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP24	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP25	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP25	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP26	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP26	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
1st Floor	BWP27	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81	1st Floor	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP28	940	EXT-W26400-9.5OSB	$ 149.69 /m	$ 140.70		BWP28	940	2020 WSP-A	$ 149.69 /m	$ 140.70	$ -
	BWP29	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP29	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP30	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP30	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP31	2740	EXT-W26400-9.5OSB	$ 149.69 /m	$ 410.14		BWP31	2740	2020 WSP-A	$ 149.69 /m	$ 410.14	$ -
	BWP32	600	EXT-W26400-9.5OSB	$ 149.69 /m	$ 89.81		BWP32	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP33	2420	EXT-W26400-9.5OSB	$ 149.69 /m	$ 362.24		BWP33	2420	2020 WSP-A	$ 149.69 /m	$ 362.24	$ -
	BWP34	775	EXT-W26400-9.5OSB	$ 149.69 /m	$ 116.01		BWP34	775	2020 WSP-A	$ 149.69 /m	$ 116.01	$ -
	BWP35	1200	INT-W26600	$ 116.08 /m	$ 139.30		BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP36	1200	INT-W26600	$ 116.08 /m	$ 139.30		BWP36	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	1st Flr	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	$ -
Basement	Extra 11 mm OSB	0	Extra 11 mm OSB	$ 30.70 /m	$ -	Basement	Extra 11 mm OSB	3656	Extra 11 mm OSB	$ 30.70 /m	$ 112.23	$ 112.23
All Flrs	Extra 12.7 Gypsum	0	Extra Gypsum Board	$ 34.92 /m	$ -	All Flrs	Extra 12.7 Gypsum	4800	Extra Gypsum Board	$ 34.92 /m	$ 167.61	$ 167.61
					$ 3,699.09						**$ 3,814.00**	**$ 114.91**

Cost Increase of Scenario B (PCF 1475) relative to Base Scenario (Existing Code)	$ 114.91
Percent Cost Increase of Scenario B relative to Base Scenario	3.1%

Anchor Bolts Difference

	Base Scenario: 2015 NBC and 2015 NBC Sa(0.2)				Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
	Spacing (mm)	Number	Unit Cost	Cost	Spacing (mm)	Number	Unit Cost	Cost	
1/2" dia. Anchor	2400	38	$ 6.13 Ea.	$ 232.94	500	41	$ 6.13 Ea.	$ 251.33	**$ 18.39**
									8%

Top Plate Splice Fasteners

	Base Scenario: 2015 NBC and 2015 NBC Sa(0.2)					Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
	No. Locations	No. Fasteners	Total	Cost per	Total Cost	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
1st Floor Framing	15	2	30	$ 0.10	$ 3.00	15	12	180	$ 0.10	$ 18.00	$ 15.00
2nd Floor Framing	21	2	42	$ 0.10	$ 4.20	21	10	210	$ 0.10	$ 21.00	
			72		**$ 7.20**			**390**		**$ 39.00**	**$ 31.80**
											442%

Base Case Total Cost	$ 3,939.23

Scenario B Total Cost	$ 4,104.33
Total Percent Increase Relative to Base Case (Existing Code)	4.2%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	4.2%
Percent Increase from Base Case Home Construction	0.06%

Average Cost of Bungalow Construction in Winnipeg
$ 293,105.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Code Analysis - Winnipeg

Archetype	Bungalow	
No. Storeys =	1.5	
Construction =	Light	
w =	12.2	m
l =	13	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.2	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.054	
HWP =	0.45	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9?	Yes	Use OSB wall sheathing

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nails Supporting 1 floor	
	2nd Floor 1 nails Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.08

HWP = 0.45 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**	
	Does the Article apply? Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	-
	% braced walls - 1st Floor	-
	% braced walls - bsmt	-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	- m
	Maximum distance between required braced wall panels measured from the edges of the panels	- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	- mm
9.23.13.6.	**Materials in Braced Wall Panels**	
	Is Sa(0.2) less than or equal to 0.9? Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm

Use OSB wall sheathing

Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	0.11	Worst Case	w =	12.2	m
Smax =	0.06	Site Class C	l =	13	m
HWP =	0.45	kPa	Stud spacing =	600	mm
S =	1.06	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.2	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Left Side and Right Side)

L_{uw} =	1.9 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**1.55 m**	

Front to Back Direction (Interior Walls)

L_{uw} =	2.92 m	**GWB-A** 5.84/2
K_{exp} =	1	for suburban
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ =	0.86	space between braced walls approx. 6.5 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**2.38 m**	Garage portion is WSP-A

Left to Right Direction (Exterior Back Wall)

L_{uw} =	1.9 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)
$K_{Wnumber}$ =	1.38	4 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**1.05 m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} =	1 m	**WSP-B**
K_{exp} =	1	for suburban
K_{roof} =	0.74	for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ =	0.54	space between braced walls approx. 4 m (averaged)

$K_{Wnumber}$ = 1.38 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 0.55 m

Left to Right Direction (Interior Garage Wall)
L_{uw} = 1.9 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.74 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)
$K_{Wnumber}$ = 1.38 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 1.05 m Can't be shrunk to this size because of 9.23.13.10.(4)

Basement Framed Walls

Front to Back Direction (Exterior Left Side and Right Side)
L_{uw} = 3.92 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.86 space between braced walls approx. 6.5 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 3.84 m

Front to Back Direction (Interior Walls)
L_{uw} = 5.625 m **GWB-A** 11.25/2
K_{exp} = 1 for suburban
K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.86 space between braced walls approx. 6.5 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 5.51 m The garage portion is constructed as a WSP-A

Left to Right Direction (Exterior Back Wall)
L_{uw} = 3.92 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)
$K_{Wnumber}$ = 1.38 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 2.60 m

Left to Right Direction (Exterior Front Wall)
L_{uw} = 2.06 m **WSP-B**
K_{exp} = 1 for suburban
K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)

$K_{Wnumber}$ = 1.38 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 1.37 m

Left to Right Direction (Interior Garage Wall)
L_{uw} = 3.92 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.89 for roof eave to ridge of 2.2 m < 3 m
$K_{Wspacing}$ = 0.54 space between braced walls approx. 4 m (averaged)
$K_{Wnumber}$ = 1.38 4 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 2.60 m Can't be shrunk to this size because of 9.23.13.10.(4)

9.23.6.1. **Anchorage of Building Frames**

Is HWP greater than 1.2 kPa	No	If "No" to both then use Table 9.23.6.1.
Is Smax greater than 2.6?	No	Use 9.23.6.1.(2)(b)

From Table 9.23.6.1.
Framing Type Selected **WSP-A**
Anchor bolt size 12.7 mm
Anchor bolt spacing 0.8 m This Table was updated since PR

From Table 9.23.6.1.
Framing Type Selected **WSP-A**
Anchor bolt size 12.7 mm
Anchor bolt spacing 0.7 m

9.23.11.4. **Joints in Top Plates**

Is HWP less than or equal to 1.2 kPa	Yes	Use Table 9.23.11.4.-B
Is Smax for Site Class C less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A

Table 9.23.11.4.-A
<= 0.6 Normal Weight

All floors	4 nails	For BWB Spacing of 10.6m	min. number of nails on each side of top plate splice for BWB
	2 nails	For BWB Spacing of ≤ 7.6m	

Table 9.23.11.4.-B
0.4 < and ≤ 0.5 Normal Weight

1st Floor	11 nails	For BWB Spacing of 10.6m	Wind Governs
	6 nails	For BWB Spacing of ≤ 7.6m	
2nd Floor	9 nails	For BWB Spacing of 10.6m	
	5 nails	For BWB Spacing of ≤ 7.6m	

PCFs 1475 and 1775 - Impact Analysis - Stacked Town

Summary of Results

Summary of NBC 2020 Seismic Hazard Values and Updated Seismic Hazard Values and the Seismic Parameter, Smax

Location	Prov.	Existing for Part 9					Proposed for Part 9							
		2020 Sa(0.2)	2020 Sa(0.5)	2020 HWP (kPa)	2020 Ss (kPa)	2020 Sr (kPa)	Updated S(0.2, C)	Updated S(0.5, C)	2020 A S_{max}	2020 B S_{max}	2020 C S_{max}	2020 D S_{max}	2020 E S_{max}	Unknown Site Class S_{max}
Victoria	BC	1.300	1.160	0.57	1.10	0.20	1.91	1.68	0.87	1.07	1.68	2.01	2.02	2.02
Lethbridge	AB	0.164	0.125	0.66	1.20	0.10	0.21	0.15	0.08	0.10	0.15	0.25	0.29	0.29
Winnipeg	MB	0.054	0.032	0.45	1.90	0.20	0.082	0.050	0.03	0.04	0.06	0.09	0.11	0.11
Ottawa (City Hall)	ON	0.439	0.237	0.41	2.40	0.40	0.66	0.39	0.26	0.38	0.44	0.51	0.60	0.60
Montréal (City Hall)	QC	0.595	0.311	0.42	2.60	0.40	0.84	0.49	0.35	0.49	0.56	0.58	0.67	0.67
St. John's	NL	0.090	0.073	0.78	2.90	0.70	0.19	0.15	0.07	0.10	0.15	0.27	0.31	0.31
Whitehorse	YK	0.334	0.258	0.38	2.00	0.10	0.47	0.40	0.17	0.22	0.41	0.62	0.70	0.70

Summary of the Change in Cost due to PCFs 1475 and 1775

Location	Prov.	Housing Construction Cost		Scenario A 2020 NBC Provisions Updated Seismic Values		Scenario B PCF Provisions Updated Seismic Values	
		Avg. $/Sq.ft.	House Cost	Cost. Diff	% Change	Cost. Diff	% Change
Victoria	BC	$ 224.10	$ 525,290.40	$ 1,242.73	0.24%	$ 618.48	0.12%
Whitehorse	YT	$ 200.00	$ 468,800.00	$ -	0%	$ 1,206.51	0.26%
Lethbridge	AB	$ 150.00	$ 351,600.00	$ -	0%	$ 764.10	0.22%
Ottawa	ON	$ 170.00	$ 398,480.00	$ -	0%	$ 302.19	0.08%
Montreal	QC	$ 165.00	$ 386,760.00	$ 2,230.45	0.58%	$ 327.75	0.08%
St. John's	NL	$ 162.50	$ 367,318.25	$ -	0%	$ 764.10	0.21%
Winnipeg	MB	$ 162.50	$ 367,318.25	$ -	0%	$ 302.19	0.08%

Notes:

1. The cost differences and % change in the above table represents the differences between each of the scenarios, A and B compared to the base scenario, which is the existing NBC 2020.

2. The house cost is based on the square footage cost and the square footage of the archetype used in the impact analysis (2,344 sq.ft.). Square footage construction costs were obtained from Altus Group - 2022 Canadian Construction Cost Guide which reflects costs of 2021. Without information for Victoria or Lethbridge, factors were applied to the 2021 data to reflect previous years' data.

3. With the lowest exterior framed wall of the archetype supporting more than two floors and a roof, it would be designed in compliance with Part 4 in all Scenarios so it was ommitted from the Impact Analysis.

Comments and Disussion of Results

Location	Prov.	Comments and Discussion
Victoria	BC	With the updated Seismic Hazard values Victoria is moved into using Part 4 for lateral loads resistance design. The PCF would keep Victoria from being pushed into Part 4 for many cases which is why Scenario B represents a cost reduction compared to Scenario A.
Whitehorse	YT	Whitehorse is currently not required to design for lateral loads resistance which is reflected by the cost increase. This archetype was governed by the seismic hazard value because the worst case maximum value was selected, assuming the designer did not have a geotechnical evaluation conducted.
Lethbridge	AB	The lateral loads design cost values for St. John's were applied to the construction cost information for Lethbridge because the two cities fall into the same seismic and wind hazard categories. The lateral loads resistance for this archetype was governed by the expected wind loads.
Winnipeg	MB	The large difference between Wind and Seismic hazards for Winnipeg would likely mean that regardless of the building dimensions, Wind will govern the design to resist lateral loads.
Ottawa (City Hall)	ON	Following the PCF's provisions, Ottawa's wind and seismic hazard values result in similar minimum lengths for braced wall panels depending on the dimensions of the building. For this archetype, Wind governed over Seismic.
Montréal (City Hall)	QC	Montreal does not currently require lateral loads resistance but with the updated seismic values it would be shifted into where the current NBC 2020 does require braced wall panels. The proposed lateral loads design provisions reduce the cost of bracing for the proposed updated seismic hazard values.
St. John's	NL	The large difference between Wind and Seismic hazards for St. John's would likely mean that regardless of the building dimensions, wind will govern the design to resist lateral loads.

Cost Differences - Victoria

Archetype	Stacked Town
No. Storeys =	3
Construction =	Light
w =	11.7 m
l =	11.8 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.1 m

Braced Wall Panel Difference

Scenario A, with the updated Seismic Data, requires Victoria to be designed according to Part 4, which has been represented as a 10% increase in panel lengths.

		Base Scenario: Existing NBC 2020				NBC 2020 Provisions with Updated Seismic Hazard Values				Difference b/w Base and Scenario A
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	1030	2015 WSP-3a	$163.94 /m	$ 168.86	1133	2015 WSP-4a	$173.60 /m	$ 196.68	$ 27.82
		170	EXT-W26600	$ 155.18 /m	$ 26.38	67	EXT-W26600	$ 155.18 /m	$ 10.40	$ (15.98)
	BWP2	750	2015 WSP-3a	$163.94 /m	$ 122.96	825	2015 WSP-4a	$173.60 /m	$ 143.22	$ 20.26
		515	EXT-W26600	$ 155.18 /m	$ 79.92	440	EXT-W26600	$ 155.18 /m	$ 68.28	$ (11.64)
	BWP3	600	2015 WSP-3a	$163.94 /m	$ 98.37	660	2015 WSP-4a	$173.60 /m	$ 114.57	$ 16.21
		100	EXT-W26600	$ 155.18 /m	$ 15.52	40	EXT-W26600	$ 155.18 /m	$ 6.21	$ (9.31)
	BWP4	2600	2015 WSP-3a	$163.94 /m	$ 426.25	2860	2015 WSP-4a	$173.60 /m	$ 496.48	$ 70.23
		275	EXT-W26600	$ 155.18 /m	$ 42.67	15	EXT-W26600	$ 155.18 /m	$ 2.33	$ (40.35)
	BWP5	600	2015 WSP-3a	$163.94 /m	$ 98.37	660	2015 WSP-4a	$173.60 /m	$ 114.57	$ 16.21
	BWP6	1500	2015 WSP-3a	$163.94 /m	$ 245.92	1650	2015 WSP-4a	$173.60 /m	$ 286.43	$ 40.52
		4000	EXT-W26600	$ 155.18 /m	$ 620.71	3850	EXT-W26600	$ 155.18 /m	$ 597.43	$ (23.28)
	BWP7	775	2015 WSP-3a	$163.94 /m	$ 127.06	852.5	2015 WSP-4a	$173.60 /m	$ 147.99	$ 20.93
	BWP8	1605	2015 WSP-3a	$163.94 /m	$ 263.13	1765.5	2015 WSP-4a	$173.60 /m	$ 306.48	$ 43.35
		785	EXT-W26600	$ 155.18 /m	$ 121.81	624.5	EXT-W26600	$ 155.18 /m	$ 96.91	$ (24.91)
	BWP9	3950	2015 WSP-3a-Interior	$157.62 /m	$ 622.61	4345	2015 WSP-4a-Interior	$167.28 /m	$ 726.81	$ 104.20
		2983	INT-W26600-B	$124.87 /m	$ 372.50	2588	2015 WSP-4a-Interior	$167.28 /m	$ 432.91	$ 60.41
	BWP10	750	2015 WSP-3a-Interior	$157.62 /m	$ 118.22	825	2015 WSP-4a-Interior	$167.28 /m	$ 138.00	$ 19.78
	BWP11	600	2015 WSP-3a-Interior	$157.62 /m	$ 94.57	660	2015 WSP-4a-Interior	$167.28 /m	$ 110.40	$ 15.83
		850	INT-W26600-B	$124.87 /m	$ 106.14	790	2015 WSP-4a-Interior	$167.28 /m	$ 132.15	$ 26.01
	BWP12	1720	2015 WSP-3a-Interior	$157.62 /m	$ 271.11	1892	2015 WSP-4a-Interior	$167.28 /m	$ 316.49	$ 45.37
2nd Flr	BWP13	600	2015 WSP-3a	$163.94 /m	$ 98.37	660	2015 WSP-4a	$173.60 /m	$ 114.57	$ 16.21
	BWP14	720	2015 WSP-3a	$163.94 /m	$ 118.04	792	2015 WSP-4a	$173.60 /m	$ 137.49	$ 19.45
	BWP15	600	2015 WSP-3a	$163.94 /m	$ 98.37	660	2015 WSP-4a	$173.60 /m	$ 114.57	$ 16.21
	BWP16	1500	2015 WSP-3a	$163.94 /m	$ 245.92	1650	2015 WSP-4a	$173.60 /m	$ 286.43	$ 40.52
		2975	EXT-W26600	$ 155.18 /m	$ 461.65	2825	EXT-W26600	$ 155.18 /m	$ 438.38	$ (23.28)
	BWP17	600	2015 WSP-3a	$163.94 /m	$ 98.37	660	2015 WSP-4a	$173.60 /m	$ 114.57	$ 16.21
		275	EXT-W26600	$ 155.18 /m	$ 42.67	215	EXT-W26600	$ 155.18 /m	$ 33.36	$ (9.31)
	BWP18	890	2015 WSP-3a	$163.94 /m	$ 145.91	979	2015 WSP-4a	$173.60 /m	$ 169.95	$ 24.04
		290	EXT-W26600	$ 155.18 /m	$ 45.00	201	EXT-W26600	$ 155.18 /m	$ 31.19	$ (13.81)
	BWP19	1470	2015 WSP-3a-Interior	$157.62 /m	$ 231.71	1617	2015 WSP-4a-Interior	$167.28 /m	$ 270.48	$ 38.78
		4150	INT-W26600-B	$124.87 /m	$ 518.22	4003	2015 WSP-4a-Interior	$167.28 /m	$ 669.60	$ 151.38
	BWP20	750	2015 WSP-3a-Interior	$157.62 /m	$ 118.22	825	2015 WSP-4a-Interior	$167.28 /m	$ 138.00	$ 19.78
	BWP21	600	2015 WSP-3a-Interior	$157.62 /m	$ 94.57	660	2015 WSP-4a-Interior	$167.28 /m	$ 110.40	$ 15.83
	BWP22	600	2015 WSP-3a	$163.94 /m	$ 98.37	660	2015 WSP-4a	$173.60 /m	$ 114.57	$ 16.21
		620	EXT-W26600	$ 155.18 /m	$ 96.21	560	EXT-W26600	$ 155.18 /m	$ 86.90	$ (9.31)
	BWP22b	750	2015 WSP-3a	$163.94 /m	$ 122.96	825	2015 WSP-4a	$173.60 /m	$ 143.22	$ 20.26
		600	EXT-W26600	$ 155.18 /m	$ 93.11	525	EXT-W26600	$ 155.18 /m	$ 81.47	$ (11.64)
	BWP23	600	2015 WSP-3a-Interior	$157.62 /m	$ 94.57	660	2015 WSP-4a-Interior	$167.28 /m	$ 110.40	$ 15.83
		100	INT-W26600-B	$124.87 /m	$ 12.49	40	2015 WSP-4a-Interior	$167.28 /m	$ 6.69	$ (5.80)
	BWP24	890	2015 WSP-3a-Interior	$157.62 /m	$ 140.28	979	2015 WSP-4a-Interior	$167.28 /m	$ 163.76	$ 23.48
		460	INT-W26600-B	$124.87 /m	$ 57.44	371	2015 WSP-4a-Interior	$167.28 /m	$ 62.06	$ 4.62
3rd Flr	BWP25	600	2015 WSP-3a	$163.94 /m	$ 98.37	660	2015 WSP-4a	$173.60 /m	$ 114.57	$ 16.21
	BWP26	720	2015 WSP-3a	$163.94 /m	$ 118.04	792	2015 WSP-4a	$173.60 /m	$ 137.49	$ 19.45
	BWP27	600	2015 WSP-3a	$163.94 /m	$ 98.37	660	2015 WSP-4a	$173.60 /m	$ 114.57	$ 16.21
	BWP28	1500	2015 WSP-3a	$163.94 /m	$ 245.92	1650	2015 WSP-4a	$173.60 /m	$ 286.43	$ 40.52
			EXT-W26600	$ 155.18 /m		-350	EXT-W26600	$ 155.18 /m	$ (54.31)	$ (54.31)
	BWP29	600	2015 WSP-3a	$163.94 /m	$ 98.37	660	2015 WSP-4a	$173.60 /m	$ 114.57	$ 16.21
	BWP30	890	2015 WSP-3a	$163.94 /m	$ 145.91	979	2015 WSP-4a	$173.60 /m	$ 169.95	$ 24.04
			EXT-W26600	$ 155.18 /m		-229	EXT-W26600	$ 155.18 /m	$ (35.54)	$ (35.54)
	BWP31	1470	2015 WSP-3a-Interior	$157.62 /m	$ 231.71	1617	2015 WSP-4a-Interior	$167.28 /m	$ 270.48	$ 38.78
		3180	INT-W26600	$116.08 /m	$ 369.15	3033	2015 WSP-4a-Interior	$167.28 /m	$ 507.35	$ 138.20
	BWP32	750	2015 WSP-3a-Interior	$157.62 /m	$ 118.22	825	2015 WSP-4a-Interior	$167.28 /m	$ 138.00	$ 19.78
		450	INT-W26600	$116.08 /m	$ 52.24	375	2015 WSP-4a-Interior	$167.28 /m	$ 62.73	$ 10.49
	BWP33	600	2015 WSP-3a-Interior	$157.62 /m	$ 94.57	660	2015 WSP-4a-Interior	$167.28 /m	$ 110.40	$ 15.83
		2735	INT-W26600	$116.08 /m	$ 317.49	2675	2015 WSP-4a-Interior	$167.28 /m	$ 447.46	$ 129.97
	BWP34	600	2015 WSP-3a	$163.94 /m	$ 98.37	660	2015 WSP-4a	$173.60 /m	$ 114.57	$ 16.21
	BWP34b	750	2015 WSP-3a	$163.94 /m	$ 122.96	825	2015 WSP-4a	$173.60 /m	$ 143.22	$ 20.26
	BWP35	735	2015 WSP-3a-Interior	$157.62 /m	$ 115.85	808.5	2015 WSP-4a-Interior	$167.28 /m	$ 135.24	$ 19.39
		1000	INT-W26600	$116.08 /m	$ 116.08	926.5	2015 WSP-4a-Interior	$167.28 /m	$ 154.98	$ 38.90
	BWP36	750	INT-W26600	$116.08 /m	$ 87.06	825	2015 WSP-4a-Interior	$167.28 /m	$ 138.00	$ 50.94
1st Flr	Extra 11 mm OSB	5337	Extra 11 mm OSB	$ 30.70 /m	$ 163.83	4803.3	Extra 11 mm OSB	$ 30.70 /m	$ 147.45	$ (16.38)
2nd Flr	Extra 11 mm OSB	8297	Extra 11 mm OSB	$ 30.70 /m	$ 254.70	7467.3	Extra 11 mm OSB	$ 30.70 /m	$ 229.23	$ (25.47)
3rd Storey	Extra 11 mm OSB	9664	Extra 11 mm OSB	$ 30.70 /m	$ 296.66	8697.6	Extra 11 mm OSB	$ 30.70 /m	$ 266.99	$ (29.67)
All Flrs	Extra 12.7 Gypsum	0	Extra Gypsum Board	$ 34.92 /m	$ -	0	Extra Gypsum Board	$ 34.92 /m	$ -	$ -
					$ 10,319.36				**$ 11,556.69**	**$ 1,237.33**

Percent Increase Relative to Base Case (Existing Code)	**12%**

		Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	1200	2020 WSP-E	$ 190.58 /m	$ 228.69	$ 59.83
					$ -	$ (26.38)
	BWP2	1265	2020 WSP-E	$ 190.58 /m	$ 241.08	$ 118.12
					$ -	$ (79.92)
	BWP3	700	2020 WSP-E	$ 190.58 /m	$ 133.40	$ 35.04
					$ -	$ (15.52)
	BWP4	2875	2020 WSP-B	$ 161.84 /m	$ 465.30	$ 39.05
					$ -	$ (42.67)
	BWP5	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ (1.26)
	BWP6	5500	2020 WSP-B	$ 161.84 /m	$ 890.15	$ 644.23
					$ -	$ (620.71)
	BWP7	775	2020 WSP-E	$ 190.58 /m	$ 147.70	$ 20.64
	BWP8	2390	2020 WSP-E	$ 190.58 /m	$ 455.48	$ 192.35
					$ -	$ (121.81)
	BWP9	6933	2020 WSP-E-Interior	$ 184.26 /m	$ 1,277.45	$ 654.84
					$ -	$ (372.50)
	BWP10	750	2020 WSP-E-Interior	$ 184.26 /m	$ 138.19	$ 19.97
	BWP11	1450	2020 WSP-E-Interior	$ 184.26 /m	$ 267.17	$ 172.60
					$ -	$ (106.14)
	BWP12	1720	2020 WSP-E-Interior	$ 184.26 /m	$ 316.92	$ 45.81
2nd Flr	BWP13	600	2020 WSP-E	$ 190.58 /m	$ 114.35	$ 15.98
	BWP14	720	2020 WSP-B	$ 161.84 /m	$ 116.53	$ (1.51)
	BWP15	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ (1.26)
	BWP16	4475	2020 WSP-B	$ 161.84 /m	$ 724.25	$ 478.34
					$ -	$ (461.65)
	BWP17	875	2020 WSP-E	$ 190.58 /m	$ 166.75	$ 68.39
					$ -	$ (42.67)
	BWP18	1180	2020 WSP-E	$ 190.58 /m	$ 224.88	$ 78.97
					$ -	$ (45.00)
	BWP19	5620	2020 WSP-B-Interior	$ 155.52 /m	$ 874.05	$ 642.34
					$ -	$ (518.22)
	BWP20	750	2020 WSP-B-Interior	$ 155.52 /m	$ 116.64	$ (1.57)
	BWP21	600	2020 WSP-B-Interior	$ 155.52 /m	$ 93.31	$ (1.26)
	BWP22	1220	2020 WSP-E	$ 190.58 /m	$ 232.50	$ 134.14
					$ -	$ (96.21)
	BWP22b	1350	2020 WSP-E	$ 190.58 /m	$ 257.28	$ 134.32
					$ -	$ (93.11)
	BWP23	700	2020 WSP-E-Interior	$ 184.26 /m	$ 128.98	$ 34.41
					$ -	$ (12.49)
	BWP24	1350	2020 WSP-E-Interior	$ 184.26 /m	$ 248.75	$ 108.46
					$ -	$ (57.44)
3rd Flr	BWP25	600	2020 WSP-E	$ 190.58 /m	$ 114.35	$ 15.98
	BWP26	720	2020 WSP-B	$ 161.84 /m	$ 116.53	$ (1.51)
	BWP27	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ (1.26)
	BWP28	1300	2020 WSP-B	$ 161.84 /m	$ 210.40	$ (35.52)
		200	EXT-W26600	$ 155.18 /m	$ 31.04	$ 31.04
	BWP29	600	2020 WSP-E	$ 190.58 /m	$ 114.35	$ 15.98
	BWP30	750	2020 WSP-E	$ 190.58 /m	$ 142.93	$ (2.98)
		140	EXT-W26600	$ 155.18 /m	$ 21.72	$ 21.72
	BWP31	4650	GWB-C Interior	$ 95.82 /m	$ 445.56	$ 213.85
					$ -	$ (369.15)
	BWP32	1200	GWB-C Interior	$ 95.82 /m	$ 114.98	$ (3.23)
						$ (52.24)
	BWP33	3335	GWB-C Interior	$ 95.82 /m	$ 319.56	$ 224.98
						$ (317.49)
	BWP34	600	2020 WSP-E	$ 190.58 /m	$ 114.35	$ 15.98
		750	EXT-W26600	$ 155.18 /m	$ 116.38	$ (6.57)
	BWP35	1735	2020 WSP-A-Interior	$ 155.52 /m	$ 269.84	$ 153.98
					$ -	$ (116.08)
	BWP36	750	2020 WSP-A-Interior	$ 155.52 /m	$ 116.64	$ 29.58
1st Flr	Extra 11 mm OSB	1127	Extra 11 mm OSB	$ 30.70 /m	$ 34.60	$ (129.24)
2nd Flr	Extra 11 mm OSB	4147	Extra 11 mm OSB	$ 30.70 /m	$ 127.30	$ (127.39)
3rd Storey	Extra 11 mm OSB	5484	Extra 11 mm OSB	$ 30.70 /m	$ 168.35	$ (128.32)
All Flrs	Extra 12.7 Gypsum		Extra Gypsum Board	$ 34.92 /m	$ -	$ -
					$ 10,730.01	**$ 410.65**

Percent Increase Relative to Base Case (Existing Code)	**4%**
Percent Increase Relative to Scenario A (Updated Seismic Values)	**-7%**

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020				NBC 2020 Provisions with Updated Seismic Hazard Values				Difference b/w Base and Scenario A
	Spacing (mm)	Number	Unit Cost	Cost	Spacing (mm)	Number	Unit Cost	Cost	
1/2" dia. Anchor	2400	21	$ 6.13 Ea.	$ 128.73	2400	21	$ 6.13 Ea.	$ 128.73	**$ -**
									0%

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost		Cost	
500/800/2400	52	$ 6.13	Ea.	$ 318.76	**$ 190.03**
					148%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020					NBC 2020 Provisions with Updated Seismic Hazard Values					Difference b/w Base and Scenario A
	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
1st Floor Framing	14	24	336	$ 0.10	$ 33.60	14	26	364	$ 0.10	$ 36.40	$ 2.80
2nd Floor Framing	13	16	208	$ 0.10	$ 20.80	13	16	208	$ 0.10	$ 20.80	$ -
3rd Floor Framing	13	6	78	$ 0.10	$ 7.80	13	8	104	$ 0.10	$ 10.40	$ 2.60
			414		**$ 62.20**			**468**		**$ 67.60**	

	Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions					Difference b/w Base and Scenario B
	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
1st Floor Framing	14	20	280	$ 0.10	$ 28.00	$ (5.60)
2nd Floor Framing	13	20	260	$ 0.10	$ 26.00	$ 5.20
3rd Floor Framing	13	20	260	$ 0.10	$ 26.00	$ 18.20
			540		**$ 80.00**	

Base Case Total Cost	$ 10,510.29

Scenario A Total Cost	$ 11,753.02
Total Percent Increase Relative to Base Case (Existing Code)	**12%**
Percent Increase from Base Case Home Construction	0.24%

Scenario B Total Cost	$ 11,128.77
Total Percent Increase Relative to Base Case (Existing Code)	6%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	-5%
Percent Increase from Base Case Home Construction	0.1%

Average Cost of Housing Construction in Victoria
$ 525,290.40 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Code Analysis - Victoria

Archetype	Stacked Town
No. Storeys =	3
Construction =	Light
w =	11.7
l =	11.8
Stud spacing =	600
Stud Height =	2.4
Eave-to-Ridge height =	2.1

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) = 1.30

HWP = 0.57 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces** Does the Article apply? No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces** Does the Article apply? Yes	Design to 9.23.13.4. to 9.23.13.7.
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces** Does the Article apply? No	-
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	Yes
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	-
	% braced walls - 1st Floor	-
	% braced walls - bsmt	-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	7.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels	6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
9.23.13.6.	**Materials in Braced Wall Panels** Is Sa(0.2) less than or equal to 0.9? No	Use OSB wall sheathing

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	N/A	N/A	mm
Plywood	11	12.5	mm
Diagonal lumber	N/A	N/A	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	No
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	Yes
	Braced Wall Panel Type	**2015 WSP-4** **2015 WSP-4a**
9.23.6.1.	**Anchorage of Building Frames**	
	1.2 < Sa(0.2) ≤ 1.3	
	Anchor bolt size 12.7 mm	Use Table 9.23.6.1.
	Anchor bolt spacing 1.9 m	Use Table 9.23.6.1.
9.23.11.4.	**Joints in Top Plates**	
	1.2 < Sa(0.2) ≤ 1.3	
	Top Plate Connections	
	1st Floor 8 nails Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 3 nails Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 1.91

HWP = 0.45 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**	
	Does the Article apply? No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	**Design to Part 4**
	Does the Article apply? Yes	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	-
	% braced walls - 1st Floor	-
	% braced walls - bsmt	-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	7.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels	6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
9.23.13.6.	**Materials in Braced Wall Panels**	
	Is Sa(0.2) less than or equal to 0.9? No	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	n/a	n/a	mm
Plywood	11	12.5	mm

	Diagonal lumber	n/a	n/a	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	No
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**Design to Part 4**
9.23.6.1.	**Anchorage of Building Frames**	
	Sa(0.2) > 1.8	**Design to Part 4**
	Anchor bolt size 12.7 mm	
	Anchor bolt spacing 1.8 m	**Use at least the highest from Table 9.23.6.1.**
9.23.11.4.	**Joints in Top Plates**	
	Sa(0.2) > 1.8	
	Top Plate Connections	**Design to Part 4**
	1st Floor **8** nails Supporting 1 floor	
	2nd Floor **4** nails Supporting 0 floors	**Use at least the highest from Table 9.23.11.4.**

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	2.02	Worst Case	w =	11.7	m
Smax =	1.68	Site Class C	l =	11.8	m
HWP =	0.57	kPa	Stud spacing =	600	mm
S =	0.70	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.1	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	No	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(4) **SEISMIC**

$L_s = L_{us} \times [K_{weight} \times K_{snow}] \times [K_{Sspacing} \times K_{Snumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Walls)

L_{us} =	8.22 m	**WSP-B**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.82	space between braced walls approx. 5.9 m
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**8.96 m**	

Front to Back Direction (Interior Party Walls)

L_{us} =	5.87 m	**WSP-E**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.82	space between braced walls approx. 5.9 m
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1.2	walls are blocked but not sheathed on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**7.68 m**	

Left to Right Direction (Exterior Back)

L_{us} =	5.87 m	**WSP-F**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.81	space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**6.32 m**	

Left to Right Direction (Exterior Front)

L_{us} =	5.87 m	**WSP-F**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.81	space between braced walls approx. 5.8 m (average)

$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 6.32 m

Left to Right Direction (Interior)
L_{us} = 5.87 m **WSP-F**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.81 space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 6.32 m

Second Storey

Front to Back Direction (Exterior Walls)
L_{us} = 5.31 m **WSP-B**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.82 space between braced walls approx. 5.9 m
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 5.79 m

Front to Back Direction (Interior Party Walls)
L_{us} = 5.31 m **WSP-B**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.82 space between braced walls approx. 5.9 m
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1.2 walls are blocked but not sheathed on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 6.95 m

Left to Right Direction (Exterior Back)
L_{us} = 3.79 m **WSP-F**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.81 space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 4.08 m

Left to Right Direction (Exterior Front)
L_{us} = 5.87 m **WSP-F**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa

$K_{Sspacing}$ = 0.81 space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 6.32 m

Left to Right Direction (Interior)
L_{us} = 3.79 m **WSP-F**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.81 space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 4.08 m

Third Storey

Front to Back Direction (Exterior Walls)
L_{us} = 2.4 m **WSP-B**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.82 space between braced walls approx. 5.9 m
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 2.62 m

Front to Back Direction (Interior Party Walls)
L_{us} = 8.42 m **GWB-C**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.82 space between braced walls approx. 5.9 m
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are blocked but not sheathed on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 9.18 m

Left to Right Direction (Exterior Back)
L_{us} = 1.72 m **WSP-F**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.81 space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 1.85 m

Left to Right Direction (Exterior Front)
L_{us} = 1.72 m **WSP-F**
K_{weight} = 1 normal weight

K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.81	space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 1.85 m

Left to Right Direction (Interior)

L_{us} =	4.57 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.81	space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 4.92 m

9.23.6.1. **Anchorage of Building Frames**

Is HWP between 0.6 kPa and 1.2 kPa	No	
Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	Yes	Use Table 9.23.6.1.

From Table 9.23.6.1.

Framing Type Selected	**WSP-B**	
Anchor bolt size	12.7	mm
Anchor bolt spacing	0.6	m

From Table 9.23.6.1.

Framing Type Selected	**0**	
Anchor bolt size	12.7	mm
Anchor bolt spacing	0.5	m

9.23.11.4.	**Joints in Top Plates**			
	Is HWP between 0.6 kPa and 1.2 kPa		No	N/A
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6		Yes	Use Table 9.23.11.4.-A
	Table 9.23.11.4.-A			
	1.2 < and ≤ 1.6		Normal Weight	
	All floors	19 nails	For BWB Spacing of 10.6m	
		10 nails	For BWB Spacing of ≤ 7.6m	
	Table 9.23.11.4.-B			
	1.2 < and ≤ 1.6			
	1st Floor	13 nails	For BWB Spacing of 10.6m	
		7 nails	For BWB Spacing of ≤ 7.6m	
	2nd Floor	7 nails	For BWB Spacing of 10.6m	
		4 nails	For BWB Spacing of ≤ 7.6m	

Cost Differences - Whitehorse

Archetype	Stacked Town
No. Storeys =	3
Construction =	Light
w =	11.7 m
l =	11.8 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.1 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

Floor Level	Braced Wall Panel	Base Scenario: Existing NBC 2020 Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	1030	EXT-W26400-9.5OSB	$149.69 /m	$ 154.18
	BWP2	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP3	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP4	2600	EXT-W26400-9.5OSB	$149.69 /m	$ 389.18
	BWP5	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP6	1500	EXT-W26400-9.5OSB	$149.69 /m	$ 224.53
	BWP7	775	EXT-W26400-9.5OSB	$149.69 /m	$ 116.01
	BWP8	1605	EXT-W26400-9.5OSB	$149.69 /m	$ 240.25
	BWP9	3950	INT-W26600-B	$124.87 /m	$ 493.25
	BWP10	750	INT-W26600-B	$124.87 /m	$ 93.65
	BWP11	600	INT-W26600-B	$124.87 /m	$ 74.92
	BWP12	1720	INT-W26600-B	$124.87 /m	$ 214.78
2nd Flr	BWP13	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP14	720	EXT-W26400-9.5OSB	$149.69 /m	$ 107.77
	BWP15	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP16	1500	EXT-W26400-9.5OSB	$149.69 /m	$ 224.53
	BWP17	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP18	890	EXT-W26400-9.5OSB	$149.69 /m	$ 133.22
	BWP19	1470	INT-W26600-B	$124.87 /m	$ 183.56
	BWP20	750	INT-W26600-B	$124.87 /m	$ 93.65
	BWP21	600	INT-W26600-B	$124.87 /m	$ 74.92
	BWP22	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP23	600	INT-W26600-B	$124.87 /m	$ 74.92
	BWP24	890	INT-W26600-B	$124.87 /m	$ 111.14
3rd Flr	BWP25	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP26	720	EXT-W26400-9.5OSB	$149.69 /m	$ 107.77
	BWP27	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP28	1500	EXT-W26400-9.5OSB	$149.69 /m	$ 224.53
	BWP29	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP30	890	EXT-W26400-9.5OSB	$149.69 /m	$ 133.22
	BWP31	1470	INT-W26600	$116.08 /m	$ 170.64
	BWP32	750	INT-W26600	$116.08 /m	$ 87.06
	BWP33	600	INT-W26600	$116.08 /m	$ 69.65
	BWP34	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP35	735	INT-W26600	$116.08 /m	$ 85.32
	BWP36	750	INT-W26600	$116.08 /m	$ 87.06
All Flrs	Extra 12.7 Gypsur	-12660	Extra Gypsum Board	$ 34.92 /m	$ (442.07)
					$ 4,538.05

Floor Level	Braced Wall Panel	Scenario B: Updated Seismic Values and New Lateral Loads Provisions Length	BWP Type	BWP Unit Cost	BWP Cost	Difference b/w Base and Scenario B
1st Flr	BWP1	775	2020 WSP-B	$ 161.84 /m	$ 125.43	$ (28.75)
	BWP2	750	EXT-W26600	$155.18 /m	$ 116.38	$ 4.12
	BWP3	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP4	2600	2020 WSP-A	$ 149.69 /m	$ 389.18	$ -
	BWP5	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP6	2050	2020 WSP-A	$ 149.69 /m	$ 306.86	$ 82.33
	BWP7	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ (18.90)
	BWP8	775	2020 WSP-B	$ 161.84 /m	$ 125.43	$ (114.82)
	BWP9	5550	GWB-D Interior	$ 97.75 /m	$ 542.52	$ 49.27
	BWP10	750	GWB-D Interior	$ 97.75 /m	$ 73.31	$ (20.34)
	BWP11	600	GWB-D Interior	$ 97.75 /m	$ 58.65	$ (16.27)
	BWP12	1995	GWB-D Interior	$ 97.75 /m	$ 195.01	$ (19.77)
2nd Flr	BWP13	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP14	720	2020 WSP-A	$ 149.69 /m	$ 107.77	$ -
	BWP15	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP16	2075	2020 WSP-A	$ 149.69 /m	$ 310.60	$ 86.07
	BWP17	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP18	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ (11.84)
	BWP19	2745	GWB-D Interior	$ 97.75 /m	$ 268.33	$ 84.76
	BWP20	750	GWB-D Interior	$ 97.75 /m	$ 73.31	$ (20.34)
	BWP21	600	GWB-D Interior	$ 97.75 /m	$ 58.65	$ (16.27)
	BWP22	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP23	600	2020 WSP-B-Interior	$ 155.52 /m	$ 93.31	$ 18.39
	BWP24	750	2020 WSP-B-Interior	$ 155.52 /m	$ 116.64	$ 5.51
3rd Flr	BWP25	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP26	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (17.96)
	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP28	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (134.72)
	BWP29	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP30	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ (11.84)
	BWP31	4250	GWB-A Interior	$ 81.17 /m	$ 344.95	$ 174.31
	BWP32	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ 10.34
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ 27.75
	BWP34	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ 12.08
	BWP36	750	2020 WSP-A-Interior	$ 155.59 /m	$ 116.70	$ 29.63
1st Flr	Extra 11 mm OSB	3462	Extra 11 mm OSB	$ 30.70 /m	$ 106.27	$ 106.27
2nd Flr	Extra 11 mm OSB	7057	Extra 11 mm OSB	$ 30.70 /m	$ 216.63	$ 216.63
3rd Flr	Extra 11 mm OSB	1544	Extra 11 mm OSB	$ 30.70 /m	$ 47.40	$ 47.40
All Flrs	Extra 12.7 Gypsum	3300	Extra Gypsum Board	$ 34.92 /m	$ 115.23	$ 557.30
					$ 5,669.45	$ 1,131.40

Total Cost Increase relative to Base Case and Scenario A	$ 1,131.40
Percent Cost Increase relative to Base Case and Scenario A	25%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020 Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	21	$ 6.13 Ea.	$ 128.73

Scenario B: 2020 NBC Smax (Worst Case) Spacing (mm)	Number	Unit Cost	Cost	Difference b/w Base and Scenario B
800/1400/2400	28	$ 6.13 Ea.	$ 171.64	$ 42.91
				33%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020 No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	2	28	$ 0.10	$ 2.80
2nd Floor Framing	13	2	26	$ 0.10	$ 2.60
3rd Floor Framing	13	2	26	$ 0.10	$ 2.60
			54		$ 8.00

	Scenario B: 2020 NBC Smax (Worst Case) No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	Difference b/w Base and Scenario B
1st Floor Framing	14	12	168	$ 0.10	$ 16.80	
2nd Floor Framing	13	12	156	$ 0.10	$ 15.60	$ 13.00
3rd Floor Framing	13	6	78	$ 0.10	$ 7.80	$ 5.20
			246		$ 40.20	

Base Case Total Cost	$ 4,674.78

Average Cost of Housing Construction in Whitehorse
$ 468,800.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Total Cost	$ 5,881.29
Total Percent Increase Relative to Base Case (Existing Code)	26%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	26%
Percent Increase in Base Case Home Construction	0.3%

Code Analysis - Whitehorse

Archetype	Stacked Town	
No. Storeys =	3	
Construction =	Light	
w =	11.7	m
l =	11.8	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.1	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.334	
HWP =	0.38	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		0.25
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		Use OSB wall sheathing
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nails Supporting 1 floor	
	2nd Floor 1 nails Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.47

HWP = 0.38 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**	
	Does the Article apply? Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	-
	% braced walls - 1st Floor	-
	% braced walls - bsmt	-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	- m
	Maximum distance between required braced wall panels measured from the edges of the panels	- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	- mm
9.23.13.6.	**Materials in Braced Wall Panels**	
	Is Sa(0.2) less than or equal to 0.9? Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm

Use OSB wall sheathing

Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**		
	Does Table 9.23.3.5.-A govern design?		Yes
	Does Table 9.23.3.5.-B govern design?		No
	Does Table 9.23.3.5.-C govern design?		No
	Braced Wall Panel Type		**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**		
	Anchor bolt size	12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing	2.4 m	
9.23.11.4.	**Joints in Top Plates**		
	Top Plate Connections		
	1st Floor 1 nail	Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail	Supporting 0 floors	Using Table 9.23.11.4.-2015

<u>Scenario B - Post Public Review</u>

<u>2020 NBC and 2020 NBC Seismic Hazard Values</u>

Smax =	0.70	Worst Case	w =	11.7	m
Smax =	0.41	Site Class C	l =	11.8	m
HWP =	0.38	kPa	Stud spacing =	600	mm
S =	1.00	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.1	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(4) **SEISMIC**

Braced Wall Panel Lengths

$L_s = L_{us} \times [K_{weight} \times K_{snow}] \times [K_{Sspacing} \times K_{Snumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Walls)

L_{us} =	4.81 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.82	space between braced walls approx. 5.9 m
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**5.25 m**	

Front to Back Direction (Interior Party Walls)

L_{us} =	4.81 m	**GWB-D**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.82	space between braced walls approx. 5.9 m
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1.2	walls are blocked but not sheathed on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**6.29 m**	

Left to Right Direction (Exterior Back)

L_{us} =	2.53 m	**WSP-B**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.81	space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_s =	**2.73 m**	

Left to Right Direction (Exterior Front)

L_{us} =	2.53 m	**WSP-B**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa

$K_{Sspacing}$ = 0.81 space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 2.73 m

Left to Right Direction (Interior)
L_{us} = 4.81 m **WSP-A**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.81 space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 5.18 m

Second Storey

Front to Back Direction (Exterior Walls)
L_{us} = 3.11 m **WSP-A**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.82 space between braced walls approx. 5.9 m
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 3.39 m

Front to Back Direction (Interior Party Walls)
L_{us} = 3.11 m **GWB-D**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.82 space between braced walls approx. 5.9 m
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1.2 walls are blocked but not sheathed on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 4.07 m

Left to Right Direction (Exterior Back)
L_{us} = 1.63 m **WSP-B**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa
$K_{Sspacing}$ = 0.81 space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ = 1.33 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_s = 1.76 m

Left to Right Direction (Exterior Front)
L_{us} = 1.63 m **WSP-B**
K_{weight} = 1 normal weight
K_{snow} = 1 roof snow load less than 2 kPa

$K_{Sspacing}$ =	0.81	space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 1.76 m

Left to Right Direction (Interior)

L_{us} =	1.63 m	**WSP-B**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.81	space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 1.76 m

Third Storey

Front to Back Direction (Exterior Walls)

L_{us} =	1.41 m	**WSP-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.82	space between braced walls approx. 5.9 m
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 1.54 m

Front to Back Direction (Interior Party Walls)

L_{us} =	6.06 m	**GWB-A**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.82	space between braced walls approx. 5.9 m
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 6.61 m

Left to Right Direction (Exterior Back)

L_{us} =	0.74 m	**WSP-B**
K_{weight} =	1	normal weight
K_{snow} =	1	roof snow load less than 2 kPa
$K_{Sspacing}$ =	0.81	space between braced walls approx. 5.8 m (average)
$K_{Snumber}$ =	1.33	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed

L_s = 0.80 m

Left to Right Direction (Exterior Front)

L_{us} =	0.74 m	**WSP-B**
K_{weight} =	1	normal weight

	K_{snow} =	1	roof snow load less than 2 kPa
	$K_{Sspacing}$ =	0.81	space between braced walls approx. 5.8 m (average)
	$K_{Snumber}$ =	1.33	3 braced wall bands
	K_{gyp} =	1	walls are sheathing on the interior with gypsum
	K_{sheath} =	1	walls are continuously wood sheathed
	L_s =	**0.80 m**	

Left to Right Direction (Interior)

L_{us} =	3.03 m	**GWB-A**	6.06/2
K_{weight} =	1	normal weight	
K_{snow} =	1	roof snow load less than 2 kPa	
$K_{Sspacing}$ =	0.81	space between braced walls approx. 5.8 m (average)	
$K_{Snumber}$ =	1.33	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_s =	**3.26 m**		

9.23.6.1. **Anchorage of Building Frames**

Is HWP greater than 1.2 kPa	No	If "No" to both then use Table 9.23.6.1.
Is Smax greater than 2.6?	No	Use 9.23.6.1.(2)(b)

<u>From Table 9.23.6.1.</u>

Framing Type Selected	**WSP-A**	
Anchor bolt size		12.7 mm
Anchor bolt spacing		0.8 m

<u>From Table 9.23.6.1.</u>

Framing Type Selected	**WSP-A**	
Anchor bolt size		12.7 mm
Anchor bolt spacing		0.7 m

9.23.11.4. **Joints in Top Plates**

Is HWP less than or equal to 1.2 kPa	Yes	Use Table 9.23.11.4.-B
Is Smax for Site Class C less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A

Table 9.23.11.4.-A

<u>≤ 0.6</u>		Normal Weight	
All floors	6 nails	For BWB Spacing of 10.6m	
	3 nails	For BWB Spacing of ≤ 7.6m	

Table 9.23.11.4.-B

<u>0.3 < and ≤ 0.4</u>		Normal Weight	
1st Floor	9 nails	For BWB Spacing of 10.6m	Wind Governs
	5 nails	For BWB Spacing of ≤ 7.6m	
2nd Floor	5 nails	For BWB Spacing of 10.6m	
	3 nails	For BWB Spacing of ≤ 7.6m	

Cost Differences - Lethbridge

Archetype	Stacked Town
No. Storeys =	3
Construction =	Light
w =	11.7 m
l =	11.8 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.1 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020			
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	870	EXT-W26400-9.5OSB	$149.69 /m	$ 130.23
	BWP2	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP3	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP4	3750	EXT-W26400-9.5OSB	$149.69 /m	$ 561.32
	BWP5	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP6	5500	EXT-W26400-9.5OSB	$149.69 /m	$ 823.27
	BWP7	625	EXT-W26400-9.5OSB	$149.69 /m	$ 93.55
	BWP8	1605	EXT-W26400-9.5OSB	$149.69 /m	$ 240.25
	BWP9	5450	INT-W26600-B	$124.87 /m	$ 680.56
	BWP10	750	INT-W26600-B	$124.87 /m	$ 93.65
	BWP11	600	INT-W26600-B	$124.87 /m	$ 74.92
	BWP12	2095	INT-W26600-B	$124.87 /m	$ 261.61
2nd Flr	BWP13	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP14	720	EXT-W26400-9.5OSB	$149.69 /m	$ 107.77
	BWP15	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP16	4825	EXT-W26400-9.5OSB	$149.69 /m	$ 722.23
	BWP17	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP18	790	EXT-W26400-9.5OSB	$149.69 /m	$ 118.25
	BWP19	6020	INT-W26600-B	$124.87 /m	$ 751.73
	BWP20	750	INT-W26600-B	$124.87 /m	$ 93.65
	BWP21	600	INT-W26600-B	$124.87 /m	$ 74.92
	BWP22	800	EXT-W26400-9.5OSB	$149.69 /m	$ 119.75
	BWP23	600	INT-W26600-B	$124.87 /m	$ 74.92
	BWP24	790	INT-W26600-B	$124.87 /m	$ 98.65
3rd Flr	BWP25	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP26	720	EXT-W26400-9.5OSB	$149.69 /m	$ 107.77
	BWP27	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP28	1125	EXT-W26400-9.5OSB	$149.69 /m	$ 168.40
	BWP29	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP30	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP31	3265	INT-W26600	$116.08 /m	$ 379.01
	BWP32	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP33	2525	INT-W26600	$116.08 /m	$ 293.11
	BWP34	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP35	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP36	750	INT-W26600	$116.08 /m	$ 87.06
All Flrs	Extra 12.7 Gypsur	-6990	Extra Gypsum Board	$ 34.92 /m	$ (244.08)
				Total	$ 7,223.96

		Scenario B: Updated Seismic Values and New Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	870	2020 WSP-C	$ 168.01 /m	$ 146.17	$ 15.94
	BWP2	750	2020 WSP-C	$ 168.01 /m	$ 126.01	$ 13.74
	BWP3	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 11.00
	BWP4	3750	2020 WSP-A	$ 149.69 /m	$ 561.32	$ -
	BWP5	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP6	5500	2020 WSP-A	$ 149.69 /m	$ 823.27	$ -
	BWP7	625	2020 WSP-C	$ 168.01 /m	$ 105.01	$ 11.45
	BWP8	1605	2020 WSP-C	$ 168.01 /m	$ 269.66	$ 29.41
	BWP9	5450	2020 WSP-B-Interior	$ 155.52 /m	$ 847.61	$ 167.05
	BWP10	750	2020 WSP-B-Interior	$ 155.52 /m	$ 116.64	$ 22.99
	BWP11	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$ 18.43
	BWP12	2095	2020 WSP-A-Interior	$ 155.59 /m	$ 325.97	$ 64.36
2nd Flr	BWP13	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 11.00
	BWP14	720	2020 WSP-A	$ 149.69 /m	$ 107.77	$ -
	BWP15	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP16	4825	2020 WSP-A	$ 149.69 /m	$ 722.23	$ -
	BWP17	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 11.00
	BWP18	790	2020 WSP-C	$ 168.01 /m	$ 132.73	$ 14.48
	BWP19	6020	GWB-D Interior	$ 97.75 /m	$ 588.46	$ (163.27)
	BWP20	750	GWB-D Interior	$ 97.75 /m	$ 73.31	$ (20.34)
	BWP21	600	GWB-D Interior	$ 97.75 /m	$ 58.65	$ (16.27)
	BWP22	800	2020 WSP-C	$ 168.01 /m	$ 134.41	$ 14.66
	BWP23	600	2020 WSP-C-Interior	$ 161.69 /m	$ 97.02	$ 22.09
	BWP24	790	2020 WSP-C-Interior	$ 161.69 /m	$ 127.74	$ 29.09
3rd Flr	BWP25	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 11.00
	BWP26	720	2020 WSP-A	$ 149.69 /m	$ 107.77	$ -
	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP28	1125	2020 WSP-A	$ 149.69 /m	$ 168.40	$ -
	BWP29	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 11.00
	BWP30	750	2020 WSP-C	$ 168.01 /m	$ 126.01	$ 13.74
	BWP31	3265	GWB-A Interior	$ 81.17 /m	$ 265.00	$ (114.01)
	BWP32	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP33	2525	GWB-A Interior	$ 81.17 /m	$ 204.94	$ (88.17)
	BWP34	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 11.00
	BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP36	750	2020 WSP-A-Interior	$ 155.59 /m	$ 116.70	$ 29.63
1st Flr	Extra 11 mm OSB	3462	Extra 11 mm OSB	$ 30.70 /m	$ 106.27	$ 106.27
2nd Flr	Extra 11 mm OSB	3587	Extra 11 mm OSB	$ 30.70 /m	$ 110.11	$ 110.11
3rd Flr	Extra 11 mm OSB	1394	Extra 11 mm OSB	$ 30.70 /m	$ 42.79	$ 42.79
All Flrs	Extra 12.7 Gypsum	1950	Extra Gypsum Board	$ 34.92 /m	$ 68.09	$ 312.17
				Total	$ 7,842.50	$ 618.54
		Total Cost Increase relative to Base Case (Existing Code)			$ 618.54	
		Percent Cost Increase relative to Base Case (Existing Code)			9%	

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020			
	Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	21	$ 6.13 Ea.	$ 128.73

Scenario B: 2020 NBC Smax (Worst Case)				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
800/1400/2400	33	$ 6.13 Ea.	$ 202.29	$ 73.56
				57%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020				
	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	2	28	$ 0.10	$ 2.80
2nd Floor Framing	13	2	26	$ 0.10	$ 2.60
3rd Floor Framing	13	2	26	$ 0.10	$ 2.60
			54		$ 8.00

	Scenario B: 2020 NBC Smax (Worst Case)					Difference b/w Base and Scenario B
	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
1st Floor Framing	14	20	280	$ 0.10	$ 28.00	$ 25.20
2nd Floor Framing	13	20	260	$ 0.10	$ 26.00	$ 23.40
3rd Floor Framing	13	20	260	$ 0.10	$ 26.00	$ 23.40
			540		$ 80.00	

Base Case Total Cost	$ 7,360.69

Average Cost of Housing Construction in Lethbridge
$ 351,600.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Total Cost	$ 8,124.79
Total Percent Increase Relative to Base Case (Existing Code)	10%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	10%
Percent Increase from Base Case Home Construction	0.2%

Code Analysis - Lethbridge

Archetype	Stacked Town	
No. Storeys =	3	
Construction =	Light	
w =	11.7	m
l =	11.8	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.1	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.09	
HWP =	0.78	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**			
	Does the Article apply?	Yes		
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-	
	Does the Article apply?	No		
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-	
	Does the Article apply?	No		
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**			
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No	
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No	
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No	
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**			
	% braced walls - 3rd Floor		0.25	
	% braced walls - 2nd Floor		-	
	% braced walls - 1st Floor		-	
	% braced walls - bsmt		-	
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		-	m
	Maximum distance between required braced wall panels measured from the edges of the panels		-	m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		-	m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		-	mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		-	mm
9.23.13.6.	**Materials in Braced Wall Panels**			
	Is Sa(0.2) less than or equal to 0.9?	Yes	Use OSB wall sheathing	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**		
	Does Table 9.23.3.5.-A govern design?		Yes
	Does Table 9.23.3.5.-B govern design?		No
	Does Table 9.23.3.5.-C govern design?		No
	Braced Wall Panel Type		**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**		
	Anchor bolt size	12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing	2.4 m	
9.23.11.4.	**Joints in Top Plates**		
	Top Plate Connections		
	1st Floor — 1 nails	Supporting 1 floor	
	2nd Floor — 1 nails	Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.19

HWP = 0.78 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm

Use OSB wall sheathing

Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	0.31	Worst Case	w =	11.7	m
Smax =	0.15	Site Class C	l =	11.8	m
HWP =	0.78	kPa	Stud spacing =	600	mm
S =	2.01	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.1	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750	mm
	Minimum length of individual gypsum board-sheathed braced wall panels:		
	• gypsum board installed on both faces of braced wall panel	1.2	m
	• gypsum board installed on one face of braced wall panel	2.4	m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2	m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.	

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	10.7 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**9.83 m**	

Front to Back Direction (Interior Party Walls)

L_{uw} =	5.62 m	**WSP-B**
K_{exp} =	1	for suburban
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1.2	walls are blocked but not sheathed on interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**6.19 m**	

Left to Right Direction (Exterior Back Wall)

L_{uw} =	4.89 m	**WSP-C**
K_{exp} =	1	for suburban
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**4.43 m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} =	4.89 m	**WSP-C**
K_{exp} =	1	for suburban
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m

$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**4.43 m**	

Left to Right Direction (Interior Walls)

L_{uw} =	5.94 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**5.39 m**	

Second Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	7.06 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.87	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**6.13 m**	

Front to Back Direction (Interior Party Walls)

L_{uw} =	7.06 m	**GWB-D**
K_{exp} =	1	for suburban
K_{roof} =	0.87	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are blocked but no gypsum sheathing on interior
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**6.13 m**	

Left to Right Direction (Exterior Back Wall)

L_{uw} =	3.23 m	**WSP-C**
K_{exp} =	1	for suburban
K_{roof} =	0.87	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**2.77 m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} =	3.23 m	**WSP-C**
K_{exp} =	1	for suburban
K_{roof} =	0.87	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m

$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.77**	**m**	

Left to Right Direction (Interior Walls)

L_{uw} =	3.23	m	**WSP-C**
K_{exp} =	1	for suburban	
K_{roof} =	0.87	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.77**	**m**	

Third Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	3.43	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.43**	**m**	

Front to Back Direction (Interior Party Walls)

L_{uw} =	9.86	m	**GWB-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**6.99**	**m**	

Left to Right Direction (Exterior Back Wall)

L_{uw} =	1.57	m	**WSP-C**
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**1.10**	**m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} =	1.57	m	**WSP-C**
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	

	$K_{Wnumber}$ = 1.28 3 braced wall bands K_{gyp} = 1 walls are sheathing on the interior with gypsum K_{sheath} = 1 walls are continuously wood sheathed **L_w = 1.10 m** Left to Right Direction (Interior Wall) L_{uw} = 4.93 m **GWB-A** 9.86/2 K_{exp} = 1 for suburban K_{roof} = 0.71 for roof eave to ridge of 2.1 m < 3 m $K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m $K_{Wnumber}$ = 1.28 3 braced wall bands K_{gyp} = 1 walls are sheathing on the interior with gypsum K_{sheath} = 1 walls are continuously wood sheathed **L_w = 3.45 m**		
9.23.6.1.	**Anchorage of Building Frames** Is HWP between 0.6 kPa and 1.2 kPa Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6 From Table 9.23.6.1. Framing Type Selected **WSP-B** Anchor bolt size 12.7 mm Anchor bolt spacing 0.8 m From Table 9.23.6.1. Framing Type Selected **WSP-B** Anchor bolt size 12.7 mm Anchor bolt spacing 0.7 m	 Yes No	 Use Table 9.23.6.1.
9.23.11.4.	**Joints in Top Plates** Is HWP between 0.6 kPa and 1.2 kPa Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6 Table 9.23.11.4.-A 0.6 < and ≤ 0.8 Normal Weight All floors 4 nails For BWB Spacing of 10.6m 2 For BWB Spacing of ≤ 7.6m Table 9.23.11.4.-B 0.6 < and ≤ 0.9 Normal Weight 1st Floor 20 nails For BWB Spacing of 10.6m **10 nails** For BWB Spacing of ≤ 7.6m 2nd Floor 15 nails For BWB Spacing of 10.6m **8 nails** For BWB Spacing of ≤ 7.6m	 Yes No	 Use Table 9.23.11.4.-B N/A Wind governs

Cost Differences - Ottawa

Archetype	Stacked Town
No. Storeys =	3
Construction =	Light
w =	11.7 m
l =	11.8 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.1 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020			
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	830	EXT-W26400-9.5OSB	$149.69 /m	$ 124.24
	BWP2	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP3	2600	EXT-W26400-9.5OSB	$149.69 /m	$ 389.18
	BWP4	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP5	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP6	2260	EXT-W26400-9.5OSB	$149.69 /m	$ 338.29
	BWP7	775	EXT-W26400-9.5OSB	$149.69 /m	$ 116.01
	BWP8	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP9	5350	INT-W26600-B	$124.87 /m	$ 668.07
	BWP10	1200	INT-W26600-B	$124.87 /m	$ 149.85
	BWP11	975	INT-W26600-B	$124.87 /m	$ 121.75
	BWP12	1720	INT-W26600-B	$124.87 /m	$ 214.78
2nd Flr	BWP13	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP14	720	EXT-W26400-9.5OSB	$149.69 /m	$ 107.77
	BWP15	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP16	2100	EXT-W26400-9.5OSB	$149.69 /m	$ 314.34
	BWP17	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP18	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP19	4240	INT-W26600-B	$124.87 /m	$ 529.46
	BWP20	1525	INT-W26600-B	$124.87 /m	$ 190.43
	BWP21	1200	INT-W26600-B	$124.87 /m	$ 149.85
	BWP22	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP22b	1025	EXT-W26400-9.5OSB	$149.69 /m	
	BWP23	600	INT-W26600-B	$124.87 /m	$ 74.92
	BWP24	750	INT-W26600-B	$124.87 /m	$ 93.65
3rd Flr	BWP25	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP26	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP27	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP28	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP29	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP30	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP31	1740	INT-W26600	$116.08 /m	$ 201.99
	BWP32	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP33	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP34	600	EXT-W26400-9.5OSB	$149.69	$ 89.81
	BWP35	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP36	750	INT-W26600	$116.08 /m	$ 87.06
All Flrs	Extra 12.7 Gypsun	-11105	Extra Gypsum Board	$ 34.92 /m	$ (387.77)
					$ 5,406.12

		Scenario B: Updated Seismic Values and New Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	830	2020 WSP-A	$ 149.69 /m	$ 124.24	$ -
	BWP2	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP3	2600	2020 WSP-A	$ 149.69 /m	$ 389.18	$ -
	BWP4	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP5	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP6	2260	2020 WSP-A	$ 149.69 /m	$ 338.29	$ -
	BWP7	775	2020 WSP-B	$ 161.84 /m	$ 125.43	$ 9.42
	BWP8	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP9	5350	GWB-D Interior	$ 97.75 /m	$ 522.97	$ (145.10)
	BWP10	1200	GWB-D Interior	$ 97.75 /m	$ 117.30	$ (32.55)
	BWP11	975	GWB-D Interior	$ 97.75 /m	$ 95.31	$ (26.44)
	BWP12	1720	GWB-D Interior	$ 97.75 /m	$ 168.13	$ (46.65)
2nd Flr	BWP13	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP14	720	2020 WSP-A	$ 149.69 /m	$ 107.77	$ -
	BWP15	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP16	2100	2020 WSP-A	$ 149.69 /m	$ 314.34	$ -
	BWP17	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP18	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP19	4240	GWB-B Interior	$ 95.53 /m	$ 405.07	$ (124.40)
	BWP20	1525	GWB-B Interior	$ 95.53 /m	$ 145.69	$ (44.74)
	BWP21	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ (35.21)
	BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP22b	1025	2020 WSP-A	$ 149.69		
	BWP23	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$ 18.43
	BWP24	750	2020 WSP-A-Interior	$ 155.59 /m	$ 116.70	$ 23.04
3rd Flr	BWP25	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP26	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP28	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP29	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP30	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP31	1740	GWB-A Interior	$ 81.17 /m	$ 141.23	$ (60.76)
	BWP32	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP34	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP36	750	2020 WSP-A-Interior	$ 155.59 /m	$ 116.70	$ 29.63
1st Flr	Extra 11 mm OSB	3112	Extra 11 mm OSB	$ 30.70 /m	$ 95.53	$ 95.53
2nd Flr	Extra 11 mm OSB	2812	Extra 11 mm OSB	$ 30.70 /m	$ 86.32	$ 86.32
3rd Flr	Extra 11 mm OSB	1997	Extra 11 mm OSB	$ 30.70 /m	$ 61.30	$ 61.30
All Flrs	Extra 12.7 Gypsum	3300	Extra Gypsum Board	$ 34.92 /m	$ 115.23	$ 503.00
					$ 5,633.20	**$ 227.08**

Total Cost Increase relative to Base Case and Scenario A	$ 227.08
Percent Cost Increase relative to Base Case and Scenario A	4%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020			
	Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	21	$ 6.13 Ea.	$ 128.73

Scenario B: 2020 NBC Smax (Worst Case)				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
800/1400/2400	28	$ 6.13 Ea.	$ 171.64	**$ 42.91**
				33%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020				
	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	2	28	$ 0.10	$ 2.80
2nd Floor Framing	13	2	26	$ 0.10	$ 2.60
3rd Floor Framing	13	2	26	$ 0.10	$ 2.60
			54		**$ 8.00**

	Scenario B: 2020 NBC Smax (Worst Case)					Difference b/w Base and Scenario B
	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
1st Floor Framing	14	12	168	$ 0.10	$ 16.80	$ 14.00
2nd Floor Framing	13	12	156	$ 0.10	$ 15.60	$ 13.00
3rd Floor Framing	13	6	78	$ 0.10	$ 7.80	$ 5.20
			246		**$ 40.20**	

Base Case Total Cost	$ 5,542.85

Average Cost of Housing Construction in Ottawa
$ 398,480.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Total Cost	$ 5,845.04
Total Percent Increase Relative to Base Case (Existing Code)	5%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	5%
Percent Increase in Base Case Home Construction	0.1%

Code Analysis - Ottawa

Archetype	Stacked Town	
No. Storeys =	3	
Construction =	Light	
w =	11.7	m
l =	11.8	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.1	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.439	
HWP =	0.41	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		0.25
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		Use OSB wall sheathing
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nails Supporting 1 floor	
	2nd Floor 1 nails Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.66

HWP = 0.41 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**	
	Does the Article apply? Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	-
	% braced walls - 1st Floor	-
	% braced walls - bsmt	-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	- m
	Maximum distance between required braced wall panels measured from the edges of the panels	- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	- mm
9.23.13.6.	**Materials in Braced Wall Panels**	
	Is Sa(0.2) less than or equal to 0.9? Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm

Use OSB wall sheathing

Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	0.60	Worst Case	w =	11.7	m
Smax =	0.44	Site Class C	l =	11.8	m
HWP =	0.41	kPa	Stud spacing =	600	mm
S =	1.48	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.1	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A

9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	10.6	m
	Maximum distance between required braced wall panels measured from the edges of the panels	6.4	m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	2.4	m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600	mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$$

First Storey

Front to Back Direction (Exterior Walls)

L_{uw} = 5.94 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.92 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.78 space between braced walls approx. 5.9 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 5.46 m

Front to Back Direction (Interior Party Walls)

L_{uw} = 5.94 m **GWB-D**
K_{exp} = 1 for suburban
K_{roof} = 0.92 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.78 space between braced walls approx. 5.9 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1.2 walls are blocked but not sheathed on interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 6.55 m

Left to Right Direction (Exterior Back Wall)

L_{uw} = 3.12 m **WSP-B**
K_{exp} = 1 for suburban
K_{roof} = 0.92 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 2.83 m

Left to Right Direction (Exterior Front Wall)

L_{uw} = 3.12 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.92 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m

$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 2.83 m

Left to Right Direction (Interior Walls)
L_{uw} = 5.94 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.92 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 5.39 m

Second Storey

Front to Back Direction (Exterior Walls)
L_{uw} = 3.92 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.78 space between braced walls approx. 5.9 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 3.40 m

Front to Back Direction (Interior Party Walls)
L_{uw} = 6.54 m **GWB-B**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.78 space between braced walls approx. 5.9 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 5.68 m

Left to Right Direction (Exterior Back Wall)
L_{uw} = 2.06 m **WSP-B**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 1.77 m

Left to Right Direction (Exterior Front Wall)
L_{uw} = 3.92 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m

$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 3.36 m

Left to Right Direction (Interior Walls)
L_{uw} = 3.92 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 3.36 m

Third Storey

Front to Back Direction (Exterior Walls)
L_{uw} = 1.9 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.71 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.78 space between braced walls approx. 5.9 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 1.35 m

Front to Back Direction (Interior Party Walls)
L_{uw} = 5.84 m **GWB-A**
K_{exp} = 1 for suburban
K_{roof} = 0.71 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.78 space between braced walls approx. 5.9 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 4.14 m

Left to Right Direction (Exterior Back Wall)
L_{uw} = 1 m **WSP-B**
K_{exp} = 1 for suburban
K_{roof} = 0.71 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 0.70 m

Left to Right Direction (Exterior Front Wall)
L_{uw} = 1.9 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.71 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m

$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 1.33 m

Left to Right Direction (Interior Wall)

L_{uw} =	2.92	m	**GWB-A**	5.84/2
K_{exp} =	1	for suburban		
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m		
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m		
$K_{Wnumber}$ =	1.28	3 braced wall bands		
K_{gyp} =	1	walls are sheathing on the interior with gypsum		
K_{sheath} =	1	walls are continuously wood sheathed		

L_w = 2.04 m

9.23.6.1.	**Anchorage of Building Frames**		
	Is HWP greater than 1.2 kPa	No	If "No" to both then use Table 9.23.6.1.
	Is Smax greater than 2.6?	No	Use 9.23.6.1.(2)(b)

From Table 9.23.6.1.
Framing Type Selected **WSP-A**
Anchor bolt size 12.7 mm
Anchor bolt spacing 0.8 m

From Table 9.23.6.1.
Framing Type Selected **WSP-A**
Anchor bolt size 12.7 mm
Anchor bolt spacing 0.7 m

9.23.11.4.	**Joints in Top Plates**		
	Is HWP less than or equal to 1.2 kPa	Yes	Use Table 9.23.11.4.-B
	Is Smax for Site Class C less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A

Table 9.23.11.4.-A

≤ 0.6			Normal Weight
All floors	4	nails	For BWB Spacing of 10.6m
	2		For BWB Spacing of ≤ 7.6m

Table 9.23.11.4.-B

0.4 < and ≤ 0.5			Normal Weight
1st Floor	11	nails	For BWB Spacing of 10.6m
	6	**nails**	For BWB Spacing of ≤ 7.6m
2nd Floor	6	nails	For BWB Spacing of 10.6m
	3	**nails**	For BWB Spacing of ≤ 7.6m

Cost Differences - Montreal

Archetype	Stacked Town
No. Storeys =	3
Construction =	Light
w =	11.7 m
l =	11.8 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.1 m

Braced Wall Panel Difference

Floor Level	Braced Wall Panel	Base Scenario: Existing NBC 2020 Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	830	EXT-W26400-9.5OSB	$149.69 /m	$ 124.24
	BWP2	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP3	2600	EXT-W26400-9.5OSB	$149.69 /m	$ 389.18
	BWP4	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP5	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP6	2260	EXT-W26400-9.5OSB	$149.69 /m	$ 338.29
	BWP7	775	EXT-W26400-9.5OSB	$149.69 /m	$ 116.01
	BWP8	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP9	5800	INT-W26600-B	$124.87 /m	$ 724.26
	BWP10	750	INT-W26600-B	$124.87 /m	$ 93.65
	BWP11	975	INT-W26600-B	$124.87 /m	$ 121.75
	BWP12	1720	INT-W26600-B	$124.87 /m	$ 214.78
2nd Flr	BWP13	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP14	720	EXT-W26400-9.5OSB	$149.69 /m	$ 107.77
	BWP15	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP16	2100	EXT-W26400-9.5OSB	$149.69 /m	$ 314.34
	BWP17	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP18	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP19	4240	INT-W26600-B	$124.87 /m	$ 529.46
	BWP20	1525	INT-W26600-B	$124.87 /m	$ 190.43
	BWP21	1200	INT-W26600-B	$124.87 /m	$ 149.85
	BWP22	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP22b	1025	EXT-W26400-9.5OSB	$149.69 /m	$ 153.43
	BWP23	650	INT-W26600-B	$124.87 /m	$ 81.17
	BWP24	1080	INT-W26600-B	$124.87 /m	$ 134.86
3rd Flr	BWP25	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP26	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP27	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP28	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP29	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP30	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP31	1740	INT-W26600	$116.08 /m	$ 201.99
	BWP32	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP33	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP34	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP35	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP36	750	INT-W26600	$116.08 /m	$ 87.06
All Flrs	Extra 12.7 Gypsur	-11105	Extra Gypsum Board	$ 34.92 /m	$ (387.77)
					$ 5,607.00

Floor Level	Braced Wall Panel	Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions Length	BWP Type	BWP Unit Cost	BWP Cost	Difference b/w Base and Scenario B
1st Flr	BWP1	830	2020 WSP-A	$ 149.69 /m	$ 124.24	$ -
	BWP2	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP3	2600	2020 WSP-A	$ 149.69 /m	$ 389.18	$ -
	BWP4	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP5	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP6	2260	2020 WSP-A	$ 149.69 /m	$ 338.29	$ -
	BWP7	775	2020 WSP-B	$ 161.84 /m	$ 125.43	$ 9.42
	BWP8	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP9	5800	GWB-D Interior	$ 97.75 /m	$ 566.96	$ (157.31)
	BWP10	750	GWB-D Interior	$ 97.75 /m	$ 73.31	$ (20.34)
	BWP11	975	2020 WSP-A-Interior	$ 155.59 /m	$ 151.70	$ 29.95
	BWP12	1720	2020 WSP-A-Interior	$ 155.59 /m	$ 267.62	$ 52.84
2nd Flr	BWP13	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP14	720	2020 WSP-A	$ 149.69 /m	$ 107.77	$ -
	BWP15	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP16	2100	2020 WSP-A	$ 149.69 /m	$ 314.34	$ -
	BWP17	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP18	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP19	4240	GWB-B Interior	$ 95.53 /m	$ 405.07	$ (124.40)
	BWP20	1525	GWB-B Interior	$ 95.53 /m	$ 145.69	$ (44.74)
	BWP21	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ (35.21)
	BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP22b	1025	2020 WSP-A	$ 149.69		$ (153.43)
	BWP23	650	2020 WSP-A-Interior	$ 155.59 /m	$ 101.14	$ 19.97
	BWP24	1080	2020 WSP-A-Interior	$ 155.59 /m	$ 168.04	$ 33.18
3rd Flr	BWP25	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP26	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP28	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP29	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP30	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP31	1740	GWB-A Interior	$ 81.17 /m	$ 141.23	$ (60.76)
	BWP32	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP34	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP36	750	2020 WSP-A-Interior	$ 155.59 /m	$ 116.70	$ 29.63
1st Flr	Extra 11 mm OSB	3112	Extra 11 mm OSB	$ 30.70 /m	$ 95.53	$ 95.53
2nd Flr	Extra 11 mm OSB	2752	Extra 11 mm OSB	$ 30.70 /m	$ 84.48	$ 84.48
3rd Flr	Extra 11 mm OSB	1997	Extra 11 mm OSB	$ 30.70 /m	$ 61.30	$ 61.30
All Flrs	Extra 12.7 Gypsum	3680	Extra Gypsum Board	$ 34.92 /m	$ 128.50	$ 516.27
					$ 5,859.64	**$ 252.64**

Total Cost Increase relative to Base Case (Existing Code)	$ 252.64
Percent Cost Increase relative to Base Case (Existing Code)	5%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020 Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	21	$ 6.13 Ea.	$ 128.73

	Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions Spacing (mm)	Number	Unit Cost	Cost	Difference b/w Base and Scenario B
1/2" dia. Anchor	800/1400/2400	28	$ 6.13 Ea.	$ 171.64	**$ 42.91**
					33%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020 No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	2	28	$ 0.10	$ 2.80
2nd Floor Framing	13	2	26	$ 0.10	$ 2.60
3rd Floor Framing	13	2	26	$ 0.10	$ 2.60
			54		**$ 8.00**

	Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	Difference b/w Base and Scenario B
1st Floor Framing	14	12	168	$ 0.10	$ 16.80	$ 14.00
2nd Floor Framing	13	12	156	$ 0.10	$ 15.60	$ 13.00
3rd Floor Framing	13	6	78	$ 0.10	$ 7.80	$ 5.20
			246		**$ 40.20**	

Base Case Total Cost	$ 5,743.73

Scenario B Total Cost	$ 6,071.48
Total Percent Increase Relative to Base Case (Existing Code)	6%

Average Cost of Housing Construction in Montreal
$ 386,760.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Percent Increase in Base Case Home Construction	0.1%

Cost Differences - Montreal

Archetype	Stacked Town
No. Storeys =	3
Construction =	Light
w =	11.7 m
l =	11.8 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.1 m

Braced Wall Panel Difference

NBC 2020 Provisions with Updated Seismic Hazard Values

Floor	Length	BWP Type	BWP Unit Cost	BWP Cost	Difference b/w Base and Scenario A
1st Flr	1030	2015 WSP-2	$162.18 /m	$ 167.04	
	750	2015 WSP-2	$162.18 /m	$ 121.63	
	600	2015 WSP-2	$162.18 /m	$ 97.31	
	2000	EXT-W26600	$ 155.18 /m	$ 310.35	
	2600	2015 WSP-2	$162.18 /m	$ 421.66	
	600	2015 WSP-2	$162.18 /m	$ 97.31	
	1500	2015 WSP-2	$162.18 /m	$ 243.26	
	760	EXT-W26600	$ 155.18 /m	$ 117.93	
	775	2015 WSP-2	$162.18 /m	$ 125.69	
	1605	2015 WSP-2	$162.18 /m	$ 260.29	
	3950	2015 WSP-3a-Interior	$157.62 /m	$ 622.61	
	1850	INT-W26600-B	$124.87 /m	$ 231.01	
	750	2015 WSP-3a-Interior	$157.62 /m	$ 118.22	
	600	2015 WSP-3a-Interior	$157.62 /m	$ 94.57	
	375	INT-W26600-B	$124.87 /m	$ 46.83	
	1720	2015 WSP-3a-Interior	$157.62 /m	$ 271.11	
2nd Flr	600	2015 WSP-2	$162.18 /m	$ 97.31	
	720	2015 WSP-2	$162.18 /m	$ 116.77	
	600	2015 WSP-2	$162.18 /m	$ 97.31	
	1500	2015 WSP-2	$162.18 /m	$ 243.26	
	600	EXT-W26600	$ 155.18 /m	$ 93.11	
	600	2015 WSP-2	$162.18 /m	$ 97.31	
	0	EXT-W26600	$ 155.18 /m	$ -	
	890	2015 WSP-2	$162.18 /m	$ 144.34	
	1470	2015 WSP-3a-Interior	$157.62 /m	$ 231.71	
	1490	INT-W26600-B	$124.87 /m	$ 186.06	
	750	2015 WSP-3a-Interior	$157.62 /m	$ 118.22	
	775	INT-W26600-B	$124.87 /m	$ 96.78	
	600	2015 WSP-3a-Interior	$157.62 /m	$ 94.57	
	600	INT-W26600-B	$124.87 /m	$ 74.92	
	600	2015 WSP-2	$162.18 /m	$ 97.31	
	50	EXT-W26600	$ 155.18 /m	$ 7.76	
	750	2015 WSP-2	$162.18 /m	$ 121.63	
	275	EXT-W26600	$ 155.18 /m	$ 42.67	
	600	2015 WSP-3a-Interior	$157.62 /m	$ 94.57	
	890	2015 WSP-3a-Interior	$157.62 /m	$ 140.28	
	190	INT-W26600-B	$124.87 /m	$ 23.73	
3rd Flr	600	2015 WSP-2	$162.18 /m	$ 97.31	
	720	2015 WSP-2	$162.18 /m	$ 116.77	
	600	2015 WSP-2	$162.18 /m	$ 97.31	
	1500	2015 WSP-2	$162.18 /m	$ 243.26	
	600	2015 WSP-2	$162.18 /m	$ 97.31	
	890	2015 WSP-2	$162.18 /m	$ 144.34	
	1470	2015 WSP-3a-Interior	$157.62 /m	$ 231.71	
	270	INT-W26600	$116.08 /m	$ 31.34	
	750	2015 WSP-3a-Interior	$157.62 /m	$ 118.22	
	450	INT-W26600	$116.08 /m	$ 52.24	
	600	2015 WSP-3a-Interior	$157.62 /m	$ 94.57	
	600	INT-W26600	$116.08 /m	$ 69.65	
	600	2015 WSP-3a-Interior	$157.62 /m	$ 94.57	
	735	2015 WSP-3a-Interior	$157.62 /m	$ 115.85	
	465	INT-W26600	$116.08 /m	$ 53.98	
	750	2015 WSP-3a-Interior	$157.62 /m	$ 118.22	
1st Flr	5337	Extra 11 mm OSB	$ 30.70 /m	$ 163.83	
2nd Flr	8297	Extra 11 mm OSB	$ 30.70 /m	$ 254.70	
3rd Storey	9664	Extra 11 mm OSB	$ 30.70 /m	$ 296.66	
All Flrs	-7400	Extra Gypsum Board	$ 34.92 /m	$ (258.40)	
				$ 7,799.85	

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions

Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	Difference b/w Scenario A and Scenario B
1st Flr	BWP1	830	2020 WSP-A	$ 149.69 /m	$ 124.24	$ (42.80)
		200	EXT-W26400-9.5OSB	$ 149.69 /m	$ 29.94	$ 29.94
	BWP2	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (31.82)
		150	EXT-W26400-9.5OSB	$ 149.69 /m	$ 22.45	$ 22.45
	BWP3	2600	2020 WSP-A	$ 149.69 /m	$ 389.18	$ 291.88
					$ -	$ (310.35)
	BWP4	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (331.84)
		2000	EXT-W26400-9.5OSB	$ 149.69 /m	$ 299.37	$ 299.37
	BWP5	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP6	2260	2020 WSP-A	$ 149.69 /m	$ 338.29	$ 95.03
					$ -	$ (117.93)
	BWP7	775	2020 WSP-B	$ 161.84 /m	$ 125.43	$ (0.26)
	BWP8	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ (138.91)
		855	EXT-W26400-9.5OSB	$ 149.69 /m	$ 127.98	$ 127.98
	BWP9	5800	GWB-D Interior	$ 97.75 /m	$ 566.96	$ (55.66)
					$ -	$ (231.01)
	BWP10	750	GWB-D Interior	$ 97.75 /m	$ 73.31	$ (44.90)
	BWP11	975	2020 WSP-A-Interior	$ 155.59 /m	$ 151.70	$ 57.13
					$ -	$ (46.83)
	BWP12	1720	2020 WSP-A-Interior	$ 155.59 /m	$ 267.62	$ (3.49)
2nd Flr	BWP13	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP14	720	2020 WSP-A	$ 149.69 /m	$ 107.77	$ (8.99)
	BWP15	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP16	2100	2020 WSP-A	$ 149.69 /m	$ 314.34	$ 71.08
					$ -	$ (93.11)
	BWP17	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ (0.20)
					$ -	$ -
	BWP18	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ (22.95)
		140	EXT-W26600	$ 155.18 /m	$ 21.72	$ 21.72
	BWP19	2960	GWB-B Interior	$ 95.53 /m	$ 282.78	$ 51.08
					$ -	$ (186.06)
	BWP20	1525	GWB-B Interior	$ 95.53 /m	$ 145.69	$ 27.47
	BWP21	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ 20.07
	BWP22	650	2020 WSP-A	$ 149.69 /m	$ 97.30	$ (0.01)
	BWP22b	1025	2020 WSP-A	$ 149.69 /m	$ 153.43	$ 31.80
					$ -	$ (42.67)
	BWP23	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$ (1.22)
	BWP24	1080	2020 WSP-A-Interior	$ 155.59 /m	$ 168.04	$ 27.76
						$ (23.73)
3rd Flr	BWP25	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP26	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (26.95)
		120	EXT-W26400-9.5OSB	$ 149.69 /m	$ 17.96	$ 17.96
	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (7.49)
	BWP28	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (153.45)
		900	EXT-W26400-9.5OSB	$ 149.69 /m	$ 134.72	$ 134.72
	BWP29	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ (0.20)
	BWP30	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ (22.95)
		140	EXT-W26400-9.5OSB	$ 149.69 /m	$ 20.96	$ 20.96
	BWP31	1740	GWB-A Interior	$ 81.17 /m	$ 141.23	$ (90.48)
					$ -	$ (31.34)
	BWP32	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (20.82)
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ 2.82
	BWP34	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ (4.76)
	BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (18.46)
					$ -	$ (53.98)
	BWP36	750	2020 WSP-A-Interior	$ 155.59 /m	$ 116.70	$ (1.52)
1st Flr	Extra 11 mm OSB	3112	Extra 11 mm OSB	$ 30.70 /m	$ 95.53	$ (68.30)
2nd Flr	Extra 11 mm OSB	2752	Extra 11 mm OSB	$ 30.70 /m	$ 84.48	$ (170.22)
3rd Storey	Extra 11 mm OSB	1997	Extra 11 mm OSB	$ 30.70 /m	$ 61.30	$ (235.36)
All Flrs	Extra 12.7 Gypsum	3630	Extra Gypsum Board	$ 34.92 /m	$ 126.75	$ 385.15
					$ 6,563.85	**$ (934.66)**

Percent Increase Relative to Scenario A (Updated Seismic Values) **-16%**

NBC 2020 Provisions with Updated Seismic Hazard Values

Spacing (mm)	Number	Unit Cost	Cost	Difference b/w Base and Scenario A
2400	21	$ 6.13 Ea.	$ 128.73	

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions

Spacing (mm)	Number	Unit Cost		Cost	Difference b/w Scenario A and Scenario B
800/1400/2400	28	$ 6.13	Ea.	$ 171.64	**$ 42.91**
					33%

NBC 2020 Provisions with Updated Seismic Hazard Values

No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	Difference b/w Base and Scenario A
14	14	196	$ 0.10	$ 19.60	
10	13	130	$ 0.10	$ 13.00	
10	13	130	$ 0.10	$ 13.00	
		326		**$ 45.60**	

Scenario B: Updated Seismic Values and Updated Lateral Loads Provisions

	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	Difference b/w Scenario A and Scenario B
1st Floor Framing	14	12	168	$ 0.10	$ 16.80	$ (8.80)
2nd Floor Framing	13	12	156	$ 0.10	$ 15.60	$ 3.60
3rd Floor Framing	13	6	78	$ 0.10	$ 7.80	$ 3.00
			246		**$ 40.20**	

Scenario A Total Cost	$ 7,974.18

Average Cost of Housing Construction in Montreal
$ 386,760.00 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Total Cost	$ 6,775.69
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	-15%

Percent Increase in Base Case Home Construction	0.1%

Code Analysis - Montreal

Archetype	Stacked Town	
No. Storeys =	3	
Construction =	Light	
w =	11.7	m
l =	11.8	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.1	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.595	
HWP =	0.42	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply? Yes		
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	-	
	Does the Article apply? No		
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	-	
	Does the Article apply? No		
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No	
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No	
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No	
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor	0.25	
	% braced walls - 2nd Floor	-	
	% braced walls - 1st Floor	-	
	% braced walls - bsmt	-	
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	-	m
	Maximum distance between required braced wall panels measured from the edges of the panels	-	m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	-	m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	-	mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	-	mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9? Yes	Use OSB wall sheathing	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	<u>Sa(0.2) ≤ 0.7</u>	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	<u>Sa(0.2) ≤ 0.7</u>	
	Top Plate Connections	
	1st Floor 1 nails Supporting 1 floor	
	2nd Floor 1 nails Supporting 0 floors	

<u>Scenario A:</u>

<u>2015 NBC and 2020 NBC Seismic Hazard Values</u>

S(0.2, C) = 0.840

HWP = 0.42 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**	
	Does the Article apply? No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	Design to 9.23.13.4. to 9.23.13.7.
	Does the Article apply? Yes	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	Yes
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	0.25
	% braced walls - 2nd Floor	0.25
	% braced walls - 1st Floor	0.40
	% braced walls - bsmt	0.75
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels	6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
9.23.13.6.	**Materials in Braced Wall Panels**	

	Is Sa(0.2, C) less than or equal to 0.9? Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

Use OSB wall sheathing

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	No
	Does Table 9.23.3.5.-B govern design?	Yes
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 WSP-3** **2015 WSP-3a**
9.23.6.1.	**Anchorage of Building Frames**	
	0.8 ≤ S(0.2, C) ≤ 0.9, HWP ≤ 1.2 kPa	
	Anchor bolt size 12.7 mm	Using Table 9.23.6.1.
	Anchor bolt spacing 2.3 m	Using Table 9.23.6.1.
9.23.11.4.	**Joints in Top Plates**	
	0.80 ≤ S(0.2, C) ≤ 0.90	
	Top Plate Connections	
	1st Floor 5 nails Supporting 1 floor	
	2nd Floor 2 nails Supporting 0 floors	

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	0.67	Worst Case	w =	11.7	m
Smax =	0.56	Site Class C	l =	11.8	m
HWP =	0.42	kPa	Stud spacing =	600	mm
S =	1.57	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.1	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m

	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:		
	• gypsum board installed on both faces of braced wall panel		1.2 m
	• gypsum board installed on one face of braced wall panel		1.2 m
	Minimum length of individual lumber-sheathed braced wall panels:		1.2 m
	Minimum total length of all braced wall panels in a braced wall band		Per Article 9.23.13.7.
9.23.13.7.	**Braced Wall Panel Length**		
9.23.13.7.(2)			
	Is HWP greater than 0.6 kPa but not greater than 1.2 kPa and is Smax for Site Class C greater than 0.47 but not greater than 2.6?	No	
	Is HWP greater than 0.6 kPa but not greater than 1.2 kPa and is Smax for Site Class C less than or equal to 0.47?	No	
	Is Smax for Site Class C greater than 0.47 but not greater 2.6, and is HWP less than or equal to 0.6 kPa?	Yes	Calculate braced wall length based on the equation for L_s (seismic)

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$$

First Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	5.94	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**5.46**	**m**	

Front to Back Direction (Interior Party Walls)

L_{uw} =	5.94	m	**GWB-D**
K_{exp} =	1	for suburban	
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are blocked but not sheathed on interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	

L_w =	**5.46**	**m**	

Left to Right Direction (Exterior Back Wall)

L_{uw} =	3.12	m	**WSP-B**
K_{exp} =	1	for suburban	
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.83**	**m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} =	3.12	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.83**	**m**	

Left to Right Direction (Interior Walls)

L_{uw} =	5.94	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**5.39**	**m**	

Second Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	3.92	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.87	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**3.40**	**m**	

Front to Back Direction (Interior Party Walls)

L_{uw} =	6.54	m	**GWB-B**
K_{exp} =	1	for suburban	
K_{roof} =	0.87	for roof eave to ridge of 2.1 m < 3 m	

$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**5.68 m**	

Left to Right Direction (Exterior Back Wall)

L_{uw} =	2.06 m	**WSP-B**
K_{exp} =	1	for suburban
K_{roof} =	0.87	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**1.77 m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} =	3.92 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.87	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**3.36 m**	

Left to Right Direction (Interior Walls)

L_{uw} =	3.92 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.87	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**3.36 m**	

Third Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	1.9 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**1.35 m**	

Front to Back Direction (Interior Party Walls)

L_{uw} =	5.84 m	**GWB-A**	
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**4.14 m**		

Left to Right Direction (Exterior Back Wall)

L_{uw} =	1 m	**WSP-B**	
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**0.70 m**		

Left to Right Direction (Exterior Front Wall)

L_{uw} =	1.9 m	**WSP-A**	
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**1.33 m**		

Left to Right Direction (Interior Wall)

L_{uw} =	2.92 m	**GWB-A**	5.84/2
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.04 m**		

9.23.6.1.	**Anchorage of Building Frames**		
	Is HWP between 0.6 kPa and 1.2 kPa	No	
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	Yes	Use Table 9.23.6.1.
	From Table 9.23.6.1.		
	Framing Type Selected **WSP-B**		
	Anchor bolt size 12.7 mm		
	Anchor bolt spacing 0.8 m		

9.23.11.4.	**Joints in Top Plates**		
	Is HWP between 0.6 kPa and 1.2 kPa	No	N/A
	Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A
	Table 9.23.11.4.-A <u>0.6 < and ≤ 0.8</u>	Normal Weight	
	All floors 6 nails	For BWB Spacing of 10.6m	
	3 nails	For BWB Spacing of ≤ 7.6m	
	Table 9.23.11.4.-B <u>0.6 < and ≤ 0.9</u>		
	1st Floor 11 nails	For BWB Spacing of 10.6m	
	6 nails	For BWB Spacing of ≤ 7.6m	
	2nd Floor 6 nails	For BWB Spacing of 10.6m	
	3 nails	For BWB Spacing of ≤ 7.6m	

Cost Differences - St. John's

Archetype	Stacked Town
No. Storeys =	3
Construction =	Light
w =	11.7 m
l =	11.8 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.1 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

Base Scenario: Existing NBC 2020

Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	870	EXT-W26400-9.5OSB	$149.69 /m	$ 130.23
	BWP2	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP3	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP4	3750	EXT-W26400-9.5OSB	$149.69 /m	$ 561.32
	BWP5	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP6	5500	EXT-W26400-9.5OSB	$149.69 /m	$ 823.27
	BWP7	625	EXT-W26400-9.5OSB	$149.69 /m	$ 93.55
	BWP8	1605	EXT-W26400-9.5OSB	$149.69 /m	$ 240.25
	BWP9	5450	INT-W26600-B	$124.87 /m	$ 680.56
	BWP10	750	INT-W26600-B	$124.87 /m	$ 93.65
	BWP11	600	INT-W26600-B	$124.87 /m	$ 74.92
	BWP12	2095	INT-W26600-B	$124.87 /m	$ 261.61
2nd Flr	BWP13	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP14	720	EXT-W26400-9.5OSB	$149.69 /m	$ 107.77
	BWP15	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP16	4825	EXT-W26400-9.5OSB	$149.69 /m	$ 722.23
	BWP17	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP18	790	EXT-W26400-9.5OSB	$149.69 /m	$ 118.25
	BWP19	6020	INT-W26600-B	$124.87 /m	$ 751.73
	BWP20	750	INT-W26600-B	$124.87 /m	$ 93.65
	BWP21	600	INT-W26600-B	$124.87 /m	$ 74.92
	BWP22	800	EXT-W26400-9.5OSB	$149.69 /m	$ 119.75
	BWP23	600	INT-W26600-B	$124.87 /m	$ 74.92
	BWP24	790	INT-W26600-B	$124.87 /m	$ 98.65
3rd Flr	BWP25	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP26	720	EXT-W26400-9.5OSB	$149.69 /m	$ 107.77
	BWP27	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP28	1125	EXT-W26400-9.5OSB	$149.69 /m	$ 168.40
	BWP29	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP30	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP31	3265	INT-W26600	$116.08 /m	$ 379.01
	BWP32	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP33	2525	INT-W26600	$116.08 /m	$ 293.11
	BWP34	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP35	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP36	750	INT-W26600	$116.08 /m	$ 87.06
All Flrs	Extra 12.7 Gypsur	-6990	Extra Gypsum Board $	34.92 /m	$ (244.08)
				Total	$ 7,223.96

Scenario B: Updated Seismic Values and New Lateral Loads Provisions

Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	Difference b/w Base and Scenario B
1st Flr	BWP1	870	2020 WSP-C	$ 168.01 /m	$ 146.17	$ 15.94
	BWP2	750	2020 WSP-C	$ 168.01 /m	$ 126.01	$ 13.74
	BWP3	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 11.00
	BWP4	3750	2020 WSP-A	$ 149.69 /m	$ 561.32	$ -
	BWP5	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP6	5500	2020 WSP-A	$ 149.69 /m	$ 823.27	$ -
	BWP7	625	2020 WSP-C	$ 168.01 /m	$ 105.01	$ 11.45
	BWP8	1605	2020 WSP-C	$ 168.01 /m	$ 269.66	$ 29.41
	BWP9	5450	2020 WSP-B-Interior	$ 155.52 /m	$ 847.61	$ 167.05
	BWP10	750	2020 WSP-B-Interior	$ 155.52 /m	$ 116.64	$ 22.99
	BWP11	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$ 18.43
	BWP12	2095	2020 WSP-A-Interior	$ 155.59 /m	$ 325.97	$ 64.36
2nd Flr	BWP13	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 11.00
	BWP14	720	2020 WSP-A	$ 149.69 /m	$ 107.77	$ -
	BWP15	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP16	4825	2020 WSP-A	$ 149.69 /m	$ 722.23	$ -
	BWP17	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 11.00
	BWP18	790	2020 WSP-C	$ 168.01 /m	$ 132.73	$ 14.48
	BWP19	6020	GWB-D Interior	$ 97.75 /m	$ 588.46	$ (163.27)
	BWP20	750	GWB-D Interior	$ 97.75 /m	$ 73.31	$ (20.34)
	BWP21	600	GWB-D Interior	$ 97.75 /m	$ 58.65	$ (16.27)
	BWP22	800	2020 WSP-C	$ 168.01 /m	$ 134.41	$ 14.66
	BWP23	600	2020 WSP-C-Interior	$ 161.69 /m	$ 97.02	$ 22.09
	BWP24	790	2020 WSP-C-Interior	$ 161.69 /m	$ 127.74	$ 29.09
3rd Flr	BWP25	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 11.00
	BWP26	720	2020 WSP-A	$ 149.69 /m	$ 107.77	$ -
	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP28	1125	2020 WSP-A	$ 149.69 /m	$ 168.40	$ -
	BWP29	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 11.00
	BWP30	750	2020 WSP-C	$ 168.01 /m	$ 126.01	$ 13.74
	BWP31	3265	GWB-A Interior	$ 81.17 /m	$ 265.00	$ (114.01)
	BWP32	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP33	2525	GWB-A Interior	$ 81.17 /m	$ 204.94	$ (88.17)
	BWP34	600	2020 WSP-C	$ 168.01 /m	$ 100.81	$ 11.00
	BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP36	750	2020 WSP-A-Interior	$ 155.59 /m	$ 116.70	$ 29.63
1st Flr	Extra 11 mm OSB	3462	Extra 11 mm OSB	$ 30.70 /m	$ 106.27	$ 106.27
2nd Flr	Extra 11 mm OSB	3587	Extra 11 mm OSB	$ 30.70 /m	$ 110.11	$ 110.11
3rd Flr	Extra 11 mm OSB	1394	Extra 11 mm OSB	$ 30.70 /m	$ 42.79	$ 42.79
All Flrs	Extra 12.7 Gypsum	1950	Extra Gypsum Board	$ 34.92 /m	$ 68.09	$ 312.17
				Total	$ 7,842.50	$ 618.54
		Total Cost Increase relative to Base Case (Existing Code)			$ 618.54	
		Percent Cost Increase relative to Base Case (Existing Code)			9%	

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020				Scenario B: 2020 NBC Smax (Worst Case)				Difference b/w Base and Scenario B
	Spacing (mm)	Number	Unit Cost	Cost	Spacing (mm)	Number	Unit Cost	Cost	
1/2" dia. Anchor	2400	21	$ 6.13 Ea.	$ 128.73	800/1400/2400	33	$ 6.13 Ea.	$ 202.29	$ 73.56
									57%

Top Plate Splice Fasteners

Base Scenario: Existing NBC 2020

	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	2	28	$ 0.10	$ 2.80
2nd Floor Framing	13	2	26	$ 0.10	$ 2.60
3rd Floor Framing	13	2	26	$ 0.10	$ 2.60
			54		$ 8.00

Scenario B: 2020 NBC Smax (Worst Case)

	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	Difference b/w Base and Scenario B
1st Floor Framing	14	20	280	$ 0.10	$ 28.00	$ 25.20
2nd Floor Framing	13	20	260	$ 0.10	$ 26.00	$ 23.40
3rd Floor Framing	13	20	260	$ 0.10	$ 26.00	$ 23.40
			540		$ 80.00	

Base Case Total Cost	$ 7,360.69

Average Cost of Housing Construction in St. John's
$ 367,318.25 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Total Cost	$ 8,124.79
Total Percent Increase Relative to Base Case (Existing Code)	10%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	10%
Percent Increase from Base Case Home Construction	0.2%

Code Analysis - St. John's

Archetype	Stacked Town	
No. Storeys =	3	
Construction =	Light	
w =	11.7	m
l =	11.8	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.1	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.09	
HWP =	0.78	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply? Yes		
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Does the Article apply? No	-	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Does the Article apply? No	-	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No	
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No	
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No	
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor	0.25	
	% braced walls - 2nd Floor	-	
	% braced walls - 1st Floor	-	
	% braced walls - bsmt	-	
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	-	m
	Maximum distance between required braced wall panels measured from the edges of the panels	-	m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	-	m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	-	mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	-	mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9? Yes	Use OSB wall sheathing	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nails Supporting 1 floor	
	2nd Floor 1 nails Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.19

HWP = 0.78 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**	
	Does the Article apply? Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**	-
	Does the Article apply? No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**	
	Is Sa(0.2) greater than 0.7 and less than 1.0?	No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?	No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?	No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**	
	% braced walls - 3rd Floor	-
	% braced walls - 2nd Floor	-
	% braced walls - 1st Floor	-
	% braced walls - bsmt	-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	- m
	Maximum distance between required braced wall panels measured from the edges of the panels	- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	- mm
9.23.13.6.	**Materials in Braced Wall Panels**	
	Is Sa(0.2) less than or equal to 0.9? Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm

Use OSB wall sheathing

Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	0.31	Worst Case	w =	11.7	m
Smax =	0.15	Site Class C	l =	11.8	m
HWP =	0.78	kPa	Stud spacing =	600	mm
S =	2.01	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.1	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	No	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A

9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands	10.6	m
	Maximum distance between required braced wall panels measured from the edges of the panels	6.4	m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel	2.4	m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel	600	mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750 mm
	Minimum length of individual gypsum board-sheathed braced wall panels:	
	• gypsum board installed on both faces of braced wall panel	1.2 m
	• gypsum board installed on one face of braced wall panel	2.4 m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2 m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$

First Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	10.7 m	**WSP-A**
K_{exp} =	1	for suburban
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**9.83 m**	

Front to Back Direction (Interior Party Walls)

L_{uw} =	5.62 m	**WSP-B**
K_{exp} =	1	for suburban
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1.2	walls are blocked but not sheathed on interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**6.19 m**	

Left to Right Direction (Exterior Back Wall)

L_{uw} =	4.89 m	**WSP-C**
K_{exp} =	1	for suburban
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m
$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**4.43 m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} =	4.89 m	**WSP-C**
K_{exp} =	1	for suburban
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m

$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 4.43 m

Left to Right Direction (Interior Walls)
L_{uw} = 5.94 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.92 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 5.39 m

Second Storey

Front to Back Direction (Exterior Walls)
L_{uw} = 7.06 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.78 space between braced walls approx. 5.9 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 6.13 m

Front to Back Direction (Interior Party Walls)
L_{uw} = 7.06 m **GWB-D**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.78 space between braced walls approx. 5.9 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are blocked but no gypsum sheathing on interior
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 6.13 m

Left to Right Direction (Exterior Back Wall)
L_{uw} = 3.23 m **WSP-C**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 2.77 m

Left to Right Direction (Exterior Front Wall)
L_{uw} = 3.23 m **WSP-C**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m

$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.77 m**		

Left to Right Direction (Interior Walls)

L_{uw} =	3.23 m		**WSP-C**
K_{exp} =	1	for suburban	
K_{roof} =	0.87	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.77 m**		

Third Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	3.43 m		**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.43 m**		

Front to Back Direction (Interior Party Walls)

L_{uw} =	9.86 m		**GWB-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**6.99 m**		

Left to Right Direction (Exterior Back Wall)

L_{uw} =	1.57 m		**WSP-C**
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**1.10 m**		

Left to Right Direction (Exterior Front Wall)

L_{uw} =	1.57 m		**WSP-C**
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	

$K_{Wnumber}$ =	1.28	3 braced wall bands
K_{gyp} =	1	walls are sheathing on the interior with gypsum
K_{sheath} =	1	walls are continuously wood sheathed
L_w =	**1.10 m**	

Left to Right Direction (Interior Wall)

L_{uw} =	4.93 m	**GWB-A**	9.86/2
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**3.45 m**		

9.23.6.1. **Anchorage of Building Frames**

Is HWP between 0.6 kPa and 1.2 kPa	Yes	
Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	No	Use Table 9.23.6.1.

From Table 9.23.6.1.

Framing Type Selected	**WSP-A**
Anchor bolt size	12.7 mm
Anchor bolt spacing	0.8 m

From Table 9.23.6.1.

Framing Type Selected	**WSP-A**
Anchor bolt size	12.7 mm
Anchor bolt spacing	0.7 m

9.23.11.4. **Joints in Top Plates**

Is HWP between 0.6 kPa and 1.2 kPa	Yes	Use Table 9.23.11.4.-B
Is Smax for Site Class C greater than 0.47 and is Smax less than or equal to 2.6	No	N/A

Table 9.23.11.4.-A

0.6 < and ≤ 0.8		Normal Weight	
All floors	4 nails	For BWB Spacing of 10.6m	
	2	For BWB Spacing of ≤ 7.6m	

Table 9.23.11.4.-B

0.6 < and ≤ 0.9		Normal Weight	
1st Floor	20 nails	For BWB Spacing of 10.6m	Wind governs
	10 nails	For BWB Spacing of ≤ 7.6m	
2nd Floor	15 nails	For BWB Spacing of 10.6m	
	8 nails	For BWB Spacing of ≤ 7.6m	

Cost Differences - Winnipeg

Archetype	Stacked Town
No. Storeys =	3
Construction =	Light
w =	11.7 m
l =	11.8 m
Stud spacing =	600 mm
Stud Height =	2.4 m
Eave-to-Ridge height =	2.1 m

Braced Wall Panel Difference

The Base Scenario and Scenario A produce the same Braced Wall Panel Lengths, Anchors, and Joint Splicing Results

		Base Scenario: Existing NBC 2020			
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost
1st Flr	BWP1	830	EXT-W26400-9.5OSB	$149.69 /m	$ 124.24
	BWP2	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP3	2600	EXT-W26400-9.5OSB	$149.69 /m	$ 389.18
	BWP4	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP5	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP6	2260	EXT-W26400-9.5OSB	$149.69 /m	$ 338.29
	BWP7	775	EXT-W26400-9.5OSB	$149.69 /m	$ 116.01
	BWP8	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP9	5800	INT-W26600-B	$124.87 /m	$ 724.26
	BWP10	750	INT-W26600-B	$124.87 /m	$ 93.65
	BWP11	975	INT-W26600-B	$124.87 /m	$ 121.75
	BWP12	1720	INT-W26600-B	$124.87 /m	$ 214.78
2nd Flr	BWP13	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP14	720	EXT-W26400-9.5OSB	$149.69 /m	$ 107.77
	BWP15	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP16	2100	EXT-W26400-9.5OSB	$149.69 /m	$ 314.34
	BWP17	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP18	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP19	4240	INT-W26600-B	$124.87 /m	$ 529.46
	BWP20	1525	INT-W26600-B	$124.87 /m	$ 190.43
	BWP21	1200	INT-W26600-B	$124.87 /m	$ 149.85
	BWP22	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP22b	1025	EXT-W26400-9.5OSB	$149.69 /m	
	BWP23	600	INT-W26600-B	$124.87 /m	$ 74.92
	BWP24	750	INT-W26600-B	$124.87 /m	$ 93.65
3rd Flr	BWP25	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP26	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP27	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP28	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP29	600	EXT-W26400-9.5OSB	$149.69 /m	$ 89.81
	BWP30	750	EXT-W26400-9.5OSB	$149.69 /m	$ 112.26
	BWP31	1740	INT-W26600	$116.08 /m	$ 201.99
	BWP32	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP33	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP34	600	EXT-W26400-9.5OSB	$149.69	$ 89.81
	BWP35	1200	INT-W26600	$116.08 /m	$ 139.30
	BWP36	750	INT-W26600	$116.08 /m	$ 87.06
All Flrs	Extra 12.7 Gypsum	-11105	Extra Gypsum Board	$ 34.92 /m	$ (387.77)
					$ 5,406.12

		Scenario B: Updated Seismic Values and New Lateral Loads Provisions				Difference b/w Base and Scenario B
Floor Level	Braced Wall Panel	Length	BWP Type	BWP Unit Cost	BWP Cost	
1st Flr	BWP1	830	2020 WSP-A	$ 149.69 /m	$ 124.24	$ -
	BWP2	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP3	2600	2020 WSP-A	$ 149.69 /m	$ 389.18	$ -
	BWP4	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP5	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP6	2260	2020 WSP-A	$ 149.69 /m	$ 338.29	$ -
	BWP7	775	2020 WSP-B	$ 161.84 /m	$ 125.43	$ 9.42
	BWP8	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP9	5800	GWB-D Interior	$ 97.75 /m	$ 566.96	$ (157.31)
	BWP10	750	GWB-D Interior	$ 97.75 /m	$ 73.31	$ (20.34)
	BWP11	975	GWB-D Interior	$ 97.75 /m	$ 95.31	$ (26.44)
	BWP12	1720	GWB-D Interior	$ 97.75 /m	$ 168.13	$ (46.65)
2nd Flr	BWP13	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP14	720	2020 WSP-A	$ 149.69 /m	$ 107.77	$ -
	BWP15	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP16	2100	2020 WSP-A	$ 149.69 /m	$ 314.34	$ -
	BWP17	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP18	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP19	4240	GWB-B Interior	$ 95.53 /m	$ 405.07	$ (124.40)
	BWP20	1525	GWB-B Interior	$ 95.53 /m	$ 145.69	$ (44.74)
	BWP21	1200	GWB-B Interior	$ 95.53 /m	$ 114.64	$ (35.21)
	BWP22	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP22b	1025	2020 WSP-A	$ 149.69		
	BWP23	600	2020 WSP-A-Interior	$ 155.59 /m	$ 93.36	$ 18.43
	BWP24	750	2020 WSP-A-Interior	$ 155.59 /m	$ 116.70	$ 23.04
3rd Flr	BWP25	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP26	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP27	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP28	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP29	600	2020 WSP-B	$ 161.84 /m	$ 97.11	$ 7.30
	BWP30	750	2020 WSP-B	$ 161.84 /m	$ 121.38	$ 9.12
	BWP31	1740	GWB-A Interior	$ 81.17 /m	$ 141.23	$ (60.76)
	BWP32	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP33	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP34	600	2020 WSP-A	$ 149.69 /m	$ 89.81	$ -
	BWP35	1200	GWB-A Interior	$ 81.17 /m	$ 97.40	$ (41.90)
	BWP36	750	2020 WSP-A-Interior	$ 155.59 /m	$ 116.70	$ 29.63
1st Flr	Extra 11 mm OSB	3112	Extra 11 mm OSB	$ 30.70 /m	$ 95.53	$ 95.53
2nd Flr	Extra 11 mm OSB	2812	Extra 11 mm OSB	$ 30.70 /m	$ 86.32	$ 86.32
3rd Flr	Extra 11 mm OSB	1997	Extra 11 mm OSB	$ 30.70 /m	$ 61.30	$ 61.30
All Flrs	Extra 12.7 Gypsum	3300	Extra Gypsum Board	$ 34.92 /m	$ 115.23	$ 503.00
					$ 5,633.20	**$ 227.08**

Total Cost Increase relative to Base Case and Scenario A	$ 227.08
Percent Cost Increase relative to Base Case and Scenario A	4%

Anchor Bolts Difference

	Base Scenario: Existing NBC 2020			
	Spacing (mm)	Number	Unit Cost	Cost
1/2" dia. Anchor	2400	21	$ 6.13 Ea.	$ 128.73

Scenario B: 2020 NBC Smax (Worst Case)				Difference b/w Base and Scenario B
Spacing (mm)	Number	Unit Cost	Cost	
800/1400/2400	28	$ 6.13 Ea.	$ 171.64	**$ 42.91**
				33%

Top Plate Splice Fasteners

	Base Scenario: Existing NBC 2020				
	No. Locations	No. Fasteners	Total	Cost per	Total Cost
1st Floor Framing	14	2	28	$ 0.10	$ 2.80
2nd Floor Framing	13	2	26	$ 0.10	$ 2.60
3rd Floor Framing	13	2	26	$ 0.10	$ 2.60
			54		**$ 8.00**

	Scenario B: 2020 NBC Smax (Worst Case)					Difference b/w Base and Scenario B
	No. Locations	No. Fasteners	Total Fasteners	Cost per	Total Cost	
1st Floor Framing	14	12	168	$ 0.10	$ 16.80	$ 14.00
2nd Floor Framing	13	12	156	$ 0.10	$ 15.60	$ 13.00
3rd Floor Framing	13	6	78	$ 0.10	$ 7.80	$ 5.20
			246		**$ 40.20**	

Base Case Total Cost	$ 5,542.85

Average Cost of Housing Construction in Winnipeg
$ 367,318.25 CAD
Based on Altus Group - 2022 Canadian Cost Guide

Scenario B Total Cost	$ 5,845.04
Total Percent Increase Relative to Base Case (Existing Code)	5%
Total Percent Increase Relative to Scenario A (Updated Seismic Values)	5%
Percent Increase in Base Case Home Construction	0.1%

Code Analysis - Winnipeg

Archetype	Stacked Town	
No. Storeys =	3	
Construction =	Light	
w =	11.7	m
l =	11.8	m
Stud spacing =	600	mm
Stud Height =	2.4	m
Eave-to-Ridge height =	2.1	m

Base Scenario

2015 NBC and 2015 NBC Seismic Hazard Values

Sa(0.2) =	0.054	
HWP =	0.45	kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		0.25
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		Use OSB wall sheathing
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm
Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**			
	Does Table 9.23.3.5.-A govern design?			Yes
	Does Table 9.23.3.5.-B govern design?			No
	Does Table 9.23.3.5.-C govern design?			No
	Braced Wall Panel Type			**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**			
	Anchor bolt size	12.7	mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing	2.4	m	
9.23.11.4.	**Joints in Top Plates**			
	Top Plate Connections			
	1st Floor	1 nails	Supporting 1 floor	
	2nd Floor	1 nails	Supporting 0 floors	

Scenario A:

2015 NBC and 2020 NBC Seismic Hazard Values

S(0.2, C) = 0.08

HWP = 0.45 kPa

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		-
	Does the Article apply?	No	
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Is Sa(0.2) greater than 0.7 and less than 1.0?		No
	Is Sa(0.2) greater than or equal to 1.0 and less than 1.8kPa?		No
	Is HWP greater than or equal to 0.8 and less than 1.2 kPa?		No
Table 9.23.13.5.	**Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels**		
	% braced walls - 3rd Floor		-
	% braced walls - 2nd Floor		-
	% braced walls - 1st Floor		-
	% braced walls - bsmt		-
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		- m
	Maximum distance between required braced wall panels measured from the edges of the panels		- m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		- m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		- mm
	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel		- mm
9.23.13.6.	**Materials in Braced Wall Panels**		
	Is Sa(0.2) less than or equal to 0.9?	Yes	

Stud spacing?	400	600	
GWB interior finish	12.7	15.9	mm
CSA O325 sheathing	W16	W24	
OSB O-1 and O-2 grades	11	12.5	mm

Use OSB wall sheathing

Waferboard R-1 grade	9.5	12.5	mm
Plywood	11	12.5	mm
Diagonal lumber	17	17	mm

9.23.3.5.	**Fasteners for Sheathing or Subflooring**	
	Does Table 9.23.3.5.-A govern design?	Yes
	Does Table 9.23.3.5.-B govern design?	No
	Does Table 9.23.3.5.-C govern design?	No
	Braced Wall Panel Type	**2015 EWP600**
9.23.6.1.	**Anchorage of Building Frames**	
	Anchor bolt size 12.7 mm	Sentence 9.23.6.1.(2) governs
	Anchor bolt spacing 2.4 m	
9.23.11.4.	**Joints in Top Plates**	
	Top Plate Connections	
	1st Floor 1 nail Supporting 1 floor	Using Table 9.23.11.4.-2015
	2nd Floor 1 nail Supporting 0 floors	Using Table 9.23.11.4.-2015

Scenario B - Post Public Review

2020 NBC and 2020 NBC Seismic Hazard Values

Smax =	0.11	Worst Case	w =	11.7	m
Smax =	0.06	Site Class C	l =	11.8	m
HWP =	0.45	kPa	Stud spacing =	600	mm
S =	1.06	kPa	Stud Height =	2.4	m
Construction =	Normal		Eave-to-Ridge height =	2.1	m

9.23.13.1.	**Requirements for Low to Moderate Wind and Seismic Forces**		
	Does the Article apply?	Yes	
9.23.13.2.	**Requirements for High Wind and Seismic Forces**		
	Is the 1-in-50 HWP ≤ 1.2 kPa?	Yes	
	Is Smax ≤ 2.6 for the Site Class	Yes	
	Does the lowest exterior frame support less than or equal to 2 floors of normal weight	Yes	Design to Article 9.23.13.4.-2020 to 9.23.13.10.-2020
	Does the lowest exterior frame support less than or equal to 1 floor of heavy weight	N/A	
9.23.13.3.	**Requirements for Extreme Wind and Seismic Forces**		
	Is Smax > 2.6?	No	
	Is Smax > 0.47 for Site Cass C and the lowest exterior frame wall supports more than 1 floor of heavy weight construction or is clad with masonry/stone veneer?	No	Design to N/A
9.23.13.5.	**Braced Wall Panels in Braced Wall Bands**		
	Maximum distance between centre lines of adjacent braced wall bands measured from the furthest points between centres of the bands		10.6 m
	Maximum distance between required braced wall panels measured from the edges of the panels		6.4 m
	Maximum distance from the end of a braced wall band to the edge of the closest required braced wall panel		2.4 m
	Minimum length of individual braced wall panels panel located at the end of a braced wall band where the braced wall panel connects to an intersecting braced wall panel		600 mm

	Minimum length of individual braced wall panels panel not located at the end of a braced wall band or braced wall panel located at the end of a braced wall band where the braced wall panel does not connect to an intersecting braced wall panel	750	mm
	Minimum length of individual gypsum board-sheathed braced wall panels:		
	• gypsum board installed on both faces of braced wall panel	1.2	m
	• gypsum board installed on one face of braced wall panel	2.4	m
	Minimum length of individual lumber-sheathed braced wall panels:	1.2	m
	Minimum total length of all braced wall panels in a braced wall band	Per Article 9.23.13.7.	

9.23.13.7. **Braced Wall Panel Length**

9.23.13.7.(3) **WIND**

$$L_w = L_{uw} \times [K_{exp} \times K_{roof}] \times [K_{Wspacing} \times K_{Wnumber}] \times [K_{gyp} \times K_{sheath}] > BWP_{min}$$

First Storey

Front to Back Direction (Exterior Walls)

L_{uw} =	5.94	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**5.46**	**m**	

Front to Back Direction (Interior Party Walls)

L_{uw} =	5.94	m	**GWB-D**
K_{exp} =	1	for suburban	
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.78	space between braced walls approx. 5.9 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1.2	walls are blocked but not sheathed on interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**6.55**	**m**	

Left to Right Direction (Exterior Back Wall)

L_{uw} =	3.12	m	**WSP-B**
K_{exp} =	1	for suburban	
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.83**	**m**	

Left to Right Direction (Exterior Front Wall)

L_{uw} =	3.12	m	**WSP-A**
K_{exp} =	1	for suburban	
K_{roof} =	0.92	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	

$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 2.83 m

Left to Right Direction (Interior Walls)
L_{uw} = 5.94 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.92 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 5.39 m

Second Storey

Front to Back Direction (Exterior Walls)
L_{uw} = 3.92 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.78 space between braced walls approx. 5.9 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 3.40 m

Front to Back Direction (Interior Party Walls)
L_{uw} = 6.54 m **GWB-B**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.78 space between braced walls approx. 5.9 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 5.68 m

Left to Right Direction (Exterior Back Wall)
L_{uw} = 2.06 m **WSP-B**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 1.77 m

Left to Right Direction (Exterior Front Wall)
L_{uw} = 3.92 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m

$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 3.36 m

Left to Right Direction (Interior Walls)
L_{uw} = 3.92 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.87 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 3.36 m

Third Storey

Front to Back Direction (Exterior Walls)
L_{uw} = 1.9 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.71 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.78 space between braced walls approx. 5.9 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 1.35 m

Front to Back Direction (Interior Party Walls)
L_{uw} = 5.84 m **GWB-A**
K_{exp} = 1 for suburban
K_{roof} = 0.71 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.78 space between braced walls approx. 5.9 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 4.14 m

Left to Right Direction (Exterior Back Wall)
L_{uw} = 1 m **WSP-B**
K_{exp} = 1 for suburban
K_{roof} = 0.71 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m
$K_{Wnumber}$ = 1.28 3 braced wall bands
K_{gyp} = 1 walls are sheathing on the interior with gypsum
K_{sheath} = 1 walls are continuously wood sheathed

L_w = 0.70 m

Left to Right Direction (Exterior Front Wall)
L_{uw} = 1.9 m **WSP-A**
K_{exp} = 1 for suburban
K_{roof} = 0.71 for roof eave to ridge of 2.1 m < 3 m
$K_{Wspacing}$ = 0.77 space between braced walls approx. 5.8 m

	$K_{Wnumber}$ =	1.28	3 braced wall bands
	K_{gyp} =	1	walls are sheathing on the interior with gypsum
	K_{sheath} =	1	walls are continuously wood sheathed
	L_w =	**1.33 m**	

Left to Right Direction (Interior Wall)

L_{uw} =	2.92 m	**GWB-A**	5.84/2
K_{exp} =	1	for suburban	
K_{roof} =	0.71	for roof eave to ridge of 2.1 m < 3 m	
$K_{Wspacing}$ =	0.77	space between braced walls approx. 5.8 m	
$K_{Wnumber}$ =	1.28	3 braced wall bands	
K_{gyp} =	1	walls are sheathing on the interior with gypsum	
K_{sheath} =	1	walls are continuously wood sheathed	
L_w =	**2.04 m**		

9.23.6.1. **Anchorage of Building Frames**

Is HWP greater than 1.2 kPa	No	If "No" to both then use Table 9.23.6.1.
Is Smax greater than 2.6?	No	Use 9.23.6.1.(2)(b)

From Table 9.23.6.1.

Framing Type Selected	**WSP-A**	
Anchor bolt size	12.7 mm	
Anchor bolt spacing	0.8 m	This Table was updated since PR

From Table 9.23.6.1.

Framing Type Selected	**WSP-B**
Anchor bolt size	12.7 mm
Anchor bolt spacing	0.7 m

9.23.11.4. **Joints in Top Plates**

Is HWP less than or equal to 1.2 kPa	Yes	Use Table 9.23.11.4.-B
Is Smax for Site Class C less than or equal to 2.6	Yes	Use Table 9.23.11.4.-A

Table 9.23.11.4.-A

<= 0.6		Normal Weight	
All floors	4 nails	For BWB Spacing of 10.6m	
	2 nails	For BWB Spacing of ≤ 7.6m	

Table 9.23.11.4.-B

0.4 < and ≤ 0.5		Normal Weight	
1st and Second Floor	11 nails	For BWB Spacing of 10.6m	Wind Governs
	6 nails	For BWB Spacing of ≤ 7.6m	
Third	8 nails	For BWB Spacing of 10.6m	
	4 nails	For BWB Spacing of ≤ 7.6m	

Submit a comment

Proposed Change 1793

Code Reference(s):	NBC20 Div.B 2.2.1.8. (first printing)
Subject:	Large Farm Buildings (General)
Title:	Fire Blocks in Concealed Wall Spaces in Farm Buildings
Description:	This proposed change introduces an alternative compliance path for fire blocking in concealed wall spaces in farm buildings, provided certain requirements are met.
Related Code Change Request(s):	CCR 1606

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [x] Design and Construction
- [ ] Building operations
- [ ] Housing
- [ ] Small Buildings
- [ ] Large Buildings
- [x] Fire Protection
- [ ] Occupant safety in use
- [ ] Accessibility
- [ ] Structural Requirements
- [ ] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

Sentence 2.2.1.8.(2) requires the installation of fire blocks in concealed wall spaces to limit void spaces to not more than 3 m high and 20 m long.

Part 3 buildings are offered an alternative compliance path to fire blocking within concealed wall spaces, as permitted in Sentence 3.1.11.2.(2), where any of the following conditions are met:

- the wall cavity is filled with insulation,
- the construction materials used are noncombustible,
- certain materials within the space have a flame-spread rating of 25 or less and fire blocks are installed at a distance of not more than 10 m vertically, or

- a single air gap that is 25 mm or less exists within an insulated wall section.

These conditions may also exist in typical farm building construction to meet NBC requirements or the operational performance needs of the finished facility.

To harmonize the requirements of Parts 2 and 3, farm building designers and owners should be offered a similar alternative compliance path for farm buildings designed in accordance with Part 2.

Justification

Many of the conditions outlined in the proposed change exist in farm buildings. While some conditions call for materials that are not currently required by the NBC, these materials are often installed for operational purposes.

Many farm buildings have insulated wall assemblies. Examples include the majority of poultry barns, many farm shops, fruit and vegetable storage facilities and milking centres.

While not a requirement of Part 2, some farm buildings may be of noncombustible construction. This design decision is typically made for durability, to meet longer span requirements for open areas, or for fabrication ease. Examples include most swine barns (concrete wall construction), some shops and storage facilities (steel building systems, concrete or masonry), and many Group G, Division 4 occupancies, such as grain bins (steel building systems), horizontal silos (concrete construction), and manure storage facilities (concrete construction).

Many of the same wall construction materials used in Part 2 buildings are used in Part 3 buildings as well. Due to their high availability and familiarity, the materials with a low flame-spread rating used in Part 3 buildings are used in Part 2 farm buildings as well. Examples include cement board, mineral wool insulation, and steel cladding.

Insulated wall assemblies with a single air gap of 25 mm or less can also be found in farm building construction. Many of the examples above require insulated wall assemblies, and the building science of wall construction is applicable.

An alternative compliance path to fire blocking in concealed wall spaces in Part 2 farm buildings would provide an equivalent level of safety, provided the described conditions are met.

This proposed change would allow compliant solutions and flexibility in wall assembly design where certain elements may already be in place as a result of other Code requirements or performance needs.

PROPOSED CHANGE

[2.2.1.8.] 2.2.1.8. Fire Blocks

[1] 1) Concealed spaces in interior wall, ceiling and crawl spaces shall be separated from concealed spaces in exterior walls and *attic or roof spaces* by *fire blocks*. (See Note A-2.2.1.8.(1).)

[2] 2) Except as permitted by Sentence (3)-2025, ~~C~~concealed spaces in walls and *partitions* shall be separated by *fire blocks* into compartments not more than 3 m in height and 20 m in length.

[3] --) The *fire blocks* described in Sentence (2) are not required, provided

[a] --) the wall space is filled with insulation,

[b] --) the exposed construction materials and any insulation within the wall space are *noncombustible*,

[c] --) the exposed materials within the space, including insulation but not including wiring, piping or similar services, have a *flame-spread rating* not more than 25 on any exposed surface, or any surface that would be exposed by cutting through the material in any direction, and *fire blocks* are installed so that the vertical distance between them is not more than 10 m, or

[d] --) the insulated wall assembly contains not more than one concealed air space, and the horizontal thickness of that air space is not more than 25 mm.

[4] 3) Horizontal concealed spaces within a floor assembly or roof assembly of *combustible construction*, in which sprinklers are not installed, shall be separated by *fire blocks* into compartments not more than 900 m^2 in area.

[5] 4) Except as permitted by Sentence (5), *fire blocks* shall be constructed of materials that will remain in place and prevent the passage of flames for not less than 15 min when subjected to the standard fire exposure in CAN/ULC-S101, "Standard Method of Fire Endurance Tests of Building Construction and Materials".

[6] 5) *Fire blocks* need not be tested in conformance with Sentence (4) if they are constructed of not less than

[a] a) 0.38 mm sheet steel,

[b] b) 12.7 mm gypsum board,

[c] c) 12.5 mm plywood, OSB or waferboard, with joints backed with similar material,

[d] d) two layers of lumber, each not less than 19 mm thick, with joints staggered, or

[e] e) 38 mm lumber.

Impact analysis

This proposed change would offer an alternative compliance path to fire blocking in wall assemblies, provided certain conditions are met. This optional path would allow wall assembly systems to be designed that provide an equivalent level of safety to fire blocking.

In some cases, this optional path might provide a cost savings in materials and labour where other details of the wall assembly are suitable and installed to meet other design objectives.

No negative impacts on regulators, industry or consumers are anticipated.

Enforcement implications

This proposed change could be enforced within the existing enforcement infrastructure. Authorities having jurisdiction would be familiar with the requirements as they apply to Part 3 buildings, as these requirements have been in force for some time. The proposed application of the requirements to Part 2 farm buildings would be similar to their application to Part 3 buildings.

Who is affected

Those concerned with the design, construction and operation of farm buildings, including engineers, architects, builders, building owners and regulators, would be affected by the proposed change.

This proposed change would offer an alternative compliance path to allow owners, in conjunction with designers, to design and construct farm buildings to meet the owners' specific requirements.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[2.2.1.8.] 2.2.1.8. ([1] 1) [F03-OS1.2]

[2.2.1.8.] 2.2.1.8. ([2] 2) [F03-OS1.2]

-- (--) no attributions

[2.2.1.8.] 2.2.1.8. ([4] 3) [F03-OS1.2]

[2.2.1.8.] 2.2.1.8. ([5] 4) [F03-OS1.2]

[2.2.1.8.] 2.2.1.8. ([6] 5) no attributions

Submit a comment

Proposed Change 1476

Code Reference(s):	NBC20 Div.B 3.1.4.2.(1) (first printing) NBC20 Div.B 3.1.5.15. (first printing)
Subject:	Building Fire Safety
Title:	Testing of Protection for Foamed Plastic Insulation
Description:	This proposed change updates existing references to test methods for the evaluation of thermal barriers for foamed plastic insulation and introduces references to CAN/ULC-S145:2018, "Standard Method of Test for the Evaluation of Protective Coverings for Foamed Plastic Insulation – Full-Scale Room Test."
Related Code Change Request(s):	CCR 943, CCR 944, CCR 1071

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [x] Design and Construction
- [ ] Building operations
- [ ] Housing
- [ ] Small Buildings
- [x] Large Buildings
- [x] Fire Protection
- [ ] Occupant safety in use
- [ ] Accessibility
- [ ] Structural Requirements
- [ ] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

The NBC includes provisions requiring that thermal barriers for the protection of foamed plastic insulation be tested in accordance with CAN/ULC-S101, "Fire Endurance Tests of Building Construction and Materials." However, this standard does not contain provisions specifically for evaluating thermal barriers.

CAN/ULC-S124:2018, "Standard Method of Test for the Evaluation of Thermal Barriers for Foamed Plastic," was updated to replace CAN/ULC-S101 for the evaluation of thermal barriers. The updated standard should be referenced to ensure that thermal barriers achieve the anticipated level of performance.

Justification

In the last Code cycle, the Standing Committee on Fire Protection was asked to address two issues relating to thermal barriers:

1. The misapplication of CAN/ULC-S101, which arose due to the lack of specific information on the required location of the thermal couples where temperatures are measured.
2. The publication of the 2018 edition of CAN/ULC-S124, a test method for evaluating thermal barriers as protection for foamed plastics, which was developed as a result of Canadian Construction Materials Centre (CCMC) evaluations.

In the meantime, a new standard, CAN/ULC-S145:2018, "Standard Method of Test for the Evaluation of Protective Coverings for Foamed Plastic Insulation – Full-Scale Room Test," was developed for the evaluation of thermal barrier materials using a test method based on CAN/ULC-9705, "Fire Tests – Full-Scale Room Test for Surface Products."

This proposed change intends to introduce references to these standards in the Code where appropriate.

PROPOSED CHANGE

[3.1.4.2.] 3.1.4.2. Protection of Foamed Plastics

[1] 1) Except as permitted in Sentence (2), foamed plastics that form part of a wall or ceiling assembly in *combustible construction* shall be protected from adjacent spaces in the *building*, other than adjacent concealed spaces within *attic or roof spaces*, crawl spaces, and wall and ceiling assemblies,

[a] a) by one of the interior finishes described in Subsections 9.29.4. to 9.29.9.,

[b] b) provided the *building* does not contain a Group A, Group B or Group C *major occupancy*, by sheet metal

[i] i) mechanically fastened to the supporting assembly independent of the insulation,

[ii] ii) not less than 0.38 mm thick, and

[iii] iii) with a melting point not below 650°C, ~~or~~

[c] c) by any thermal barrier that meets the requirements of Sentence 3.1.5.15.(2) (see Note A-3.1.4.2.(1)(c))~~.~~, or

[d] --) by any protective covering that meets the requirements of classification 10 min when tested in conformance with CAN/ULC-S145:2018, “Standard Method of Test for the Evaluation of

Protective Coverings for Foamed Plastic Insulation – Full-Scale Room Test."

(See Note A-3.1.4.2.(1).)

[3.1.5.15.] 3.1.5.15. Foamed Plastic Insulation

(See Notes A-3.1.4.2. and A-3.1.4.2.(1).)

[1] 1) Foamed plastic insulation is permitted to be installed above roof decks, outside of *foundation* walls below ground level, and beneath concrete slabs-on-ground of a *building* required to be of *noncombustible construction*.

[2] 2) Except as provided in Sentences (3), (4) and 3.1.5.7.(1), foamed plastic insulation with a *flame-spread rating* not more than 500 on any exposed surface, or any surface that would be exposed by cutting through the material in any direction, is permitted in a *building* required to be of *noncombustible construction*, provided the insulation is protected from adjacent space in the *building*, other than adjacent concealed spaces within wall assemblies, by a thermal barrier consisting of

[a] a) not less than 12.7 mm thick gypsum board mechanically fastened to a supporting assembly independent of the insulation,

[b] b) lath and plaster, mechanically fastened to a supporting assembly independent of the insulation,

[c] c) masonry,

[d] d) concrete, ~~or~~

[e] e) any thermal barrier that meets the requirements of classification B2 when tested in conformance with CAN/ULC-S124:2018, "Standard Method of Test for the Evaluation of ~~Protective Coverings~~Thermal Barriers for Foamed Plastic,~~.~~" or

[f] --) any protective covering that meets the requirements of classification 20 min when tested in conformance with CAN/ULC-S145:2018, "Standard Method of Test for the Evaluation of Protective Coverings for Foamed Plastic Insulation – Full-Scale Room Test."

[3] 3) Foamed plastic insulation with a *flame-spread rating* more than 25 but not more than 500 on any exposed surface, or any surface that would be exposed by cutting through the material in any direction, is permitted in the exterior walls of a *building* required to be of *noncombustible construction* that is not *sprinklered* and is more than 18 m high, measured from *grade* to the underside of the roof, provided the insulation is protected from adjacent space in the *building*, other than adjacent concealed spaces within wall assemblies, by a thermal barrier consisting of

[a] a) gypsum board not less than 12.7 mm thick, mechanically fastened to a supporting assembly independent of the insulation and with all joints either backed or taped and filled,

[b] b) lath and plaster, mechanically fastened to a supporting assembly independent of the insulation,

[c] c) masonry or concrete not less than 25 mm thick, ~~or~~

[d] d) any thermal barrier that~~, when tested in conformance with CAN/ULC-S101, "Standard Method of Fire Endurance Tests of Building Construction and Materials", does not develop an average temperature rise more than 140°C or a maximum temperature rise more than 180°C at any point on its unexposed face within 10 min (see Note A-3.1.5.14.(5)(d)) (see also Article 3.2.3.7.).~~ meets the requirements of classification B1 when tested in conformance with CAN/ULC-S124:2018, “Standard Method of Test for the Evaluation of Thermal Barriers for Foamed Plastic,” or

[e] --) any protective covering that meets the requirements of classification 20 min when tested in conformance with CAN/ULC-S145:2018, “Standard Method of Test for the Evaluation of Protective Coverings for Foamed Plastic Insulation – Full-Scale Room Test.”

[4] 4) Foamed plastic insulation with a *flame-spread rating* more than 25 but not more than 500 on any exposed surface, or any surface that would be exposed by cutting through the material in any direction, is permitted in the interior walls, within ceilings and within roof assemblies of a *building* required to be of *noncombustible construction* that is not *sprinklered* and is more than 18 m high, measured from *grade* to the underside of the roof, provided the insulation is protected from adjacent space in the *building*, other than adjacent concealed spaces within wall assemblies, by a thermal barrier consisting of

[a] a) Type X gypsum board not less than 15.9 mm thick, mechanically fastened to a supporting assembly independent of the insulation and with all joints either backed or taped and filled, conforming to

[i] i) ASTM C1177/C1177M, "Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing",

[ii] ii) ASTM C1178/C1178M, "Standard Specification for Coated Glass Mat Water-Resistant Gypsum Backing Panel",

[iii] iii) ASTM C1396/C1396M, "Standard Specification for Gypsum Board", or

[iv] iv) CAN/CSA A82.27-M, "Gypsum Board",

[b] b) non-*loadbearing* masonry or concrete not less than 50 mm thick,

[c] c) *loadbearing* masonry or concrete not less than 75 mm thick, or

[d] d) any thermal barrier that~~, when tested in conformance with CAN/ULC-S101, "Standard Method of Fire Endurance Tests of~~

~~Building Construction and Materials",~~ meets the requirements of classification AH40 when tested in conformance with CAN/ULC-S124:2018, "Standard Method of Test for the Evaluation of Thermal Barriers for Foamed Plastic."

~~[i] i) does not develop an average temperature rise more than 140°C or a maximum temperature rise more than 180°C at any point on its unexposed face within 20 min, and~~

~~[ii] ii) remains in place for not less than 40 min.~~

Impact analysis

This proposed change would clarify the application of the Code and provide an additional option for compliance through testing.

Any additional cost of testing a material using this new option could be offset by avoiding the cost of pursuing an alternative solution to meet the Code requirements.

Enforcement implications

This proposed change could be enforced by the current enforcement infrastructure for the Code.

Who is affected

Architects, engineers, designers, regulators and builders.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[3.1.4.2.] 3.1.4.2. ([1] 1) [F01-OS1.1] [F02-OS1.2]

[3.1.4.2.] 3.1.4.2. ([1] 1) [F01-OP1.1] [F02-OP1.2]

[3.1.5.15.] 3.1.5.15. ([1] 1) no attributions

[3.1.5.15.] 3.1.5.15. ([2] 2) no attributions

[3.1.5.15.] 3.1.5.15. ([3] 3) no attributions

[3.1.5.15.] 3.1.5.15. ([4] 4) no attributions

Submit a comment

Proposed Change 1791

Code Reference(s):	NBC20 Div.B 3.1.4.8. (first printing) NBC20 Div.B 3.2.2.10. (first printing) NBC20 Div.B 3.2.5.6. (first printing)
Subject:	Combustible Construction — Fire Protection and Safety
Title:	Combustible Cladding and Street Frontage of Mid-rise Combustible Buildings
Description:	This proposed change revises the requirements for mid-rise combustible buildings regarding cladding and street frontage.
Related Code Change Request(s):	CCR 1384

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [x] Design and Construction
- [ ] Building operations
- [ ] Housing
- [ ] Small Buildings
- [x] Large Buildings
- [x] Fire Protection
- [ ] Occupant safety in use
- [ ] Accessibility
- [ ] Structural Requirements
- [ ] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

Currently, the Code allows mid-rise combustible buildings facing a single street to have combustible cladding on up to 10% of the area of each exterior wall, including those that do not face a street.

The potential risks associated with combustible cladding without fire performance or testing are not sufficiently well managed where the cladding is permitted to be located on the building face of a mid-rise combustible building that is not reachable by fire services from an adjacent street. With limited access for fire services, the combustible cladding has a greater risk of potential uncontrolled fire, which could lead to significant damage to buildings.

Also, the existing Code language links the combustibility of cladding to general requirements for street frontage, but provides no instruction on how this link could be applied to other scenarios. Due to the specific requirements for minimum street frontage, some lots may be left undeveloped as combustible mid-rise construction is not an option.

Justification

Combustible cladding presents a greater potential fire risk than noncombustible cladding. The expected performance level for combustible cladding accepts some risk when firefighting intervention is possible; however, limited access to the exterior of the building can impede firefighting intervention. Exterior walls of mid-rise combustible buildings that are not accessible to external firefighting intervention should be adequately protected.

Permitting combustible cladding where there is no potential for external firefighting intervention suggests an unequal level of performance. The risks associated with combustible cladding can be limited where sufficient access allows for external firefighting intervention (similar to the approach applied to mid-rise combustible buildings in respect to restricting the combustibility of roof coverings based on roof height).

This proposed change would permit a building that has a higher percentage of street frontage to have some percentage of combustible cladding on a greater portion of the building, compared to a building with a limited percentage of street frontage, which can only have a limited portion with combustible cladding.

Addressing the risks associated with combustible cladding by directly linking the amount of combustible cladding to the possibility of external firefighting intervention would allow for the removal of the unique facing-one-street requirement linked to combustible cladding. Every mid-rise combustible building that is sprinklered will still be required to face a street located in conformance with the requirements of Articles 3.2.5.4. and 3.2.5.5. for access routes.

The street frontage requirements not only dictate potential cladding requirements, but also dictate the type of building construction. A building can only face a certain amount of street due to lot size. With that in mind, if all buildings were required to have a certain percentage (10% to 25%) of street frontage, the number of developable lots would be directly impacted by those requirements. This proposed change would allow the selection of appropriate cladding and cladding locations, rather than fire protection based on the percentage of basic street frontage for lots that previously would not have been permitted to have combustible mid-rise construction.

With this proposed change, the hazard of combustible exterior cladding would be reduced by limiting the amount of combustible cladding that is permitted to be on the building, based on the physical distance between the cladding and an adjacent street. This proposed change would also ensure an acceptable level of fire risk to buildings and occupants.

This proposed change would directly link the permitted use of combustible cladding on mid-rise buildings to perimeter street access, while also removing the unique provisions for street frontage measurements for mid-rise combustible buildings that are sprinklered.

This proposed change would also delete the cross-reference to the previous Sentence 3.2.2.10.(3) in Sentence 3.2.5.6.(2). The 20 m requirement in Sentence 3.2.5.6.(2) is still relevant for buildings conforming to Article 3.2.2.51. or 3.2.2.60.

It was decided to refer to Sentence 3.2.2.10.(1) for general requirements for access routes.

PROPOSED CHANGE

[3.1.4.8.] 3.1.4.8. Exterior Cladding

[1] 1) Except as provided in Sentence (2)-2020, ~~not less than 90% of the exterior~~ cladding on ~~each~~an exterior wall assembly of a *building* or part of a *building*~~*s*~~ conforming to Article 3.2.2.51. or 3.2.2.60. shall consist of

[a] a) *noncombustible* cladding, or

[b] b) except as provided in Sentence (4), a wall assembly that satisfies the criteria of Clause 3.1.5.5.(1)(b).

(See Note A-3.1.4.8.(1).) (See also Notes A-3.1.5.5.(1)(b)(i) and A-3.1.5.5.(1)(b)(ii).)

[2] 2) For *buildings* conforming to Article 3.2.2.51. or 3.2.2.60., *combustible* cladding is permitted to represent up to 10% of the cladding on the face of an exterior wall facing a *street* or access route, provided all portions of the *combustible* cladding are located not more than 15 m from a *street* or access route conforming to Article 3.2.5.6., measured horizontally from the face of the *building*.~~Where a *building* is considered to face 1 *street* in accordance with Clause 3.2.2.10.(3)(b), the exterior cladding on each exterior wall of *buildings* conforming to Article 3.2.2.51. or 3.2.2.60. shall consist of~~

~~[a] a) *noncombustible* cladding, or~~

~~[b] b) except as provided in Sentence (4), a wall assembly that satisfies the criteria of Clause 3.1.5.5.(1)(b).~~

[3] 3) A wall assembly conforming to Clause (1)(b) ~~or (2)(b)~~ that includes *combustible* cladding made of *fire-retardant-treated wood* shall be tested

for fire exposure after the cladding has been subjected to the accelerated weathering test specified in ASTM D2898, "Standard Practice for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing".

[4] 4) Exterior wall assemblies constructed in accordance with Section D-6. of Appendix D are deemed to comply with Clause~~s~~ (1)(b) ~~and (2)(b)~~.

[3.2.2.10.] 3.2.2.10. Streets

[1] 1) Every *building* shall face a *street* located in conformance with the requirements of Articles 3.2.5.4. and 3.2.5.5. for access routes.

[2] 2) For the purposes of Subsections 3.2.2. and 3.2.5. an access route conforming to Subsection 3.2.5. is permitted to be considered as a *street*.

~~[3] 3) A *building* conforming to Article 3.2.2.51. or 3.2.2.60. is considered to face 1 *street* where~~

~~[a] a) not less than 25% of the *building* perimeter is located within 15 m of a *street* or *streets*, or~~

~~[b] b) not less than 10% of the *building* perimeter is located within 15 m of a *street* or *streets*, provided the exterior cladding conforms to Sentence 3.1.4.8.(2).~~

[4] 4) A *building* is considered to face 2 *streets* provided not less than 50% of the *building* perimeter is located within 15 m of the *street* or *streets*.

[5] 5) A *building* is considered to face 3 *streets* provided not less than 75% of the *building* perimeter is located within 15 m of the *street* or *streets*.

[6] 6) Enclosed spaces, tunnels, bridges and similar structures, even though used for vehicular or pedestrian traffic, are not considered as *streets* for the purpose of this Part.

[3.2.5.6.] 3.2.5.6. Access Route Design

[1] 1) A portion of a roadway or yard provided as a required access route for fire department use shall

[a] a) have a clear width not less than 6 m, unless it can be shown that lesser widths are satisfactory,

[b] b) have a centre-line radius not less than 12 m,

[c] c) have an overhead clearance not less than 5 m,

[d] d) have a change of gradient not more than 1 in 12.5 over a minimum distance of 15 m,

[e] e) be designed to support the expected loads imposed by firefighting equipment and be surfaced with concrete, asphalt or other material designed to permit accessibility under all climatic conditions,

[f] f) have turnaround facilities for any dead-end portion of the access route more than 90 m long, and

[g] g) be connected with a public thoroughfare.

(See Note A-3.2.5.6.(1).)

[2] 2) For *buildings* conforming to Article 3.2.2.51. or 3.2.2.60., no portion of ~~the~~an access route ~~described in Sentence 3.2.2.10.(3)~~ required by Sentence 3.2.2.10.(1) shall be more than 20 m below the uppermost floor level.

Impact analysis

No additional costs are expected. However, some potential savings (e.g., developmental costs) might arise as developers would have more flexibility in selecting lots of various sizes and frontages for the construction of mid-rise combustible buildings.

Enforcement implications

This proposed change could be enforced by existing the enforcement infrastructure.

Since the street access requirement associated with the percentage of building perimeter and distance from a street would be removed, buildings conforming to Article 3.2.2.51. or 3.2.2.60. would only need to comply with the general requirements for access routes. As authorities having jurisdiction would no longer be required to measure the building perimeter to assess Code compliance, this proposed change would facilitate the enforcement of the Code.

Who is affected

Architects, engineers, building owners, regulators, manufacturers and fire services.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[3.1.4.8.] 3.1.4.8. ([1] 1) [F02,F03-OP3.1]

[3.1.4.8.] 3.1.4.8. ([2] 2) [F02,F03-OP3.1]

[3.1.4.8.] 3.1.4.8. ([3] 3) no attributions

[3.1.4.8.] 3.1.4.8. ([4] 4) no attributions

[3.2.2.10.] 3.2.2.10. ([1] 1) [F12-OS1.2,OS1.5]

[3.2.2.10.] 3.2.2.10. ([1] 1) [F12-OP1.2]

[3.2.2.10.] 3.2.2.10. ([2] 2) no attributions

~~[3.2.2.10.] 3.2.2.10. ([3] 3) no attributions~~

[3.2.2.10.] 3.2.2.10. ([4] 4) no attributions

[3.2.2.10.] 3.2.2.10. ([5] 5) no attributions

[3.2.2.10.] 3.2.2.10. ([6] 6) no attributions

[3.2.5.6.] 3.2.5.6. ([1] 1) [F12-OS1.2]

[3.2.5.6.] 3.2.5.6. ([1] 1) [F12-OP1.2]

[3.2.5.6.] 3.2.5.6. ([2] 2) [F02,F12-OS1.2]

[3.2.5.6.] 3.2.5.6. ([2] 2) [F02,F12,F03-OP1.2]

[3.2.5.6.] 3.2.5.6. ([2] 2) [F02,F12,F03-OP3.1]

Submit a comment

Proposed Change 1786

Code Reference(s):	NBC20 Div.B 3.1.5. (first printing)
Subject:	Other — Fire Protection
Title:	Combustible Components in Swimming Pools and Hot Tubs
Description:	This proposed change adds an exemption for combustible components in pools and hot tubs.
Related Code Change Request(s):	CCR 1594

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [x] Design and Construction
- [ ] Building operations
- [ ] Housing
- [ ] Small Buildings
- [ ] Large Buildings
- [x] Fire Protection
- [ ] Occupant safety in use
- [ ] Accessibility
- [ ] Structural Requirements
- [ ] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

The NBC 2020 does not clearly differentiate combustible construction from combustible components, which may lead to the misinterpretation of the intended application of Subsection 3.1.5. regarding components that could be considered as building components because they are permanent.

Subsection 3.1.5. deals with noncombustible construction and provide exemptions for the use of combustible materials and components deemed to not significantly contribute to fire growth and spread. Currently, combustible components used in swimming pools and hot tubs (including, but not limited to, main drains, piping, skimmers, return inlets, steps, ladder rungs and liners) are not listed as exemptions in Subsection 3.1.5. As such, these components used in noncombustible construction are required to be noncombustible. This requirement causes difficulties for the industry as, in practice, combustible components in swimming pools and hot tubs are already in use and are not known to pose a significant fire hazard.

Justification

This proposed change would clarify the application of the requirements for noncombustible construction in Subsection 3.1.5. with respect to combustible components used in swimming pools and hot tubs regardless of whether these components are interpreted as being permanent or not. This proposed change would permit the use of combustible components in swimming pools and hot tubs in noncombustible construction, which aligns with industry practice.

In addition, this proposed change would harmonize the requirements of the NBC with those of the Ontario Building Code (OBC), as proposed NBC Article 3.1.5.25. originates from OBC Article 3.1.5.22. The OBC provides requirements specific to public pools in OBC Section 3.11. and public spas in OBC Section 3.12. of Division B (the term "hot tub" is used instead of "spa" in the NBC). The requirements are largely based upon guidelines and standards developed by the Ontario Ministry of Health in the late 1980s. Although the OBC includes definitions of the terms "public pool" and "public spa" in OBC Article 1.4.1.2. of Division A, it was recognized that this proposed change to the NBC is not limited to public pools and hot tubs; thus, it was agreed that there was no need to propose the introduction of those definitions in the NBC at this time.

PROPOSED CHANGE

[3.1.5.] 3.1.5. Noncombustible Construction

[3.1.5.1.] 3.1.5.1. Noncombustible Materials

(See Note A-3.1.4.1.(1).)

[1] 1) Except as permitted by Sentences (2) to (4) and Articles 3.1.5.2. to 3.1.5.25.~~to 3.1.5.24.~~, 3.1.13.4. and 3.2.2.16., a *building* or part of a *building* required to be of *noncombustible construction* shall be constructed with *noncombustible* materials. (See also Subsection 3.1.13. for the requirements regarding the *flame-spread rating* of interior finishes.)

[2] 2) Notwithstanding the definition of *noncombustible* materials stated in Article 1.4.1.2. of Division A, a material is permitted to be used in *noncombustible construction* provided that, when tested in accordance with ULC-S135, "Standard Test Method for the Determination of

Combustibility Parameters of Building Materials Using an Oxygen Consumption Calorimeter (Cone Calorimeter)", at a heat flux of 50 kW/m^2,

[a] a) its average total heat release is not more than 3 MJ/m^2,

[b] b) its average total smoke extinction area is not more than 1.0 m^2, and

[c] c) the test duration is extended beyond the time stipulated in the referenced standard until it is clear that there is no further release of heat or smoke.

[3] 3) If a material referred to in Sentence (2) consists of a number of discrete layers and testing reveals that the surface layer or layers protect the underlying layers such that complete combustion of the underlying layers does not occur, the test shall be repeated by removing the outer layers sequentially until all layers have been exposed during testing, or until complete combustion has occurred.

[4] 4) The acceptance criteria for a material tested in accordance with Sentence (3) shall be based on the cumulative emissions from all layers, which must not exceed the criteria stated in Clauses (2)(a) and (b).

[3.1.5.23.] 3.1.5.23. Non-metallic Raceways

[3.1.5.24.] 3.1.5.24. Decorative Wood Cladding

[3.1.5.25.] --- Combustible Components in Swimming Pools and Hot Tubs

[1] --) *Combustible* fittings and components used in a swimming pool or hot tub, including main drains, piping, skimmers, return inlets, steps, ladder rungs, and liners, are permitted in a *building* required to be of *noncombustible construction.*

Impact analysis

This proposed change is a clarification of the application of Subsection 3.1.5. and would help regulators better assess the risk of using combustible components in swimming pools and hot tubs. No additional costs are anticipated as a result of this proposed change because combustible components are already used in practice.

Enforcement implications

This proposed change is a clarification of the application of Subsection 3.1.5. and, therefore, is anticipated to facilitate enforcement of the Code provisions. This proposed change also harmonizes the NBC requirements with those of the OBC.

Who is affected

Regulators, engineers, building owners, and contractors would benefit from this proposed clarification of the intent of the Code.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[3.1.5.1.] 3.1.5.1. ([1] 1) [F02-OS1.2]

[3.1.5.1.] 3.1.5.1. ([1] 1) [F02-OP1.2]

[3.1.5.1.] 3.1.5.1. ([2] 2) no attributions

[3.1.5.1.] 3.1.5.1. ([3] 3) no attributions

[3.1.5.1.] 3.1.5.1. ([4] 4) no attributions

[3.1.5.2.] 3.1.5.2. ([1] 1) no attributions

[3.1.5.3.] 3.1.5.3. ([1] 1) no attributions

[3.1.5.3.] 3.1.5.3. ([2] 2) no attributions

[3.1.5.3.] 3.1.5.3. ([2] 2) ([c] c)

[3.1.5.3.] 3.1.5.3. ([3] 3) no attributions

[3.1.5.3.] 3.1.5.3. ([4] 4) no attributions

[3.1.5.4.] 3.1.5.4. ([1] 1) no attributions

[3.1.5.4.] 3.1.5.4. ([2] 2) no attributions

[3.1.5.4.] 3.1.5.4. ([3] 3) no attributions

[3.1.5.4.] 3.1.5.4. ([4] 4) no attributions

[3.1.5.4.] 3.1.5.4. ([4] 4) ([b] b)

[3.1.5.4.] 3.1.5.4. ([5] 5) no attributions

[3.1.5.5.] 3.1.5.5. ([1] 1) no attributions

[3.1.5.5.] 3.1.5.5. ([2] 2) [F03,F02-OP3.1]

[3.1.5.5.] 3.1.5.5. ([3] 3) no attributions

[3.1.5.5.] 3.1.5.5. ([4] 4) no attributions

[3.1.5.6.] 3.1.5.6. ([1] 1) no attributions

[3.1.5.6.] 3.1.5.6. ([2] 2) no attributions

[3.1.5.7.] 3.1.5.7. ([1] 1) no attributions

[3.1.5.7.] 3.1.5.7. ([2] 2) no attributions

[3.1.5.7.] 3.1.5.7. ([3] 3) no attributions

[3.1.5.8.] 3.1.5.8. ([1] 1) no attributions

[3.1.5.9.] 3.1.5.9. ([1] 1) no attributions

[3.1.5.10.] 3.1.5.10. ([1] 1) no attributions

[3.1.5.10.] 3.1.5.10. ([2] 2) no attributions

[3.1.5.10.] 3.1.5.10. ([2] 2) no attributions

[3.1.5.10.] 3.1.5.10. ([3] 3) no attributions

[3.1.5.10.] 3.1.5.10. ([4] 4) no attributions

[3.1.5.11.] 3.1.5.11. ([1] 1) no attributions

[3.1.5.12.] 3.1.5.12. ([1] 1) no attributions

[3.1.5.12.] 3.1.5.12. ([2] 2) no attributions

[3.1.5.12.] 3.1.5.12. ([3] 3) no attributions

[3.1.5.12.] 3.1.5.12. ([4] 4) no attributions

[3.1.5.13.] 3.1.5.13. ([1] 1) no attributions

[3.1.5.14.] 3.1.5.14. ([1] 1) no attributions

[3.1.5.14.] 3.1.5.14. ([2] 2) no attributions

[3.1.5.14.] 3.1.5.14. ([3] 3) no attributions

[3.1.5.14.] 3.1.5.14. ([4] 4) no attributions

[3.1.5.14.] 3.1.5.14. ([5] 5) no attributions

[3.1.5.14.] 3.1.5.14. ([5] 5) no attributions

[3.1.5.14.] 3.1.5.14. ([6] 6) no attributions

[3.1.5.14.] 3.1.5.14. ([6] 6) no attributions

[3.1.5.15.] 3.1.5.15. ([1] 1) no attributions

[3.1.5.15.] 3.1.5.15. ([2] 2) no attributions

[3.1.5.15.] 3.1.5.15. ([3] 3) no attributions

[3.1.5.15.] 3.1.5.15. ([4] 4) no attributions

[3.1.5.16.] 3.1.5.16. ([1] 1) no attributions

[3.1.5.16.] 3.1.5.16. ([2] 2) no attributions

[3.1.5.16.] 3.1.5.16. ([3] 3) no attributions

[3.1.5.17.] 3.1.5.17. ([1] 1) no attributions

[3.1.5.18.] 3.1.5.18. ([1] 1) no attributions

[3.1.5.18.] 3.1.5.18. ([2] 2) no attributions

[3.1.5.18.] 3.1.5.18. ([3] 3) no attributions

[3.1.5.19.] 3.1.5.19. ([1] 1) no attributions

[3.1.5.19.] 3.1.5.19. ([2] 2) no attributions

[3.1.5.19.] 3.1.5.19. ([3] 3) no attributions

[3.1.5.20.] 3.1.5.20. ([1] 1) no attributions

[3.1.5.21.] 3.1.5.21. ([1] 1) no attributions

[3.1.5.21.] 3.1.5.21. ([2] 2) [F02-OS1.2]

[3.1.5.21.] 3.1.5.21. ([2] 2) [F02-OP1.2]

[3.1.5.21.] 3.1.5.21. ([3] 3) [F02-OS1.2]

[3.1.5.21.] 3.1.5.21. ([3] 3) [F02-OP1.2]

[3.1.5.21.] 3.1.5.21. ([3] 3) no attributions

[3.1.5.21.] 3.1.5.21. ([4] 4) no attributions

[3.1.5.22.] 3.1.5.22. ([1] 1) no attributions

[3.1.5.23.] 3.1.5.23. ([1] 1) [F02-OS1.2]

[3.1.5.23.] 3.1.5.23. ([1] 1) [F02-OP1.2]

[3.1.5.23.] 3.1.5.23. ([1] 1) no attributions

[3.1.5.23.] 3.1.5.23. ([2] 2) no attributions

[3.1.5.23.] 3.1.5.23. ([2] 2) [F02-OS1.2]

[3.1.5.23.] 3.1.5.23. ([2] 2) [F02-OP1.2]

[3.1.5.24.] 3.1.5.24. ([1] 1) no attributions

-- (--) no attributions

Submit a comment

Proposed Change 1699

Code Reference(s):	NBC20 Div.B 3.1.8.11.(3) (first printing)
Subject:	Fire Alarm and Detection Systems
Title:	Activation of Smoke Dampers by Smoke Detectors
Description:	This proposed change introduces Note A-3.1.8.11.(3) to clarify that the activation of a smoke damper or combination smoke/fire damper by a smoke detector does not necessarily require that device to be part of a fire alarm system where such system is not otherwise required by the NBC.
Related Proposed Change(s):	PCF 1700
Related Provision(s):	NBC 2015 Div. B 3.2.4.1.

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [ ] Design and Construction
- [ ] Building operations
- [ ] Housing
- [x] Small Buildings
- [ ] Large Buildings
- [x] Fire Protection
- [x] Occupant safety in use
- [ ] Accessibility
- [ ] Structural Requirements
- [ ] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

Sentence 3.1.8.11.(3) requires the installation of a smoke detector to automatically close the adjacent smoke damper or combination smoke/fire damper upon signal, except as required by a smoke control system. The Sentence also requires that the smoke detector be located as described in CAN/ULC-S524, "Standard for Installation of Fire Alarm Systems." The latter requirement has created some confusion and has been misinterpreted to mean that a fire alarm system is required even in buildings that would not otherwise be required to have one.

Potentially adding to the confusion, Sentence 3.2.4.10.(1) does not specify that smoke detectors only intended for connection to releasing devices such as smoke dampers and combination smoke/fire dampers do not need to be connected to a fire alarm system.

Justification

Article 3.1.8.11. was added in the 2015 edition of the NBC. The related intent statements, functional statements and objectives only cover the operation and activation of the smoke damper to prevent the spread of smoke. The functional statements for Article 3.1.8.11. are F03 and F82:

F03 – To retard the effects of fire on areas beyond its point of origin.

F82 – To minimize the risk of inadequate performance due to improper maintenance or lack of maintenance.

There is no clear indication that the smoke detector used for this purpose is also required to:

- be connected to a fire alarm system;
- activate the fire alarm system; or
- notify occupants for timely evacuation.

The determination of the requirement for a fire alarm system is clearly and sufficiently covered in Article 3.2.4.1. This Article does not link to the requirement in Sentence 3.1.8.11.(3), signifying that there is no clear necessity for an interconnection between the fire alarm system and the smoke detector that is intended to activate the adjacent smoke damper or combination smoke/fire damper.

By introducing Note A-3.1.8.11.(3), this proposed change clarifies the intent of the Code: smoke detectors that are located as described in CAN/ULC-S524 and only intended to activate smoke dampers and combination smoke/fire dampers are not required to be connected to a fire alarm system if such system is not required in the building by Article 3.2.4.1. Sentence 3.1.8.11.(3) does not extend the requirement for a fire alarm system beyond the requirement in Article 3.2.4.1.

PROPOSED CHANGE

[3.1.8.11.] 3.1.8.11. Installation of Smoke Dampers

[1] 3) Except as required by a smoke control system, smoke dampers and combination smoke/*fire dampers* shall be configured so as to close automatically upon a signal from an adjacent *smoke detector* located as described in CAN/ULC-S524, "Standard for Installation of Fire Alarm

Systems", within 1.5 m horizontally of the duct or air-transfer opening in the *fire separation*

[a] a) on both sides of the air-transfer opening, or

[b] b) in the duct downstream of the smoke damper or combination smoke/*fire damper*.

(See Note A-3.1.8.11.(3).)

Note A-3.1.8.11.(3) Requirement for a Fire Alarm System.

Sentence 3.1.8.11.(3) is not intended to invoke the requirement for a fire alarm system where not otherwise required by Article 3.2.4.1.

Impact analysis

This proposed clarification would result in economic savings and reduced costs for buildings that are not required to have a fire alarm system, but have smoke dampers and combination smoke/fire dampers installed. There would be no reduction in fire protection or level of fire safety.

Enforcement implications

This proposed change is not anticipated to cause enforcement challenges because it intends to clarify the Code requirement and reduce potential misinterpretations.

Who is affected

Regulators, engineers, building owners, installers, contractors and fire services.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[3.1.8.11.] 3.1.8.11. ([1] 3) [F03-OS1.2]

[3.1.8.11.] 3.1.8.11. ([1] 3) [F03-OP1.2]

Submit a comment

Proposed Change 1792

Code Reference(s):	NBC20 Div.B 3.2.2.48. (first printing)
Subject:	Encapsulated Mass Timber Construction
Title:	Increase of Height Limit for EMTC Buildings in Group C, up to 12 Storeys and Sprinklered
Description:	This proposed change increases the maximum physical height in Clause 3.2.2.48.(1)(c) to 50 m.
Related Code Change Request(s):	CCR 1395
Related Proposed Change(s):	PCF 1794

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [x] Design and Construction
- [ ] Building operations
- [ ] Housing
- [ ] Small Buildings
- [x] Large Buildings
- [x] Fire Protection
- [x] Occupant safety in use
- [ ] Accessibility
- [x] Structural Requirements
- [ ] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

In the last Code cycle, provisions were added in Division B of the NBC 2020 that permit the construction of buildings up to 12 storeys in building height using encapsulated mass timber construction (EMTC).

Currently, NBC Clause 3.2.2.48.(1)(c) mandates a maximum physical height of 42 m (measured between the floor of the first storey and the uppermost floor level that does not service a rooftop enclosure as specified) for EMTC buildings in Group C that are up to 12 storeys in building height and sprinklered.

The maximum physical height of 42 m results in an average floor-to-floor height of 3.8 m for a 12-storey building. However, many of the buildings currently being designed and constructed in Canada have an average floor-to-floor height of 4.5 to 4.6 m. This proposed change would increase the maximum physical height to 50 m to better reflect market trends in demand.

Justification

The physical height limit in the NBC 2020 was based on (1) a review of EMTC buildings that had already been constructed or were under construction in Canada, (2) historical physical height limits for buildings in the International Building Code (IBC) as applied in the USA, and (3) conventional industry practice regarding floor-to-floor height in steel-and-concrete buildings.

As such, at the time of the development of the existing EMTC provisions, very few tall mass timber buildings had been completed or were in the design-and-construction phase in Canada and even fewer in the USA. All of these buildings had been approved as alternative solutions, with a resulting wide variety of approaches to the overall design. As a result of the small and diverse sample size, the height of a storey in mass timber construction varied significantly between those buildings and there was not much convergence on a typical floor-to-floor height, nor was much consensus developed regarding optimal or typical designs for tall buildings of mass timber construction.

The approach of applying the historical physical height limits for buildings in the IBC and conventional industry practice regarding floor-to-floor height in steel-and-concrete buildings was utilized, given the lack of information related to tall buildings of modern mass timber construction. The approach was logical at the time, but could not anticipate how much the design of tall buildings of modern mass timber construction would diverge from that of tall buildings of typical steel-and-concrete construction.

As well, the requirements for EMTC related to structural design, fire-resistance ratings and encapsulation were concurrently under development. Therefore, at the time, it was challenging to determine the effect of those future EMTC requirements on individual storeys or floor-to-floor height.

As the number of construction projects for tall mass timber buildings has multiplied over the past five years, it has become clear that the combination of requirements (structural, fire-resistance rating, encapsulation, acoustic design, constructability, among others) and current market expectations for interior design space require a greater floor-to-floor height than originally anticipated when the NBC provisions for tall buildings using EMTC were developed and approved. As a result, a higher maximum physical height would be beneficial.

In addition, changes to the IBC regarding tall mass timber buildings were approved in December 2019, including design provisions for 12-storey mass timber buildings that have fire-protection (i.e., encapsulation) requirements similar to the EMTC provisions in the NBC 2020. The IBC requirements include specific limits regarding the allowable building height measured between grade (grade plane) and the average height of the highest roof surface. For 12-storey residential and business occupancies, the maximum permitted building height is 55 m (180 ft.), equivalent to an average storey height of 4.6 m (15 ft.).

This proposed change would increase the maximum permitted physical height to 50 m (164 ft.), measured between the floor of the first storey and the uppermost floor level that does not service a rooftop enclosure as specified, with an average storey height of 4.6 m (15 ft.), which is considered a more appropriate value than the current 42 m (138 ft.) with an average storey height of 3.8 m (12.5 ft.).

PROPOSED CHANGE

[3.2.2.48.] 3.2.2.48. Group C, up to 12 storeys, Sprinklered

[1] 1) A *building* classified as Group C is permitted to conform to Sentence (2), provided

- [a] a) it is *sprinklered* throughout,
- [b] b) it is not more than 12 *storeys* in *building height*,
- [c] c) it has a height not more than ~~42~~50 m measured between the floor of the *first storey* and the uppermost floor level that does not serve a rooftop enclosure for elevator machinery, a stairway or a *service room* used only for service to the *building*, and
- [d] d) it has a *building area* not more than 6 000 m^2.

[2] 2) Except as provided in Article 3.2.2.16., the *building* referred to in Sentence (1) is permitted to be of *encapsulated mass timber construction* or *noncombustible construction*, used singly or in combination, and

- [a] a) except as provided in Sentence (3), floor assemblies shall be *fire separations* with a *fire-resistance rating* not less than 2 h,
- [b] b) *mezzanines* shall have a *fire-resistance rating* not less than 1 h, and
- [c] c) *loadbearing* walls, columns and arches shall have a *fire-resistance rating* not less than that required for the supported assembly.

[3] 3) In a *building* that contains *dwelling units* that have more than one *storey*, subject to the requirements of Sentence 3.3.4.2.(3), the floor assemblies, including floors over *basements*, that are entirely contained within these *dwelling units* shall have a *fire-resistance rating* not less than 1 h, but need not be constructed as *fire separations*.

[4] 4) Group A, Division 2 *major occupancies*, Group E *major occupancies* and *storage garages* located in a *building* or part of a *building* within the scope of this Article are permitted to be constructed in accordance with this Article, provided

[a] a) the Group A, Division 2 *major occupancy* is located below the fourth *storey*,

[b] b) the Group E *major occupancy* is located below the third *storey*, and

[c] c) the *storage garage* is located below the fifth *storey* (see also Article 4.4.2.1.).

(See Note A-3.2.2.48.(4) and 3.2.2.57.(3).)

Impact analysis

This proposed change would not entail any additional costs because it would increase (i.e., relax) a physical height limit, although it would also allow taller EMTC buildings. This proposed change would be beneficial to builders, architects and engineers, and allow greater freedom with respect to constructability. It would also respond to current market expectations for interior design space, as well as other code and design requirements, regarding floor-to-floor height.

Enforcement implications

This proposed change would have no enforcement implications.

Who is affected

Architects, engineers, building owners, regulators and manufacturers.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[3.2.2.48.] 3.2.2.48. ([1] 1) no attributions

[3.2.2.48.] 3.2.2.48. ([2] 2) no attributions

[3.2.2.48.] 3.2.2.48. ([2] 2) ([b] b),([c] c) [F04-OS1.3]

[3.2.2.48.] 3.2.2.48. ([2] 2) ([b] b),([c] c) [F04-OP1.3]

[3.2.2.48.] 3.2.2.48. ([2] 2) ([a] a),([c] c) [F03-OS1.2] [F04-OS1.2,OS1.3]

[3.2.2.48.] 3.2.2.48. ([2] 2) ([a] a),([c] c) [F03-OP1.2] [F04-OP1.2,OP1.3]

[3.2.2.48.] 3.2.2.48. ([3] 3) no attributions

[3.2.2.48.] 3.2.2.48. ([4] 4) no attributions

Submit a comment

Proposed Change 1794

Code Reference(s):	NBC20 Div.B 3.2.2.57. (first printing)
Subject:	Encapsulated Mass Timber Construction
Title:	Increase of Height Limit for EMTC Buildings in Group D, up to 12 Storeys and Sprinklered
Description:	This proposed change increases the maximum physical height in Clause 3.2.2.57.(1)(c) to 50 m.
Related Code Change Request(s):	CCR 1396
Related Proposed Change(s):	PCF 1792

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [x] Design and Construction
- [ ] Building operations
- [ ] Housing
- [ ] Small Buildings
- [x] Large Buildings
- [x] Fire Protection
- [x] Occupant safety in use
- [ ] Accessibility
- [x] Structural Requirements
- [ ] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

In the last Code cycle, provisions were added in Division B of the NBC 2020 that permit the construction of buildings up to 12 storeys in building height using encapsulated mass timber construction (EMTC).

Currently, NBC Clause 3.2.2.57.(1)(c) mandates a maximum physical height of 42 m (measured between the floor of the first storey and the uppermost floor level that does not service a rooftop enclosure as specified) for EMTC buildings in Group D that are up to 12 storeys in building height and sprinklered.

The maximum physical height of 42 m results in an average floor-to-floor height of 3.8 m for a 12-storey building. However, many of the buildings currently being designed and constructed in Canada have an average floor-to-floor height of 4.5 to 4.6 m. This proposed change would increase the maximum physical height to 50 m to better reflect market trends in demand.

Justification

The physical height limit in the NBC 2020 was based on (1) a review of EMTC buildings that had already been constructed or were under construction in Canada, (2) historical physical height limits for buildings in the International Building Code (IBC) as applied in the USA, and (3) conventional industry practice regarding floor-to-floor height in steel-and-concrete buildings.

As such, at the time of the development of the existing EMTC provisions, very few tall mass timber buildings had been completed or were in the design-and-construction phase in Canada and even fewer in the USA. All of these buildings had been approved as alternative solutions, with a resulting wide variety of approaches to the overall design. As a result of the small and diverse sample size, the height of a storey in mass timber construction varied significantly between those buildings and there was not much convergence on a typical floor-to-floor height, nor was much consensus developed regarding optimal or typical designs for tall buildings of mass timber construction.

The approach of applying the historical physical height limits for buildings in the IBC and conventional industry practice regarding floor-to-floor height in steel-and-concrete buildings was utilized, given the lack of information related to tall buildings of modern mass timber construction. The approach was logical at the time, but could not anticipate how much the design of tall buildings of modern mass timber construction would diverge from that of tall buildings of typical steel-and-concrete construction.

As well, the requirements for EMTC related to structural design, fire-resistance ratings and encapsulation were concurrently under development. Therefore, at the time, it was challenging to determine the effect of those future EMTC requirements on individual storeys or floor-to-floor height.

As the number of construction projects for tall mass timber buildings has multiplied over the past five years, it has become clear that the combination of requirements (structural, fire-resistance rating, encapsulation, acoustic design, constructability, among others) and current market expectations for interior design space require a greater floor-to-floor height than originally anticipated when the NBC provisions for tall buildings using EMTC were developed and approved. As a result, a higher maximum physical height would be beneficial.

In addition, changes to the IBC regarding tall mass timber buildings were approved in December 2019, including design provisions for 12-storey mass timber buildings that have fire-protection (i.e., encapsulation) requirements similar to the EMTC provisions in the NBC 2020. The IBC requirements include specific limits regarding the allowable building height measured between grade (grade plane) and the average height of the highest roof surface. For 12-storey residential and business occupancies, the maximum permitted building height is 55 m (180 ft.), equivalent to an average storey height of 4.6 m (15 ft.).

This proposed change would increase the maximum permitted physical height to 50 m (164 ft.), measured between the floor of the first storey and the uppermost floor level that does not service a rooftop enclosure as specified, with an average storey height of 4.6 m (15 ft.), which is considered a more appropriate value than the current 42 m (138 ft.) with an average storey height of 3.8 m (12.5 ft.).

PROPOSED CHANGE

[3.2.2.57.] 3.2.2.57. Group D, up to 12 storeys, Sprinklered

[1] 1) A *building* classified as Group D is permitted to conform to Sentence (2), provided

[a] a) it is *sprinklered* throughout,

[b] b) it is not more than 12 *storeys* in *building height*,

[c] c) it has a height not more than ~~42~~50 m measured between the floor of the *first storey* and the uppermost floor level that does not serve a rooftop enclosure for elevator machinery, a stairway or a *service room* used only for service to the *building*, and

[d] d) it has a *building area* not more than 7 200 m^2.

[2] 2) Except as provided in Article 3.2.2.16., the *building* referred to in Sentence (1) is permitted to be of *encapsulated mass timber construction* or *noncombustible construction*, used singly or in combination, and

[a] a) floor assemblies shall be *fire separations* with a *fire-resistance rating* not less than 2 h,

[b] b) *mezzanines* shall have a *fire-resistance rating* not less than 1 h, and

[c] c) *loadbearing* walls, columns and arches shall have a *fire-resistance rating* not less than that required for the supported assembly.

[3] 3) Group A, Division 2 *major occupancies*, Group E *major occupancies*, Group F, Division 2 and 3 *major occupancies*, and *storage garages* located in a *building* or part of a *building* within the scope of this Article are permitted to be constructed in accordance with this Article, provided

[a] a) the Group A, Division 2 *major occupancy* is located below the fourth *storey*,

[b] b) the Group E *major occupancy* and Group F, Division 2 or 3 *major occupancy* are located below the third *storey*, and

[c] c) the *storage garage* is located below the fifth *storey* (see also Article 4.4.2.1.).

(See Note A-3.2.2.48.(4) and 3.2.2.57.(3).)

Impact analysis

This proposed change would not entail any additional costs because it would increase (i.e., relax) a physical height limit, although it would also allow taller EMTC buildings. This proposed change would be beneficial to builders, architects and engineers, and allow greater freedom with respect to constructability. It would also respond to current market expectations for interior design space, as well as other code and design requirements, regarding floor-to-floor height.

Enforcement implications

This proposed change would have no enforcement implications.

Who is affected

Architects, engineers, building owners, regulators and manufacturers.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[3.2.2.57.] 3.2.2.57. ([1] 1) no attributions

[3.2.2.57.] 3.2.2.57. ([2] 2) no attributions

[3.2.2.57.] 3.2.2.57. ([2] 2) ([b] b),([c] c) [F04-OS1.3]

[3.2.2.57.] 3.2.2.57. ([2] 2) ([b] b),([c] c) [F04-OP1.3]

[3.2.2.57.] 3.2.2.57. ([2] 2) ([a] a),([c] c) [F03-OS1.2] [F04-OS1.2,OS1.3]

[3.2.2.57.] 3.2.2.57. ([2] 2) ([a] a),([c] c) [F03-OP1.2] [F04-OP1.2,OP1.3]

[3.2.2.57.] 3.2.2.57. ([3] 3) no attributions

Submit a comment

Proposed Change 1680

Code Reference(s):	NBC20 Div.B 3.2.3.1. (first printing)
Subject:	Spatial Separation Between Buildings
Title:	Spatial Separation Table Values
Description:	This proposed change corrects errors in Tables 3.2.3.1.-C to -E (spatial separation tables) and introduces the equation with which the values were calculated.
Related Code Change Request(s):	CCR 1183
Related Proposed Change(s):	PCF 1701

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [x] Design and Construction
- [ ] Building operations
- [ ] Housing
- [ ] Small Buildings
- [x] Large Buildings
- [x] Fire Protection
- [ ] Occupant safety in use
- [ ] Accessibility
- [ ] Structural Requirements
- [ ] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

This proposed change would correct inconsistencies between the values in the spatial separation tables (Tables 3.2.3.1.-C to -E) in the NBC 2020 and those calculated using the equation the table values were originally derived from. These inconsistencies were observed during an attempt to replicate the table values using the original equation [1],[2].

This proposed change would align the values in Table 3.2.3.1.-E with those intended by the calculation. The table values were first included in the NBC 1995; prior to that edition, the NBC permitted the values from the tables for unsprinklered buildings and fire compartments to be doubled where a building was sprinklered. The values in the tables for unsprinklered areas were calculated based on the equation in this proposed change, and then rounded to the nearest whole number.

When Tables 3.2.3.1.-D and -E were developed, they were based on doubling the values of Tables 3.2.3.1.-B and -C, respectively (corresponding to a ratio of L/H or H/L of 3). This meant that the rounding of the values in Tables 3.2.3.1.-B and -C artificially increased or decreased the values in Tables 3.2.3.1.-D and -E relative to the actual (equation-based) values by approximately 1%.

The increases and decreases are more significant where the maximum exposing building face area is 200 m² in Table 3.2.3.1.-E. This area did not have a corresponding area in Table 3.2.3.1.-C from which a doubling of values could be determined. Thus, for this area, linear interpolation was used to derive the values from the corresponding values for areas of 150 m² and 250 m² in Table 3.2.3.1.-C, which were then doubled. This calculation resulted in values that departed more significantly from those calculated using the original equation (i.e., approximately 2% to 4% difference).

As such, the current values in Tables 3.2.3.1.-D and -E may not provide Code users with an accurate estimate of the permitted area of unprotected openings. This inaccuracy could affect the design and construction of new buildings, which could be avoided by using more accurate values that are calculated from the original equation. For situations where a larger exposing building face area and longer limiting distance are applicable, the values in Table 3.2.3.1.-E could be up to 4% larger than the calculated value, meaning that a larger unprotected opening would be allowed by the current provision. This could lead to a higher risk of fire spreading from one building to an adjacent building through an unprotected opening, which would impose a higher risk to the buildings and occupants inside.

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[1] Williams-Leir, G. "Approximations for Spatial Separation," Division of Building Research, National Research Council (Canada), 1966.

[2] Williams-Leir, G. "Program for Pocket Calculator to Derive Spatial Separations to Deter Fire Spread," Division of Building Research, National Research Council (Canada), 1978.

Justification

The proposed change to Table 3.2.3.1.-C would correct an error in one table value related to the original calculations for the table.

The proposed changes to Table 3.2.3.1.-E would correct compounded rounding errors in the table values and align the values with those calculated using the equation originally used to calculate the values in the tables for unsprinklered buildings and fire compartments.

The proposed addition of explanatory Note A-3.2.3.1.(1) would address situations where the limiting distance, exposing building face area and ratio differ from the values provided in the tables. As industry practice generally allows for linear interpolation to be used to determine these values, this option would be maintained and clearly stated in the proposed explanatory Note.

The proposed addition of explanatory Note A-3.2.3.1.(1) would also provide a means to calculate the area of unprotected openings in cases where the governing input factors do not align with the tables, by using the original equation with which the tables for unsprinklered buildings and fire compartments were calculated.

This proposed change would not only correct inaccuracies in the current tables, it would also show Code users how the table values are calculated using the equation in the explanatory Note. The resulting values would be more accurate than those in the tables or those calculated using linear interpolation. Access to this information would help Code users determine the actual permitted area of unprotected openings to better design the building to accommodate occupants' needs without compromising the fire performance of the buildings.

PROPOSED CHANGE

[3.2.3.1.] 3.2.3.1. Limiting Distance and Area of Unprotected Openings

[1] 1) Except as permitted by Articles 3.2.3.10. to 3.2.3.12., the area of *unprotected openings* in an *exposing building face* for the applicable *limiting distance* shall be not more than the value determined in accordance with

[a] a) Table 3.2.3.1.-B or 3.2.3.1.-C for an *exposing building face* conforming to Article 3.2.3.2. of a *building* or *fire compartment* which is not *sprinklered*, or

[b] b) Table 3.2.3.1.-D or 3.2.3.1.-E for an *exposing building face* conforming to Article 3.2.3.2. of a *sprinklered fire compartment* that is part of a *building* which is *sprinklered* in conformance with Section 3.2.

(See Notes A-3.2.3.1.(1) and A-3.)
(See also Article 3.1.18.3.)

[2] 2) The area of the *unprotected openings* in an *exposing building face* shall be the aggregate area of *unprotected openings* expressed as a percentage of the area of the *exposing building face* in Table 3.2.3.1.-B, 3.2.3.1.-C, 3.2.3.1.-D or 3.2.3.1.-E. (See Sentence 3.2.3.2.(1).)

[3] 3) For the purpose of determining the type of construction and cladding and the *fire-resistance rating* of an exterior wall,

[a] a) the *exposing building face* shall be taken as the projection of the exterior wall onto a vertical plane located so that no portion of the

exterior wall of the *building* or of a *fire compartment*, if the *fire compartment* complies with the requirements of Article 3.2.3.2., is between the vertical plane and the line to which the *limiting distance* is measured, and

[b] b) the area of *unprotected openings* shall be determined from Table 3.2.3.1.-B, 3.2.3.1.-C, 3.2.3.1.-D or 3.2.3.1.-E.

[4] 4) For the purpose of determining the actual percentage of *unprotected openings* permitted in an exterior wall, the location of the *exposing building face* is permitted to be taken at a vertical plane located so that there are no *unprotected openings* between the vertical plane and the line to which the *limiting distance* is measured. (See Note A-3.2.3.1.(4).)

[5] 5) Except for *buildings* that are *sprinklered*, where the *limiting distance* is 2 m or less, individual *unprotected openings* in an *exposing building face* shall be no greater than

[a] a) the area stated in Table 3.2.3.1.-A, or

[b] b) where the *limiting distance* is equal to or greater than 1.2 m, the area calculated by

$$\text{Area} = 0.24(2 \times \text{LD} - 1.2)^2$$

where

Area = area of the *unprotected opening*, and
LD = *limiting distance*.

Table [3.2.3.1.-A] 3.2.3.1.-A
Maximum Concentrated Area of Unprotected Openings
Forming Part of Sentence [3.2.3.1.] 3.2.3.1.([5] 5)

Limiting Distance, m	Maximum Area of Individual *Unprotected Openings*, m^2
1.2	0.35
1.5	0.78
2.0	1.88

[6] 6) The spacing between individual *unprotected openings* described in Sentence (5) that serve a single room or space described in Sentence (7) shall not be less than

[a] a) 2 m horizontally of another *unprotected opening* that is on the same *exposing building face* and serves the single room or space, or

[b] b) 2 m vertically of another *unprotected opening* that serves the single room or space, or another room or space on the same *storey*.

[7] 7) For the purpose of Sentence (6), “single room or space” shall mean

[a] a) two or more adjacent spaces having a full-height separating wall extending less than 1.5 m from the interior face of the exterior wall, or

[b] b) two or more stacked spaces that are on the same *storey*.

[8] 8) A *limiting distance* equal to half the actual *limiting distance* shall be used as input to Tables 3.2.3.1.-B and 3.2.3.1.-C, where

[a] a) the time from receipt of notification of a fire by the fire department until the arrival of the first fire department vehicle at the *building* exceeds 10 min in 10% or more of all fire department calls to the *building*, and

[b] b) any *storey* in the *building* is not *sprinklered*.

(See Notes A-3.2.3.1.(8) and A-3.2.3.)

[9] 9) If the surface temperature on the unexposed surface of a wall assembly exceeds the temperature limit of a standard fire test as permitted by Article 3.1.7.2., an allowance shall be made for the radiation from the hot unexposed wall surface by adding an equivalent area of *unprotected opening* to the area of actual openings as follows:

$$A_C = A + \left(A_F \times F_{EO}\right)$$

where

A_C = corrected area of *unprotected openings* including actual and equivalent openings,

A = actual area of *unprotected openings*,

A_F = area of exterior surface of the *exposing building face*, exclusive of openings, on which the temperature limit of the standard test is exceeded, and

F_{EO} = an equivalent opening factor derived from the following expression:

$$F_{EO} = \frac{\left(T_u + 273\right)^4}{\left(T_e + 273\right)^4}$$

T_u = average temperature in degrees Celsius of the unexposed wall surface at the time the required *fire-resistance rating* is reached under test conditions,

T_e

= 892°C for a *fire-resistance rating* not less than 45 min, 927°C for a *fire-resistance rating* not less than 1 h, and 1 010°C for a *fire-resistance rating* not less than 2 h.

[10] 10) Unless a *closure* used to protect an opening in an *exposing building face* has a protective performance equivalent to that required for the wall assembly in which it is located, an equivalent area of *unprotected opening*, determined in accordance with the procedures of Sentence (9) shall be added to the greater of

[a] a) the actual area of *unprotected openings*, or

[b] b) the corrected area of *unprotected openings*.

Table [3.2.3.1.-B] 3.2.3.1.-B
Unprotected Opening Limits for a Building or Fire Compartment that is not Sprinklered Throughout
Forming Part of Article 3.2.3.1.

Exposing Building Face		Area of *Unprotected Opening* for Groups A, C, D, and F, Division 3 *Occupancies*, %																									
Max. Area, m^2	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																									
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50
	Less than 3 : 1	0	8	10	18	29	46	91	100																		
10	3 : 1 to 10 : 1	0	8	12	21	33	50	96	100																		
	over 10 : 1	0	11	18	32	48	68	100																			
	Less than 3 : 1	0	7	9	14	22	33	63	100																		
15	3 : 1 to 10 : 1	0	8	10	17	25	37	67	100																		

Exposing Building Face		Area of *Unprotected Opening* for Groups A, C, D, and F, Division 3 *Occupancies*, %																									
Max. Area, m^2	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																									
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50
	over 10 : 1	0	10	15	26	39	53	87	100																		
	Less than 3 : 1	0	7	9	12	18	26	49	81	100																	
20	3 : 1 to 10 : 1	0	8	10	15	21	30	53	85	100																	
	over 10 : 1	0	9	14	23	33	45	72	100																		
	Less than 3 : 1	0	7	8	11	16	23	41	66	98	100																
25	3 : 1 to 10 : 1	0	8	9	13	19	26	45	70	100																	

Exposing Building Face		Area of *Unprotected Opening* for Groups A, C, D, and F, Division 3 *Occupancies*, %																									
Max. Area, m^2	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																									
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50
	over 10 : 1	0	9	13	21	30	39	62	90	100																	
	Less than 3 : 1	0	7	8	11	15	20	35	56	83	100																
30	3 : 1 to 10 : 1	0	7	9	12	17	23	39	61	88	100																
	over 10 : 1	0	8	12	19	27	36	56	79	100																	
	Less than 3 : 1	0	7	8	10	13	17	28	44	64	89	100															
40	3 : 1 to 10 : 1	0	7	8	11	15	20	32	48	69	93	100															

Exposing Building Face		Area of *Unprotected Opening* for Groups A, C, D, and F, Division 3 *Occupancies*, %																									
Max. Area, m^2	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																									
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50
	over 10 : 1	0	8	11	17	24	31	47	66	88	100																
	Less than 3 : 1	0	7	8	9	12	15	24	37	53	72	96	100														
50	3 : 1 to 10 : 1	0	7	8	10	14	18	28	41	57	77	100															
	over 10 : 1	0	8	10	15	21	28	41	57	76	97	100															
	Less than 3 : 1	0	7	8	9	11	14	21	32	45	62	81	100														
60	3 : 1 to 10 : 1	0	7	8	10	13	16	25	36	49	66	85	100														

Exposing Building Face		Area of *Unprotected Opening* for Groups A, C, D, and F, Division 3 *Occupancies*, %																									
Max. Area, m²	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																									
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50
	over 10 : 1	0	8	10	14	20	25	38	51	67	85	100															
	Less than 3 : 1	0	7	7	8	10	12	18	26	36	48	62	79	98	100												
80	3 : 1 to 10 : 1	0	7	8	9	11	14	21	29	40	52	67	84	100													
	over 10 : 1	0	8	9	13	17	22	32	44	56	70	86	100														
	Less than 3 : 1	0	7	7	8	9	11	16	22	30	40	51	65	80	97	100											
100	3 : 1 to 10 : 1	0	7	8	9	11	13	18	25	34	44	56	69	84	100												

Exposing Building Face		Area of *Unprotected Opening* for Groups A, C, D, and F, Division 3 *Occupancies*, %																									
Max. Area, m^2	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																									
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50
	over 10 : 1	0	7	9	12	16	20	29	39	49	61	74	89	100													
	Less than 3 : 1	0	7	7	8	9	10	13	17	22	29	37	46	56	67	79	93	100									
150	3 : 1 to 10 : 1	0	7	7	8	10	11	15	20	26	33	41	50	60	71	84	97	100									
	over 10 : 1	0	7	8	11	13	17	24	31	39	48	57	68	79	91	100											
	Less than 3 : 1	0	7	7	7	8	9	10	13	16	20	25	30	36	43	51	59	68	87	100							
250	3 : 1 to 10 : 1	0	7	7	8	9	10	12	15	19	24	28	34	40	47	55	63	72	92	100							

Exposing Building Face		Area of *Unprotected Opening* for Groups A, C, D, and F, Division 3 *Occupancies*, %																									
Max. Area, m^2	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																									
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50
	over 10 : 1	0	7	8	9	11	14	19	24	30	36	43	50	57	65	73	82	92	100								
	Less than 3 : 1	0	7	7	7	8	8	9	11	14	16	20	24	28	33	38	44	50	64	81	99	100					
350	3 : 1 to 10 : 1	0	7	7	8	8	9	11	13	16	19	23	27	32	37	42	48	55	69	85	100						
	over 10 : 1	0	7	8	9	10	12	16	21	25	30	36	41	47	53	59	66	73	88	100							
	Less than 3 : 1	0	7	7	7	7	8	9	10	12	14	16	19	22	25	29	33	37	47	59	71	100					
500	3 : 1 to 10 : 1	0	7	7	7	8	8	10	12	14	16	19	22	25	29	33	37	41	52	63	76	100					

Exposing Building Face		Area of *Unprotected Opening* for Groups A, C, D, and F, Division 3 *Occupancies*, %																									
Max. Area, m²	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																									
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50
	over 10 : 1	0	7	7	8	9	11	14	18	22	25	30	34	38	43	48	53	58	70	82	96	100					
	Less than 3 : 1	0	7	7	7	7	7	8	9	9	10	12	13	14	16	18	20	22	27	33	39	58	82	100			
1 000	3 : 1 to 10 : 1	0	7	7	7	7	8	9	10	11	12	14	15	17	19	21	23	26	31	37	43	63	86	100			
	over 10 : 1	0	7	7	8	8	9	11	13	16	19	21	24	27	30	33	36	39	46	53	60	82	100				

Exposing Building Face		Area of *Unprotected Opening* for Groups A, C, D, and F, Division 3 *Occupancies*, %																									
Max. Area, m^2	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																									
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50
2 000	Less than 3 : 1	0	7	7	7	7	7	7	8	8	9	9	10	11	12	13	14	15	17	20	23	33	44	58	74	93	100
	3 : 1 to 10 : 1	0	7	7	7	7	7	8	8	9	10	11	12	13	14	15	16	17	20	23	27	37	49	63	79	97	100
	over 10 : 1	0	7	7	7	8	8	9	11	12	14	16	18	19	21	23	25	27	32	36	40	53	66	82	99	100	

Note to Table [3.2.3.1.-B] 3.2.3.1.-B:

(1) Apply whichever ratio is greater.

L	= Length of *exposing building face*
H	= Height of *exposing building face*

Table [3.2.3.1.-C] 3.2.3.1.-C
Unprotected Opening Limits for a Building or Fire Compartment that is not Sprinklered Throughout
Forming Part of Article 3.2.3.1.

Exposing Building Face		Area of *Unprotected Openings* for Groups E and F, Division 1 and 2 *Occupancies*, %																													
Max. Area, m^2	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																													
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50	55	60	65	70
	Less than 3 : 1	0	4	5	9	15	23	46	77	100																					
10	3 : 1 to 10 : 1	0	4	6	10	17	25	48	79	100																					
	over 10 : 1	0	5	9	16	24	34	58	91	100																					
	Less than 3 : 1	0	4	5	7	11	16	32	53	79	100																				
15	3 : 1 to 10 : 1	0	4	5	8	13	18	34	55	82	100																				

Exposing Building Face		Area of *Unprotected Openings* for Groups E and F, Division 1 and 2 *Occupancies*, %																													
Max. Area, m^2	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																													
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50	55	60	65	70
	over 10 : 1	0	5	8	13	19	26	43	66	93	100																				
	Less than 3 : 1	0	4	4	6	9	13	25	40	61	85	100																			
20	3 : 1 to 10 : 1	0	4	5	7	11	15	27	43	63	87	100																			
	over 10 : 1	0	5	7	11	17	22	36	53	74	99	100																			
	Less than 3 : 1	0	4	4	6	8	11	20	33	49	69	92	100																		
25	3 : 1 to 10 : 1	0	4	5	7	9	13	22	35	51	71	94	100																		

Exposing Building Face		Area of *Unprotected Openings* for Groups E and F, Division 1 and 2 *Occupancies*, %																													
Max. Area, m²	Ratio (L/H or H/L)(1)	*Limiting Distance*, m																													
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50	55	60	65	70
	over 10 : 1	0	4	6	10	15	20	31	45	62	82	100																			
	Less than 3 : 1	0	4	4	5	7	10	18	28	42	58	77	100																		
30	3 : 1 to 10 : 1	0	4	4	6	9	12	20	30	44	60	80	100																		
	over 10 : 1	0	4	6	10	14	18	28	40	54	71	91	100																		
	Less than 3 : 1	0	4	4	5	6	8	14	22	32	44	59	76	94	100																
40	3 : 1 to 10 : 1	0	4	4	6	8	10	16	24	34	47	61	78	97	100																

Exposing Building Face		Area of *Unprotected Openings* for Groups E and F, Division 1 and 2 *Occupancies*, %																													
Max. Area, m^2	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																													
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50	55	60	65	70
	over 10 : 1	0	4	5	8	12	15	23	33	44	57	72	89	100																	
	Less than 3 : 1	0	4	4	5	6	7	12	18	26	36	48	61	76	93	100															
50	3 : 1 to 10 : 1	0	4	4	5	7	9	14	20	29	38	50	63	79	95	100															
	over 10 : 1	0	4	5	8	11	14	21	29	38	48	61	74	90	100																
	Less than 3 : 1	0	4	4	4	5	7	11	16	23	31	40	52	64	78	94	100														
60	3 : 1 to 10 : 1	0	4	4	5	6	8	12	18	25	33	43	54	66	81	96	100														

Exposing Building Face		Area of *Unprotected Openings* for Groups E and F, Division 1 and 2 *Occupancies*, %																													
Max. Area, m^2	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																													
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50	55	60	65	70
	over 10 : 1	0	4	5	7	10	13	19	26	34	43	53	64	77	92	100															
	Less than 3 : 1	0	4	4	4	5	6	9	13	18	24	31	40	49	60	71	84	98	100												
80	3 : 1 to 10 : 1	0	4	4	5	6	7	10	15	20	26	33	42	51	62	74	86	100													
	over 10 : 1	0	4	5	6	9	11	16	22	28	35	43	52	62	73	85	98	100													
	Less than 3 : 1	0	4	4	4	5	5	8	11	15	20	26	32	40	48	58	68	79	100												
100	3 : 1 to 10 : 1	0	4	4	4	5	6	9	13	17	22	28	35	42	51	60	70	81	100												

Exposing Building Face		Area of *Unprotected Openings* for Groups E and F, Division 1 and 2 *Occupancies*, %																													
Max. Area, m^2	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																													
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50	55	60	65	70
	over 10 : 1	0	4	4	6	8	10	14	19	25	31	37	44	52	61	71	81	92	100												
	Less than 3 : 1	0	4	4	4	4	5	6	8	11	14	18	23	28	33	40	46	54	70	89	100										
150	3 : 1 to 10 : 1	0	4	4	4	5	6	8	10	13	16	20	25	30	36	42	49	56	73	92	100										
	over 10 : 1	0	4	4	5	7	8	12	16	20	24	29	34	39	46	52	59	67	84	100											
	Less than 3 : 1	0	4	4	4	4	4	5	7	8	10	12	15	18	22	25	29	34	44	55	68	100									
250	3 : 1 to 10 : 1	0	4	4	4	4	5	6	8	10	12	14	17	20	24	27	32	36	46	57	70	100									

Exposing Building Face		Area of *Unprotected Openings* for Groups E and F, Division 1 and 2 *Occupancies*, %																													
Max. Area, m²	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																													
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50	55	60	65	70
	over 10 : 1	0	4	4	5	6	7	9	12	15	18	21	25	28	32	37	41	46	56	68	81	100									
	Less than 3 : 1	0	4	4	4	4	4	5	6	7	8	10	12	14	16	19	22	25	32	40	49	77	100								
350	3 : 1 to 10 : 1	0	4	4	4	4	4	5	7	8	10	12	14	16	18	21	24	27	34	43	52	79	100								
	over 10 : 1	0	4	4	4	5	6	8	10	13	15	18	21	23	26	30	33	36	44	53	62	90	100								
	Less than 3 : 1	0	4	4	4	4	4	4	5	6	7	8	9	11	13	14	16	19	24	29	36	55	78	100							
500	3 : 1 to 10 : 1	0	4	4	4	4	4	5	6	7	8	9	11	13	14	16	18	21	26	31	38	57	80	100							

Exposing Building Face		Area of *Unprotected Openings* for Groups E and F, Division 1 and 2 *Occupancies*, %																												
Max. Area, m ^{2}	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																												
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50	55	60	65	70
	over 10 : 1	0	4	4	4	5	5	7	9	11	13	15	17	19	21	24	26	29	35	41	48	68	92	100							
	Less than 3 : 1	0	4	4	4	4	4	4	4	5	5	6	6	7	8	9	10	11	14	16	20	29	41	55	71	89	100				
1 000	3 : 1 to 10 : 1	0	4	4	4	4	4	4	5	5	6	7	8	9	10	11	12	13	15	18	22	31	43	57	73	91	100				
	over 10 : 1	0	4	4	4	4	5	6	7	8	9	11	12	13	15	16	18	20	23	26	30	41	53	68	84	100					

Exposing Building Face		Area of *Unprotected Openings* for Groups E and F, Division 1 and 2 *Occupancies*, %																													
Max. Area, m [2]	Ratio (L/H or H/L) (1)	*Limiting Distance*, m																													
		0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	25	30	35	40	45	50	55	60	65	70
	Less than 3 : 1	0	4	4	4	4	4	4	4	4	4	5	5	5	6	6	7	7	9	10	12	16	22	29	37	46	~~56~~ 57	68	80	94	100
2 000	3 : 1 to 10 : 1	0	4	4	4	4	4	4	4	5	5	5	6	6	7	7	8	9	10	12	13	18	24	31	39	49	59	70	83	96	100
	over 10 : 1	0	4	4	4	4	4	5	5	6	7	8	9	10	11	12	13	14	16	18	20	26	33	41	50	59	70	81	94	100	

Note to Table [3.2.3.1.-C] 3.2.3.1.-C:

(1) Apply whichever ratio is greater.

L = Length of *exposing building face*
H = Height of *exposing building face*

Table [3.2.3.1.-D] 3.2.3.1.-D
Unprotected Opening Limits for a Building or Fire Compartment that is Sprinklered Throughout
Forming Part of Sentence 3.1.6.9.(5) and Article 3.2.3.1.

Exposing Building Face	Area of *Unprotected Opening* for Groups A, B, C, D and F, Division 3 *Occupancies*, %											
Max. Area, m^2	*Limiting Distance*, m											
	0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9
10	0	~~16~~17	24	~~42~~41	66	~~100~~99	100					
15	0	16	~~20~~21	~~34~~33	~~50~~51	~~74~~73	100					
20	0	~~16~~15	~~20~~19	~~30~~29	~~42~~43	60	100					
25	0	~~16~~15	18	~~26~~27	38	52	90	100				
30	0	~~14~~15	18	~~24~~25	34	46	78	100				
40	0	~~14~~15	~~16~~17	22	30	~~40~~39	64	96	100			
50	0	~~14~~15	16	~~20~~21	~~28~~27	~~36~~35	~~56~~55	~~82~~81	100			
60	0	14	16	20	~~26~~25	32	~~50~~49	~~72~~71	~~98~~99	100		
80	0	14	~~16~~15	~~18~~19	~~22~~23	28	~~42~~41	58	~~80~~79	100		
100	0	14	~~16~~15	18	~~22~~21	26	~~36~~37	~~50~~51	68	88	100	
150 or more	0	14	~~14~~15	~~16~~17	~~20~~19	22	30	40	52	~~66~~65	~~82~~81	100

Table [3.2.3.1.-E] 3.2.3.1.-E
Unprotected Opening Limits for a Building or Fire Compartment that is Sprinklered Throughout
Forming Part of Sentence 3.1.6.9.(5) and Article 3.2.3.1.

Exposing Building Face	Area of *Unprotected Opening* for Groups E and F, Division 1 and 2 *Occupancies*, %																	
Max. Area, m^2	*Limiting Distance*, m																	
	0	1.2	1.5	2.0	2.5	3	4	5	6	7	8	9	10	11	12	13	14	15
10	0	8	12	~~20~~21	~~34~~33	50	96	100										
15	0	8	10	~~16~~17	~~26~~25	~~36~~37	~~68~~67	100										
20	0	8	10	~~14~~15	~~22~~21	30	~~54~~53	~~86~~85	100									
25	0	8	~~10~~9	~~14~~13	~~18~~19	26	~~44~~45	70	100									
30	0	~~8~~7	~~8~~9	12	~~18~~17	~~24~~23	~~40~~39	~~60~~61	88	100								
40	0	~~8~~7	8	~~12~~11	~~16~~15	20	32	48	~~68~~69	~~94~~93	100							
50	0	~~8~~7	8	10	14	18	28	~~40~~41	~~58~~57	~~76~~77	100							
60	0	~~8~~7	8	10	~~12~~13	16	~~24~~25	36	~~50~~49	66	~~86~~85	100						
80	0	~~8~~7	8	~~10~~9	~~12~~11	14	~~20~~21	~~30~~29	40	52	~~66~~67	84	100					
100	0	~~8~~7	8	~~8~~9	~~10~~11	~~12~~13	18	~~26~~25	34	44	56	~~70~~69	84	100				
150	0	~~8~~7	~~8~~7	8	10	~~12~~11	~~16~~15	20	26	~~32~~33	~~40~~41	50	60	~~72~~71	84	~~98~~97	100	
200 or more	0	~~8~~7	~~8~~7	8	~~8~~9	10	~~14~~13	~~18~~17	22	~~28~~27	~~34~~33	~~42~~40	~~50~~48	~~60~~56	~~68~~66	~~80~~76	~~92~~88	100

Note A-3.2.3.1.(1) Calculation of Area of Unprotected Openings.

For Tables 3.2.3.1.-B to 3.2.3.1.-E, the formula used to calculate the permitted area of unprotected openings, in %, where the limiting distance is equal to or greater than 1.2 m, is as follows:

$$\text{Area of unprotected openings, \%} = 100 \times S_p\left(\frac{\varphi_c}{\varphi}\right) \text{ or 100\%, whichever is lower}$$

where

S_p	= 1 for an exposing building face conforming to Article 3.2.3.2. of a building or fire compartment that is not sprinklered, and = 2 for an exposing building face conforming to Article 3.2.3.2. of a sprinklered fire compartment that is part of a building which is sprinklered in conformance with Section 3.2.,
φ_c	= 0.035 for a Group E or Group F, Division 1 or 2 occupancy, and = 0.07 for a Group A, Group B, Group C, Group D or Group F, Division 3 occupancy, and
φ	= configuration factor, calculated as follows:

$$\varphi = \left(\frac{2}{\Pi}\right)\left[\left(\sqrt{\frac{\frac{T}{S}}{\frac{T}{S}+4}}\right)\arctan\left(\sqrt{\frac{T \times S}{\frac{T}{S}+4}}\right) + \left(\sqrt{\frac{T \times S}{T \times S + 4}}\right)\arctan\left(\sqrt{\frac{\frac{T}{S}}{T \times S + 4}}\right)\right]$$

where

Π	= 3.14159,
S	= L/H or H/L, whichever ratio is greater, for an exposing building face conforming to Article 3.2.3.2. of a building or fire compartment that is not sprinklered, and = 3 for an exposing building face conforming to Article 3.2.3.2. of a sprinklered fire compartment that is part of a building which is sprinklered in conformance with Section 3.2., and

$$T = \frac{A}{d^2}$$

where

L	= length of the exposing building face, in m,
H	= height of the exposing building face, in m,
A	= maximum area of the exposing building face, in m², and

$$d = 2(LD - 0.9144)$$

where

LD = limiting distance, in m.

Linear interpolation may also be used to determine values between the entries in Tables 3.2.3.1.-B to 3.2.3.1.-E, where the limiting distance is equal to or greater than 1.2 m; further information can be found in the "User's Guide – NBC 1995, Fire Protection, Occupant Safety and Accessibility (Part 3)."

Impact analysis

This proposed change would correct errors in the spatial separation tables, which would align the table values with the principles upon which the spatial separation requirements were based and the original tables were developed. Seven of the proposed revised values in Tables 3.2.3.1.-D and -E result in a permitted maximum area of unprotected openings that impacts the fire-resistance rating and type of construction of the exterior wall and cladding, respectively, in Table 3.2.3.7. Four of the revised values result in more restrictive construction and fire-resistance ratings, whereas three of the revised values result in less restrictive construction and fire-resistance ratings. Since the NBC 2020 table values are slightly increased or decreased, differing by 1% to 4% from the original table values, the overall impact on the building industry would be negligible.

As the proposed changes to the values may impose more or less restrictive construction and fire-resistance ratings, they could lead to either a slight cost increase or savings for a project, depending on specific design situations. It is anticipated that the overall cost implications would be minimal for the building industry. However, the benefit of this proposed change would be to minimize the degree of error in the calculation of the maximum area of unprotected openings at the design stage and to ensure the building has an appropriate level of fire performance.

The introduction of the equation with which the spatial separation values are calculated would facilitate design that better aligns with the intent of the spatial separation requirements and increase the range of permitted areas of unprotected openings for various exposing building face areas and limiting distances. The increase in design flexibility offered by the use of the equation and the broadened range of resulting permitted areas of unprotected openings would further limit the impact that the more restrictive minor corrections may have on the design and construction of the exterior walls of the building. The introduction of the equation would also simplify the application of the spatial separation requirements by showing Code users how the values were calculated.

As identified in the Problem statement, Tables 3.2.3.1.-C to -E currently provide values that are up to 4% larger than the calculated values, therefore, a higher risk is introduced by the larger permitted area of unprotected openings. The adjacent buildings would be exposed to a higher risk of fire spread through the unprotected openings. This proposed change would mitigate this risk by providing more accurate values that are calculated using the equation to safeguard the buildings and their occupants.

Enforcement implications

This proposed change would not have any enforcement implications beyond those already associated with the enforcement of the spatial separation tables.

Who is affected

This proposed change is a correction and would provide additional information in the NBC; therefore, it is not expected to negatively impact regulators, engineers, building owners, contractors or fire services.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[3.2.3.1.] 3.2.3.1. ([1] 1) [F03-OP3.1]

[3.2.3.1.] 3.2.3.1. ([2] 2) no attributions

[3.2.3.1.] 3.2.3.1. ([3] 3) no attributions

[3.2.3.1.] 3.2.3.1. ([4] 4) no attributions

[3.2.3.1.] 3.2.3.1. ([5] 5) [F03-OP3.1]

[3.2.3.1.] 3.2.3.1. ([6] 6) [F03-OP3.1]

[3.2.3.1.] 3.2.3.1. ([7] 7) no attributions

[3.2.3.1.] 3.2.3.1. ([8] 8) [F03-OP3.1]

[3.2.3.1.] 3.2.3.1. ([9] 9) [F03-OP3.1]

[3.2.3.1.] 3.2.3.1. ([10] 10) [F03-OP3.1]

Submit a comment

Proposed Change 1763

Code Reference(s):	NBC20 Div.B 3.8.3.13. (first printing) NBC20 Div.B 3.8.3.17. (first printing)
Subject:	Accessibility — Inclusive Plumbing Accommodation
Title:	Emergency Lighting in Universal Washrooms and Shower Rooms
Description:	This proposed change clarifies that emergency lighting is required to be installed in universal washrooms and universal dressing and shower rooms to provide the same level of safety as that provided in other washrooms.
Related Proposed Change(s):	PCF 1561, PCF 1569, PCF 1591, PCF 1762, PCF 1766

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [x] Design and Construction
- [ ] Building operations
- [ ] Housing
- [x] Small Buildings
- [x] Large Buildings
- [ ] Fire Protection
- [x] Occupant safety in use
- [x] Accessibility
- [ ] Structural Requirements
- [ ] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

The NBC 2020 introduced new requirements for universal washrooms and universal dressing and shower rooms. Universal washrooms are now required where washrooms are provided (Sentence 3.8.2.8.(1)). Universal dressing and shower rooms are also to be provided where shower facilities are available (Sentence 3.8.2.8.(13)).

Emergency lighting for these spaces is also required under Part 3 (Article 3.2.7.3). However, designers of a Part 9 building that must comply with Section 3.8. may not have clear direction to the requirements for emergency lighting that apply to universal washrooms and universal dressing and shower rooms for compliance. These spaces require emergency lighting to limit the probability of inadequate illumination, which could lead to safety hazards or delays in evacuation.

Justification

To limit the probability of inadequate illumination in universal washrooms and universal dressing and shower rooms, this proposed change would update the requirements for these spaces in Articles 3.8.3.13. and 3.8.3.17. to point designers to Article 3.2.7.3. These spaces require the same level of illumination for users as other washrooms. Furthermore, emergency lighting in these spaces is essential to facilitate the assistance provided by attendants as universal washrooms and universal dressing and shower rooms serve persons that may be accompanied.

PROPOSED CHANGE

[3.8.3.13.] 3.8.3.13. Universal Washrooms

(See Note A-3.8.3.13.)

[1] 1) A universal washroom shall

[a] a) be served by a *barrier-free* path of travel,

[b] b) have a door complying with Article 3.8.3.6. that

[i] i) has a latch-operating mechanism located 900 mm to 1 100 mm above the floor that complies with Clause 3.8.3.8.(1)(b) and is capable of being locked from the inside, and released from the outside in case of emergency, and

[ii] ii) if it is an outward swinging door that is not self-closing, has a door pull not less than 140 mm long located on the inside so that its midpoint is not less than 200 mm and not more than 300 mm from the hinged side of the door and not less than 900 mm and not more than 1 100 mm above the floor (see Note A-3.8.3.12.(1)(d)(vi)),

[c] c) have one lavatory conforming to Article 3.8.3.16.,

[d] d) have one water closet conforming to Article 3.8.3.14. and Clause 3.8.3.12.(1)(e),

[e] e) have a clear lateral transfer space adjacent to the water closet that conforms to Clause 3.8.3.12.(1)(b),

[f] f) have grab bars conforming to Clauses 3.8.3.12.(1)(f) and (g),

[g] g) have a coat hook conforming to Clause 3.8.3.12.(1)(h),

[h] h) have a toilet paper dispenser conforming to Clause 3.8.3.12.(1)(i),

[i] i) unless a counter is provided, have a shelf located not more than 1 200 mm above the floor, ~~and~~

[j] j) be designed to permit a wheelchair to turn in an open space not less than 1 700 mm in diameter~~.~~, and

[k] --) provide emergency lighting conforming to Article 3.2.7.3.

[2] 2) A universal washroom required to have an accessible change space as stipulated in Sentence 3.8.2.8.(15) shall

[a] a) be equipped with an adult-sized change table,

[b] b) have a clear floor space to accommodate the adult-sized change table that is 810 mm wide by 1 830 mm long and does not overlap with the clear spaces required by Clauses (1)(e), (1)(j) and (c), and

[c] c) have a clear transfer space of 900 mm by 1 350 mm adjacent to the long side of the clear floor space for the adult-sized change table.

[3.8.3.17.] 3.8.3.17. Showers

[1] 1) Showers required by Sentence 3.8.2.8.(12) shall

[a] a) be not less than 1 500 mm wide and 900 mm deep,

[b] b) have a clear floor space at the entrance to the shower that is not less than 900 mm deep and the same width as the shower, except that fixtures are permitted to project into that space provided they do not restrict access to the shower (see Note A-3.8.3.17.(1)(b)),

[c] c) have no doors or curtains that obstruct the controls or the clear floor space at the entrance to the shower,

[d] d) have a slip-resistant floor surface,

[e] e) have a threshold not more than 13 mm higher than the finished floor, and where it is higher than 6 mm, beveled to a slope no steeper than 1 in 2 (50%),

[f] f) have 2 grab bars

[i] i) that conform to Sentence 3.7.2.7.(1),

[ii] ii) one of which is not less than 1 000 mm long and located vertically on the side wall 50 mm to 80 mm from the adjacent clear floor space, with its lower end 600 mm to 650 mm above the floor, and,

[iii] iii) one of which is L-shaped and located on the wall opposite the entrance to the shower, with a horizontal member not less than 1 000 mm long mounted 750 mm to 870 mm above the floor and a vertical member not less than 750 mm long mounted 400 mm to 500 mm from the side wall on which the other vertical grab bar is mounted,

(see Note A-3.8.3.17.(1)(f)),

[g] g) have a hinged seat that is not spring-loaded or a fixed seat with a smooth, slip-resistant surface and no rough edges, the seat being

[i] i) not less than 450 mm wide and 400 mm deep,

[ii] ii) mounted on the same side wall as the vertical grab bar, at 460 mm to 480 mm above the floor, and

[iii] iii) designed to carry a minimum load of 1.3 kN,

[h] h) have a pressure-equalizing or thermostatic-mixing valve and other controls that

[i] i) comply with Clause 3.8.3.8.(1)(b),

[ii] ii) are mounted on the wall opposite the entrance to the shower at not more than 1 200 mm above the floor and within reach of the seat,

[i] i) have a hand-held shower head with not less than 1 800 mm of flexible hose located so that it

[i] i) can be reached from a seated position,

[ii] ii) can be used in a fixed position at a height of 1 200 mm and 2 030 mm, and

[iii] iii) does not obstruct the use of the grab bars, and

[j] j) have recessed soap holders that can be reached from the seated position.

[2] 2) A universal dressing and shower room required by Sentence 3.8.2.8.(13) shall

[a] a) be located in a *barrier-free* path of travel,

[b] b) have a door capable of being locked from the inside and released from the outside in the event of an emergency,

[c] c) have a lavatory and a mirror conforming to Article 3.8.3.16.,

[d] d) have a shower conforming to Sentence (1),

[e] e) have a bench that is at least 1 830 mm long by 760 mm wide and 480 mm to 520 mm high,

[f] f) have a clear transfer space adjacent to the long side of the bench that is 900 mm wide and as long as the bench (see Note A-3.8.3.17.(2)(f)), ~~and~~

[g] g) have a coat hook conforming to Clause 3.8.3.12.(1)(h)~~.~~, and

[h] --) provide emergency lighting conforming to Article 3.2.7.3.

Impact analysis

The cost associated with the supply and installation of a twin-head emergency battery unit, including receptacle, mounting bracket and installation is estimated to be between $800 and $1200 per unit. In a building where an emergency power system is installed and the emergency lighting can be wired to the emergency power system, the cost to supply and install the emergency lighting heads (without the battery pack) is estimated to be between $120 and $160 per unit.

The benefit is not directly quantifiable since it relates to the safety of people using the universal washrooms and universal dressing and shower rooms. Without emergency lighting in these spaces, people would be exposed to an unacceptable level of risk of missteps or falls. Furthermore, without emergency lighting during a loss of normal building power in an emergency situation or evacuation, people using these spaces could be exposed to an unacceptable level of risk by being delayed or impeded.

Enforcement implications

This proposed change can be enforced using the same infrastructure used to enforce other emergency lighting requirements in the Code.

Who is affected

Building occupants, who would benefit from emergency lighting while using these spaces in the event of an emergency.

Architects, designers and engineers, who need to ensure emergency lighting requirements are met and proper systems are in place in the buildings being designed.

Authorities having jurisdiction, who need to verify that adequate emergency lighting systems are provided in buildings.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[3.8.3.13.] 3.8.3.13. ([1] 1) [F74-OA2]

[3.8.3.13.] 3.8.3.13. ([1] 1) ([b] b) [F10-OS3.7]

[3.8.3.13.] 3.8.3.13. ([1] 1) ([c] c)

[3.8.3.13.] 3.8.3.13. ([1] 1) ([d] d)

[3.8.3.13.] 3.8.3.13. ([1] 1) ([f] f)

[3.8.3.13.] 3.8.3.13. ([1] 1) ([g] g) [F30-OS3.1]

[3.8.3.13.] 3.8.3.13. ([1] 1) ([i] i) [F74-OA2]

[3.8.3.13.] 3.8.3.13. ([1] 1) [F72-OH2.1] [F71-OH2.3]

[3.8.3.13.] 3.8.3.13. ([1] 1) ([b] b) [F74-OA2]

[3.8.3.13.] 3.8.3.13. ([2] 2) [F72-OH2.1] [F71-OH2.3]

[3.8.3.17.] 3.8.3.17. ([1] 1) [F74-OA2]

[3.8.3.17.] 3.8.3.17. ([1] 1) ([d] d),([e] e) [F30-OS3.1]

[3.8.3.17.] 3.8.3.17. ([1] 1) ([f] f) [F30-OS3.1]

[3.8.3.17.] 3.8.3.17. ([1] 1) ([h] h) [F31-OS3.2]

[3.8.3.17.] 3.8.3.17. ([2] 2) [F74-OA2]

[3.8.3.17.] 3.8.3.17. ([2] 2) [F71-OH2.3]

[3.8.3.17.] 3.8.3.17. ([2] 2) ([a] a) [F73-OA1]

[3.8.3.17.] 3.8.3.17. ([2] 2) ([b] b) [F10-OS3.7]

[3.8.3.17.] 3.8.3.17. ([2] 2) ([b] b) [F74-OA2]

[3.8.3.17.] 3.8.3.17. ([2] 2) ([g] g) [F74-OA2]

Submit a comment

Proposed Change 1801

Code Reference(s):	NBC20 Div.B 5.9.1.1. (first printing)
Subject:	Environmental Separation Table 5.9.1.1.
Title:	Deletion of Reference to Outdated CAN/CGSB Standard
Description:	This proposed change deletes the reference to CAN/CGSB-93.1-M85, “Sheet, Aluminum Alloy, Prefinished, Residential,” from Table 5.9.1.1.

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [x] Design and Construction
- [ ] Building operations
- [ ] Housing
- [ ] Small Buildings
- [x] Large Buildings
- [ ] Fire Protection
- [ ] Occupant safety in use
- [ ] Accessibility
- [ ] Structural Requirements
- [x] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

CAN/CGSB-93.1-M85, “Sheet, Aluminum Alloy, Prefinished, Residential,” which is currently referenced in Table 5.9.1.1. of the NBC, has not been updated since 1985 and was withdrawn in 2012.

The withdrawal of the standard over 10 years ago means that industry is no longer using this standard as a reference for minimum performance or material suitability. Therefore, if the reference to the standard were to remain in the NBC, it would cause confusion and conflict between designers, manufacturers, authorities having jurisdiction and the legal community. These conflicts would occur when

- authorities having jurisdiction request documentation from manufacturers during permit reviews to prove Code compliance,
- designers require Code compliance for use of their design specifications on a project, or
- lawyers demand proof of Code compliance during possible court cases.

Justification

At the mid-cycle review of updates to the standards currently referenced in Table 5.9.1.1., the Standing Committee on Environmental Separation determined that CAN/CGSB-93.1-M85

- was withdrawn in 2012, and
- is no longer used in practice.

Therefore, the Standing Committee agreed to delete the reference to this withdrawn standard.

By deleting reference to the standard from the NBC, the need to prove compliance with a standard that is no longer relevant to the industry is removed. This would eliminate potential conflict and confusion for designers, manufacturers, authorities having jurisdiction and the legal community, as noted above.

It is noted that the remaining performance requirements in NBC, Division B, Part 5 would still apply to any use of prefinished aluminum alloy sheet in residential use under Part 5.

PROPOSED CHANGE

[5.9.1.1.] 5.9.1.1. Compliance with Applicable Standards

[1] 1) Except as provided in Sentence (2) and elsewhere in this Part, materials and components, and their installation, shall conform to the requirements of the applicable standards in Table 5.9.1.1. where those materials or components are

[a] a) incorporated into environmental separators or assemblies exposed to the exterior, and

[b] b) installed to fulfill the requirements of this Part.

(See Note A-5.9.1.1.(1).)

[2] 2) The requirements for *flame-spread ratings* contained in thermal insulation standards shall be applied only as required in Part 3.

Table [5.9.1.1.] 5.9.1.1.
Standards Applicable to Environmental Separators and Assemblies Exposed to the Exterior
Forming Part of Sentence [5.9.1.1.] 5.9.1.1.([1] 1)

Issuing Agency	Document Number	Title of Document
ANSI	A135.6	Engineered Wood Siding
ASME	B18.6.1	Wood Screws (Inch Series)
ASTM	A123/A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM	A153/A153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

Issuing Agency	Document Number	Title of Document
ASTM	A653/A653M	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM	C4	Standard Specification for Clay Drain Tile and Perforated Clay Drain Tile
ASTM	C73	Standard Specification for Calcium Silicate Brick (Sand-Lime Brick)
ASTM	C126	Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units
ASTM	C212	Standard Specification for Structural Clay Facing Tile
ASTM	C412M	Standard Specification for Concrete Drain Tile
ASTM	C444M	Standard Specification for Perforated Concrete Pipe
ASTM	C553	Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM	C612	Standard Specification for Mineral Fiber Block and Board Thermal Insulation
ASTM	C700	Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM	C726	Standard Specification for Mineral Wool Roof Insulation Board
ASTM	C834 (1)	Standard Specification for Latex Sealants
ASTM	C840	Standard Specification for Application and Finishing of Gypsum Board
ASTM	C920 (1)	Standard Specification for Elastomeric Joint Sealants
ASTM	C991	Standard Specification for Flexible Fibrous Glass Insulation for Metal Buildings
ASTM	C1002	Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs
ASTM	C1177/C1177M	Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing
ASTM	C1178/C1178M	Standard Specification for Coated Glass Mat Water-Resistant Gypsum Backing Panel
ASTM	C1184 (1)	Standard Specification for Structural Silicone Sealants

Issuing Agency	Document Number	Title of Document
ASTM	C1280	Standard Specification for Application of Exterior Gypsum Panel Products for Use as Sheathing
ASTM	C1311 (1)	Standard Specification for Solvent Release Sealants
ASTM	C1330 (1)	Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants
ASTM	C1396/C1396M (2)	Standard Specification for Gypsum Board
ASTM	C1658/C1658M (3)	Standard Specification for Glass Mat Gypsum Panels
ASTM	D1227/D1227M	Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing
ASTM	D2178/D2178M	Standard Specification for Asphalt Glass Felt Used in Roofing and Waterproofing
ASTM	D3019/D3019M (4)	Standard Specification for Lap Cement Used with Asphalt Roll Roofing, Non-Fibered, and Fibered
ASTM	D4479/D4479M	Standard Specification for Asphalt Roof Coatings – Asbestos-Free
ASTM	D4637/D4637M	Standard Specification for EPDM Sheet Used In Single-Ply Roof Membrane
ASTM	D4811/D4811M	Standard Specification for Nonvulcanized (Uncured) Rubber Sheet Used as Roof Flashing
ASTM	D6878/D6878M	Standard Specification for Thermoplastic Polyolefin Based Sheet Roofing
ASTM	E2190	Standard Specification for Insulating Glass Unit Performance and Evaluation
BNQ	BNQ 3624-115	Polyethylene (PE) Pipe and Fittings for Soil and Foundation Drainage
CGSB	CAN/CGSB-11.3-M	Hardboard
CGSB	CAN/CGSB-12.1	Safety Glazing
CGSB	CAN/CGSB-12.2-M	Flat, Clear Sheet Glass
CGSB	CAN/CGSB-12.3-M	Flat, Clear Float Glass
CGSB	CAN/CGSB-12.4-M	Heat Absorbing Glass
CGSB	CAN/CGSB-12.8	Insulating glass units
CGSB	CAN/CGSB-12.9	Spandrel glass

Issuing Agency	Document Number	Title of Document
CGSB	37-GP-9Ma	Primer, Asphalt, Unfilled, for Asphalt Roofing, Dampproofing and Waterproofing
CGSB	CAN/CGSB-37.50-M	Hot-Applied, Rubberized Asphalt for Roofing and Waterproofing
CGSB	CAN/CGSB-37.54	Polyvinyl Chloride Roofing and Waterproofing Membrane
CGSB	CAN/CGSB-37.58-M	Membrane, Elastomeric, Cold-Applied Liquid, for Non-Exposed Use in Roofing and Waterproofing
CGSB	CAN/CGSB-41.24	Rigid Vinyl Siding, Soffits and Fascia
CGSB	CAN/CGSB-51.32-M	Sheathing, Membrane, Breather Type
CGSB	CAN/CGSB-51.33-M	Vapour Barrier Sheet, Excluding Polyethylene, for Use in Building Construction
CGSB	CAN/CGSB-51.34-M	Vapour Barrier, Polyethylene Sheet for Use in Building Construction
~~CGSB~~	~~CAN/CGSB-93.1-M~~	~~Sheet, Aluminum Alloy, Prefinished, Residential~~
CGSB	CAN/CGSB-93.2-M	Prefinished Aluminum Siding, Soffits, and Fascia, for Residential Use
CSA	A23.1	Concrete materials and methods of concrete construction
CSA	CAN/CSA-A82	Fired masonry brick made from clay or shale
CSA	CAN3-A93-M	Natural Airflow Ventilators for Buildings
CSA	CAN/CSA-A123.2	Asphalt-Coated Roofing Sheets
CSA	A123.3	Asphalt Saturated Organic Roofing Felt
CSA	CAN/CSA-A123.4	Asphalt for Constructing Built-Up Roof Coverings and Waterproofing Systems
CSA	A123.5	Asphalt shingles made from glass felt and surfaced with mineral granules
CSA	CAN/CSA-A123.16	Asphalt-coated glass-base sheets
CSA	A123.17	Asphalt Glass Felt Used in Roofing and Waterproofing
CSA	A123.23	Product specification for polymer-modified bitumen sheet, prefabricated and reinforced
CSA	A123.51	Asphalt shingle application on roof slopes 1:6 and steeper
CSA	A165.1	Concrete block masonry units
CSA	A165.2	Concrete brick masonry units

Issuing Agency	Document Number	Title of Document
CSA	A165.3	Prefaced concrete masonry units
CSA	CAN/CSA-A179	Mortar and Grout for Unit Masonry
CSA	CAN/CSA-A220 Series	Concrete Roof Tiles
CSA	CAN/CSA-A371	Masonry Construction for Buildings
CSA	A3001	Cementitious Materials for Use in Concrete
CSA	B182.1	Plastic drain and sewer pipe and pipe fittings
CSA	G40.21	Structural quality steel
CSA	CAN/CSA-G401	Corrugated steel pipe products
CSA	CAN/CSA-O80 Series	Wood preservation
CSA	O118.1	Western Red Cedar Shakes and Shingles
CSA	O118.2	Eastern White Cedar Shingles
CSA	O121	Douglas fir plywood
CSA	O141	Softwood Lumber
CSA	O151	Canadian softwood plywood
CSA	O153	Poplar plywood
CSA	O325	Construction sheathing
CSA	O437.0	OSB and Waferboard
HPVA	ANSI/HPVA HP-1	American National Standard for Hardwood and Decorative Plywood
ULC	CAN/ULC-S701.1	Standard for Thermal Insulation, Polystyrene Boards
ULC	CAN/ULC-S702.1	Standard for Mineral Fibre Thermal Insulation for Buildings, Part 1: Material Specification
ULC	CAN/ULC-S703	Standard for Cellulose Fibre Insulation (CFI) for Buildings
ULC	CAN/ULC-S704.1	Standard for Thermal Insulation, Polyurethane and Polyisocyanurate, Boards, Faced
ULC	CAN/ULC-S705.1	Standard for Thermal Insulation – Spray Applied Rigid Polyurethane Foam, Medium Density – Material Specification
ULC	CAN/ULC-S705.2	Standard for Thermal Insulation – Spray Applied Rigid Polyurethane Foam, Medium Density – Application

Issuing Agency	Document Number	Title of Document
ULC	CAN/ULC-S706.1	Standard for Wood Fibre Insulating Boards for Buildings
ULC	CAN/ULC-S710.1	Standard for Bead-Applied One Component Polyurethane Air Sealant Foam, Part 1: Material Specification
ULC	CAN/ULC-S711.1	Standard for Bead-Applied Two Component Polyurethane Air Sealant Foam, Part 1: Material Specification
ULC	CAN/ULC-S717.1	Standard for Flat Wall Insulating Concrete Form (ICF) Units – Material Properties

Notes to Table [5.9.1.1.] 5.9.1.1.:

(1) See Note A-Table 5.9.1.1.

(2) The *flame-spread rating* of gypsum board shall be determined in accordance with CAN/ULC-S102, in lieu of ASTM E84 as indicated in ASTM C1396/C1396M.

(3) The *flame-spread rating* of gypsum panels shall be determined in accordance with CAN/ULC-S102, in lieu of ASTM E84 as indicated in ASTM C1658/C1658M.

(4) For the purpose of compliance with Part 5, ASTM D3019/D3019M shall only apply to the non-fibered and non-asbestos-fibered types of asphalt roll roofing.

Impact analysis

This proposed change is expected to have a positive impact in that it would resolve all potential conflicts created by the Code reference to this outdated standard as a minimum requirement and align the Code with current industry practice.

There is no negative impact as no additional costs to industry are expected since the standard is not actually being used.

Enforcement implications

Removing the reference to this standard as a minimum requirement would also remove the potential expectations of proof of compliance with the standard. This means that the conflict that could be created if an authority having jurisdiction were to demand proof of compliance with the standard, which is not used by industry, would also be eliminated.

Who is affected

Designers, specifiers, manufacturers, building owners, building officials, lawyers and contractors. These groups would benefit from the elimination of the potential conflicts addressed above.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[5.9.1.1.] 5.9.1.1. ([1] 1)
[F20,F22,F51,F54,F55,F61,F63,F80-OH1.1,OH1.2] [F41,F55-OH1.1] [F55,F61,F80-OH1.3]

[5.9.1.1.] 5.9.1.1. ([1] 1)
[F20,F80-OS2.1] [F20,F22,F51,F61,F63,F80-OS2.3] [F51-OS2.5]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F20-OS2.2] [F80-OS2.3]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F80,F61,F63-OS3.1]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F80,F61,F63-OH4]

[5.9.1.1.] 5.9.1.1. ([1] 1) ([a] a) [F61,F63-OS1.4]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F20,F80-OP2.1,OP2.3] [F22,F80-OP2.4]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F42-OH2.5]

[5.9.1.1.] 5.9.1.1. ([2] 2) no attributions

Submit a comment

Proposed Change 1802

Code Reference(s):	NBC20 Div.B 5.9.1.1. (first printing)
Subject:	Environmental Separation Table 5.9.1.1.
Title:	Deletion of Reference to Outdated CAN/CGSB Standard
Description:	This proposed change deletes the reference to CAN/CGSB-93.2-M91, “Prefinished Aluminum Siding, Soffits, and Fascia, for Residential Use,” from Table 5.9.1.1.

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [x] Design and Construction
- [ ] Building operations
- [ ] Housing
- [ ] Small Buildings
- [x] Large Buildings
- [ ] Fire Protection
- [ ] Occupant safety in use
- [ ] Accessibility
- [ ] Structural Requirements
- [x] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

CAN/CGSB-93.2-M91, “Prefinished Aluminum Siding, Soffits, and Fascia, for Residential Use,” which is currently referenced in Table 5.9.1.1. of Division B of the NBC, was not updated since 1991 and withdrawn in 2012.

The withdrawal of the standard over 10 years ago means that industry is no longer using this standard as a reference for minimum performance or material suitability. Therefore, if the reference to the standard were to remain in the NBC, it would cause confusion and conflict between designers, manufacturers, authorities having jurisdiction and the legal community. These conflicts would occur when

- authorities having jurisdiction request documentation from manufacturers during permit reviews to prove Code compliance,
- designers require Code compliance for use of their design specifications on a project, or
- lawyers demand proof of Code compliance during possible court cases.

Justification

At the mid-cycle review of updates to the standards currently referenced in Table 5.9.1.1., it was determined that CAN/CGSB-93.2-M91

- was withdrawn in 2012, and
- is no longer used in practice.

Therefore, it was agreed to delete the reference to this withdrawn standard.

By deleting reference to the standard from the NBC, the need to prove compliance with a standard that is no longer relevant to the industry is removed. This would eliminate potential conflicts and confusion for designers, manufacturers, authorities having jurisdiction, and the legal community, as noted above.

It is noted that the remaining performance requirements in NBC, Division B, Part 5 would still apply to any use of prefinished aluminum siding, soffits or facia in residential use under Part 5.

PROPOSED CHANGE

[5.9.1.1.] 5.9.1.1. Compliance with Applicable Standards

[1] 1) Except as provided in Sentence (2) and elsewhere in this Part, materials and components, and their installation, shall conform to the requirements of the applicable standards in Table 5.9.1.1. where those materials or components are

[a] a) incorporated into environmental separators or assemblies exposed to the exterior, and

[b] b) installed to fulfill the requirements of this Part.

(See Note A-5.9.1.1.(1).)

[2] 2) The requirements for *flame-spread ratings* contained in thermal insulation standards shall be applied only as required in Part 3.

Table [5.9.1.1.] 5.9.1.1.
Standards Applicable to Environmental Separators and Assemblies Exposed to the Exterior
Forming Part of Sentence [5.9.1.1.] 5.9.1.1.([1] 1)

Issuing Agency	Document Number	Title of Document
ANSI	A135.6	Engineered Wood Siding
ASME	B18.6.1	Wood Screws (Inch Series)
ASTM	A123/A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

Issuing Agency	Document Number	Title of Document
ASTM	A153/A153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM	A653/A653M	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM	C4	Standard Specification for Clay Drain Tile and Perforated Clay Drain Tile
ASTM	C73	Standard Specification for Calcium Silicate Brick (Sand-Lime Brick)
ASTM	C126	Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units
ASTM	C212	Standard Specification for Structural Clay Facing Tile
ASTM	C412M	Standard Specification for Concrete Drain Tile
ASTM	C444M	Standard Specification for Perforated Concrete Pipe
ASTM	C553	Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM	C612	Standard Specification for Mineral Fiber Block and Board Thermal Insulation
ASTM	C700	Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM	C726	Standard Specification for Mineral Wool Roof Insulation Board
ASTM	C834 (1)	Standard Specification for Latex Sealants
ASTM	C840	Standard Specification for Application and Finishing of Gypsum Board
ASTM	C920 (1)	Standard Specification for Elastomeric Joint Sealants
ASTM	C991	Standard Specification for Flexible Fibrous Glass Insulation for Metal Buildings
ASTM	C1002	Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs
ASTM	C1177/C1177M	Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing
ASTM	C1178/C1178M	Standard Specification for Coated Glass Mat Water-Resistant Gypsum Backing Panel

Issuing Agency	Document Number	Title of Document
ASTM	C1184 (1)	Standard Specification for Structural Silicone Sealants
ASTM	C1280	Standard Specification for Application of Exterior Gypsum Panel Products for Use as Sheathing
ASTM	C1311 (1)	Standard Specification for Solvent Release Sealants
ASTM	C1330 (1)	Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants
ASTM	C1396/C1396M (2)	Standard Specification for Gypsum Board
ASTM	C1658/C1658M (3)	Standard Specification for Glass Mat Gypsum Panels
ASTM	D1227/D1227M	Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing
ASTM	D2178/D2178M	Standard Specification for Asphalt Glass Felt Used in Roofing and Waterproofing
ASTM	D3019/D3019M (4)	Standard Specification for Lap Cement Used with Asphalt Roll Roofing, Non-Fibered, and Fibered
ASTM	D4479/D4479M	Standard Specification for Asphalt Roof Coatings – Asbestos-Free
ASTM	D4637/D4637M	Standard Specification for EPDM Sheet Used In Single-Ply Roof Membrane
ASTM	D4811/D4811M	Standard Specification for Nonvulcanized (Uncured) Rubber Sheet Used as Roof Flashing
ASTM	D6878/D6878M	Standard Specification for Thermoplastic Polyolefin Based Sheet Roofing
ASTM	E2190	Standard Specification for Insulating Glass Unit Performance and Evaluation
BNQ	BNQ 3624-115	Polyethylene (PE) Pipe and Fittings for Soil and Foundation Drainage
CGSB	CAN/CGSB-11.3-M	Hardboard
CGSB	CAN/CGSB-12.1	Safety Glazing
CGSB	CAN/CGSB-12.2-M	Flat, Clear Sheet Glass
CGSB	CAN/CGSB-12.3-M	Flat, Clear Float Glass
CGSB	CAN/CGSB-12.4-M	Heat Absorbing Glass
CGSB	CAN/CGSB-12.8	Insulating glass units

Issuing Agency	Document Number	Title of Document
CGSB	CAN/CGSB-12.9	Spandrel glass
CGSB	37-GP-9Ma	Primer, Asphalt, Unfilled, for Asphalt Roofing, Dampproofing and Waterproofing
CGSB	CAN/CGSB-37.50-M	Hot-Applied, Rubberized Asphalt for Roofing and Waterproofing
CGSB	CAN/CGSB-37.54	Polyvinyl Chloride Roofing and Waterproofing Membrane
CGSB	CAN/CGSB-37.58-M	Membrane, Elastomeric, Cold-Applied Liquid, for Non-Exposed Use in Roofing and Waterproofing
CGSB	CAN/CGSB-41.24	Rigid Vinyl Siding, Soffits and Fascia
CGSB	CAN/CGSB-51.32-M	Sheathing, Membrane, Breather Type
CGSB	CAN/CGSB-51.33-M	Vapour Barrier Sheet, Excluding Polyethylene, for Use in Building Construction
CGSB	CAN/CGSB-51.34-M	Vapour Barrier, Polyethylene Sheet for Use in Building Construction
CGSB	CAN/CGSB-93.1-M	Sheet, Aluminum Alloy, Prefinished, Residential
~~CGSB~~	~~CAN/CGSB-93.2-M~~	~~Prefinished Aluminum Siding, Soffits, and Fascia, for Residential Use~~
CSA	A23.1	Concrete materials and methods of concrete construction
CSA	CAN/CSA-A82	Fired masonry brick made from clay or shale
CSA	CAN3-A93-M	Natural Airflow Ventilators for Buildings
CSA	CAN/CSA-A123.2	Asphalt-Coated Roofing Sheets
CSA	A123.3	Asphalt Saturated Organic Roofing Felt
CSA	CAN/CSA-A123.4	Asphalt for Constructing Built-Up Roof Coverings and Waterproofing Systems
CSA	A123.5	Asphalt shingles made from glass felt and surfaced with mineral granules
CSA	CAN/CSA-A123.16	Asphalt-coated glass-base sheets
CSA	A123.17	Asphalt Glass Felt Used in Roofing and Waterproofing
CSA	A123.23	Product specification for polymer-modified bitumen sheet, prefabricated and reinforced
CSA	A123.51	Asphalt shingle application on roof slopes 1:6 and steeper
CSA	A165.1	Concrete block masonry units

Issuing Agency	Document Number	Title of Document
CSA	A165.2	Concrete brick masonry units
CSA	A165.3	Prefaced concrete masonry units
CSA	CAN/CSA-A179	Mortar and Grout for Unit Masonry
CSA	CAN/CSA-A220 Series	Concrete Roof Tiles
CSA	CAN/CSA-A371	Masonry Construction for Buildings
CSA	A3001	Cementitious Materials for Use in Concrete
CSA	B182.1	Plastic drain and sewer pipe and pipe fittings
CSA	G40.21	Structural quality steel
CSA	CAN/CSA-G401	Corrugated steel pipe products
CSA	CAN/CSA-O80 Series	Wood preservation
CSA	O118.1	Western Red Cedar Shakes and Shingles
CSA	O118.2	Eastern White Cedar Shingles
CSA	O121	Douglas fir plywood
CSA	O141	Softwood Lumber
CSA	O151	Canadian softwood plywood
CSA	O153	Poplar plywood
CSA	O325	Construction sheathing
CSA	O437.0	OSB and Waferboard
HPVA	ANSI/HPVA HP-1	American National Standard for Hardwood and Decorative Plywood
ULC	CAN/ULC-S701.1	Standard for Thermal Insulation, Polystyrene Boards
ULC	CAN/ULC-S702.1	Standard for Mineral Fibre Thermal Insulation for Buildings, Part 1: Material Specification
ULC	CAN/ULC-S703	Standard for Cellulose Fibre Insulation (CFI) for Buildings
ULC	CAN/ULC-S704.1	Standard for Thermal Insulation, Polyurethane and Polyisocyanurate, Boards, Faced
ULC	CAN/ULC-S705.1	Standard for Thermal Insulation – Spray Applied Rigid Polyurethane Foam, Medium Density – Material Specification

Issuing Agency	Document Number	Title of Document
ULC	CAN/ULC-S705.2	Standard for Thermal Insulation – Spray Applied Rigid Polyurethane Foam, Medium Density – Application
ULC	CAN/ULC-S706.1	Standard for Wood Fibre Insulating Boards for Buildings
ULC	CAN/ULC-S710.1	Standard for Bead-Applied One Component Polyurethane Air Sealant Foam, Part 1: Material Specification
ULC	CAN/ULC-S711.1	Standard for Bead-Applied Two Component Polyurethane Air Sealant Foam, Part 1: Material Specification
ULC	CAN/ULC-S717.1	Standard for Flat Wall Insulating Concrete Form (ICF) Units – Material Properties

Notes to Table [5.9.1.1.] 5.9.1.1.:

(1) See Note A-Table 5.9.1.1.

(2) The *flame-spread rating* of gypsum board shall be determined in accordance with CAN/ULC-S102, in lieu of ASTM E84 as indicated in ASTM C1396/C1396M.

(3) The *flame-spread rating* of gypsum panels shall be determined in accordance with CAN/ULC-S102, in lieu of ASTM E84 as indicated in ASTM C1658/C1658M.

(4) For the purpose of compliance with Part 5, ASTM D3019/D3019M shall only apply to the non-fibered and non-asbestos-fibered types of asphalt roll roofing.

Impact analysis

This proposed change is expected to have a positive impact in that it would resolve all potential conflicts created by the Code reference to this outdated standard as a minimum requirement and align the Code with current industry practice.

There is no negative impact as no additional costs to industry are expected since the standard is not actually being used.

Enforcement implications

Removing the reference to this standard as a minimum requirement would also remove the potential expectations of proof of compliance with the standard. This means that the conflict that could be created if an authority having jurisdiction were to demand proof of compliance with the standard, which is not used by industry, would also be eliminated.

Who is affected

Designers, specifiers, manufacturers, building owners, building officials, lawyers and contractors. These groups would benefit from the elimination of the potential conflicts addressed above.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[5.9.1.1.] 5.9.1.1. ([1] 1) [F20,F22,F51,F54,F55,F61,F63,F80-OH1.1,OH1.2] [F41,F55-OH1.1] [F55,F61,F80-OH1.3]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F20,F80-OS2.1] [F20,F22,F51,F61,F63,F80-OS2.3] [F51-OS2.5]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F20-OS2.2] [F80-OS2.3]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F80,F61,F63-OS3.1]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F80,F61,F63-OH4]

[5.9.1.1.] 5.9.1.1. ([1] 1) ([a] a) [F61,F63-OS1.4]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F20,F80-OP2.1,OP2.3] [F22,F80-OP2.4]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F42-OH2.5]

[5.9.1.1.] 5.9.1.1. ([2] 2) no attributions

Submit a comment

Proposed Change 1803

Code Reference(s):	NBC20 Div.B 5.9.1.1. (first printing)
Subject:	Spray-Applied Polyurethane Insulation
Title:	Introduction of References to New Material and Installation Standards for Light Density, Open Cell Spray-applied Polyurethane Foam
Description:	This proposed change introduces CAN/ULC-S712.1-17, "Standard for Thermal Insulation – Light Density, Open Cell Spray Applied Semi-rigid Polyurethane Foam – Material Specification," and CAN/ULC-S712.2-17, "Standard for Thermal Insulation – Light Density, Open Cell Spray Applied Semi-rigid Polyurethane Foam – Installation," to Table 5.9.1.1.
Related Code Change Request(s):	CCR 1210, CCR 1211, CCR 1256

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [x] Design and Construction
- [ ] Building operations
- [ ] Housing
- [ ] Small Buildings
- [x] Large Buildings
- [ ] Fire Protection
- [ ] Occupant safety in use
- [ ] Accessibility
- [ ] Structural Requirements
- [x] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

There are currently no explicit requirements related to light density, open cell spray applied semi-rigid polyurethane foam in Part 5 of the NBC. Nevertheless, the material is commonly used in practice to provide resistance to heat flow and air movement.

This situation leads to inconsistency in the design, construction and performance of these materials across Canada. This inconsistency could result in poor thermal barrier and air barrier performance, which could result in inadequate indoor air quality, potential mould growth, and reduced resistance to the deterioration of wall and roof assemblies.

Justification

The current practice of using light density, open cell spray-applied semi-rigid polyurethane foam in Canada is not governed by minimum requirements in the NBC. Therefore, it is very difficult for building officials to enforce minimum performance requirements, which has led to inconsistent design and construction. Therefore, there is a need to introduce a standard reference to minimum material and installation requirements in the Code.

CAN/ULC-S712.1, "Standard for Thermal Insulation – Light Density, Open Cell Spray Applied Semi-rigid Polyurethane Foam – Material Specification," and CAN/ULC-S712.2, "Standard for Thermal Insulation – Light Density, Open Cell Spray Applied Semi-rigid Polyurethane Foam – Installation,"

- reflect the minimum performance level in terms of material and installation
- are suitable for referencing in the NBC
- will harmonize minimum performance across Canada
- will support minimizing the risks to health of Canadians due to poor thermal and air barrier performance, which could result in inadequate indoor air quality, potential mould growth and reduced resistance to the deterioration of wall and roof assemblies.

PROPOSED CHANGE

[5.9.1.1.] 5.9.1.1. Compliance with Applicable Standards

[1] 1) Except as provided in Sentence (2) and elsewhere in this Part, materials and components, and their installation, shall conform to the requirements of the applicable standards in Table 5.9.1.1. where those materials or components are

[a] a) incorporated into environmental separators or assemblies exposed to the exterior, and

[b] b) installed to fulfill the requirements of this Part.

(See Note A-5.9.1.1.(1).)

[2] 2) The requirements for *flame-spread ratings* contained in thermal insulation standards shall be applied only as required in Part 3.

Table [5.9.1.1.] 5.9.1.1.
Standards Applicable to Environmental Separators and Assemblies Exposed to the Exterior
Forming Part of Sentence [5.9.1.1.] 5.9.1.1.([1] 1)

Issuing Agency	Document Number	Title of Document
ANSI	A135.6	Engineered Wood Siding
ASME	B18.6.1	Wood Screws (Inch Series)

Issuing Agency	Document Number	Title of Document
ASTM	A123/A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM	A153/A153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM	A653/A653M	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM	C4	Standard Specification for Clay Drain Tile and Perforated Clay Drain Tile
ASTM	C73	Standard Specification for Calcium Silicate Brick (Sand-Lime Brick)
ASTM	C126	Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units
ASTM	C212	Standard Specification for Structural Clay Facing Tile
ASTM	C412M	Standard Specification for Concrete Drain Tile
ASTM	C444M	Standard Specification for Perforated Concrete Pipe
ASTM	C553	Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM	C612	Standard Specification for Mineral Fiber Block and Board Thermal Insulation
ASTM	C700	Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM	C726	Standard Specification for Mineral Wool Roof Insulation Board
ASTM	C834 (1)	Standard Specification for Latex Sealants
ASTM	C840	Standard Specification for Application and Finishing of Gypsum Board
ASTM	C920 (1)	Standard Specification for Elastomeric Joint Sealants
ASTM	C991	Standard Specification for Flexible Fibrous Glass Insulation for Metal Buildings
ASTM	C1002	Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs
ASTM	C1177/C1177M	Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing

Issuing Agency	Document Number	Title of Document
ASTM	C1178/C1178M	Standard Specification for Coated Glass Mat Water-Resistant Gypsum Backing Panel
ASTM	C1184 (1)	Standard Specification for Structural Silicone Sealants
ASTM	C1280	Standard Specification for Application of Exterior Gypsum Panel Products for Use as Sheathing
ASTM	C1311 (1)	Standard Specification for Solvent Release Sealants
ASTM	C1330 (1)	Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants
ASTM	C1396/C1396M (2)	Standard Specification for Gypsum Board
ASTM	C1658/C1658M (3)	Standard Specification for Glass Mat Gypsum Panels
ASTM	D1227/D1227M	Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing
ASTM	D2178/D2178M	Standard Specification for Asphalt Glass Felt Used in Roofing and Waterproofing
ASTM	D3019/D3019M (4)	Standard Specification for Lap Cement Used with Asphalt Roll Roofing, Non-Fibered, and Fibered
ASTM	D4479/D4479M	Standard Specification for Asphalt Roof Coatings – Asbestos-Free
ASTM	D4637/D4637M	Standard Specification for EPDM Sheet Used In Single-Ply Roof Membrane
ASTM	D4811/D4811M	Standard Specification for Nonvulcanized (Uncured) Rubber Sheet Used as Roof Flashing
ASTM	D6878/D6878M	Standard Specification for Thermoplastic Polyolefin Based Sheet Roofing
ASTM	E2190	Standard Specification for Insulating Glass Unit Performance and Evaluation
BNQ	BNQ 3624-115	Polyethylene (PE) Pipe and Fittings for Soil and Foundation Drainage
CGSB	CAN/CGSB-11.3-M	Hardboard
CGSB	CAN/CGSB-12.1	Safety Glazing
CGSB	CAN/CGSB-12.2-M	Flat, Clear Sheet Glass
CGSB	CAN/CGSB-12.3-M	Flat, Clear Float Glass
CGSB	CAN/CGSB-12.4-M	Heat Absorbing Glass

Issuing Agency	Document Number	Title of Document
CGSB	CAN/CGSB-12.8	Insulating glass units
CGSB	CAN/CGSB-12.9	Spandrel glass
CGSB	37-GP-9Ma	Primer, Asphalt, Unfilled, for Asphalt Roofing, Dampproofing and Waterproofing
CGSB	CAN/CGSB-37.50-M	Hot-Applied, Rubberized Asphalt for Roofing and Waterproofing
CGSB	CAN/CGSB-37.54	Polyvinyl Chloride Roofing and Waterproofing Membrane
CGSB	CAN/CGSB-37.58-M	Membrane, Elastomeric, Cold-Applied Liquid, for Non-Exposed Use in Roofing and Waterproofing
CGSB	CAN/CGSB-41.24	Rigid Vinyl Siding, Soffits and Fascia
CGSB	CAN/CGSB-51.32-M	Sheathing, Membrane, Breather Type
CGSB	CAN/CGSB-51.33-M	Vapour Barrier Sheet, Excluding Polyethylene, for Use in Building Construction
CGSB	CAN/CGSB-51.34-M	Vapour Barrier, Polyethylene Sheet for Use in Building Construction
CGSB	CAN/CGSB-93.1-M	Sheet, Aluminum Alloy, Prefinished, Residential
CGSB	CAN/CGSB-93.2-M	Prefinished Aluminum Siding, Soffits, and Fascia, for Residential Use
CSA	A23.1	Concrete materials and methods of concrete construction
CSA	CAN/CSA-A82	Fired masonry brick made from clay or shale
CSA	CAN3-A93-M	Natural Airflow Ventilators for Buildings
CSA	CAN/CSA-A123.2	Asphalt-Coated Roofing Sheets
CSA	A123.3	Asphalt Saturated Organic Roofing Felt
CSA	CAN/CSA-A123.4	Asphalt for Constructing Built-Up Roof Coverings and Waterproofing Systems
CSA	A123.5	Asphalt shingles made from glass felt and surfaced with mineral granules
CSA	CAN/CSA-A123.16	Asphalt-coated glass-base sheets
CSA	A123.17	Asphalt Glass Felt Used in Roofing and Waterproofing
CSA	A123.23	Product specification for polymer-modified bitumen sheet, prefabricated and reinforced
CSA	A123.51	Asphalt shingle application on roof slopes 1:6 and steeper

Issuing Agency	Document Number	Title of Document
CSA	A165.1	Concrete block masonry units
CSA	A165.2	Concrete brick masonry units
CSA	A165.3	Prefaced concrete masonry units
CSA	CAN/CSA-A179	Mortar and Grout for Unit Masonry
CSA	CAN/CSA-A220 Series	Concrete Roof Tiles
CSA	CAN/CSA-A371	Masonry Construction for Buildings
CSA	A3001	Cementitious Materials for Use in Concrete
CSA	B182.1	Plastic drain and sewer pipe and pipe fittings
CSA	G40.21	Structural quality steel
CSA	CAN/CSA-G401	Corrugated steel pipe products
CSA	CAN/CSA-O80 Series	Wood preservation
CSA	O118.1	Western Red Cedar Shakes and Shingles
CSA	O118.2	Eastern White Cedar Shingles
CSA	O121	Douglas fir plywood
CSA	O141	Softwood Lumber
CSA	O151	Canadian softwood plywood
CSA	O153	Poplar plywood
CSA	O325	Construction sheathing
CSA	O437.0	OSB and Waferboard
HPVA	ANSI/HPVA HP-1	American National Standard for Hardwood and Decorative Plywood
ULC	CAN/ULC-S701.1	Standard for Thermal Insulation, Polystyrene Boards
ULC	CAN/ULC-S702.1	Standard for Mineral Fibre Thermal Insulation for Buildings, Part 1: Material Specification
ULC	CAN/ULC-S703	Standard for Cellulose Fibre Insulation (CFI) for Buildings
ULC	CAN/ULC-S704.1	Standard for Thermal Insulation, Polyurethane and Polyisocyanurate, Boards, Faced
ULC	CAN/ULC-S705.1	Standard for Thermal Insulation – Spray Applied Rigid Polyurethane Foam, Medium Density – Material Specification

Issuing Agency	Document Number	Title of Document
ULC	CAN/ULC-S705.2	Standard for Thermal Insulation – Spray Applied Rigid Polyurethane Foam, Medium Density – Application
ULC	CAN/ULC-S706.1	Standard for Wood Fibre Insulating Boards for Buildings
ULC	CAN/ULC-S710.1	Standard for Bead-Applied One Component Polyurethane Air Sealant Foam, Part 1: Material Specification
ULC	CAN/ULC-S711.1	Standard for Bead-Applied Two Component Polyurethane Air Sealant Foam, Part 1: Material Specification
ULC	CAN/ULC-S712.1-17	Standard for Thermal Insulation – Light Density, Open Cell Spray Applied Semi-rigid Polyurethane Foam – Material Specification
ULC	CAN/ULC-S712.2-17	Standard for Thermal Insulation – Light Density, Open Cell Spray Applied Semi-rigid Polyurethane Foam – Installation
ULC	CAN/ULC-S717.1	Standard for Flat Wall Insulating Concrete Form (ICF) Units – Material Properties

Notes to Table [5.9.1.1.] 5.9.1.1.:

(1) See Note A-Table 5.9.1.1.

(2) The *flame-spread rating* of gypsum board shall be determined in accordance with CAN/ULC-S102, in lieu of ASTM E84 as indicated in ASTM C1396/C1396M.

(3) The *flame-spread rating* of gypsum panels shall be determined in accordance with CAN/ULC-S102, in lieu of ASTM E84 as indicated in ASTM C1658/C1658M.

(4) For the purpose of compliance with Part 5, ASTM D3019/D3019M shall only apply to the non-fibered and non-asbestos-fibered types of asphalt roll roofing.

Impact analysis

In practice, manufacturers have been expected to meet the material standard (CAN/ULC-S712.1) for approximately 12 years (first edition published in 2010 and second edition published in 2017). Designers and installers have had access to the installation standard (CAN/ULC-S712.2) for five years (first and current edition published in 2017). However, neither standard was included in Part 5 of Division B of the NBC and, therefore, there was no ability for designers and authorities having jurisdiction to enforce minimum requirements for use of those materials.

Adding the references to the standards would decrease possible confusion for building officials, designers, specification writers, contractors and manufacturers as there would be explicit minimum performance requirements within the Code.

Enforcement implications

Building officials would be able to request proof of compliance with the material standard CAN/ULC-S712.1 and the installation standard CAN/ULC-S712.2. These standards could be enforced without additional resources.

In addition, the inclusion of these minimum performance requirements would create an even playing field for building officials when evaluating design submissions, thus improving the enforcement of the Code.

Who is affected

Designers, specification writers, manufacturers, contractors, building owners and building officials.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[5.9.1.1.] 5.9.1.1. ([1] 1)
[F20,F22,F51,F54,F55,F61,F63,F80-OH1.1,OH1.2] [F41,F55-OH1.1] [F55,F61,F80-OH1.3]

[5.9.1.1.] 5.9.1.1. ([1] 1)
[F20,F80-OS2.1] [F20,F22,F51,F61,F63,F80-OS2.3] [F51-OS2.5]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F20-OS2.2] [F80-OS2.3]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F80,F61,F63-OS3.1]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F80,F61,F63-OH4]

[5.9.1.1.] 5.9.1.1. ([1] 1) ([a] a) [F61,F63-OS1.4]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F20,F80-OP2.1,OP2.3] [F22,F80-OP2.4]

[5.9.1.1.] 5.9.1.1. ([1] 1) [F42-OH2.5]

[5.9.1.1.] 5.9.1.1. ([2] 2) no attributions

Submit a comment

Proposed Change 1475

Code Reference(s):	NBC20 Div.B 9.4.1.1. (first printing) NBC20 Div.B 9.4.2. (first printing) NBC20 Div.B 9.20.1. (first printing) NBC20 Div.B 9.23.1.1. (first printing) NBC20 Div.B 9.23.3.1. (first printing) NBC20 Div.B 9.23.3.4. (first printing) NBC20 Div.B 9.23.3.5. (first printing) NBC20 Div.B 9.23.6.1. (first printing) NBC20 Div.B 9.23.11.4. (first printing) NBC20 Div.B 9.23.13. (first printing) NBC20 Div.B 9.23.16.1. (first printing) NBC20 Div.B 9.23.16.5. (first printing) NBC20 Div.B 9.31.6.2.(3) (first printing) NBC20 Div.B 9.33.4.7.(2) (first printing)
Subject:	Structural Design (Part 9) — Lateral Loads
Title:	Resistance to Lateral Loads
Description:	The proposed change updates the Part 9 provisions for resistance to lateral loads due to earthquakes and wind. It responds to an increase in seismic hazard values for many locations in Canada by replacing Sa(0.2) with the seismic design parameter, Smax, and by defining new wood-frame wall types.
Related Proposed Change(s):	PCF 1775

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [ ] Design and Construction
- [ ] Building operations
- [x] Housing
- [x] Small Buildings
- [ ] Large Buildings
- [ ] Fire Protection
- [ ] Occupant safety in use
- [ ] Accessibility
- [ ] Structural Requirements
- [ ] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [ ] Plumbing
- [ ] Construction and Demolition Sites

Problem

General

With trends in home construction shifting to larger open-concept houses with fewer interior partition walls and larger windows, the redundancy once expected in and characteristic of light-frame construction is decreasing (refer to "Review of Structural Materials and Methods for Home Building in the United States: 1900 to 2000" in the supporting documents). As such, lateral loads, such as those due to earthquakes and wind, could negatively affect houses in low-seismicity zones, which currently are not required to be braced to resist these loads.

Seismic Loads

Changes have been made to seismicity values assigned for locations in Canada listed in Appendix C of the NBC 2020. The impact is that some regions will require more stringent prescriptive solutions per Part 9 due to the higher spectral hazard values, and there will be more regions with a spectral hazard of $S_a(0.2)$ greater than 1.8; these regions will thus fall outside the limits of the prescriptive solutions in Part 9 and require design per Part 4. Since some more remote areas have difficulties accessing professional engineers, it is proposed that prescriptive requirements be developed for areas where $S_a(0.2)$ is greater than 1.8.

Wind Loads

The threshold for the 1-in-50-year hourly wind pressure (HWP), above which wind needs to be considered in Part 9 of the NBC 2020, is 0.8 kPa. In conducting the analysis to establish new prescriptive provisions for higher seismic hazard proposed for the NBC 2020 a comparison was made to determine the wind pressures that would produce an equivalent base shear for each of the archetypes examined. The results suggested that the minimum trigger of 0.8 kPa was too high and that braced wall bands would be justified for lower triggers of HWP than are currently set in Part 9. It was observed that there were only 7 locations within Canada with a HWP greater than 0.8 kPa listed in Appendix C. It was also observed that the trigger reflected wind speeds similar to wind speeds associated with EF2 level tornadoes.

Justification

Seismic Loads

The proposed change will add a new band of more stringent prescriptive solutions in Part 9 for wood-frame construction. This will provide prescriptive requirements for regions with a spectral hazard of $S_a(0.2)$ greater than 1.8. Proposed modifications to provisions for insulating concrete form (ICF) and masonry construction are limited to ensuring that the seismic triggers in the proposed change are equivalent to those used in the NBC 2020, thereby limiting the impact on the ICF and masonry construction industry.

With changing energy codes where builders are opting to replace wood sheathing with foam sheathing in some locations, and where interior partitions are fewer, windows are larger, and houses are bigger, the experience that Part 9 is based on no longer applies and reconsideration is warranted. In addition, a few provinces are recommending bracing for low-seismicity zones for Part 9 buildings. For example, in the Yukon it is recommended "for low seismic zone … adoption of all wall distances and minimum wall panel lengths with added total length of braced wall panels in a braced wall band to be roughly 80% of tabulated length if unblocked and 50% of tabulated length if blocked." The proposed change is closing a loophole in Part 9 to prevent buildings that could have practically close to zero lateral resistance.

Wind Loads

The proposed change attempts to reduce the large gap between Part 9 and Part 4 provisions and introduces minimum requirements for lateral design to resist wind loads for all regions in Canada.

Considering the current trend for more open concept design of houses, the increase in rare wind events, and the decision to require a minimum consideration for lateral resisting elements for all seismic levels, it was deemed appropriate to provide similar minimum requirements for wind loads.

Also, the NBC 2015 introduced a topographic factor, C_t, which magnifies wind loads for structures located on exposed hills or escarpments. The terrain factor is not taken into account in Part 9 even with the proposed revision.

A design review was conducted to Part 4 requirements for a small house on an exposed coastal hill in Newfoundland where the HWP is listed as 0.78 kPa, indicating it does not require any consideration for wind loads. The design results to Part 4, including the C_t factor, indicated that the design wind pressure was so great that a conventional wood-frame structure could not be constructed to resist the wind loads yet Part 9 requires no consideration for wind in this location. The existing structure on this site shows signs of distress due to wind loads.

Cripple Walls

The proposed change includes new provisions related to cripple walls to add clarification for authorities having jurisdiction that typically consider a cripple wall as an additional storey, which could move a Part 9 structure into Part 4. The proposed change defines when a cripple wall is and is not required to be considered as an additional storey.

PROPOSED CHANGE

[9.4.1.1.] 9.4.1.1. General

(See Note A-9.4.1.1. and Article 2.2.7.6. of Division C.)

[1] 1) Subject to the application limitations defined elsewhere in this Part, structural members and their connections shall

[a] a) conform to requirements provided elsewhere in this Part,

[b] b) be designed according to good engineering practice such as that provided in the CWC ~~2014,~~ "Engineering Guide for Wood Frame Construction," or

[c] c) be designed according to Part 4 using the loads and deflection and vibration limits specified in

[i] i) Part 9, or

[ii] ii) Part 4.

[2] 2) Where floor framing is designed in accordance with Clause (1)(b) or (c), and where supporting wall framing and fastenings, or footings are designed according to Clause (1)(a), the maximum specified *live load* on the floor according to Table 4.1.5.3. shall not exceed 2.4 kPa.

[3] 3) Location-specific information for structural design, including snow and wind loads and ~~seismic spectral accelerations~~seismic design parameters, shall be determined according to Subsection 1.1.3.

Note A-9.4.1.1. Structural Design.

Article 9.4.1.1. establishes the principle that the structural members of Part 9 buildings must

- comply with the prescriptive requirements provided in Part 9,
- be designed in accordance with accepted good practice, or
- be designed in accordance with Part 4 using the loads and limits on deflection and vibration specified in Part 9 or Part 4.

Usually a combination of approaches is used. For example, even if the snow load calculation on a wood roof truss is based on Subsection 9.4.2., the joints must be designed in accordance with Part 4. Wall framing may comply with the prescriptive requirements in Subsections 9.23.3., 9.23.10., 9.23.11. and 9.23.12., while the floor framing may be engineered.

Design according to Part 4 or accepted good engineering practice, such as that described in the CWC ~~2014,~~ "Engineering Guide for Wood Frame Construction," requires engineering expertise. The CWC Guide contains alternative solutions and provides information on the applicability of the Part 9 prescriptive structural requirements to further assist designers and building officials to identify the appropriate design approach. The need for professional involvement in the structural design of a building, whether to Part 4 or Part 9 requirements or accepted good practice, is defined by provincial and territorial legislation.

[9.4.2.] 9.4.2. Specified Loads

[9.4.2.1.] 9.4.2.1. Application

[9.4.2.2.] 9.4.2.2. Specified Snow Loads

[9.4.2.3.] 9.4.2.3. Platforms Subject to Snow and Occupancy Loads

[9.4.2.4.] 9.4.2.4. Attics and Roof Spaces

[9.4.2.5.] --- Seismic Design Parameter
(See Note A-9.4.2.5.)

[1] --) Except as provided in Sentence (2) and unless otherwise indicated, the value of the seismic design parameter, S_{max}, at a location listed in Table C-3 of Appendix C shall be taken as S_{max} for unknown Site Class. (See Note A-9.4.2.5.(1).)

[2] --) Where the Site Class is determined in accordance with Sentence 4.1.8.4.(3), the value of the seismic design parameter, S_{max}, at a location listed in Table C-3 of Appendix C, is permitted to be taken as S_{max} for the determined Site Class. (See Note A-9.4.2.5.(2).)

Note A-9.4.2.5. Seismic Design Parameter.

The seismic design parameter, S_{max}, is used as a trigger for the application of seismic design provisions in Part 9. It was derived by considering the upper limit on the specified lateral earthquake force, V, as defined in Clause 4.1.8.11.(2)(c), and is taken as the larger of (2/3)S(0.2) and S(0.5), with S(0.2) and S(0.5) determined in accordance with Sentence 4.1.8.4.(6).

Note A-9.4.2.5.(1) Seismic Design Parameter for Site Class C.

The seismic design parameter, S_{max}, for Site Class C is used as a trigger for the application of certain seismic design provisions in Part 9, where indicated.

Note A-9.4.2.5.(2) Determination of Site Class.

To benefit from a refined, and possibly less conservative, value of S_{max}, the Site Class can be determined on the basis of the ground profile at the site in accordance with Sentence 4.1.8.4.(3). Determination of the Site Class will require the involvement of a suitably qualified and experienced professional engineer.

[9.20.1.] 9.20.1. Application

[9.20.1.1.] 9.20.1.1. General

[1] 1) Except as provided in Article 9.20.1.2., this Section applies to

[a] a) unreinforced masonry and masonry veneer walls not in contact with the ground, where

[i] i) the height of the walls constructed on the *foundation* walls does not exceed 11 m, and

[ii] ii) the roof or floor assembly above the *first storey* is not of concrete construction, and

[b] b) flat insulating concrete form walls not in contact with the ground that (see Note A-9.15.1.1.(1)(c) and 9.20.1.1.(1)(b))

[i] i) have a maximum floor-to-floor height of 3 m,

[ii] ii) are erected in *buildings* not more than 2 *storeys* in *building height*, and

[iii] iii) are erected in locations where the seismic ~~spectral acceleration, $S_a(0.2)$~~design parameter, S_{max}, for Site Class C is not greater than ~~0.4~~0.27 (see also Article 9.4.2.5.~~Note A-9.20.1.2.~~).

[2] 2) For walls other than those described in Sentence (1), or where the masonry walls or insulating concrete form walls not in contact with the ground are designed for specified loads on the basis of ultimate and serviceability limit states, Subsection 4.3.2. shall apply.

[9.20.1.2.] 9.20.1.2. Earthquake Reinforcement

(See ~~Note A-9.20.1.2.~~also Article 9.4.2.5.)

[1] 1) In locations where the ~~spectral acceleration, $S_a(0.2)$,~~ seismic design parameter, S_{max}, for Site Class C is greater than ~~0.55~~0.37, *loadbearing* elements of masonry *buildings* more than 1 *storey* in *building height* shall be reinforced with not less than the minimum amount of reinforcement required by Subsection 9.20.15.

[2] 2) In locations where the ~~spectral acceleration, $S_a(0.2)$,~~seismic design parameter, S_{max}, for Site Class C is greater than ~~0.35~~0.23 but ~~less than or equal to~~not greater than ~~0.55~~0.37, *loadbearing* elements of masonry *buildings* 3 *storeys* in *building height* shall be reinforced with not less than the minimum amount of reinforcement required by Subsection 9.20.15.

~~Note A-9.20.1.2. Seismic Information.~~

~~Information on spectral acceleration values for various locations can be found in Appendix C.~~

[9.23.1.1.] 9.23.1.1. Limitations

(See Note A-9.23.1.1.)

[1] 1) Subject to the application limitations defined elsewhere in this Part, ~~T~~this Section applies to constructions where wall, floor and roof planes are generally comprised of lumber frames of small repetitive structural members, or engineered components, and where

[a] a) roof and wall planes are clad, sheathed or braced on at least one side,

[b] b) the small repetitive structural members are spaced not more than 600 mm o.c.,

[c] c) the constructions do not serve as *foundations*,

[d] d) the specified *live load* on supported subfloors and floor framing does not exceed 2.4 kPa, and

[e] e) the span of any structural member does not exceed 12.20 m.

(See Note A-9.23.1.1.(1).)

[2] 2) Where the conditions in Sentence (1) are exceeded for wood constructions, the design of the framing and fastening shall conform to Subsection 4.3.1.

[9.23.3.1.] 9.23.3.1. Standards for Nails and Screws

[1] 1) Except as provided in Sentence (2) and unless otherwise indicated, nails specified in this Section shall be common steel wire nails or common spiral nails conforming to

[a] a) ASTM F1667, "Standard Specification for Driven Fasteners: Nails, Spikes, and Staples", or

[b] b) CSA B111, "Wire Nails, Spikes and Staples".

[2] 2) Nails used to comply with Tables 9.23.3.4. and 9.23.3.5.-A to 9.23.3.5.-C shall have a diameter not less than that stated in Table 9.23.3.1. (See Note A-9.23.3.1.(2).)

Table [9.23.3.1.] 9.23.3.1.
Diameter of Nails
Forming Part of Sentence [9.23.3.1.] 9.23.3.1.([2] 2)

Minimum Length of Nails, mm	Minimum Diameter of Nails, mm
45	2.64
51	2.84
57	2.87
63	3.25
76	3.66
82	3.66
101 or greater	4.88

[3] 3) Wood screws specified in this Section shall conform to ASME B18.6.1, "Wood Screws (Inch Series)". (See Note A-9.23.3.1.(3).)

Note A-9.23.3.1.(2) Alternative Nail Sizes.

Where power nails or nails with a diameter smaller ~~diameters~~ than that required by ~~Table 9.23.3.4.~~ Table 9.23.3.1. or 9.23.3.5.-C are used to connect framing, the following equations can be used to determine the required spacing or required number of nails.

The maximum spacing can be reduced using the following equation:

$$S_{adj} = S_{table}\left(\frac{D_{red}}{D_{table}}\right)^2$$

where

S_{adj} = adjusted nail spacing ≥ 20 × nail diameter,
S_{table} = nail spacing required by Table 9.23.3.4., 9.23.3.5.-A, 9.23.3.5.-B or 9.23.3.5.-C,
D_{red} = nail diameter smaller ~~nail diameter~~ than that required by Table 9.23.3.1. or 9.23.3.5.-C, and
D_{table} = nail diameter required by Table 9.23.3.1. or 9.23.3.5.-C.

The number of nails can be increased using the following equation:

$$N_{adj} = N_{table}\left(\frac{D_{table}}{D_{red}}\right)^2$$

where

N_{adj} = adjusted number of nails,
N_{table} = number of nails required by Table 9.23.3.4., 9.23.3.5.-A, 9.23.3.5.-B or 9.23.3.5.-C,
D_{table} = nail diameter required by Table 9.23.3.1. or 9.23.3.5.-C, and
D_{red} = ~~smaller~~ nail diameter smaller than that required by Table 9.23.3.1. or 9.23.3.5.-C.

Note that nails should be spaced ~~sufficiently far apart—preferably~~ no less than 55 mm apart ~~—~~to avoid splitting of framing lumber.

[9.23.3.4.] 9.23.3.4. Nailing of Framing

[1] 1) Except as provided in Sentence (2), nailing of framing shall conform to Table 9.23.3.4.

[2] 2) Where the bottom wall plate or sole plate of an exterior wall is not nailed to floor joists, *rim joists* or blocking in conformance with Table 9.23.3.4., the exterior wall is permitted to be fastened to the floor framing by

[a] a) having plywood, OSB or waferboard sheathing extend down over floor framing and fastened to the floor framing by nails or staples conforming to Article 9.23.3.5., or

[b] b) tying the wall framing to the floor framing by galvanized-metal strips

[i] i) 50 mm wide,

[ii] ii) not less than 0.41 mm thick,

[iii] iii) spaced not more than 1.2 m apart, and

[iv] iv) fastened at each end with at least two 63 mm nails.

Table [9.23.3.4.] 9.23.3.4.
Nailing for Framing
Forming Part of Sentences [9.23.3.4.] 9.23.3.4.([1] 1) and 9.23.14.4.(2)

Construction Detail	Minimum Length of Nails, mm	Minimum Number or Maximum Spacing of Nails (1)
Floor joist or blocking perpendicular to sill plate or top wall plate below – toe nail	82	2 per floor joist or blocking
Rim joist, trimmer joist or blocking – supporting walls with required *braced wall panels* – to sill plate or top wall plate – toe nail	82	150 mm o.c.
Wood or metal strapping to underside of floor joists	57	2
Cross bridging to joists	57	2 at each end
Double header or trimmer joists	76	300 mm o.c.
Floor joist to stud (balloon construction)	76	2

Construction Detail	Minimum Length of Nails, mm	Minimum Number or Maximum Spacing of Nails (1)
Ledger strip to wood beam	82	2 per joist
Joist to joist splice (see also Table 9.23.14.8.)	76	2 at each end
Tail joist to adjacent header joist	82	5
(end nailed) around openings	101	3
Each header joist to adjacent trimmer joist	82	5
(end nailed) around openings	101	3
Blocking to stud or ~~S~~stud to wall plate (each end) – toe nail	63	4
or end nail	82	2
Doubled studs at openings, or studs at walls or wall intersections and corners	76	750 mm o.c.
Doubled studs at openings, within walls, or abutting studs at wall intersections and corners – in required *braced wall panels*	76	300 mm o.c.
Doubled top wall plates (2)	76	600 mm o.c.
Bottom wall plate or sole plate to floor joists, *rim joists* or blocking (exterior walls) (3)	82	400 mm o.c.
Bottom wall plate or sole plate – in required *braced wall panels* – to floor joists, *rim joists* or blocking (exterior walls) (3)	82	150 mm o.c.
Interior walls to framing or subflooring	82	600 mm o.c.
Required *braced wall panels* – in interior walls – to framing above and below	82	150 mm o.c.
Horizontal member over openings in non-*loadbearing* walls – each end	82	2
Lintels to studs	82	2 at each end
Ceiling joist to plate – toe nail each end	82	2
Roof rafter, roof truss or roof joist to plate – toe nail (4)	82	3
Rafter plate to each ceiling joist	101	2
Rafter to joist (with ridge supported)	76	3
Rafter to joist (with ridge unsupported)	76	see Table 9.23.14.8.
Gusset plate to each rafter at peak	57	4
Rafter to ridge board – toe nail – end nail	82	3
Collar tie to rafter – each end	76	3
Collar tie lateral support to each collar tie	57	2
Jack rafter to hip or valley rafter	82	2
Roof strut to rafter	76	3
Roof strut to *loadbearing* wall – toe nail	82	2
38 mm × 140 mm or less plank decking to support	82	2
Plank decking wider than 38 mm × 140 mm to support	82	3
38 mm edge laid plank decking to support (toe nail)	76	1
38 mm edge laid plank to each other	76	450 mm o.c.
End-joist or end-rafter to built-up wall stud ~~(5)~~	76	5 or 8 (6)

Notes to Table [9.23.3.4.] 9.23.3.4.:

(1) See Note A-9.23.3.1.(2).

(2) See Article 9.23.11.4. for requirements on the nailing of top plate~~s~~ splices in *braced wall bands*.

(3) See Sentence 9.23.3.4.(2).

(4) See Sentence 9.23.3.4.(3).

~~(5) See Sentence 9.23.13.5.(3).~~

(6) Where heavyweight construction is used in the roof of the space, at least 8 nails are required (see Note A-9.23.13.2.(3)~~Note A-9.23.13.2.(1)(a)(i)~~).

[3] 3) Where the 1-in-50 hourly wind pressure is equal to or greater than 0.8 kPa, roof rafters, joists or trusses shall be tied to the wall framing with connectors that will resist a factored uplift load of 3 kN.

[4] 4) Galvanized-steel straps are deemed to comply with Sentence (3), provided they are
- [a] a) 50 mm wide,
- [b] b) not less than 0.91 mm thick, and
- [c] c) fastened at each end with at least four 63 mm nails.

[9.23.3.5.] 9.23.3.5. Fasteners for Sheathing or Subflooring

[1] 1) ~~Except as provided in Sentence (2) to (4), f~~Fastening of ~~sheathing and subflooring~~the following shall conform to Table 9.23.3.5.-A:~~.~~
- [a] --) subflooring,
- [b] --) wall sheathing not in a required *braced wall panel*, and
- [c] --) roof sheathing where the 1-in-50-year hourly wind pressure (HWP) is not greater than 0.6 kPa and the seismic design parameter, S_{max}, for Site Class C is not greater than 0.47.

Table [9.23.3.5.-A] 9.23.3.5.-A
Fasten~~ers~~ing ~~for~~of Subflooring, ~~and for~~Wall Sheathing Not in a Required Braced Wall Panel, and Roof Sheathing ~~w~~Where ~~the 1-in-50~~ HWP ~~< 0.8~~≤ 0.6 kPa and ~~$S_a(0.2)$ ≤ 0.70~~S_{max} for Site Class C ≤ 0.47
Forming Part of Sentence [9.23.3.5.] 9.23.3.5.([1] 1)

Element	Minimum Length of Fasteners, mm				Minimum Number or Maximum Spacing of Fasteners (1)
	Common or Spiral Nails	Ring Thread Nails or Screws	Roofing Nails	Staples	
Board lumber 184 mm or less wide	51	45	n/a	51	2 per support
Board lumber more than 184 mm wide	51	45	n/a	51	3 per support
Fibreboard sheathing up to 13 mm thick	n/a	n/a	44	28	150 mm o.c. along edges and 300 mm o.c. along intermediate supports
Gypsum sheathing up to 13 mm thick	n/a	n/a	44	n/a	
Plywood, OSB or waferboard up to 10 mm thick	51	45	n/a	38	
Plywood, OSB or waferboard over 10 mm and up to 20 mm thick	51	45	n/a	51	
Plywood, OSB or waferboard over 20 mm and up to 25 mm thick	57	51	n/a	n/a	

Note to Table [9.23.3.5.-A] 9.23.3.5.-A:

(1) See Note A-9.23.3.1.(2).

[2] 2) Except as provided in Sentence (4), ~~F~~fastening of roof sheathing ~~and sheathing in required *braced wall panels*~~ shall conform to Table 9.23.3.5.-B, where

[a] --) the 1-in-50-year hourly wind pressure (HWP) is ~~equal to or~~ greater than ~~0.8~~0.6 kPa ~~and less~~ but not greater than 1.2 kPa ~~and the seismic spectral acceleration, $S_a(0.2)$, is not more than 0.90~~, or

[b] --) the seismic ~~spectral acceleration~~design parameter, ~~$S_a(0.2)$~~S_{max}, for Site Class C is greater than ~~0.70~~0.47 but S_{max} is not greater~~and not more~~ than ~~0.90~~2.6.

Table [9.23.3.5.-B] 9.23.3.5.-B
Fastening~~ers~~ ~~for~~of Roof Sheathing W~~w~~here ~~0.8 kPa ≤ 1-in-50~~0.6 kPa < HWP ~~<~~≤ 1.2 kPa ~~and~~or Where S_{max} for Site Class C > 0.47 and S_{max} ≤ 2.6 ~~$S_a(0.2)$ ≤ 0.90 or where 0.70 < $S_a(0.2)$ ≤ 0.90~~
Forming Part of Sentence [9.23.3.5.] 9.23.3.5.([2] 2)

HWP and S_{max} (1) Limits	Element	Minimum Length of Fasteners, mm			Minimum Number or Maximum Spacing of Fasteners (2)
		Common, Spiral or Ring Thread Nails	Screws	14-G~~g~~auge Staples	
0.6 kPa < HWP ≤ 0.8 kPa and S_{max} ≤ 0.6 or S_{max} for Site Class C > 0.47, S_{max} ≤ 0.6 and HWP ≤ 0.8 kPa	Board lumber 184 mm or less wide (3)	63	51	63	2 per support
	Board lumber more than 184 mm wide (3)	63	51	63	3 per support
	Plywood, OSB or waferboard up to 20 mm thick (4)	63	51	63	150 mm o.c. along the edges of sheathing panels and 300 mm o.c. along intermediate supports~~; and for roof sheathing where HWP is equal to or greater than 0.8 kPa and less than 1.2 kPa, and 50 mm o.c. within 1 m of the edges of the roof~~
	Plywood, OSB or waferboard over 20 mm and up to 25 mm thick	63	57	n/a	
0.8 kPa < HWP ≤ 1.2 kPa and S_{max} ≤ 2.6 or S_{max} for Site Class C > 0.47, 0.6 < S_{max} ≤ 2.6 and HWP ≤ 1.2 kPa	Plywood, OSB or waferboard up to 20 mm thick	63	51	n/a	75 mm o.c. along the edges of sheathing panels, 300 mm o.c. along intermediate supports, and where 0.8 kPa < HWP ≤ 1.2 kPa, 50 mm o.c. within 1 m of the edges of the roof
	Plywood, OSB or waferboard over 20 mm and up to 25 mm thick	63	57	n/a	

Notes to Table [9.23.3.5.-B] 9.23.3.5.-B:

(1) See Article 9.4.2.5.

(2) See Note A-9.23.3.1.(2).

(3) See Article 9.23.16.5.

~~(4) See Note A-Table 9.23.3.5.-B.~~

[3] 3) Except as provided in Sentence (4), f~~F~~astening of ~~roof sheathing and~~ wall sheathing in required *braced wall panels* shall conform to the reference framing types specified in Table 9.23.3.5.-C~~, where~~.

~~[a] --) the 1-in-50 hourly wind pressure (HWP) is equal to or greater than 0.8 kPa and less than 1.2 kPa and the spectral acceleration, $S_a(0.2)$, is not more than 1.8, or~~

~~[b] --) the seismic spectral acceleration, $S_a(0.2)$, is greater than 0.90 and not more than 1.8.~~

Table [9.23.3.5.-C]
Fastening of Wall Sheathing in Required Braced Wall Panels Where HWP ≤ 1.2 kPa and S_{max} ≤ 2.6
Forming Part of Sentence [9.23.3.5.] 9.23.3.5.([3] 3)

Reference Framing Type [1]	Minimum Sheathing Element [2] and Maximum Stud Spacing	Minimum Specifications for Fasteners		Minimum Number or Maximum Spacing of Fasteners [3] [4] along Panel Edges Fastened to Framing
		Common, Spiral or Ring Thread Nails	Screws	
GWB-O (interior side of WSP and DWB framing types)	12.5 mm gypsum board for 600 mm stud spacing	2.48 mm diameter ring thread with 20 mm penetration into support framing [5]	3.45 mm shank diameter, Type W, with 20 mm penetration into support framing [6]	200 mm o.c. for nails or 300 mm o.c. for screws
GWB-A	12.5 mm gypsum board for 600 mm stud spacing			200 mm o.c for nails or 300 mm o.c. for screws
GWB-B	12.5 mm gypsum board for 400 mm stud spacing			200 mm o.c.
GWB-C	12.5 mm gypsum board for 400 mm stud spacing or 12.5 mm gypsum board, blocked, [7] for 600 mm stud spacing			150 mm o.c. or 200 mm o.c. for blocked
GWB-D	12.5 mm gypsum board for 400 mm stud spacing			100 mm o.c.
WSP-A	9.5 mm plywood, OSB or waferboard for 400 mm stud spacing	2.84 mm × 51 mm [8]	NP [9]	150 mm o.c.
WSP-B	11 mm plywood, OSB or waferboard, blocked, [7] for 600 mm stud spacing	3.25 mm × 63 mm [8]		150 mm o.c.
WSP-C	11 mm plywood, OSB or waferboard, blocked, [7] for 600 mm stud spacing	3.25 mm × 63 mm [8]		100 mm o.c.

Reference Framing Type (1)	Minimum Sheathing Element (2) and Maximum Stud Spacing	Minimum Specifications for Fasteners		Minimum Number or Maximum Spacing of Fasteners (3) (4) along Panel Edges Fastened to Framing
		Common, Spiral or Ring Thread Nails	Screws	
WSP-D	11 mm plywood, OSB or waferboard, blocked (7) for 600 mm stud spacing	3.25 mm × 63 mm (8)		75 mm o.c.
WSP-E	15.5 mm plywood, OSB or waferboard, blocked, (7) for 600 mm stud spacing	3.66 mm × 63 mm (8)		75 mm o.c.
DWB	19 mm diagonal lumber board	3.25 mm × 63 mm (8)	3.25 mm × 51 mm	2 per support framing where lumber width ≤ 184 mm or 3 per support framing where lumber width > 184 mm

Notes to Table [9.23.3.5.-C] :

(1) See Note A-Table 9.23.3.5.-C.

(2) Plywood, OSB, waferboard and board lumber shall conform to the material standards specified in Subsection 9.23.17. Wood-based panels may be installed vertically or horizontally. Gypsum sheathing shall conform to the requirements for gypsum board set out in Subsection 9.29.5.

(3) See Note A-9.23.3.1.(2).

(4) For plywood, OSB, or waferboard panel sheathing, the maximum fastener spacing along intermediate supports shall be 300 mm o.c. For gypsum sheathing, the maximum spacing along intermediate supports shall conform to Sentence 9.29.5.8.(4) for nails and to Sentence 9.29.5.9.(4) for screws.

(5) Nails for GWB framing types shall conform to Article 9.29.5.6.

(6) Screws for GWB framing types shall conform to Article 9.29.5.7.

(7) Where blocking is required, horizontal joints of panel sheathing shall occur over blocking consisting of not less than 38 mm × 89 mm lumber oriented either edgewise or flatwise, and the panel sheathing shall be fastened to the blocking.

(8) Nails for WSP and DWB framing types shall conform to Article 9.23.3.1.

(9) NP = not permitted.

~~Table [9.23.3.5.-D]~~
~~Fasteners for Sheathing where 0.8 kPa ≤ 1-in-50 HWP < 1.2 kPa and Sa(0.2) ≤ 1.8 or where 0.90 < Sa(0.2) ≤ 1.8~~
~~Forming Part of Sentence [9.23.3.5.] 9.23.3.5.([3] 3)~~

~~Element~~	~~Minimum Length of Fasteners, mm~~		~~Minimum Number or Maximum Spacing of Fasteners~~
	~~Common, Spiral or Ring Thread Nails~~	~~Screws~~	
~~Plywood, OSB or waferboard up to 20 mm thick (1)~~	~~63~~	~~51~~	~~75 mm o.c. along edges and 300 mm o.c. along intermediate supports; and for roof sheathing where 1-in-50 HWP is equal to or greater than 0.8 kPa and less than 1.2 kPa, 50 mm o.c. within 1 m of the edges of the roof~~
~~Plywood, OSB or waferboard over 20 mm and up to 25 mm thick~~	~~63~~	~~57~~	

~~Note to Table [9.23.3.5.-D] :~~

~~(1) See Note A-Table 9.23.3.5.-B.~~

[4] 4) Fastening of wall sheathing in required *braced wall panels* and roof sheathing shall conform to Part 4, where
[a] a) ~~where~~ the 1-in-50-year hourly wind pressure (HWP) is ~~equal to or~~ greater than 1.2 kPa, ~~or~~
~~[b] --) for required *braced wall panels*, where the seismic spectral acceleration, Sa(0.2), is greater than 1.8.~~
[c] b) the seismic design parameter, S_{max}, is greater than 2.6, or
[d] --) the seismic design parameter, S_{max}, for Site Class C is greater than 0.47, for *buildings* of 3 *storeys* in *building height* and
[i] --) of heavyweight construction,
[ii] --) clad at full height with masonry veneer, or
[iii] --) clad at full height with stone veneer
(see Sentence 9.23.13.2.(3)).

[5] 5) Staples shall not be less than 1.6 mm in diameter or thickness, with not less than a 9.5 mm crown driven with the crown parallel to framing.

[6] 6) Roofing nails for the attachment of fibreboard or gypsum sheathing shall not be less than 3.2 mm in diameter with a minimum head diameter of 11.1 mm.

[7] 7) Flooring screws shall not be less than 3.2 mm in diameter.

~~[8] 8) The edges of sheathing in a *braced wall panel* shall be supported and fastened to wood blocking where~~
~~[a] a) the seismic spectral acceleration, $S_a(0.2)$, is greater than 1.2, or~~
~~[b] b) the *braced wall panel* supports more than a roof of lightweight construction.~~

Note A-Table 9.23.3.5.-C Reference Framing Types.

Table 9.23.3.5.-C describes the fastening of sheathing elements for each reference framing type available for use as a braced wall panel. The reference framing types fall into three categories: wood-sheathed panel (WSP), diagonal wood (lumber) board (DWB), and gypsum board (GWB).

~~Note A-Table 9.23.3.5.-B Alternative Nail Sizes.~~

~~Where power nails or nails having a different diameter than the diameters listed in CSA B111, "Wire Nails, Spikes and Staples", are used to connect the edges of the wall sheathing to the wall framing of wood-sheathed braced wall panels, the maximum spacing should be as shown in Table A-Table 9.23.3.5.-B.~~

~~Table [Table 9.23.3.5.-B] A-Table 9.23.3.5.-B~~
~~Alternative Nail Diameters and Spacing~~

~~Element~~	~~Nail Diameter, mm (1)~~	~~Maximum Spacing of Nails Along Edges of Wall Sheathing, mm o.c.~~
~~Plywood, OSB or waferboard~~	~~2.19–2.52~~	~~75~~
	~~2.53–2.82~~	~~100~~
	~~2.83–3.09~~	~~125~~
	~~> 3.09~~	~~150~~

~~Note to Table [Table 9.23.3.5.-B] A-Table 9.23.3.5.-B:~~

~~(1)~~ ~~For alternative nail lengths of 63 mm or longer.~~

[9.23.6.1.] 9.23.6.1. Anchorage of Building Frames

[1] 1) Except as required by Sentence 9.23.6.3.(1), *building* frames shall be anchored to the *foundation* unless a structural analysis that considers wind and earthquake loads and lateral earth pressures shows that anchorage is not required.

[2] 2) Except as provided in Sentences (3) to (6), anchorage shall be provided by
- [a] a) embedding the ends of the first floor joists in concrete, or
- [b] b) fastening the sill plate to the *foundation* with not less than 12.7 mm diam anchor bolts spaced not more than 2.4 m o.c.

[3] 3) ~~For buildings with 2 or more floors supported by frame walls that are in areas where the seismic spectral acceleration, Sa(0.2), is not greater than 0.70 or the 1-in-50 hourly wind pressure (HWP) is equal to or greater than 0.80 kPa but not greater than 1.20 kPa~~Except as provided in Sentence (6), where the seismic design parameter, S_{max}, for Site Class C is greater than 0.47, anchorage of *braced wall panels* shall be provided by fastening the sill plate to the *foundation* with ~~not less than two~~ anchor bolts ~~per *braced wall panel*, where all anchor bolts used are~~, such that
- [a] a) there are not less than ~~15.9 mm in diameter, located~~ two anchor bolts per *braced wall panel*, located at opposite ends of the *braced wall panel* within 0.5 m of the *foundation* end ~~of the *foundation*, and spaced not more than 2.4 m o.c,~~ or within 0.3 m of the end of the *braced wall panel*, and
- [b] b) ~~not less than 12.7 mm in diameter, located within 0.5 m of the end of the *foundation*, and spaced not more than 1.7 m o.c.~~the anchor bolts are spaced in accordance with Table 9.23.6.1.

(See Note A-9.23.6.1.(3).)

~~[4] 4) For *buildings* supported by frame walls that are in areas where the seismic spectral acceleration, $S_a(0.2)$, is greater than 0.70 but not greater than 1.8 and the 1-in-50 hourly wind pressure (HWP) is not greater than 1.20 kPa, anchorage shall be provided by fastening the sill plate to the *foundation* with not less than two anchor bolts per *braced wall panel* located within 0.5 m of the end of the *foundation* and spaced in accordance with Table 9.23.6.1.~~

Table [9.23.6.1.-A]
Anchor Bolt Spacing within Braced Wall Panels W~~w~~here ~~the 1-in-50~~ HWP ≤ 1.2~~0~~ kPa~~,~~ ~~and 0.70 < Sa(0.2) ≤ 1.8~~S_{max} for Site Class C > 0.47 and S_{max} ≤ 2.6
Forming Part of Sentence [9.23.6.1.] 9.23.6.1.([3] 3)

Reference Framing Type	Maximum Spacing of Anchor Bolts within *Braced Wall Panels*, m	
	Anchor Bolt Diameter	
	12.7 mm	15.9 mm
GWB-A	2.4	2.4
GWB-B	2.4	2.4
GWB-C	1.8	2.4
GWB-D	1.4	2.1
WSP-A	1.4	2.1

Reference Framing Type	Maximum Spacing of Anchor Bolts within *Braced Wall Panels*, m	
	Anchor Bolt Diameter	
	12.7 mm	15.9 mm
WSP-B	0.8	1.2
WSP-C	0.7	1.0
WSP-D	0.6	0.9
WSP-E	0.5	0.8
DWB	0.8	1.2

~~Anchor Bolt Diameter, mm~~	~~$S_a(0.2)$~~	~~Maximum Spacing of Anchor Bolts Along *Braced Wall Band*, m~~				
		~~Light Construction~~			~~Heavy Construction (1)~~	
		~~Number of Floors Supported (2)~~				
		~~1~~	~~2~~	~~3~~	~~1~~	~~2~~
~~12.7~~	~~$0.70 < S_a(0.2) \le 0.80$~~	~~2.4~~	~~2.3~~	~~1.8~~	~~2.4~~	~~2.0~~
	~~$0.80 < S_a(0.2) \le 0.90$~~	~~2.4~~	~~2.3~~	~~1.8~~	~~2.4~~	~~2.0~~
	~~$0.90 < S_a(0.2) \le 1.0$~~	~~2.4~~	~~2.2~~	~~1.5~~	~~2.4~~	~~1.8~~
	~~$1.0 < S_a(0.2) \le 1.1$~~	~~2.4~~	~~2.1~~	~~1.4~~	~~2.4~~	~~1.6~~
	~~$1.1 < S_a(0.2) \le 1.2$~~	~~2.4~~	~~2.0~~	~~1.3~~	~~2.4~~	~~1.5~~
	~~$1.2 < S_a(0.2) \le 1.3$~~	~~2.4~~	~~1.9~~	~~1.3~~	~~2.4~~	~~1.5~~
	~~$1.3 < S_a(0.2) \le 1.35$~~	~~2.4~~	~~1.8~~	~~1.2~~	~~2.3~~	~~1.4~~
	~~$1.35 < S_a(0.2) \le 1.8$~~	~~2.4~~	~~1.8~~	~~1.1~~	~~2.3~~	~~1.4~~
~~15.9Table9.23.6.1~~	~~$0.70 < S_a(0.2) \le 0.80$~~	~~2.4~~	~~2.4~~	~~2.2~~	~~2.4~~	~~2.4~~
	~~$0.80 < S_a(0.2) \le 0.90$~~	~~2.4~~	~~2.4~~	~~2.2~~	~~2.4~~	~~2.4~~
	~~$0.90 < S_a(0.2) \le 1.0$~~	~~2.4~~	~~2.4~~	~~2.1~~	~~2.4~~	~~2.3~~
	~~$1.0 < S_a(0.2) \le 1.1$~~	~~2.4~~	~~2.4~~	~~1.9~~	~~2.4~~	~~2.3~~
	~~$1.1 < S_a(0.2) \le 1.2$~~	~~2.4~~	~~2.4~~	~~1.9~~	~~2.4~~	~~2.2~~
	~~$1.2 < S_a(0.2) \le 1.3$~~	~~2.4~~	~~2.4~~	~~1.8~~	~~2.4~~	~~2.1~~
	~~$1.3 < S_a(0.2) \le 1.35$~~	~~2.4~~	~~2.3~~	~~1.7~~	~~2.4~~	~~2.0~~
	~~$1.35 < S_a(0.2) \le 1.8$~~	~~2.4~~	~~2.2~~	~~1.6~~	~~2.4~~	~~1.9~~

~~Notes to :~~

~~(1)~~ ~~See Note A-9.23.13.2.(1)(a)(i).~~

~~(2)~~ ~~All constructions include support of a roof load in addition to the indicated number of floors.~~

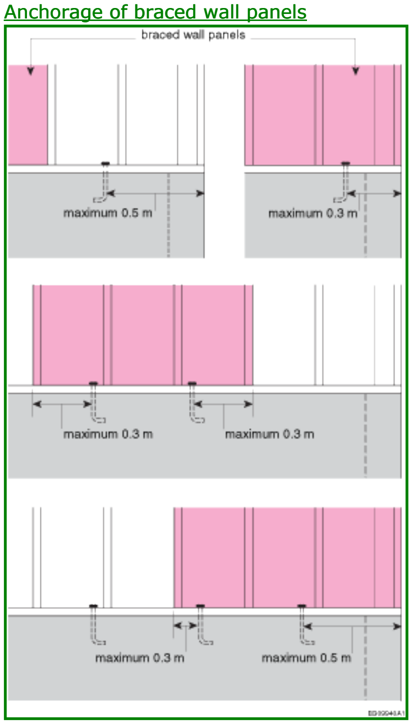
[5] 5) Anchor bolts referred to in Sentences (2) ~~to~~and (3~~4~~) shall be
- [a] a) fastened to the sill plate with nuts and washers,
- [b] b) embedded not less than 100 mm in the *foundation*, and
- [c] c) so designed that they may be tightened without withdrawing them from the *foundation*.

[6] 6) ~~Where the seismic spectral acceleration, $S_a(0.2)$, is greater than 1.8 or the 1-in-50 hourly wind pressure is equal to or greater than 1.2 kPa, a~~Anchorage shall be designed according to Part 4, where~~.~~
- [a] --) the 1-in-50-year hourly wind pressure (HWP) is greater than 1.2 kPa,
- [b] --) the seismic design parameter, S_{max}, is greater than 2.6, or

[c] --) the seismic design parameter, S_{max}, for Site Class C is greater than 0.47, for *buildings* of 3 *storeys* in *building height* and
[i] --) of heavyweight construction,
[ii] --) clad at full height with masonry veneer, or
[iii] --) clad at full height with stone veneer
(see Sentence 9.23.13.2.(3)).

Note A-9.23.6.1.(3) Anchorage of Braced Wall Panels.

Figure [A-9.23.6.1.(3)]
Anchorage of braced wall panels



[9.23.11.4.] 9.23.11.4. Joints in Top Plates

[1] 1) Joints in the top plates of *loadbearing* walls shall be staggered not less than ~~one stud spacing.~~
[a] --) one stud spacing where the minimum number of nails required by Sentence (5) is not more than 16,
[b] --) two stud spacings where the minimum number of nails required by Sentence (5) is greater than 16 but not more than 32, and
[c] --) three stud spacings where the minimum number of nails required by Sentence (5) is greater than 32.

[2] 2) The top plates in *loadbearing* walls shall be lapped or otherwise tied at corners and intersecting walls in accordance with Sentence (4).

[3] 3) Joints in single top plates used with *loadbearing* walls shall be tied in accordance with Sentence (4).

[4] 4) Ties referred to in Sentences (2) and (3) shall be the equivalent of not less than 75 mm by 150 mm by 0.91 mm thick galvanized steel nailed to each wall with at least three 63 mm nails.

[5] 5) ~~Where the seismic spectral acceleration, $S_a(0.2)$, is greater than 0.70 but not more than 1.8~~Except as provided in Sentence (7), doubled top plates in *braced wall bands* shall be fastened on each side of a splice with not less than 76 mm long common steel wire nails or spiral nails in accordance with the minimum number of nails required by Table 9.23.11.4. or 9.23.11.4.-C, whichever is greater, where
[a] --) the seismic design parameter, S_{max}, for Site Class C is greater than 0.47 and S_{max} is not greater than 2.6, or
[b] --) the 1-in-50-year hourly wind pressure (HWP) is equal to or greater than 0.6 kPa but not greater than 1.2 kPa.

Table [9.23.11.4.-A] 9.23.11.4.
Fasteners in Doubled Top Plate Splice Connections in Braced Wall Bands W~~w~~here ~~0.70 < $S_a(0.2)$ ≤ 1.8~~S_{max} for Site Class C > 0.47 and S_{max} ≤ 2.6
Forming Part of Sentence [9.23.11.4.] 9.23.11.4.([5] 5)

S_{max} (1)	Minimum Number of Nails on Each Side of Doubled Top Plate Splice for *Braced Wall Band* Spacing of 10.6 m (2)			
	Weight of Construction or Cladding Type (3)			
	Normal-Weight Construction	Heavyweight Construction (4)	Masonry Veneer (on one or more *building* faces) (4) (5)	Stone Veneer (on one or more *building* faces) (4) (5)
S_{max} ≤ 0.60	4	7	8	10
0.6 < S_{max} ≤ 0.8	6	8	9	12
0.8 < S_{max} ≤ 1.2	9	12	14	19
1.2 < S_{max} ≤ 1.6	12	16	19	25
1.6 < S_{max} ≤ 2.0	14	20	23	31
2.0 < S_{max} ≤ 2.6	19	25	30	40

Notes to Table [9.23.11.4.-A] 9.23.11.4.:

(1) See Article 9.4.2.5.

(2) For a *braced wall band* spacing of 7.6 m or less, the minimum number of nails may be divided by 2.

(3) See Sentence 9.23.13.2.(3).

(4) Limited to 2 *storeys* in *building height*. See Sentence (7).

(5) Where the height of the masonry or stone veneer does not exceed a half *storey* above the *foundation*, the veneer may be disregarded.

~~$S_a(0.2)$~~	~~Minimum Number of Nails on Each Side of Doubled Top Plate Splice~~				
	~~Light Construction~~			~~Heavy Construction (1)~~	
	~~Number of Supported Floors (2)~~				
	~~0~~	~~1~~	~~2~~	~~0~~	~~1~~
~~0.70 < $S_a(0.2)$ ≤ 0.80~~	~~2~~	~~5~~	~~8~~	~~3~~	~~8~~
~~0.80 < $S_a(0.2)$ ≤ 0.90~~	~~2~~	~~5~~	~~8~~	~~4~~	~~8~~
~~0.90 < $S_a(0.2)$ ≤ 1.0~~	~~3~~	~~6~~	~~10~~	~~4~~	~~10~~
~~1.0 < $S_a(0.2)$ ≤ 1.1~~	~~3~~	~~7~~	~~11~~	~~5~~	~~11~~
~~1.1 < $S_a(0.2)$ ≤ 1.2~~	~~3~~	~~7~~	~~11~~	~~5~~	~~12~~
~~1.2 < $S_a(0.2)$ ≤ 1.3~~	~~3~~	~~8~~	~~12~~	~~5~~	~~12~~
~~1.3 < $S_a(0.2)$ ≤ 1.35~~	~~4~~	~~8~~	~~12~~	~~5~~	~~13~~
~~1.35 < $S_a(0.2)$ ≤ 1.8~~	~~4~~	~~8~~	~~13~~	~~5~~	~~13~~

~~Notes to :~~

~~(1) See Note A-9.23.13.2.(1)(a)(i).~~

~~(2) All constructions include support of a roof load in addition to the number of floors indicated.~~

Table [9.23.11.4.-C]
Fasteners in Doubled Top Plate Splice Connections in Braced Wall Bands Where 0.6 kPa < HWP ≤ 1.2 kPa
Forming Part of Sentence [9.23.11.4.] 9.23.11.4.([5] 5)

HWP	Minimum Number of Nails on Each Side of Doubled Top Plate Splice for *Braced Wall Band* Spacing of 10.6 m, (1) Rough Terrain (2), and Roof Eave-to-Ridge Height of 3 m (3)
HWP ≤ 0.3	7
0.3 < HWP ≤ 0.4	9
0.4 < HWP ≤ 0.5	11
0.5 < HWP ≤ 0.6	13
0.6 < HWP≤ 0.9	20
0.9 < HWP ≤ 1.2	26

Notes to Table [9.23.11.4.-C] :

(1) For a *braced wall band* spacing of 7.6 m or less, the minimum number of nails may be divided by 2.

(2) For open terrain, multiply the minimum number of nails by the wind exposure adjustment factor, K_{exp}, as provided in Table 9.23.13.7.-B. See Note A-9.23.13.7.(3) and (4).

(3) For roof-level top plates (i.e., top plates supporting roof framing), multiply the minimum number of nails by the roof eave-to-ridge height adjustment factor, K_{roof}, as provided in Table 9.23.13.7-B.

[6] --) Nails referred to in Sentence (5) shall be spaced not less than 75 mm o.c. along the top plate in rows spaced not less than 35 mm apart.

[7] --) Doubled top plates in *braced wall bands* shall be designed according to Part 4 where
- [a] --) the 1-in-50-year hourly wind pressure (HWP) is greater than 1.2 kPa,
- [b] --) the seismic design parameter, S_{max}, is greater than 2.6, or
- [c] --) the seismic design parameter, S_{max}, for Site Class C is greater than 0.47, for *buildings* of 3 *storeys* in *building height* and
  - [i] --) of heavyweight construction,
  - [ii] --) clad with masonry veneer, or
  - [iii] --) clad with stone veneer

  (see Sentence 9.23.13.2.(3)).

[9.23.13.] 9.23.13. Bracing to Resist Lateral Loads Due to Wind and Earthquake

(See Note A-9.23.13.)

[9.23.13.1.] 9.23.13.1. Requirements for Low to Moderate Wind and Seismic Forces

~~(See Note A-9.23.13.1.)~~

[1] 1) This Article applies ~~in locations~~ where ~~the seismic spectral acceleration, $S_a(0.2)$, is not more than 0.70 and the 1-in-50 hourly wind pressure is less than 0.80 kPa.~~
- [a] --) the seismic design parameter, S_{max}, for Site Class C is not greater than 0.47,
- [b] --) the 1-in-50-year hourly wind pressure (HWP) is not greater than 0.6 kPa,
- [c] --) the unsupported height of the *braced wall panels* in the *building* is not greater than 3.1 m, and
- [d] --) the lowest exterior frame wall supports a roof and not more than 2 floors.

[2] 2) Bracing to resist lateral loads shall be designed and constructed ~~as follows~~in accordance with~~:~~
- [a] a) ~~exterior walls shall be~~the simplified approach outlined in Article 9.23.13.11., where the seismic design parameter, S_{max}, is not greater than 0.47 and the 1-in-50-year hourly wind pressure (HWP) is not greater than 0.6 kPa,
  - ~~[i] i) clad with panel-type cladding in accordance with Section 9.27.,~~
  - ~~[ii] ii) sheathed with plywood, OSB, waferboard, fibreboard, gypsum board or diagonal lumber sheathing complying with Subsection 9.23.17. and fastened in accordance with Table 9.23.3.5.-A, or~~
  - ~~[iii] iii) finished on the interior with a panel-type material in accordance with the requirements of Section 9.29., or~~
- [b] b) ~~in accordance with~~Articles 9.23.13.4. to 9.23.13.10.,

~~[i] i) Articles 9.23.13.4. to 9.23.13.7.,~~
~~[ii] ii) Part 4, or~~
~~[iii] iii) good engineering practice such as that provided in CWC 2014, "Engineering Guide for Wood Frame Construction".~~
[c] --) Part 4, or
[d] --) good engineering practice such as that provided in the CWC "Engineering Guide for Wood Frame Construction."

[9.23.13.2.] 9.23.13.2. Requirements for High Wind and Seismic Forces

[1] 1) Except as provided in Article 9.23.13.1., this Article applies ~~in locations~~ where
[a] --) the unsupported height of the *braced wall panels* in the *building* is not greater than 3.1 m,
[b] b) the 1-in-50-year hourly wind pressure (HWP) is ~~less~~not greater than 1.2~~0~~ kPa,~~.~~
[c] --) the seismic design parameter, S_{max}, is not greater than 2.6, and
[d] a) ~~the seismic spectral acceleration, $S_a(0.2)$, is greater than 0.70 but not more than 1.8 and~~ the lowest exterior frame wall supports a roof and not more than
[i] i) ~~the lowest exterior frame wall supports not more than~~ 2~~1~~ floors in a *building~~s~~* of normal-weight~~of heavy~~ construction ~~(see Note A-9.23.13.2.(1)(a)(i))~~, or
[ii] ii) ~~the lowest exterior frame wall supports not more than 2~~1 floors in ~~other types of~~a *building* of heavyweight construction or clad at full height with masonry veneer or stone veneer.~~, and~~

[2] 2) Bracing to resist lateral loads shall be designed and constructed in accordance with
[a] a) Articles 9.23.13.4. to 9.23.13.~~7~~10.,
[b] b) Part 4, or
[c] c) good engineering practice such as that provided in the CWC ~~2014,~~ "Engineering Guide for Wood Frame Construction."

[3] --) For the purposes of Sentence (1) and this Part,
[a] --) in a *building* of normal-weight construction, the average dead weight per *storey* shall not exceed
[i] --) 0.5 kPa for floors and 0.5 kPa for *partitions* and interior walls,
[ii] --) 0.5 kPa for the roof, and
[iii] --) 0.4 kPa for exterior walls,
[b] --) in a *building* of heavyweight construction, the average dead weight per *storey* shall conform to Clause (a), except that the average dead weight per *storey* shall not exceed
[i] --) 1.5 kPa for floors and 0.5 kPa for *partitions* and interior walls,
[ii] --) 1.0 kPa for the roof, or
[iii] --) 1.2 kPa for exterior walls,
[c] --) in a *building* clad with masonry veneer, the average dead weight of the masonry veneer shall not exceed 1.9 kPa, and
[d] --) in a *building* clad with stone veneer, the average dead weight of the stone veneer shall not exceed 3.2 kPa.
(See Note A-9.23.13.2.(3).)

[9.23.13.3.] 9.23.13.3. Requirements for Extreme Wind and Seismic Forces

[1] 1) Except as provided in Articles 9.23.13.1. and 9.23.13.2., this Article applies ~~in locations~~ where
~~[a] a) the seismic spectral acceleration, $S_a(0.2)$, is~~
~~[i] i) greater than 1.8,~~
~~[ii] ii) greater than 0.70 and the lowest exterior frame wall supports more than 2 floors in *buildings* of light construction, or~~
~~[iii] iii) greater than 0.70 and the lowest exterior frame wall supports more than 1 floor in *buildings* of heavy construction, or~~
[b] a) the 1-in-50-year hourly wind pressure (HWP) is ~~equal to or~~ greater than 1.2~~0~~ kPa~~.~~,
[c] b) the seismic design parameter, S_{max}, is greater than 2.6, or
[d] --) the seismic design parameter, S_{max}, for Site Class C is greater than 0.47, and the lowest exterior frame wall supports a roof and more than 1 floor in a *building* of heavyweight construction or clad at full height with masonry veneer or stone veneer.

[2] 2) Bracing to resist lateral loads shall be designed and constructed in accordance with
[a] a) Part 4, or
[b] b) good engineering practice such as that provided in the CWC ~~2014,~~ "Engineering Guide for Wood Frame Construction."

[9.23.13.4.] 9.23.13.4. Braced Wall Bands
(See Note A-9.23.13.4.)

[1] 1) *Braced wall bands* shall

[a] --) surround the perimeter of the *building,*

[b] a) be full *storey* height,

[c] b) be not more than 1.2 m wide,

[d] c) lap at both ends with another *braced wall band*,

[e] d) be aligned with *braced wall bands* on *storeys* above and below, and

[f] e) conform to the spacing and dimensions given in Table 9.23.13.5. and Article 9.23.13.7.-2025

~~[2] 2) The perimeter of the *building* shall be located within *braced wall bands*.~~

[3] 3) For split-level *buildings*, a *braced wall band* shall be located where there is a change in floor level greater than the depth of one floor joist.

[9.23.13.5.] 9.23.13.5. Braced Wall Panels in Braced Wall Bands

[1] 1) Except as provided in Sentences (2) ~~to (5)~~ and 9.23.13.10.(2) to (4) and Article 9.23.13.7.-2025, *braced wall panels* shall

[a] a) be located within *braced wall bands*,

[b] --) be laterally supported at each floor level and the roof,

[c] b) extend, as applicable, from the top of the supporting footing, slab or subfloor to the underside of the floor, ceiling or roof framing above, and

[d] c) conform to the spacing and dimensions given in Table 9.23.13.5. and Article 9.23.13.7.-2025

Table [9.23.13.5.] 9.23.13.5.
Spacing and Dimensions of Braced Wall Bands and Braced Wall Panels
Forming Part of Sentences [9.23.13.4.] 9.23.13.4.([1] 1) and [9.23.13.5.] 9.23.13.5.([1] 1)

Description	Spacing and Dimensions of *Braced Wall Bands* and *Braced Wall Panels* (1) (2) (3)	
	~~Seismic and Wind Loads~~	
	~~0.70 < $S_a(0.2)$ < 1.0~~	~~1.0 ≤ $S_a(0.2)$ ≤ 1.8 or 0.80 ≤ HWP ≤ 1.2 kPa~~
Maximum distance between centre lines of adjacent *braced wall bands* measured from the furthest points between centres of the bands (4)	10.6 m	~~7.6 m~~
Maximum distance between required *braced wall panels* measured from the edges of the panels	6.4 m	~~6.4 m~~
Maximum distance from the end of a *braced wall band* to the edge of the closest required *braced wall panel*	2.4 m	~~2.4 m~~
Minimum length of individual wood-sheathed *braced wall panels*:		
• panel located at the end of a *braced wall band* where the *braced wall panel* connects to an intersecting *braced wall panel*	600 mm	~~600 mm~~
• panel not located at the end of a *braced wall band* or *braced wall panel* located at the end of a *braced wall band* where the *braced wall panel* does not connect to an intersecting *braced wall panel*	750 mm	~~750 mm~~
Minimum length of individual *braced wall panels* sheathed only with gypsum board	1.2 m	
Minimum length of individual diagonal-lumber-sheathed *braced wall panels*	1.2 m	
Minimum total length of all *braced wall panels* in a *braced wall band*	Per Article 9.23.13.7.-2025	
~~• supporting 3 floors, light construction~~	~~75% of length of *braced wall band*~~	
~~• supporting 2 floors, heavy construction (5)~~	~~75% of length of *braced wall band*~~	
~~• supporting 2 floors, light construction~~	~~40% of length of *braced wall band*~~	

Description	Spacing and Dimensions of *Braced Wall Bands* and *Braced Wall Panels* (1) (2) (3)	
	~~Seismic and Wind Loads~~	
	~~0.70 < $S_a(0.2)$ < 1.0~~	~~1.0 ≤ $S_a(0.2)$ ≤ 1.8 or 0.80 ≤ HWP ≤ 1.2 kPa~~
~~• supporting 1 floor, heavy construction (5)~~	~~40% of length of *braced wall band*~~	
~~• supporting 1 floor, light construction~~	~~25% of length of *braced wall band*~~	
~~• not supporting a floor~~	~~25% of length of *braced wall band*~~	

Notes to Table [9.23.13.5.] 9.23.13.5.:

(1) See Note A-Table 9.23.13.5.

(2) All constructions include support of a roof load in addition to the indicated number of floors.

(3) See Article 9.23.13.~~7~~10. for ~~alternative~~additional system considerations~~methods of compliance~~.

(4) See Sentence (2) for an exception for *basements* and crawl spaces.

~~(5) See Sentence 9.23.13.3.(1) for overall limit on application to heavy construction.~~

[2] 2) In *basements* or crawl spaces where the perimeter *foundation* walls extend from the footings to the underside of the supported floor, *braced wall bands* constructed with *braced wall panels* shall ~~be spaced not more than~~

[a] --) have a total length of *braced wall panels* not less than the total length of *braced wall panels* in the *braced wall band* in the *storey* above, and

[b] b) be spaced not more than

[i] --) 15 m from the perimeter *foundation* walls,

[ii] --) 15 m from interior *foundation* walls, and

[iii] --) 15 m from adjacent *braced wall bands* constructed with *braced wall panels*.

~~[c] a) 15 m from the perimeter *foundation* walls,~~

~~[d] b) 15 m from interior *foundation* walls, and~~

~~[e] c) 15 m from adjacent *braced wall bands* constructed with *braced wall panels*.~~

(See Note A-9.23.13.5.(2).)

[3] --) Interior or exterior wood-sheathed *braced wall panels*, other than panels of WSP-A framing type, in the uppermost *storey* shall

[a] --) extend to the roof framing, and

[b] --) have their top plate connected to

[i] --) top chords of perpendicular or offset parallel trusses by using blocking panels or other methods of lateral load transfer designed by the roof truss manufacturer,

[ii] --) perpendicular or offset parallel joists or rafters by using blocking of the same construction as the *braced wall panel* below, or

[iii] --) rafters, joists or trusses by using methods of lateral load transfer designed in accordance with good engineering practice.

(See Note A-9.23.13.5.(3) and (4).)

[4] --) The top plates of *braced wall panels* described in Sentence (3) shall be fastened in accordance with Table 9.23.3.4.

(See Note A-9.23.13.5.(3) and (4).)

~~[5] 3) Portions of the perimeter of a single open or enclosed space need not comply with Sentence (1), where~~

~~[a] a) the roof of the space projects not more than~~

~~[i] i) 3.5 m from the face of the framing of the nearest parallel *braced wall band*, and~~

~~[ii] ii) the perpendicular plan dimension,~~

~~[b] b) that portion of the perimeter structure does not support a floor,~~

~~[c] c) the roof of the space is~~

~~[i] i) integral with the roof of the rest of the *building* with framing members not more than 400 mm o.c. where roof sheathing edges are not supported on blocking and not more than 600 mm o.c. where roof sheathing edges are supported on blocking securely fastened between framing members, or~~

~~[ii] ii) constructed with roof framing not more than 400 mm o.c. where roof sheathing edges are not supported on blocking and not more than 600 mm o.c. where roof sheathing edges are supported on blocking securely fastened between framing members, and fastened to the wall framing (see Table 9.23.3.4. and Article 9.23.9.1. for balloon framing), and~~

~~[d] d) the end-joists or end-rafters for the roof of the space are fastened to a 3-ply, 38 mm × 140 mm built-up column or a 5-ply, 38 mm × 89 mm built-up column that is integral with the wall framing.~~

~~(See Note A-9.23.13.5.(3).)~~

~~[6] 4) Walls in detached garages and in accessory *buildings* serving a single *dwelling unit*, and the front wall of attached garages serving a single *dwelling unit* need not comply with Sentence (1) where these walls do not support a floor.~~

~~[7] 5) *Braced wall panels* in the *braced wall band* at the front of an attached garage serving a single *dwelling unit* need not comply with Sentence (1), provided~~

~~[a] a) the maximum spacing between the front of the garage and the back wall of the garage does not exceed 7.6 m,~~

~~[b] b) there is not more than one floor above the garage,~~

~~[c] c) not less than 50% of the length of the back wall of the garage is constructed of *braced wall panels*, and~~

~~[d] d) not less than 25% of the length of the side walls is constructed of *braced wall panels*.~~

[9.23.13.6.] 9.23.13.6. Materials in Braced Wall Panels

[1] 1) Required *braced wall panels* shall be

~~[a] a) clad with panel-type cladding complying with Section 9.27. and Table 9.23.3.4.,~~

[b] b) sheathed on the exterior side with plywood, OSB, waferboard or diagonal lumber ~~sheathing~~ complying with Subsection 9.23.1~~6~~7. and ~~Table 9.23.13.6., and~~ fastened in accordance with ~~Article9.23.3.5.~~Sentence 9.23.3.5.(3)~~Article 9.23.3.5., or~~, and finished on the interior side with gypsum board complying with Subsection 9.29.5., or

~~[c] c) finished on the interior with a panel-type material in accordance with the requirements of Section 9.29. and Table 9.23.13.6.~~

[d] c) sheathed on the interior side or exterior side with gypsum board complying with Subsection 9.29.5. and fastened in accordance with Sentence 9.23.3.5.(3).

(See Note A-9.23.13.6.(1).)

[2] --) Except as provided in Sentences (4) and (5), *braced wall bands* shall be constructed of *braced wall panels* of the same sheathing material.

[3] 6) ~~At *braced wall band* spacing intervals of not more than 15 m,~~ ~~*b*~~*Braced wall panels* in *basements* and crawl spaces shall be sheathed~~constructed~~ with OSB, plywood, waferboard or diagonal lumber~~. (See Note A-9.23.13.6.(5) and (6).)~~

[a] --) at *braced wall band* spacing intervals of not more than 15 m, and

[b] --) under all interior *braced wall bands* containing wood-sheathed *braced wall panels*.

(See Note A-9.23.13.6.(3).)

[4] --) Mixing of *braced wall panel* framing types is permitted in stacked *braced wall bands*, provided that wood-sheathed *braced wall panels* are not located above *braced wall bands* containing

[a] --) gypsum-sheathed *braced wall panels*, or

[b] --) diagonal-lumber-sheathed *braced wall panels*.

[5] --) Mixing of *braced wall panel* framing types is permitted along a *braced wall band* within the same *storey*, provided that

[a] --) panels of WSP-A or WSP-B framing type are substituted for panels of a GWB framing type, and the total length of all the *braced wall panels* is determined based on the GWB framing type, or

[b] --) the lengths of the *braced wall panels* of mixed framing types are based on accepted engineering principles.

(See Note A-9.23.13.6.(5).)

~~Table [9.23.13.6.] 9.23.13.6.~~
~~Minimum Thicknesses of Cladding, Sheathing or Interior Finish for Braced Wall Panels~~
~~Forming Part of Sentence [9.23.13.6.] 9.23.13.6.([1] 1)~~

~~Panel-Type Cladding, Sheathing or Interior Finish~~	~~Minimum Thickness~~			
	~~Where $S_a(0.2) \leq 0.90$~~		~~Where $S_a(0.2) > 0.90$~~	
	~~With supports 400 mm o.c.~~	~~With supports 600 mm o.c.~~	~~With supports 400 mm o.c.~~	~~With supports 600 mm o.c.~~
~~Gypsum board interior finish (1)~~	~~12.7 mm~~	~~15.9 mm~~	~~12.7 mm~~	~~15.9 mm~~
~~Sheathing complying with CSA O325~~	~~W16~~	~~W24~~	~~W16~~	~~W24~~
~~OSB O-1 and O-2 grades~~	~~11 mm~~	~~12.5 mm~~	~~11 mm~~	~~12.5 mm~~
~~Waferboard R-1 grade~~	~~9.5 mm~~	~~12.5 mm~~	~~n/a~~	~~n/a~~
~~Plywood~~	~~11 mm~~	~~12.5 mm~~	~~11 mm~~	~~12.5 mm~~
~~Diagonal lumber~~	~~17 mm~~	~~17 mm~~	~~n/a~~	~~n/a~~

~~Note to Table [9.23.13.6.] 9.23.13.6.:~~

~~(1) See Sentences (5) and (6).~~

~~[6] 2) Except as provided in Sentence (3), required interior *braced wall panels* shall be~~
~~[a] a) sheathed or finished on both sides with a wood-based material, or~~
~~[b] b) finished on both sides with gypsum board.~~

~~[7] 3) Required interior *braced wall panels* of wood-based material may be sheathed on one side only, provided~~
~~[a] a) the sheathing material is plywood, OSB or waferboard, and~~
~~[b] b) the maximum spacing of fasteners along the edge is half of the maximum spacing shown in Table 9.23.3.5.-B.~~

~~[8] 4) For stacked *braced wall bands*, where the construction of any one *braced wall panel* is required to be of a wood-based material, a wood-based material shall be installed in all the required *braced wall panels* in that *braced wall band*.~~

~~[9] 5) Gypsum board interior finish shall not be considered as an acceptable sheathing material to provide the required bracing in exterior walls. (See Note A-9.23.13.6.(5) and (6).)~~

[9.23.13.7.] --- Braced Wall Panel Length

[1] --) Except as provided in Tables 9.23.13.7.-B and 9.23.13.7.-D, all adjustment factors required for the calculation of the minimum total length of *braced wall panels* in accordance with this Article shall be taken as 1.

[2] --) The minimum total length of *braced wall panels* in a *braced wall band* shall be taken as the greater of L_w, as determined in Sentence (3) for the appropriate 1-in-50-year hourly wind pressure (HWP), and L_s, as determined in Sentence (4) for the appropriate seismic design parameter, S_{max}, where
[a] --) HWP is not greater than 1.2 kPa, and
[b] --) S_{max} for Site Class C is not greater than 2.6.

[3] --) For resistance to wind pressure, the minimum total length of *braced wall panels* in each *braced wall band*, L_w, shall be determined by applying the adjustment factors provided in Table 9.23.13.7.-B to the unadjusted minimum total *braced wall panel* length, L_{uw}, provided in Table 9.23.13.7.-A, using the following equation:

$$L_w = L_{uw} K_{exp} K_{roof} K_{Wspacing} K_{Wnumber} K_{gyp} K_{sheath} \geq BWP_{min}$$

where

K_{exp} = wind exposure adjustment factor, and
= 1 for rough terrain (suburban, urban or wooded terrain extending upwind from the *building* uninterrupted for at least 1 km),

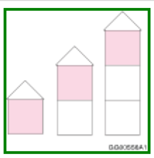
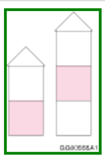
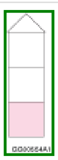
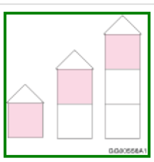
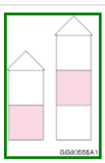
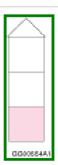
K_{roof} = roof eave-to-ridge height adjustment factor, and
= 1 for a roof eave-to-ridge height of 3 m,

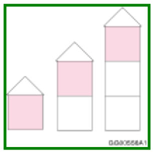
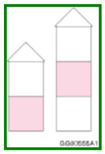
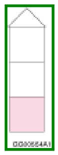
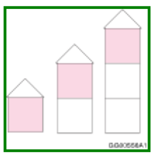
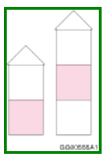
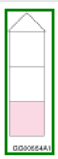
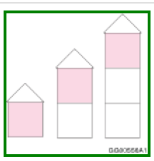
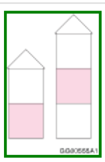
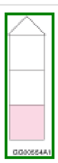
$K_{Wspacing}$ = *braced wall band* spacing adjustment factor for wind (see Sentence (5)-2025), per *building* plan direction, and
= 1 for a *braced wall band* spacing of 7.6 m,

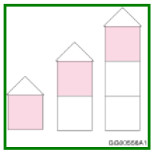
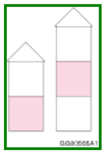
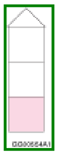
$K_{Wnumber}$	= number of parallel *braced wall bands* adjustment factor for wind, per *building* plan direction, and
	= 1 for two exterior walls and no intermediate parallel *braced wall bands*,
K_{gyp}	= interior gypsum board adjustment factor, and
	= 1 for *braced wall panels* with gypsum board installed on the interior side,
K_{sheath}	= intermittent *braced wall panels* adjustment factor, and
	= 1 for continuously sheathed *braced wall bands*, and
BWP_{min}	= minimum length of individual *braced wall panels*, as per Table 9.23.13.5.

(See Note A-9.23.13.7.(3) for an alternative procedure to calculate L_w directly and Note A-9.23.13.7.(3) and (4).)

Table [9.23.13.7.-A]
Unadjusted Minimum Total Braced Wall Panel Lengths for Wind
Forming Part of Sentence [9.23.13.7.] -- ([3] --)

HWP	*Storey*	Unadjusted Minimum Total *Braced Wall Panel* Length for Wind, L_{uw}, m [(1)]									
		Diagonal-Lumber-Sheathed Framing Type (with gypsum board on opposite side) [(2)]	Gypsum-Sheathed Framing Type (with gypsum board on only one side) [(2)] [(3)]				Wood-Sheathed Framing Type (with gypsum board on opposite side) [(2)]				
		DWB	GWB-A	GWB-B	GWB-C	GWB-D	WSP-A	WSP-B	WSP-C	WSP-D	WSP-E
HWP ≤ 0.3		0.65	3.29	1.91	1.42	1.14	1.14	0.60	0.52	0.48	0.43
		1.33	6.75	3.92	2.91	2.35	2.35	1.24	1.08	0.98	0.88
		2.02	10.21	5.93	4.40	3.57	3.57	1.87	1.63	1.49	1.34
0.3 < HWP ≤ 0.4		0.86	4.38	2.54	1.89	1.52	1.52	0.80	0.70	0.64	0.57
		1.78	9.00	5.23	3.88	3.14	3.14	1.65	1.43	1.31	1.18
		2.69	13.61	7.91	5.86	4.75	4.75	2.50	2.17	1.98	1.79

0.4 < HWP ≤ 0.5		1.08	5.84	3.18	2.36	1.90	1.90	1.00	0.87	0.79	0.72
		2.22	11.25	6.54	4.85	3.92	3.92	2.06	1.79	1.63	1.47
		3.37	17.01	9.88	7.33	5.94	5.94	3.12	2.72	2.48	2.23
0.5 < HWP ≤ 0.6		1.29	6.57	3.82	2.83	2.29	2.29	1.20	1.05	0.95	0.86
		2.67	13.50	7.84	5.82	4.71	4.71	2.47	2.15	1.96	1.77
		4.04	20.42	11.86	8.79	7.13	7.13	3.75	3.26	2.97	2.68
0.6 < HWP ≤ 0.9		1.94	9.86	5.73	4.25	3.43	3.43	1.80	1.57	1.43	1.29
		4.00	20.25	11.76	8.72	7.06	7.06	3.71	3.23	2.94	2.65
		6.06	30.62	17.79	13.19	10.70	10.70	5.62	4.89	4.46	4.02

0.9 < HWP ≤ 1.2		2.59	13.14	7.63	5.66	4.57	4.57	2.40	2.09	1.91	1.72
		5.33	27.00	15.68	11.63	9.41	9.41	4.95	4.30	3.92	3.54
		8.08	40.83	23.72	17.59	14.26	14.26	7.50	6.52	5.94	5.36

Notes to Table [9.23.13.7.-A] :

(1) Unadjusted minimum total *braced wall panel* lengths are for the applicable conditions corresponding to an adjustment factor of 1 in the equation for L_w.

(2) See Sentence 9.23.3.5.(3) for a description of framing types and fastening requirements.

(3) See Sentence (6)-2025 for *braced wall panels* with gypsum board installed on both sides.

Table [9.23.13.7.-B]
Adjustment Factors for the Determination of Minimum Total Braced Wall Panel Lengths for Wind
Forming Part of Sentence [9.23.13.7.] -- ([3] --)

Symbol	Description	*Storey*	Condition	Adjustment Factor
K_{exp} (1)	Wind exposure: apply factor to all *storeys* in both directions	All *storeys*	Rough terrain	1.00
		All *storeys* in 1-*storey building*	Open terrain	1.29
		All *storeys* in 2-*storey building*		1.40
		All *storeys* in 3-*storey building*		1.48
K_{roof} (2)	Roof eave-to-ridge height: apply factor separately to each *storey*	*Storey* supporting roof only	≤ 1.5 m	0.52
			3.0 m	1.00
			4.5 m	1.58
			6.0 m	1.99
		Storey supporting roof and 1 floor	≤ 1.5 m	0.79
			3.0 m	1.00
			4.5 m	1.26
			6.0 m	1.47

		Storey supporting roof and 2 floors	≤ 1.5 m	0.87
			3.0 m	1.00
			4.5 m	1.16
			6.0 m	1.31
$K_{Wspacing}$(2)(3)(4)	*Braced wall band* spacing: apply factor to all *braced wall panels* per *building* plan direction	Any *storey*	3.8 m	0.51
			7.6 m	1.00
			10.6 m	1.35
			15 m (5)	1.86
$K_{Wnumber}$	Number of parallel *braced wall bands*: apply factor to all *braced wall panels* per *building* plan direction	Any *storey*	2	1.00
			3	1.28
			4	1.38
			≥ 5	1.43
K_{gyp}	Interior gypsum board: apply factor in accordance with whether gypsum board is installed or omitted on interior side of *braced wall panels*	Any *storey*	Installed	1.00
			Omitted, blocked wall	1.20
			Omitted, unblocked wall	1.40
K_{sheath}	Intermittent *braced wall panels*: apply factor in accordance with continuity of sheathing within *braced wall band*	Any *storey*	Continuously sheathed	1.00
			Intermittently sheathed	1.15

Notes to Table [9.23.13.7.-B] :

(1) K_{exp} is determined based on the terrain. Rough terrain is suburban, urban or wooded terrain extending upwind from the *building* uninterrupted for at least 1 km. Open terrain is level terrain with only scattered trees, *buildings* or other obstructions, open water or shorelines.

(2) For K_{roof}, linear interpolation between roof eave-to-ridge heights is permitted.

(3) For for $K_{Wspacing}$, linear interpolation between *braced wall band* spacings is permitted.

(4) An average *braced wall band* spacing is permitted to be used for the determination of $K_{Wspacing}$. See Sentence (5)-2025.

(5) A *braced wall band* spacing of 15 m is only permitted in basements and crawl spaces.

[4] --) For resistance to seismic forces, the minimum total length of *braced wall panels* in each *braced wall band*, L_s, shall be determined by applying the adjustment factors provided in Table 9.23.13.7.-D to the unadjusted minimum total *braced wall panel* length, L_{us}, provided in Table 9.23.13.7.-C, using the following equation:

$$L_s = L_{us} K_{weight} K_{snow} K_{Sspacing} K_{Snumber} K_{gyp} K_{sheath} \geq BWP_{min}$$

where

K_{weight} = weight of construction and cladding adjustment factor, and
= 1 for normal-weight construction (see Sentence 9.23.13.2.(3)),
K_{snow} = roof snow load adjustment factor, and
= 1 for a specified roof snow load of 2 kPa or less, as calculated in accordance with Article 9.4.2.2.,
$K_{Sspacing}$

= *braced wall band* spacing adjustment factor for seismic forces (see Sentence (5)-2025), per *building* plan direction, and
= 1 for a *braced wall band* spacing of 7.6 m,

$K_{Snumber}$ = number of parallel *braced wall bands* adjustment factor for seismic forces, per *building* plan direction, and
= 1 for two exterior walls and no intermediate parallel *braced wall bands*,

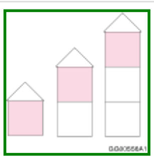
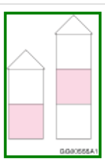
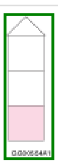
K_{gyp} = interior gypsum board adjustment factor, and
= 1 for *braced wall panels* with gypsum board installed on the interior side,

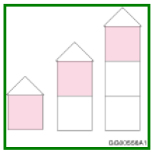
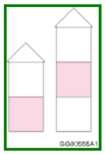
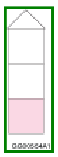
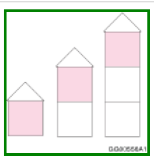
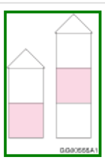
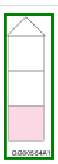
K_{sheath} = intermittent *braced wall panels* adjustment factor, and
= 1 for continuously sheathed *braced wall bands*, and

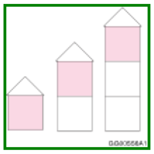
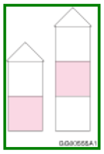
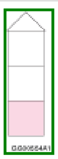
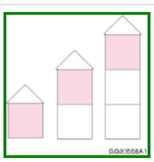
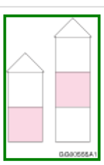
BWP_{min} = minimum length of individual *braced wall panels*, as per Table 9.23.13.5.

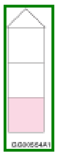
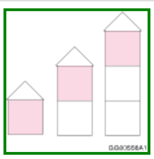
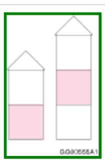
(See Note A-9.23.13.7.(4) for an alternative procedure to calculate L_s directly and Note A-9.23.13.7.(3) and (4).)

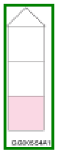
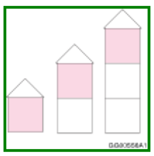
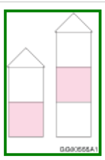
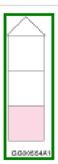
Table [9.23.13.7.-C]
Unadjusted Minimum Total Braced Wall Panel Lengths for Seismic Forces
Forming Part of Sentence [9.23.13.7.] -- ([4] --)

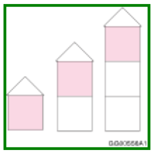
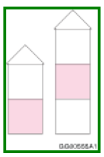
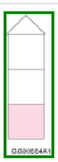
S_{max}	*Storey*	*Building* Plan Dimension Parallel to *Braced Wall Band*, L_{wl}, m	Unadjusted Minimum Total *Braced Wall Panel* Length for Seismic Forces, L_{us}, m (1) (2)									
			Diagonal-Lumber-Sheathed Framing Type (with gypsum board on opposite side) (3)	Gypsum-Sheathed Framing Type (with gypsum board on only one side) (3) (4)				Wood-Sheathed Framing Type (with gypsum board on opposite side) (3)				
			DWB	GWB-A	GWB-B	GWB-C	GWB-D	WSP-A	WSP-B	WSP-C	WSP-D	WSP-E
$S_{max} \le 0.2$		3.1	0.06	0.47	0.27	0.20	0.17	0.11	0.06	0.05	0.05	0.04
		6.1	0.11	0.81	0.47	0.35	0.28	0.19	0.10	0.09	0.08	0.07
		9.1	0.15	1.15	0.67	0.50	0.40	0.27	0.14	0.12	0.11	0.10
		12.2	0.20	1.5	0.87	0.65	0.53	0.35	0.18	0.16	0.15	0.13
		15.2	0.24	1.81	1.05	0.78	0.64	0.43	0.23	0.20	0.18	0.16
		18.3	0.29	2.20	1.28	0.95	0.77	0.51	0.27	0.23	0.21	0.19
		3.1	0.15	1.10	0.65	0.48	0.39	0.26	0.14	0.12	0.11	0.10
		6.1	0.24	1.84	1.07	0.79	0.65	0.43	0.23	0.20	0.18	0.16
		9.1	0.34	2.57	1.49	1.11	0.90	0.60	0.32	0.27	0.25	0.23
		12.2	0.44	3.32	1.93	1.43	1.17	0.78	0.41	0.36	0.32	0.29
		15.2	0.54	3.99	2.31	1.72	1.40	0.95	0.50	0.43	0.39	0.36
		18.3	0.64	4.80	2.79	2.07	1.68	1.12	0.59	0.51	0.47	0.42
		3.1	0.23	1.76	1.02	0.76	0.62	0.41	0.22	0.19	0.17	0.15
		6.1	0.38	2.87	1.67	1.24	1.01	0.67	0.35	0.31	0.28	0.25
		9.1	0.53	3.99	1.49	1.72	1.40	0.93	0.49	0.43	0.39	0.35
		12.2	0.68	5.14	2.99	2.21	1.80	1.20	0.63	0.55	0.50	0.45
		15.2	0.83	6.16	3.58	2.65	2.16	1.46	0.77	0.67	0.61	0.55
		18.3	0.98	7.41	4.30	3.19	2.60	1.73	0.91	0.79	0.72	0.65

0.2 < S_{max} ≤ 0.4		3.1	0.13	0.94	0.55	0.41	0.33	0.22	0.12	0.10	0.09	0.08
		6.1	0.22	1.63	0.94	0.70	0.57	0.38	0.20	0.17	0.16	0.14
		9.1	0.31	2.31	1.34	0.99	0.81	0.54	0.28	0.25	0.22	0.20
		12.2	0.40	3.01	1.75	1.30	1.05	0.70	0.37	0.32	0.29	0.26
		15.2	0.49	3.63	2.11	1.56	1.27	0.86	0.45	0.39	0.36	0.32
		18.3	0.58	4.39	2.55	1.89	1.54	1.03	0.54	0.47	0.43	0.39
		3.1	0.30	2.23	1.30	0.96	0.78	0.52	0.27	0.24	0.22	0.20
		6.1	0.49	3.69	2.14	1.59	1.29	0.86	0.45	0.39	0.36	0.32
		9.1	0.68	5.14	2.99	2.21	1.80	1.20	0.63	0.55	0.50	0.45
		12.2	0.88	6.65	3.86	2.86	2.33	1.55	0.82	0.71	0.65	0.58
		15.2	1.07	7.97	4.63	3.43	2.79	1.89	1.00	0.87	0.79	0.71
		18.3	1.27	9.61	5.58	4.14	3.37	2.25	1.18	1.03	0.94	0.84
		3.1	0.47	DR (1.12)	2.04	1.51	1.23	0.82	0.43	0.38	0.34	0.31
		6.1	0.76	5.50	3.34	2.48	2.01	1.34	0.71	0.61	0.56	0.50
		9.1	1.06	7.98	4.63	3.44	2.80	1.86	0.98	0.85	0.78	0.70
		12.2	1.36	10.29	5.97	4.43	3.61	2.40	1.26	1.10	1.00	0.90
		15.2	1.66	12.31	7.15	5.30	4.32	2.93	1.54	1.34	1.22	1.10
		18.3	1.96	14.82	8.61	6.38	5.20	3.46	1.82	1.58	1.44	1.30
0.4 < S_{max} ≤ 0.6		3.1	0.19	1.42	0.82	0.61	0.50	0.33	0.17	0.15	0.14	0.12
		6.1	0.32	2.44	1.42	1.05	0.85	0.57	0.30	0.26	0.24	0.21
		9.1	0.46	3.46	2.01	1.49	1.21	0.81	0.42	0.37	0.34	0.30
		12.2	0.60	4.51	2.62	1.94	1.58	1.05	0.55	0.48	0.44	0.40
		15.2	0.73	5.44	3.16	2.34	1.91	1.29	0.68	0.59	0.54	0.49
		18.3	0.87	6.59	3.83	2.84	2.31	1.54	0.81	0.70	0.64	0.58
		3.1	0.44	DR (1.67)	1.94	1.44	1.17	0.78	0.41	0.36	0.33	0.29
		6.1	0.73	5.53	3.21	2.38	1.94	1.29	0.68	0.59	0.54	0.49
		9.1	1.02	7.71	4.48	3.32	2.70	1.80	0.95	0.82	0.75	0.68
		12.2	1.32	9.97	5.79	4.29	3.50	2.33	1.23	1.07	0.97	0.88
		15.2	1.61	11.96	6.94	5.15	4.19	2.84	1.49	1.30	1.18	1.07
		18.3	1.91	14.41	8.37	6.21	5.05	3.37	1.77	1.54	1.40	1.27
		3.1	0.70	DR (2.64)	3.06	2.27	1.85	1.23	0.65	0.56	0.51	0.46
		6.1	1.14	DR (4.31)	5.01	3.71	3.02	2.01	1.06	0.92	0.84	0.76
		9.1	1.59	DR (5.99)	6.95	5.15	4.20	2.80	1.47	1.28	1.17	1.05
		12.2	2.04	DR (7.72)	8.96	6.64	5.41	3.61	1.90	1.65	1.50	1.35
		15.2	2.49	DR (9.24)	10.73	7.96	6.48	4.39	2.31	2.01	1.83	1.65

		18.3	2.95	DR (11.12)	12.91	9.58	7.80	5.20	2.73	2.38	2.17	1.95
0.6 < S_{max} ≤ 0.8		3.1	0.25	1.89	1.10	0.81	0.66	0.44	0.23	0.20	0.18	0.17
		6.1	0.43	3.25	1.89	1.40	1.14	0.76	0.40	0.35	0.32	0.29
		9.1	0.61	4.61	2.68	1.99	1.62	1.08	0.57	0.49	0.45	0.40
		12.2	0.80	6.02	3.49	2.59	2.11	1.41	0.74	0.64	0.59	0.53
		15.2	0.98	7.25	4.21	3.12	2.54	1.72	0.91	0.79	0.72	0.65
		18.3	1.16	8.78	5.10	3.78	3.08	2.05	1.08	0.94	0.86	0.77
		3.1	0.59	DR (2.23)	2.59	1.92	1.56	1.04	0.55	0.48	0.43	0.39
		6.1	0.98	DR (3.69)	4.28	3.18	2.58	1.72	0.91	0.79	0.72	0.65
		9.1	1.36	DR (5.14)	5.97	4.43	3.61	2.40	1.26	1.10	1.00	0.90
		12.2	1.76	DR (6.65)	7.72	5.73	4.66	3.11	1.63	1.42	1.29	1.17
		15.2	2.15	DR (7.97)	9.26	6.87	5.59	3.79	1.99	1.73	1.58	1.42
		18.3	2.55	DR (9.61)	11.16	8.28	6.74	4.49	2.36	2.05	1.87	1.69
		3.1	0.93	DR	DR (2.04)	3.03	2.46	1.64	0.86	0.75	0.68	0.62
		6.1	1.52	DR (5.75)	DR (3.34)	4.95	4.03	2.69	1.41	1.23	1.12	1.01
		9.1	2.11	DR (7.98)	DR (4.64)	6.87	5.59	3.73	1.96	1.71	1.55	1.40
		12.2	2.72	DR (10.29)	11.95	8.86	7.21	4.81	2.53	2.20	2.00	1.81
		15.2	3.32	DR (12.32)	14.30	10.61	8.63	5.85	3.08	2.68	2.44	2.20
		18.3	3.93	DR (14.83)	17.22	12.77	10.39	6.93	3.64	3.17	2.89	2.60
0.8 < S_{max} ≤ 1.2		3.1	0.38	2.83	1.65	1.22	0.99	0.66	0.35	0.30	0.28	0.25
		6.1	0.65	4.88	2.83	2.10	1.71	1.14	0.60	0.52	0.47	0.43
		9.1	0.92	6.92	4.02	2.98	2.42	1.62	0.85	0.74	0.67	0.61
		12.2	1.20	9.03	5.24	3.89	3.16	2.11	1.11	0.96	0.88	0.79
		15.2	1.47	10.88	6.32	4.69	3.81	2.59	1.36	1.18	1.08	0.97
		18.3	1.75	13.18	7.65	5.67	4.62	3.08	1.62	1.41	1.28	1.16
		3.1	0.89	DR	DR (1.95)	2.88	2.35	1.56	0.82	0.71	0.65	0.59
		6.1	1.46	DR (5.53)	DR (3.21)	4.76	3.88	2.58	1.36	1.18	1.08	0.97

		9.1	2.04	DR (7.72)	8.96	6.64	5.41	3.61	1.90	1.65	1.50	1.35
		12.2	2.64	DR (9.97)	11.58	8.59	6.99	4.66	2.45	2.13	1.94	1.75
		15.2	3.22	DR (11.96)	13.89	10.30	8.38	5.68	2.99	2.60	2.37	2.13
		18.3	3.82	DR (14.41)	16.74	12.41	10.11	6.74	3.54	3.08	2.81	2.53
		3.1	1.40	DR	DR (3.06)	DR (2.27)	DR (1.85)	2.46	1.30	1.13	1.03	0.93
		6.1	2.28	DR	DR (5.01)	DR (3.72)	6.04	4.03	2.12	1.84	1.68	1.51
		9.1	3.17	DR	DR (6.95)	DR (5.16)	8.39	5.59	2.94	2.56	2.33	2.10
		12.2	4.09	DR	DR (8.96)	DR (6.65)	10.82	7.21	3.79	3.30	3.01	2.71
		15.2	4.97	DR	DR (10.73)	DR (7.96)	12.95	8.78	4.61	4.01	3.66	3.30
		18.3	5.89	DR	DR (12.92)	DR (9.58)	15.59	10.39	5.46	4.75	4.33	3.90
1.2 < S_{max} ≤ 1.6		3.1	0.50	DR (1.89)	2.19	1.63	1.32	0.88	0.46	0.40	0.37	0.33
		6.1	0.86	DR (3.25)	3.78	2.80	2.28	1.52	0.80	0.69	0.63	0.57
		9.1	1.22	DR (4.61)	5.36	3.67	3.23	2.16	1.13	0.99	0.90	0.81
		12.2	1.59	12.03	6.99	5.18	4.22	2.81	1.48	1.29	1.17	1.06
		15.2	1.95	14.51	8.43	6.25	5.09	3.45	1.81	1.58	1.44	1.30
		18.3	2.33	17.57	10.20	7.57	6.16	4.11	2.16	1.88	1.71	1.54
		3.1	1.18	DR	DR (2.59)	DR (1.92)	3.13	2.08	1.10	0.95	0.87	0.78
		6.1	1.95	DR	DR (4.28)	DR (3.18)	5.17	3.45	1.81	1.58	1.44	1.29
		9.1	2.72	DR	DR (5.98)	8.86	7.21	4.81	2.53	2.20	2.00	1.81
		12.2	3.52	DR	DR (7.72)	11.45	9.32	6.21	3.27	2.84	2.59	2.33
		15.2	4.29	DR	DR (9.26)	13.73	11.18	7.58	3.98	3.46	3.16	2.85
		18.3	5.09	DR	DR (11.16)	16.55	13.47	8.98	4.72	4.11	3.74	3.37

		3.1	1.86	DR	DR	DR (3.03)	DR (2.47)	DR	1.73	1.50	1.37	1.23
		6.1	3.05	DR	DR	DR (4.95)	DR (4.03)	5.37	2.82	2.46	2.24	2.02
		9.1	4.23	DR	DR	DR (6.87)	DR (5.60)	7.46	3.92	3.41	3.11	2.80
		12.2	5.45	DR	DR (11.95)	DR (8.86)	DR (7.21)	9.62	5.06	4.40	4.01	3.61
		15.2	6.63	DR	DR (14.31)	DR (10.61)	DR (8.64)	11.70	6.15	5.35	4.88	4.40
		18.3	7.85	DR	DR (17.22)	DR (12.77)	DR (10.40)	13.86	7.29	6.34	5.78	5.21
1.6 < S_{max} ≤ 2.0		3.1	0.63	DR (2.36)	2.74	2.03	1.66	1.10	0.58	0.50	0.46	0.41
		6.1	1.08	DR (4.07)	4.72	3.50	2.85	1.90	1.00	0.87	0.79	0.71
		9.1	1.53	DR (5.77)	6.70	4.96	4.04	2.69	1.42	1.23	1.12	1.01
		12.2	1.99	DR (7.52)	8.74	6.48	5.27	3.52	1.85	1.61	1.47	1.32
		15.2	2.44	DR (9.07)	10.53	7.81	6.36	4.31	2.27	1.97	1.80	1.62
		18.3	2.91	DR (10.98)	12.75	9.46	7.70	5.13	2.70	2.35	2.14	1.93
		3.1	1.48	DR	DR	DR (2.40)	DR (1.96)	2.61	1.37	1.19	1.09	0.98
		6.1	2.44	DR	DR (5.35)	DR (3.97)	DR (3.23)	4.31	2.26	1.97	1.80	1.62
		9.1	3.41	DR	DR (7.47)	DR (5.54)	DR (4.51)	6.01	3.16	2.75	2.50	2.26
		12.2	4.40	DR	DR (9.65)	DR (7.16)	11.65	7.77	4.08	3.55	3.24	2.92
		15.2	5.37	DR	DR (11.08)	DR (8.58)	13.97	9.47	4.98	4.33	3.95	3.56
		18.3	6.36	DR	DR (13.95)	DR (10.35)	16.84	11.23	5.90	5.13	4.68	4.22
		3.1	2.33	DR	DR	DR	DR (3.08)	DR	2.16	1.88	1.71	1.54
		6.1	3.81	DR	DR	DR	DR (5.04)	DR	3.53	3.07	2.80	2.52
		9.1	5.28	DR	DR	DR (8.59)	DR (7.00)	DR	4.90	4.26	3.89	3.50
		12.2	6.81	DR	DR	DR (11.08)	DR (9.02)	12.02	6.32	5.50	5.01	4.51

		15.2	8.29	DR	DR	DR (13.26)	DR (11.00)	14.63	7.69	6.69	6.10	5.49
		18.3	9.82	DR	DR	DR (15.96)	DR (13.00)	17.32	9.11	7.92	7.22	6.51
2.0 < S_{max} ≤ 2.6		3.1	0.81	DR (3.07)	DR (1.79)	2.65	2.15	1.44	0.75	0.66	0.60	0.54
		6.1	1.40	DR (5.28)	DR (3.07)	4.55	3.70	2.47	1.30	1.13	1.03	0.93
		9.1	1.99	DR (7.50)	8.70	6.45	5.25	3.50	1.84	1.60	1.46	1.32
		12.2	2.59	DR (9.78)	11.36	8.42	6.86	4.57	2.40	2.09	1.90	1.72
		15.2	3.18	DR (11.79)	13.69	10.15	8.27	5.60	2.95	2.56	2.34	2.11
		18.3	3.78	DR (14.28)	16.58	12.30	10.01	6.67	3.51	3.05	2.78	2.51
		3.1	1.92	DR	DR	DR	DR (2.54)	DR	1.78	1.55	1.41	1.27
		6.1	3.17	DR	DR	DR (5.16)	DR (4.20)	5.60	2.94	2.56	2.33	2.10
		9.1	4.43	DR	DR	DR (7.20)	DR (5.86)	7.81	4.11	3.57	3.26	2.93
		12.2	5.72	DR	DR	DR (9.31)	DR (7.58)	10.10	5.31	4.62	4.21	3.79
		15.2	6.98	DR	DR (15.05)	DR (11.16)	DR (9.58)	12.31	6.47	5.63	5.13	4.62
		18.3	8.27	DR	DR (18.14)	DR (13.45)	DR (10.95)	14.60	7.67	6.67	6.08	5.48
		3.1	3.03	DR	DR	DR	DR	DR	2.81	2.44	2.23	2.01
		6.1	4.95	DR	DR	DR	DR	DR	4.59	3.99	3.64	3.28
		9.1	6.87	DR	DR	DR	DR (9.09)	DR	6.37	5.54	5.05	4.55
		12.2	8.86	DR	DR	DR	DR (11.72)	DR	8.22	7.14	6.51	5.87
		15.2	10.78	DR	DR	DR	DR (14.03)	DR	10.00	8.69	7.92	7.14
		18.3	12.76	DR	DR	DR	DR (16.89)	DR	11.84	10.30	9.38	8.46

Notes to Table [9.23.13.7.-C] :

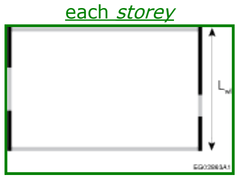
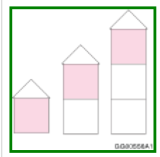
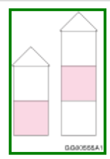
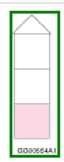
(1) Unadjusted minimum total *braced wall panel* lengths are for the applicable conditions corresponding to an adjustment factor of 1 in the equation for L_s.

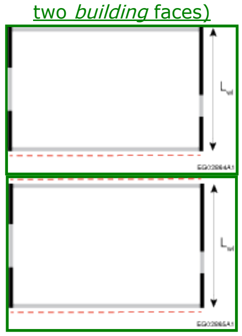
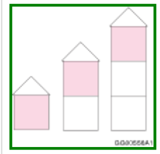
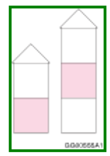
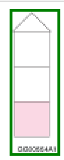
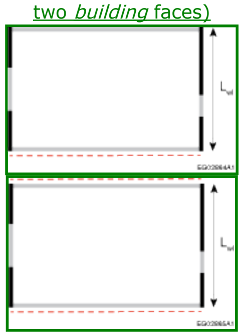
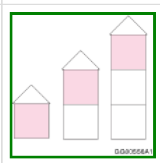
(2) DR = design required, using the procedure outlined in Note A-9.23.13.7.(4) or according to Part 4, for *braced wall panels* with typical sheathing. L_{us} values within round brackets, to which the reduction set out in Sentence (6)-2025 has been applied, are permitted for *braced wall panels* with gypsum board installed on both sides.

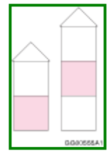
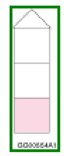
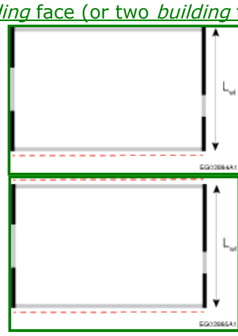
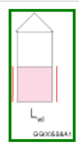
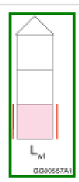
(3) See Sentence 9.23.3.5.(3) for a description of framing types and fastening requirements.

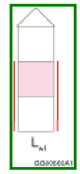
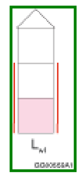
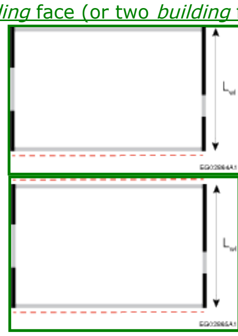
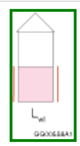
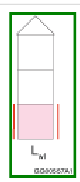
(4) See Sentence (6)-2025 for *braced wall panels* with gypsum board installed on both sides.

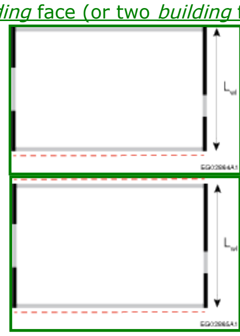
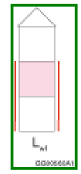
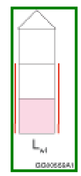
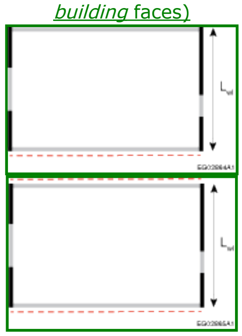
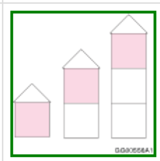
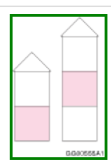
Table [9.23.13.7.-D]
Adjustment Factors for the Determination of Minimum Total Braced Wall Panel Lengths for Seismic Forces
Forming Part of Sentence [9.23.13.7.] -- ([4] --)

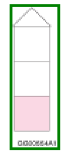
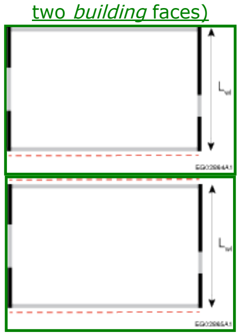
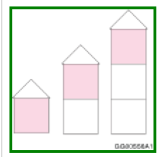
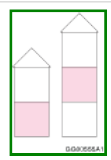
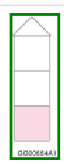
Symbol	Description	*Storey*	Condition	Adjustment Factor
K_{weight} (1) (2)	Normal-weight construction	Any *storey*	Any L_{wl}	1.00
	Heavy construction: apply factor corresponding to L_{wl} separately to each *storey* 	 *Storey* supporting roof only	L_{wl} ≤ 3.1 m	1.72
			L_{wl} = 6.1 m	1.54
			L_{wl} = 9.1 m	1.46
			L_{wl} = 12.2 m	1.42
			L_{wl} = 15.2 m	1.39
			L_{wl} ≥ 18.3 m	1.38
		 *Storey* supporting roof and 1 floor	L_{wl} ≤ 3.1 m	1.92
			L_{wl} = 6.1 m	1.71
			L_{wl} = 9.1 m	1.62
			L_{wl} = 12.2 m	1.57
			L_{wl} = 15.2 m	1.54
			L_{wl} ≥ 18.3 m	1.51
		 *Storey* supporting roof and 2 floors	L_{wl} ≤ 3.1 m	1.97
			L_{wl} = 6.1 m	1.76
			L_{wl} = 9.1 m	1.67
			L_{wl} = 12.2 m	1.61
			L_{wl} = 15.2 m	1.58
			L_{wl} ≥ 18.3 m	1.56
	Masonry veneer half *storey* above *foundation*: apply factor corresponding to one *building* face (or two *building* faces)	*Storey* supporting roof and up to 2 floors	Any L_{wl}	1.00 (1.00)

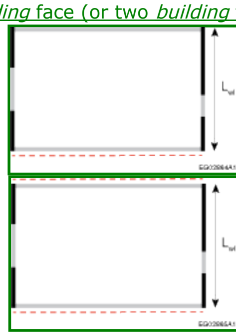
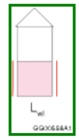
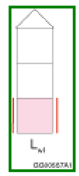
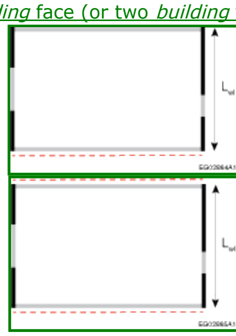
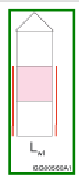
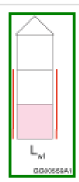
	Masonry veneer cladding perpendicular to *braced wall band*, fully clad: [3] apply factor corresponding to L_{wl} for one *building* face (or two *building* faces) 	 *Storey* supporting roof only	$L_{wl} \leq 3.1$ m	1.54 (2.13)
			$L_{wl} = 6.1$ m	1.30 (1.64)
			$L_{wl} = 9.1$ m	1.21 (1.45)
			$L_{wl} = 12.2$ m	1.15 (1.34)
			$L_{wl} = 15.2$ m	1.12 (1.28)
			$L_{wl} \geq 18.3$ m	1.10 (1.23)
		 *Storey* supporting roof and 1 floor	$L_{wl} \leq 3.1$ m	1.69 (2.43)
			$L_{wl} = 6.1$ m	1.40 (1.85)
			$L_{wl} = 9.1$ m	1.28 (1.60)
			$L_{wl} = 12.2$ m	1.21 (1.46)
			$L_{wl} = 15.2$ m	1.17 (1.38)
			$L_{wl} \geq 18.3$ m	1.14 (1.31)
		 *Storey* supporting roof and 2 floors	$L_{wl} \leq 3.1$ m	1.73 (2.51)
			$L_{wl} = 6.1$ m	1.43 (1.91)
			$L_{wl} = 9.1$ m	1.30 (1.65)
			$L_{wl} = 12.2$ m	1.22 (1.50)
			$L_{wl} = 15.2$ m	1.18 (1.41)
			$L_{wl} \geq 18.3$ m	1.15 (1.33)
	Masonry veneer cladding perpendicular to *braced wall band*, partially clad: [3] apply factor corresponding to L_{wl} for one *building* face (or two *building* faces) 	 *Storey* supporting roof only	$L_{wl} \leq 3.1$ m	1.23 (1.52)
			$L_{wl} = 6.1$ m	1.13 (1.29)
			$L_{wl} = 9.1$ m	1.08 (1.20)
			$L_{wl} = 12.2$ m	1.06 (1.15)
			$L_{wl} = 15.2$ m	1.04 (1.12)
			$L_{wl} \geq 18.3$ m	1.03 (1.09)

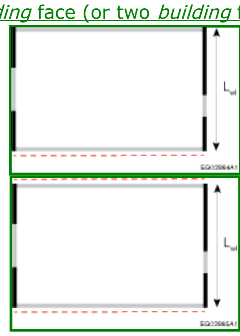
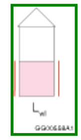
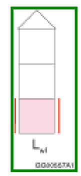
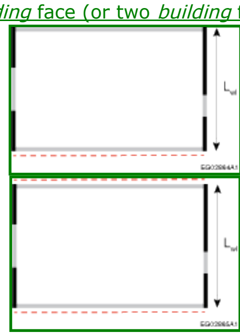
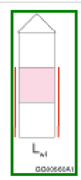
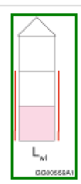
		 *Storey* supporting roof and 1 floor	L_{wl} ≤ 3.1 m	1.30 (1.66)
			L_{wl} = 6.1 m	1.17 (1.39)
			L_{wl} = 9.1 m	1.11 (1.27)
			L_{wl} = 12.2 m	1.08 (1.20)
			L_{wl} = 15.2 m	1.06 (1.16)
			L_{wl} ≥ 18.3 m	1.05 (1.13)
		 *Storey* supporting roof and 2 floors	L_{wl} ≤ 3.1 m	1.31 (1.70)
			L_{wl} = 6.1 m	1.18 (1.42)
			L_{wl} = 9.1 m	1.12 (1.29)
			L_{wl} = 12.2 m	1.08 (1.21)
			L_{wl} = 15.2 m	1.07 (1.17)
			L_{wl} ≥ 18.3 m	1.05 (1.14)
	Masonry veneer cladding perpendicular to *braced wall band*, 1-*storey* height, partially clad: (3) apply factor corresponding to L_{wl} for one *building* face (or two *building* faces) 	 *Storey* supporting roof and 1 floor	L_{wl} ≤ 3.1 m	1.23 (1.48)
			L_{wl} = 6.1 m	1.13 (1.28)
			L_{wl} = 9.1 m	1.09 (1.20)
			L_{wl} = 12.2 m	1.07 (1.15)
			L_{wl} = 15.2 m	1.06 (1.13)
			L_{wl} ≥ 18.3 m	1.05 (1.10)
		 *Storey* supporting roof and 2 floors	L_{wl} ≤ 3.1 m	1.15 (1.30)
			L_{wl} = 6.1 m	1.09 (1.18)
			L_{wl} = 9.1 m	1.06 (1.13)
			L_{wl} = 12.2 m	1.04 (1.10)
			L_{wl} = 15.2 m	1.04 (1.08)
			L_{wl} ≥ 18.3 m	1.03 (1.07)

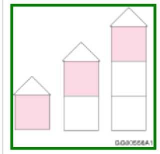
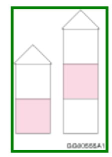
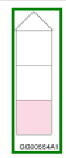
	Masonry veneer cladding perpendicular to *braced wall band*, 2-*storey* height, partially clad: (3) apply factor corresponding to L_{wl} for one *building* face (or two *building* faces) 	 *Storey* supporting roof and 1 floor	L_{wl} ≤ 3.1 m	1.10 (1.22)
			L_{wl} = 6.1 m	1.06 (1.13)
			L_{wl} = 9.1 m	1.04 (1.09)
			L_{wl} = 12.2 m	1.03 (1.07)
			L_{wl} = 15.2 m	1.02 (1.05)
			L_{wl} ≥ 18.3 m	1.02 (1.04)
		 *Storey* supporting roof and 2 floors	L_{wl} ≤ 3.1 m	1.19 (1.42)
			L_{wl} = 6.1 m	1.11 (1.25)
			L_{wl} = 9.1 m	1.07 (1.17)
			L_{wl} = 12.2 m	1.05 (1.13)
			L_{wl} = 15.2 m	1.04 (1.10)
			L_{wl} ≥ 18.3 m	1.03 (1.08)
	Masonry veneer cladding perpendicular to *braced wall band*, 1-*storey* height, fully clad: (3) apply factor corresponding to L_{wl} for one *building* face (or two *building* faces) 	 *Storey* supporting roof and 1 floor	L_{wl} ≤ 3.1 m	1.23 (1.48)
			L_{wl} = 6.1 m	1.13 (1.28)
			L_{wl} = 9.1 m	1.09 (1.20)
			L_{wl} = 12.2 m	1.07 (1.15)
			L_{wl} = 15.2 m	1.06 (1.13)
			L_{wl} ≥ 18.3 m	1.05 (1.10)
		 *Storey* supporting roof and 2 floors	L_{wl} ≤ 3.1 m	1.15 (1.30)
			L_{wl} = 6.1 m	1.09 (1.18)
			L_{wl} = 9.1 m	1.06 (1.13)
			L_{wl} = 12.2 m	1.04 (1.10)
			L_{wl} = 15.2 m	1.04 (1.08)
			L_{wl} ≥ 18.3 m	1.03 (1.07)

	Masonry veneer cladding perpendicular to *braced wall band*, 2-*storey* height, fully clad: (3) apply factor corresponding to L_{wl} for one *building* face (or two *building* faces) 	 *Storey* supporting roof and 1 floor	L_{wl} ≤ 3.1 m	1.23 (1.48)
			L_{wl} = 6.1 m	1.13 (1.28)
			L_{wl} = 9.1 m	1.09 (1.20)
			L_{wl} = 12.2 m	1.07 (1.15)
			L_{wl} = 15.2 m	1.06 (1.13)
			L_{wl} ≥ 18.3 m	1.05 (1.10)
		 *Storey* supporting roof and 2 floors	L_{wl} ≤ 3.1 m	1.44 (1.91)
			L_{wl} = 6.1 m	1.26 (1.55)
			L_{wl} = 9.1 m	1.18 (1.39)
			L_{wl} = 12.2 m	1.13 (1.30)
			L_{wl} = 15.2 m	1.11 (1.24)
			L_{wl} ≥ 18.3 m	1.09 (1.20)
	Stone veneer half *storey* above *foundation*: apply factor corresponding to one *building* face (or two *building* faces)	*Storey* supporting roof and up to 2 floors	Any L_{wl}	1.00 (1.00)
	Stone veneer cladding perpendicular to *braced wall band*, fully clad: (3) apply factor corresponding to L_{wl} for one *building* face (or two *building* faces) 	 *Storey* supporting roof only	L_{wl} ≤ 3.1 m	1.95 (2.95)
			L_{wl} = 6.1 m	1.54 (2.13)
			L_{wl} = 9.1 m	1.38 (1.79)
			L_{wl} = 12.2 m	1.28 (1.60)
			L_{wl} = 15.2 m	1.23 (1.49)
			L_{wl} ≥ 18.3 m	1.19 (1.40)
		 *Storey* supporting roof and 1 floor	L_{wl} ≤ 3.1 m	2.21 (3.48)
			L_{wl} = 6.1 m	1.72 (2.50)
			L_{wl} = 9.1 m	1.51 (2.06)
			L_{wl} = 12.2 m	1.38 (1.82)
			L_{wl} = 15.2 m	1.31 (1.66)

			$L_{wl} \geq 18.3$ m	1.26 (1.55)
		 *Storey* supporting roof and 2 floors	$L_{wl} \leq 3.1$ m	2.28 (3.63)
			$L_{wl} = 6.1$ m	1.77 (2.60)
			$L_{wl} = 9.1$ m	1.55 (2.14)
			$L_{wl} = 12.2$ m	1.41 (1.88)
			$L_{wl} = 15.2$ m	1.33 (1.72)
			$L_{wl} \geq 18.3$ m	1.28 (1.60)
	Stone veneer cladding perpendicular to *braced wall band*, partially clad:[3] apply factor corresponding to L_{wl} for one *building* face (or two *building* faces) 	 *Storey* supporting roof only	$L_{wl} \leq 3.1$ m	1.44 (1.94)
			$L_{wl} = 6.1$ m	1.25 (1.54)
			$L_{wl} = 9.1$ m	1.17 (1.37)
			$L_{wl} = 12.2$ m	1.13 (1.28)
			$L_{wl} = 15.2$ m	1.10 (1.23)
			$L_{wl} \geq 18.3$ m	1.08 (1.18)
		 *Storey* supporting roof and 1 floor	$L_{wl} \leq 3.1$ m	1.56 (2.19)
			$L_{wl} = 6.1$ m	1.33 (1.71)
			$L_{wl} = 9.1$ m	1.22 (1.50)
			$L_{wl} = 12.2$ m	1.17 (1.38)
			$L_{wl} = 15.2$ m	1.13 (1.31)
			$L_{wl} \geq 18.3$ m	1.11 (1.25)
		 *Storey* supporting roof and 2 floors	$L_{wl} \leq 3.1$ m	1.59 (2.26)
			$L_{wl} = 6.1$ m	1.35 (1.76)
			$L_{wl} = 9.1$ m	1.24 (1.53)
			$L_{wl} = 12.2$ m	1.18 (1.41)
			$L_{wl} = 15.2$ m	1.14 (1.33)
			$L_{wl} \geq 18.3$ m	1.12 (1.27)

	Stone veneer cladding perpendicular to *braced wall band*, 1-*storey* height, partially clad: (3) apply factor corresponding to L_{wl} for one *building* face (or two *building* faces) 	 *Storey* supporting roof and 1 floor	$L_{wl} \leq 3.1$ m	1.19 (1.40)
			$L_{wl} = 6.1$ m	1.11 (1.24)
			$L_{wl} = 9.1$ m	1.07 (1.17)
			$L_{wl} = 12.2$ m	1.06 (1.13)
			$L_{wl} = 15.2$ m	1.04 (1.10)
			$L_{wl} \geq 18.3$ m	1.04 (1.08)
		 *Storey* supporting roof and 2 floors	$L_{wl} \leq 3.1$ m	1.12 (1.25)
			$L_{wl} = 6.1$ m	1.07 (1.15)
			$L_{wl} = 9.1$ m	1.05 (1.11)
			$L_{wl} = 12.2$ m	1.04 (1.08)
			$L_{wl} = 15.2$ m	1.03 (1.07)
			$L_{wl} \geq 18.3$ m	1.02 (1.05)
	Stone veneer cladding perpendicular to *braced wall band*, 2-*storey* height, partially clad: (3) apply factor corresponding to L_{wl} for one *building* face (or two *building* faces) 	 *Storey* supporting roof and 1 floor	$L_{wl} \leq 3.1$ m	1.19 (1.40)
			$L_{wl} = 6.1$ m	1.11 (1.24)
			$L_{wl} = 9.1$ m	1.07 (1.17)
			$L_{wl} = 12.2$ m	1.06 (1.13)
			$L_{wl} = 15.2$ m	1.04 (1.10)
			$L_{wl} \geq 18.3$ m	1.04 (1.08)
		 *Storey* supporting roof and 2 floors	$L_{wl} \leq 3.1$ m	1.36 (1.76)
			$L_{wl} = 6.1$ m	1.21 (1.45)
			$L_{wl} = 9.1$ m	1.14 (1.32)
			$L_{wl} = 12.2$ m	1.11 (1.24)
			$L_{wl} = 15.2$ m	1.09 (1.20)
			$L_{wl} \geq 18.3$ m	1.07 (1.16)

	Stone veneer cladding perpendicular to *braced wall band*, 1-*storey* height, fully clad:[3] apply factor corresponding to L_{wl} for one *building* face (or two *building* faces) 	 *Storey* supporting roof and 1 floor	$L_{wl} \le 3.1$ m	1.40 (1.83)
			$L_{wl} = 6.1$ m	1.24 (1.50)
			$L_{wl} = 9.1$ m	1.17 (1.35)
			$L_{wl} = 12.2$ m	1.13 (1.27)
			$L_{wl} = 15.2$ m	1.10 (1.22)
			$L_{wl} \ge 18.3$ m	1.09 (1.18)
		 *Storey* supporting roof and 2 floors	$L_{wl} \le 3.1$ m	1.26 (1.53)
			$L_{wl} = 6.1$ m	1.15 (1.32)
			$L_{wl} = 9.1$ m	1.11 (1.23)
			$L_{wl} = 12.2$ m	1.08 (1.18)
			$L_{wl} = 15.2$ m	1.07 (1.14)
			$L_{wl} \ge 18.3$ m	1.06 (1.12)
	Stone veneer cladding perpendicular to *braced wall band*, 2-*storey* height, fully clad:[3] apply factor corresponding to L_{wl} for one *building* face (or two *building* faces) 	 *Storey* supporting roof and 1 floor	$L_{wl} \le 3.1$ m	1.40 (1.83)
			$L_{wl} = 6.1$ m	1.24 (1.50)
			$L_{wl} = 9.1$ m	1.17 (1.35)
			$L_{wl} = 12.2$ m	1.13 (1.27)
			$L_{wl} = 15.2$ m	1.10 (1.22)
			$L_{wl} \ge 18.3$ m	1.09 (1.18)
		 *Storey* supporting roof and 2 floors	$L_{wl} \le 3.1$ m	1.77 (2.58)
			$L_{wl} = 6.1$ m	1.46 (1.96)
			$L_{wl} = 9.1$ m	1.33 (1.68)
			$L_{wl} = 12.2$ m	1.25 (1.53)
			$L_{wl} = 15.2$ m	1.20 (1.43)
			$L_{wl} \ge 18.3$ m	1.17 (1.36)

K_{snow} (4)	Roof snow load: apply factor in accordance with the specified roof snow load	 *Storey* supporting roof only	≤ 2kPa	1.00
			3 kPa	1.20
			4 kPa	1.40
			5 kPa	1.60
			6 kPa	1.80
		 *Storey* supporting roof and 1 floor	≤ 2kPa	1.00
			3 kPa	1.10
			4 kPa	1.20
			5 kPa	1.30
			6 kPa	1.40
		 *Storey* supporting roof and 2 floors	≤ 2kPa	1.00
			3 kPa	1.06
			4 kPa	1.10
			5 kPa	1.20
			6 kPa	1.24
$K_{Sspacing}$ (5) (6)	*Braced wall band* spacing: apply factor to all *braced wall panels* per *building* plan direction	Any *storey*	3.8 m	0.60
			7.6 m	1.00
			10.6 m	1.35
			15 m (7)	1.90
$K_{Snumber}$	Number of parallel *braced wall bands*: apply factor to all *braced wall panels* per *building* plan direction	Any *storey*	2	1.00
			3	1.33
			4	1.50
			≥ 5	1.60
K_{gyp}	Interior gypsum board: apply factor in accordance with whether gypsum board is installed or omitted on interior side of *braced wall panels*	Any *storey*	Installed	1.00
			Omitted, blocked wall	1.20
			Omitted, unblocked wall	1.40
K_{sheath}	Intermittent *braced wall panels*: apply factor in accordance with continuity of sheathing within *braced wall band*	Any *storey*	Continuously sheathed	1.00
			Intermittently sheathed	1.15

Notes to Table [9.23.13.7.-D] :

(1) See Sentence 9.23.13.2.(3).

(2) For K_{weight}, linear interpolation between L_{wl} values and between fully clad and partially clad veneer conditions is permitted.

(3) "Fully clad" means that there are no openings, and "partially clad" means 50% or less coverage of an elevation.

(4) For K_{snow}, linear interpolation between roof snow loads is permitted.

(5) For $K_{Sspacing}$, linear interpolation between *braced wall band* spacings is permitted.

(6) An average *braced wall band* spacing is permitted to be used for the determination of $K_{Sspacing}$. See Sentence (5).

(7) A *braced wall band* spacing of 15 m is only permitted in *basements* and crawl spaces.

[5] --) For 3 or more parallel *braced wall bands* that are not evenly spaced, an average *braced wall band* spacing is permitted to be used for the determination of $K_{Wspacing}$ or $K_{Sspacing}$, provided that no single *braced wall band* spacing exceeds 10.6 m, except as provided in Sentence 9.23.13.6.(3)-2025.

[6] --) Where *braced wall panels* of a gypsum-sheathed framing type have gypsum board installed on both sides, the minimum total length of the *braced wall panels* determined in Sentence 9.23.13.7.(3) or (4)-2025 is permitted to be reduced by 50%.

[9.23.13.8.] --- Foundation Cripple Walls

(See Note A-9.23.13.8.)

[1] --) Except as provided in Sentences (2) and (3), *foundation* cripple walls supporting *braced wall panels* shall be

[a] --) considered as an additional *storey*, or

[b] --) designed in accordance with Part 4.

[2] --) Where the seismic design parameter, S_{max}, is not greater than 0.60, *foundation* cripple walls need not comply with Sentence (1), provided they

[a] --) are not more than 1.2 m in height,

[b] --) are not more than 6 m in length,

[c] --) are either

[i] --) framed with solid blocking, or

[ii] --) of the same construction as the *braced wall panels* of the *storey* above but sheathed with wood sheathing regardless of the construction, where the length of the cripple wall bracing is equal to the length of the *braced wall panels* multiplied by an adjustment factor of 1.2, in addition to any adjustments required by Sentences 9.23.13.7.(1) and (2)-2025, and

[d] --) do not support heavyweight construction, masonry veneer or stone veneer.

(See Note A-9.23.13.8.(2).)

[3] --) Where the seismic design parameter, S_{max}, is greater than 0.60, *foundation* cripple walls need not comply with Sentence (1), provided they

[a] --) comply with Clauses (2)(c) and (d),

[b] --) are not more than 350 mm in height, and

[c] --) are not more than 5 m in length.

(See Note A-9.23.13.8.(3).)

[4] --) Where interior finish, such as gypsum board, is omitted from the interior side of the cripple wall referred to in Sentence (2) or (3), the interior gypsum board adjustment factor described in Sentence 9.23.13.7.(3) or (4)-2025 shall be applied to the length of the cripple wall bracing.

[9.23.13.9.] --- Cripple Walls in Stepped Foundations

[1] --) Cripple walls in stepped *foundations* need not be braced in accordance with Sentences 9.23.13.8.(2) to (4), provided

[a] --) the lowest floor framing rests directly on a sill plate anchored to a *foundation* not less than 2.4 m in length within a *braced wall band* not more than 7.6 m in length,

[b] --) the top plate of the cripple wall extends not less than 1.2 m along the *foundation*, and

[c] --) anchor bolts are located not more than 300 mm and 900 mm from the step in the *foundation*.

(See Note A-9.23.13.9.(1).)

[9.23.13.10.] 9.23.13.7. Additional System Considerations

[1] --) This Article applies where

[a] --) the seismic design parameter, S_{max}, is not greater than 1.2, and

[b] --) the 1-in-50-year hourly wind pressure (HWP) is not greater than 1.2 kPa.

[2] 3) Portions of the perimeter of a single open or enclosed space need not comply with Sentence 9.23.13.5.(1), where

[a] a) the roof of the space projects not more than

[i] i) 3.5 m from the face of the framing of the nearest parallel *braced wall band*, and

[ii] ii) the perpendicular plan dimension,

[b] b) that portion of the perimeter structure does not support a floor,

[c] c) the roof of the space is

[i] i) integral with the roof of the rest of the *building* with framing members not more than 400 mm o.c. where roof sheathing edges are not supported on blocking and not more than 600 mm o.c. where roof sheathing edges are supported on blocking securely fastened between framing members, or

[ii] ii) constructed with roof framing not more than 400 mm o.c. where roof sheathing edges are not supported on blocking and not more than 600 mm o.c. where roof sheathing edges are supported on blocking securely fastened between framing members, and fastened to the wall framing (see Table 9.23.3.4. and Article 9.23.9.1. for balloon framing), and

[d] d) the end-joists or end-rafters for the roof of the space are fastened to a 3-ply, 38 mm × 140 mm built-up column or a 5-ply, 38 mm × 89 mm built-up column that is integral with the wall framing.

(See Note A-9.23.13.10.(2).)

[3] 4) Walls in detached garages and in accessory *buildings* serving a single *dwelling unit*, and the front wall of attached garages serving a single *dwelling unit* need not comply with Sentence 9.23.13.5.(1) where these walls do not support a floor.

[4] 5) *Braced wall panels* in the *braced wall band* at the front of an attached garage serving a single *dwelling unit* need not comply with Sentence 9.23.13.5.(1), provided

[a] a) the maximum spacing between the front of the garage and the back wall of the garage does not exceed 7.6 m,

[b] b) there is not more than one floor above the garage,

[c] c) not less than 50% of the length of the back wall of the garage is constructed of wood-sheathed *braced wall panels*, and

[d] d) not less than 25% of the length of the side walls is constructed of wood-sheathed *braced wall panels*.

[5] 1) Except as provided in Sentences (~~2~~6) and (~~3~~7)-2025, one exterior wall of the uppermost *storey* in each orthogonal direction may be set back from the exterior wall of the *storey* below, provided the adjacent interior *braced wall band* of the *storey* below the setback

[a] a) is spaced not more than 10.6 m from the exterior wall of the *storey* below the setback wall,

[b] b) consists of *braced wall panels* that are constructed of a wood-based material in conformance with Sentence 9.23.13.6.(1~~2~~),

[c] c) extends to the *foundation*, and

[d] d) is not taken into consideration when providing *braced wall panels* constructed of a wood-based material at spacing intervals of not more than 15 m as per Sentence 9.23.13.6.(3~~6~~).

[6] 2) Where the exterior wall of the uppermost *storey* is set back from the exterior wall of the *storey* below, the roof and floor space supporting the setback wall shall be sheathed with a wood-based material between the exterior wall of the *storey* below the setback and the adjacent interior *braced wall bands* of the *storey* below the setback.

[7] 3) Where the exterior wall of the uppermost *storey* is set back from the exterior wall of the *storey* below, the exterior walls perpendicular to the setback wall shall

[a] a) have their top plate connected with nails that are spaced at no greater than half the spacing required in Table 9.23.3.4., and

[b] b) have their top plate splices fastened with twice the number of nails specified in Sentence~~s~~ 9.23.11.4.~~(4) and~~ (5).

[8] 4) The maximum distance between adjacent required *braced wall panels* in a *braced wall band*, measured from the edge of the panels, may be increased to 7.3 m provided that, throughout the height of the *building*, the length of any *braced wall panel* within the *braced wall band* is not less than 1.2 m.

[9] ~~5) The maximum spacing between the centre lines of required *braced wall bands* given in Table 9.23.13.5. may be increased from 7.6 m to no more than 10.6 m, provided that the interior *braced wall band* whose spacing is being increased is replaced with an interior *braced wall band* that~~

~~[a] a) consists of *braced wall panels* that are constructed of a wood-based material in conformance with Sentence 9.23.13.6.(2),~~

~~[b] b) extends to the *foundation*, and~~

~~[c] c) is not taken into consideration when providing *braced wall panels* constructed of a wood-based material at spacing intervals no greater than 15 m as per Sentence 9.23.13.6.(6).~~

[10] ~~6) For each orthogonal direction of the *building*, the length of required *braced wall panels* of one exterior wall given in Table 9.23.13.5. may be reduced from 40% to no less than 25% of the length of the *braced wall band*, provided an additional parallel and adjacent interior *braced wall band* is constructed that~~

~~[a] a) is spaced not more than 10.6 m from the exterior wall,~~

~~[b] b) consists of *braced wall panels* that are constructed of a wood-based material in conformance with Sentence 9.23.13.6.(2) and whose lengths sum to no less than 25% of the length of the *braced wall band*,~~

~~[c] c) extends to the *foundation*, and~~

~~[d] d) is not taken into consideration when providing *braced wall panels* constructed of a wood-based material at spacing intervals no greater than 15 m as per Sentence 9.23.13.6.(6).~~

~~[11] 7) Where the length of required *braced wall panels* of an exterior wall is reduced as described in Sentence (10)-2020, the ratio of the length of *braced wall panels* in the respective upper *braced wall bands* to the length of *braced wall panels* in the reduced exterior *braced wall band* shall not exceed 2.~~

[9.23.13.11.] --- Simplified Approach for Determining Braced Wall Panel Length

[1] --) This Article applies where

[a] --) the seismic design parameter, S_{max}, is not greater than 0.47,

[b] --) the 1-in-50-year hourly wind pressure (HWP) is not greater than 0.6 kPa,

[c] --) the specified roof snow load, as calculated in accordance with Article 9.4.2.2., is not greater than 2 kPa,

[d] --) the plan dimensions of the *building* are each not greater than 21.2 m,

[e] --) the *building* is located in rough terrain, as described in Note A-9.23.13.7.(3) and (4),

[f] --) the greatest eave-to-ridge height of the roof is not greater than 3 m,

[g] --) the *braced wall panels* are constructed with gypsum board on at least one side,

[h] --) the *braced wall bands* are continuously sheathed, and

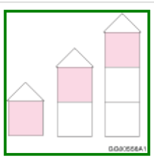
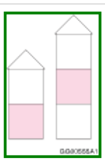
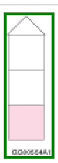
[i] --) the *building* is of normal-weight construction, as defined in Clause 9.23.13.2.(3)(a), except as provided in Sentence (4).

[2] --) Except as provided in Sentence (3), the minimum total length of all *braced wall panels* in each *braced wall band* in each direction shall be determined in accordance with

[a] --) Table 9.23.13.11-A where the seismic design parameter, S_{max}, is not greater than 0.3 and the 1-in-50-year hourly wind pressure (HWP) is not greater than 0.5 kPa, or

[b] --) Table 9.23.13.11-B.

Table [9.23.13.11.-A]
Minimum Total Length of Braced Wall Panels Where HWP ≤ 0.5 kPa and S_{max} ≤ 0.3
Forming Part of Sentence [9.23.13.11.] -- ([2] --)

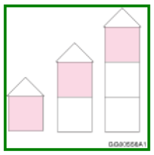
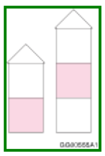
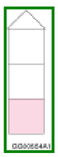
Storey	Minimum Total Length of *Braced Wall Panels*, m									
	Diagonal-Lumber-Sheathed Framing Type (with gypsum board on opposite side) (1)	Gypsum-Sheathed Framing Type (with gypsum board on only one side) (1) (2)				Wood-Sheathed Framing Type (with gypsum board on opposite side) (1)				
	DWB	GWB-A	GWB-B	GWB-C	GWB-D	WSP-A	WSP-B	WSP-C	WSP-D	WSP-E
	1.89	9.47 (4.74)	5.50 (2.75)	4.08 (2.04)	3.32 (1.66)	3.32	1.76	1.53	1.39	1.26
	3.89	19.45 (9.73)	11.30 (5.65)	8.38 (4.19)	6.82 (3.41)	6.82	3.61	3.14	2.86	2.59
	5.88	NP (14.71)	17.09 (8.55)	12.67 (6.34)	10.31 (5.16)	10.31	5.46	4.74	4.33	3.92

Notes to Table [9.23.13.11.-A] :

(1) See Sentence 9.23.3.5.(3) for a description of framing types and fastening requirements.

(2) NP = not permitted. Values within round brackets are permitted for *braced wall panels* with gypsum board installed on both sides.

Table [9.23.13.11.-B]
Minimum Total Length of Braced Wall Panels Where HWP ≤ 0.6 kPa and S_{max} ≤ 0.47
Forming Part of Sentence [9.23.13.11.] -- ([2] --)

Storey	Minimum Total Length of *Braced Wall Panels*, m									
	Diagonal-Lumber-Sheathed Framing Type (with gypsum board on opposite side) (1)	Gypsum-Sheathed Framing Type (with gypsum board on only one side) (1) (2)				Wood-Sheathed Framing Type (with gypsum board on opposite side) (1)				
	DWB	GWB-A	GWB-B	GWB-C	GWB-D	WSP-A	WSP-B	WSP-C	WSP-D	WSP-E
	2.27	11.36 (5.68)	6.60 (3.30)	4.89 (2.45)	3.98 (1.99)	3.98	2.11	1.83	1.67	1.51
	4.66	NP (11.68)	13.56 (6.78)	10.06 (5.03)	8.18 (4.09)	8.18	4.34	3.76	3.44	3.11
	7.05	NP (17.96)	20.86 (10.43)	15.47 (7.74)	12.59 (6.30)	12.37	6.56	5.69	5.19	4.70

Notes to Table [9.23.13.11.-B] :

(1) See Sentence 9.23.3.5.(3) for a description of framing types and fastening requirements.

(2) NP = not permitted. Values within round brackets are permitted for *braced wall panels* with gypsum board installed on both sides.

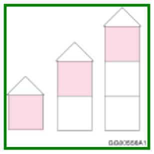
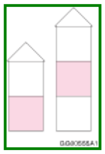
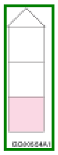
[3] --) Except as provided in Sentence (4), the minimum total length of all *braced wall panels* in each *braced wall band* in the direction perpendicular to a single *building* face partially clad with masonry veneer shall be determined in accordance with

[a] --) Table 9.23.13.11-C where the seismic design parameter, S_{max}, is not greater than 0.3 and the 1-in-50-year hourly wind pressure (HWP) is not greater than 0.5 kPa, or

[b] --) Table 9.23.13.11-D.

Table [9.23.13.11.-C]
Minimum Total Length of Braced Wall Panels in a Braced Wall Band Perpendicular to a Building Face Partially Clad with Masonry Veneer Where HWP ≤ 0.5 kPa and S_{max} ≤ 0.3
Forming Part of Sentence [9.23.13.11.] -- ([3] --)

Storey	Minimum Total Length of *Braced Wall Panels*, m									
	Diagonal-Lumber-Sheathed Framing Type (with gypsum board on opposite side) (1)	Gypsum-Sheathed Framing Type (with gypsum board on only one side) (1) (2)				Wood-Sheathed Framing Type (with gypsum board on opposite side) (1)				
	DWB	GWB-A	GWB-B	GWB-C	GWB-D	WSP-A	WSP-B	WSP-C	WSP-D	WSP-E

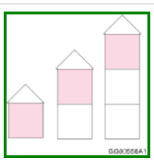
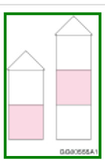
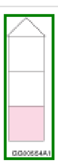
	1.89	9.47 (4.74)	5.50 (2.75)	4.08 (2.04)	3.25 (1.63)	3.32	1.76	1.53	1.39	1.26
	3.89	19.45 (9.73)	11.30 (5.65)	8.38 (4.19)	6.75 (3.37)	6.82	3.61	3.14	2.86	2.59
	5.88	NP (15.01)	17.44 (8.72)	12.93 (6.46)	10.49 (5.25)	10.31	5.46	4.74	4.33	3.92

Notes to Table [9.23.13.11.-C] :

(1) See Sentence 9.23.3.5.(3) for a description of framing types and fastening requirements.

(2) NP = not permitted. Values within round brackets are permitted for *braced wall panels* with gypsum board installed on both sides.

Table [9.23.13.11.-D]
Minimum Total Length of Braced Wall Panels in a Braced Wall Band Perpendicular to a Building Face Partially Clad with Masonry Veneer Where HWP ≤ 0.6 kPa and S_{max} ≤ 0.47
Forming Part of Sentence [9.23.13.11.] -- ([3] --)

Storey	Minimum Total Length of *Braced Wall Panels*, m									
	Diagonal-Lumber-Sheathed Framing Type (with gypsum board on opposite side) (1)	Gypsum-Sheathed Framing Type (with gypsum board on only one side) (1) (2)				Wood-Sheathed Framing Type (with gypsum board on opposite side) (1)				
	DWB	GWB-A	GWB-B	GWB-C	GWB-D	WSP-A	WSP-B	WSP-C	WSP-D	WSP-E
	2.27	13.12 (6.56)	7.63 (3.81)	5.66 (2.83)	4.89 (2.44)	3.98	2.11	1.83	1.67	1.51
	4.66	NP (15.14)	17.59 (8.79)	13.04 (6.52)	10.57 (5.28)	8.18	4.34	3.76	3.44	3.11
	7.05	NP	NP (13.66)	20.27 (10.13)	16.49 (8.24)	12.37	6.56	5.69	5.19	4.70

Notes to Table [9.23.13.11.-D] :

(1) See Sentence 9.23.3.5.(3) for a description of framing types and fastening requirements.

(2) NP = not permitted. Values within round brackets are permitted for *braced wall panels* with gypsum board installed on both sides.

[4] --) Wall portions clad with masonry veneer that are located both perpendicular to a *braced wall band* and within a *braced wall band* are permitted to be considered as normal-weight construction.

[5] --) Bracing to resist lateral loads shall be designed and constructed in accordance with Articles 9.23.13.4. to 9.23.13.6. and 9.23.13.8. to 9.23.13.10.

Note A-9.23.13. Bracing for Resistance to Lateral Loads.

Subsection 9.23.13. along with Articles 9.4.2.5., Article 9.23.3.4., 9.23.3.5., 9.23.6.1., 9.23.9.8., 9.23.11.4., 9.23.15.5., 9.29.5.8., 9.29.5.9., 9.29.6.3. and 9.29.9.3. ~~provide explicit requirements to~~ contain design and bracing provisions that address the resistance of light wood-frame structures and non-structural components to wind and earthquake loads ~~in higher wind and earthquake regions of Canada~~.

~~Table [A-9.23.13.-A] A-9.23.13.~~
~~Application of Lateral Load Requirements~~

~~Applicable Requirements~~	~~Wind (HWP)~~			~~Earthquake $S_a(0.2)$~~				
	~~Low to Moderate~~	~~High~~	~~Extreme~~	~~Low to Moderate~~	~~High~~	~~Extreme~~	~~High~~	~~Extreme~~
	~~HWP < 0.80 kPa~~	~~0.80 ≤ HWP < 1.20 kPa~~	~~HWP ≥ 1.20 kPa~~	~~$S_a(0.2) \leq 0.70$~~	~~$0.70 < S_a(0.2) \leq 1.8$~~	~~$S_a(0.2) > 1.8$~~	~~$0.70 < S_a(0.2) \leq 1.8$~~	~~$S_a(0.2) > 1.8$~~
	~~All Construction~~			~~All Construction~~	~~Heavy Construction (1)~~		~~Light Construction~~	
~~Design requirements in 9.23.16.2., 9.27., 9.29.~~	~~X (2)~~	~~N/A~~	~~N/A~~	~~X~~	~~N/A~~	~~N/A~~	~~N/A~~	~~N/A~~
~~Bracing requirements in 9.23.13.~~	~~X~~	~~X~~	~~N/A~~	~~X~~	~~X (3) (4)~~	~~N/A~~	~~X (4) (5)~~	~~N/A~~
~~Part 4 or CWC Guide~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
~~X = requirements are applicable~~								

~~Notes to Table [A-9.23.13.-A] A-9.23.13.:~~

~~(1) See Note A-9.23.13.2.(1)(a)(i).~~

~~(2) Requirements apply to exterior walls only.~~

~~(3) Requirements apply where lowest exterior frame walls support not more than one floor.~~

~~(4) All constructions may include the support of a roof in addition to the stated number of floors.~~

~~(5) Requirements apply where lowest exterior frame walls support not more than two floors.~~

The bracing provisions were developed based on a combination of performance history and engineering calculations, as are most Part 9 provisions. The placement and construction methods for braced walls were determined by the following approach. The lateral forces were analyzed in accordance with Part 4 for various configurations of buildings in different locations across Canada. The lateral resistance of walls was established using an approach adapted from CSA O86, "Engineering Design in Wood." Construction details and required lengths for braced walls were determined based on location, building height, wind exposure and construction weight. This approach relied on the following assumptions:

• A short-term load duration factor, K_D, of 1.25 was used for the calculation of resistance to wind and seismic shear forces.

• The ductility- and overstrength-related force modification factors, R_d and R_o, were assumed to have the values listed in the following table:

Seismic Force Resisting System (SFRS)	R_d	R_o
Nailed or screwed wood-based shear walls in combination with gypsum board	3.0	1.7
Nailed or screwed diagonal lumber board shear walls in combination with gypsum board	3.0	1.7
Nailed or screwed gypsum board shear walls	2.0	1.7

• A level of resistance of up to 50% of the wind or seismic lateral load demand was assumed to be provided by interior partitions and other non-structural components, such as cabinetry and cladding.

It is important to note that not all buildings satisfying the bracing provisions will have the configurations or details assumed in the calculations, which are necessary to provide adequate resistance against lateral loads. For example, buildings with a limited number of interior partitions and other non-structural components may have a lower lateral resistance than predicted. In such cases, the Part 9 provisions for bracing to resist lateral loads may not be adequate to satisfy the objectives of the NBC, and bracing requirements should instead be determined in accordance with Part 4.

See Note A-9.4.2.5. for more information on the seismic design parameter, S_{max}, used in the seismic design provisions.

~~Note A-9.23.13.1.~~

~~Bracing to Resist Lateral Loads in Low Load Locations~~

~~Of the 679 locations identified in Appendix C, 614 are locations where the seismic spectral acceleration, $S_a(0.2)$, is less than or equal to 0.70 and the 1-in-50 hourly wind pressure is less than 0.80 kPa. For buildings in these locations, Sentence 9.23.13.1.(2) requires only that exterior walls be braced using the acceptable materials and fastening specified. There are no spacing or dimension requirements for braced wall panels in these buildings.~~

~~Structural Design for Lateral Wind and Earthquake Loads~~

~~In cases where lateral load design is required, CWC 2014, "Engineering Guide for Wood Frame Construction", provides acceptable engineering solutions as an alternative to Part 4. The CWC Guide also contains alternative solutions and provides information on the applicability of the Part 9 prescriptive structural requirements to further assist designers and building officials to identify the appropriate design approach.~~

Note A-9.23.13.2.(3~~1~~)~~(a)(i)~~ ~~Heavy~~Weight of Construction and Cladding.

Normal-Weight Construction

Normal-weight floor construction (with a maximum average dead weight of 0.5 kPa) accommodates ceramic tile, hardwood, carpet and other finishes weighing no more than 0.25 kPa. Normal-weight roof construction (with a maximum average dead weight of 0.5 kPa) accommodates asphalt shingles, wood shingles, steel roofing and other roofing weighing no more than 0.12 kPa. Normal-weight exterior wall construction (with a maximum average dead weight of 0.4 kPa) accommodates fibre-cement board, wood, vinyl, lightweight metal panels and other cladding weighing no more than 0.10 kPa.

These finish, roofing and cladding weights are based on typical light wood-frame construction where

- floor assemblies include a plywood subfloor, 38 mm by 286 mm lumber floor joists spaced at 400 mm o.c., and a gypsum board ceiling;
- roof assemblies include plywood roof sheathing, trusses, RSI 10.6 (R60) insulation, and a gypsum board ceiling; and
- wall assemblies include OSB exterior sheathing, strapping, 38 mm by 140 mm studs spaced at 400 mm o.c., insulation, and gypsum board interior finish.

Heavyweight Construction

In a building of "heavyweight construction," the average dead weight per storey of the floors, roof or exterior walls is permitted to exceed the value stated in Clause 9.23.13.2.(3)(a), but must not exceed the maximum average dead weight per storey stated in Clause 9.23.13.2.(3)(b). The three possible cases are described in Table A-9.23.13.2.(3).

Heavyweight floor construction, which allows for an additional average dead weight of 1.0 kPa compared to normal-weight floor construction, accommodates a 38 mm thick normal-weight concrete topping, for example. Heavyweight roof construction accommodates slate or clay tile shingles weighing up to 0.65 kPa (provided they are not installed over existing normal-weight roofing). Heavyweight roof construction also accommodates the installation of solar panels (which weigh approximately 0.12 kPa) over normal-weight roofing such as asphalt shingles. Heavyweight wall construction, which allows for cladding weighing up to 0.85 kPa, accommodates cementitious stucco, heavier weight metal panels and, if averaged with lighter claddings, adhered manufactured or natural stone veneer. Heavyweight wall construction does not accommodate masonry or stone veneer, unless it is averaged with lighter claddings using an "area-weighted average," as explained below.

Table [9.23.13.2.(31)(a)(i)] A-9.23.13.2.(3)
Maximum Average Dead Weights per Storey for Heavyweight Construction
Forming Part of Note A-9.23.13.2.(3)

Description of Heavyweight Construction	Maximum Average Dead Weight per Storey, kPa			
	Floors	Partitions and Interior Walls	Roof	Exterior Walls
Normal-weight floors and roof with heavyweight exterior walls	0.5	0.5	0.5	1.2
Normal-weight floors and exterior walls with heavyweight roof	0.5	0.5	1.0	0.4
Normal-weight exterior walls and roof with heavyweight floors	1.5	0.5	0.5	0.4

Masonry or Stone Veneer Wall Cladding

Clay brick, concrete block, concrete brick, concrete stone and calcium silicate masonry veneers with a bed thickness of not more than 90 mm are considered to meet the weight limit of 1.9 kPa provided in Clause 9.23.13.2.(3)(c) for buildings clad with masonry veneer.

Natural stone veneers of limestone and sandstone (but not granite) with a bed thickness of not more than 125 mm are considered to meet the weight limit of 3.2 kPa provided in Clause 9.23.13.2.(3)(d) for buildings clad with stone veneer.

Area-Weighted Average

An "area-weighted average" can be used to determine the average dead weight per storey of a building's walls, floors or roof. The area-weighted average is calculated for each assembly by averaging the weights of materials, weighted by their respective areas, over the total area of the assembly.

For instance, using an area-weighted average, wall cladding weights can be averaged over exterior wall areas to determine whether the exterior walls are of normal-weight or heavyweight construction according to Sentence 9.23.13.2.(3). Exterior walls that are partially clad with heavier materials, such as stucco, masonry veneer or stone veneer, may qualify as normal-weight construction if an area-weighted average of the cladding weights does not exceed 0.4 kPa per storey or as heavyweight construction if the area-weighted average does not exceed 1.2 kPa per storey. The same approach can be applied to floor and roof assemblies.

For example, if a floor has a total area of 400 m^2, of which 25 m^2 has a concrete topping (floor assembly weight of 1.25 kPa) and the remaining 375 m^2 has hardwood floors (floor assembly weight of 0.45 kPa), the area-weighted average dead weight per storey is calculated as follows:

$$\frac{(1.25\ \text{kPa})\left(25\ \text{m}^2\right)+(0.45\ \text{kPa})\left(375\ \text{m}^2\right)}{400\ \text{m}^2}=0.5\ \text{kPa}$$

With an average dead weight per storey of 0.5 kPa, the floor qualifies as normal-weight construction.

~~“Heavy construction” refers to buildings with tile roofs, stucco walls or floors with concrete topping, or that are clad with directly-applied heavyweight materials.~~

~~Heavyweight construction assemblies increase the lateral load on the structure during an earthquake. Assemblies should be considered as heavyweight where their average dead weight is as follows (an additional partition weight of 0.5 kPa per floor is assumed):~~

- ~~floor: 0.5 to 1.5 kPa~~
- ~~roof: 0.5 to 1.0 kPa~~
- ~~wall (vertical area): 0.32 to 1.2 kPa~~

Note A-9.23.13.4. Braced Wall Bands.

Article 9.23.13.4. specifies the required characteristics of braced wall bands and their position in the building.
Figures A-9.23.13.4.-A, A-9.23.13.4.-B and A-9.23.13.4.-C illustrate these requirements.

Figure [A-9.23.13.4.-A] A-9.23.13.4.-A
Braced wall bands in an example building section ([~~[~~Clauses 9.23.13.4.(1)~~(a),~~ (b), (c) and (e~~d~~)-2025)~~]~~

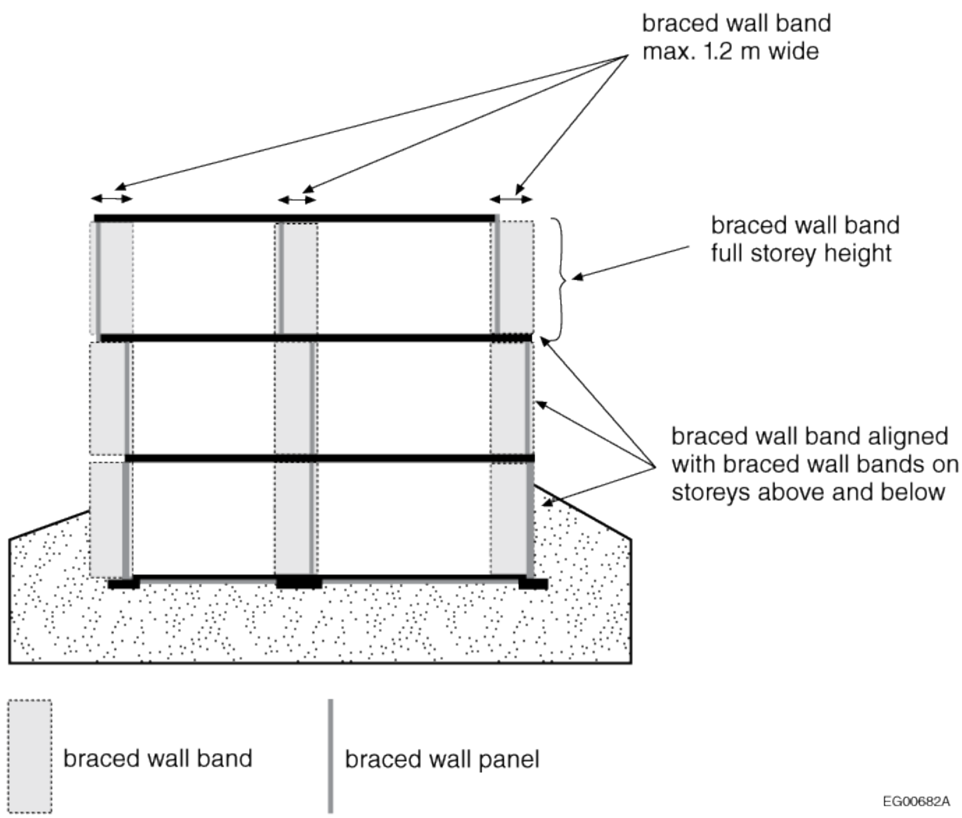


Figure [A-9.23.13.4.-B] A-9.23.13.4.-B
Lapping bands and building perimeter within braced wall bands (~~[~~Clauses 9.23.13.4.(1)(~~c~~a) and (d)-2025~~Sentence 9.23.13.4.(2)]~~)

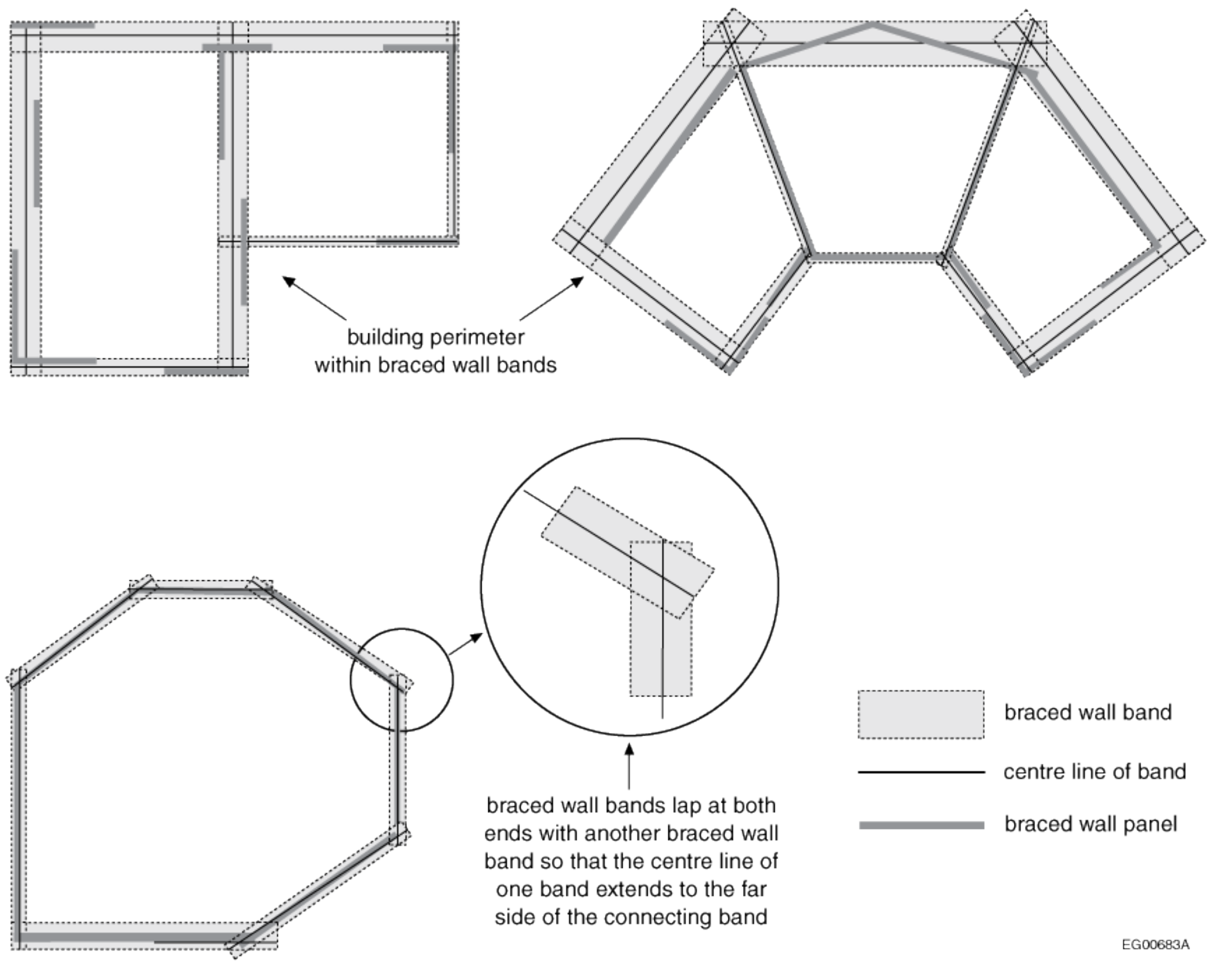
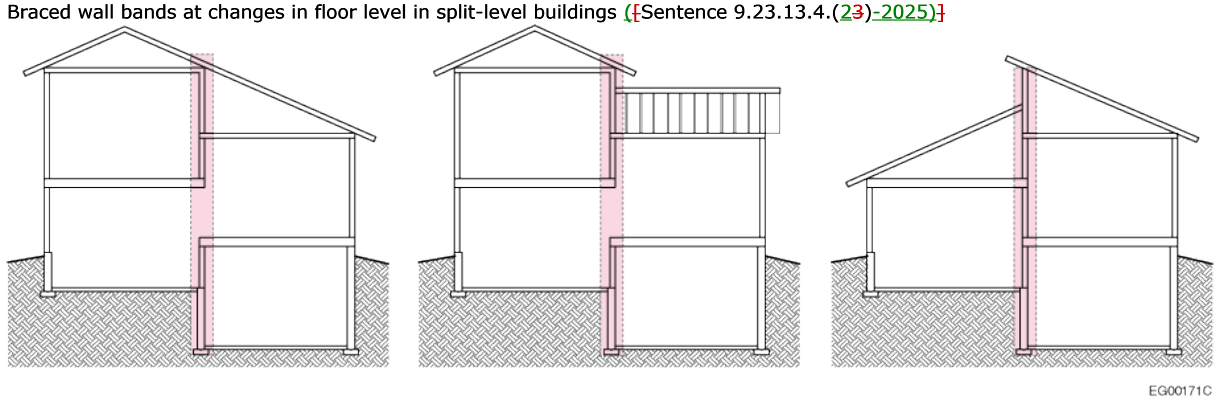


Figure [A-9.23.13.4.-C] A-9.23.13.4.-C
Braced wall bands at changes in floor level in split-level buildings (~~[~~Sentence 9.23.13.4.(2~~3~~)-2025)~~]~~



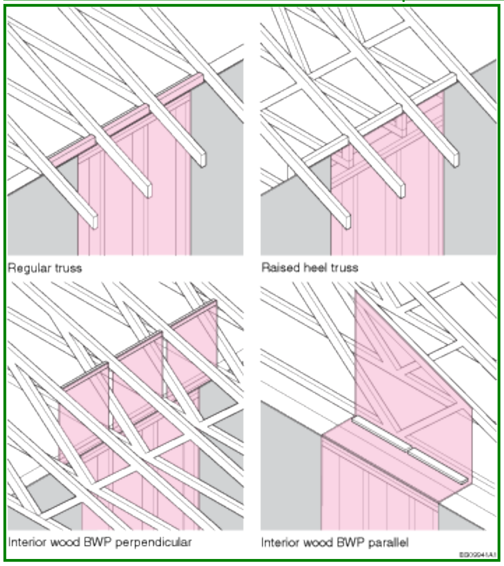
Note A-9.23.13.5.(3) and (4) Connection of Braced Wall Panels to Roof Framing.

Braced wall panels that are sheathed with gypsum board alone have a significantly lower lateral resistance than wood-sheathed braced wall panels. For gypsum-sheathed braced wall panels, the typical lateral bracing of trusses is usually adequate to transfer the lateral loads from the bottom chords to the top chords of the truss.

The connection of interior gypsum-sheathed braced wall panels to trusses also needs to accommodate vertical movement of the roof framing in order to facilitate “truss uplift” and to prevent the gypsum board from cracking.

The connection of interior or exterior wood-sheathed braced wall panels (BWP), other than panels of WSP-A framing type, to roof framing is illustrated in Figure A-9.23.13.5.(3) and (4).

Figure [A-9.23.13.5.(3) and (4)]
Connection of wood-sheathed braced wall panels to roof framing (Sentence 9.23.13.5.(3)-2025)



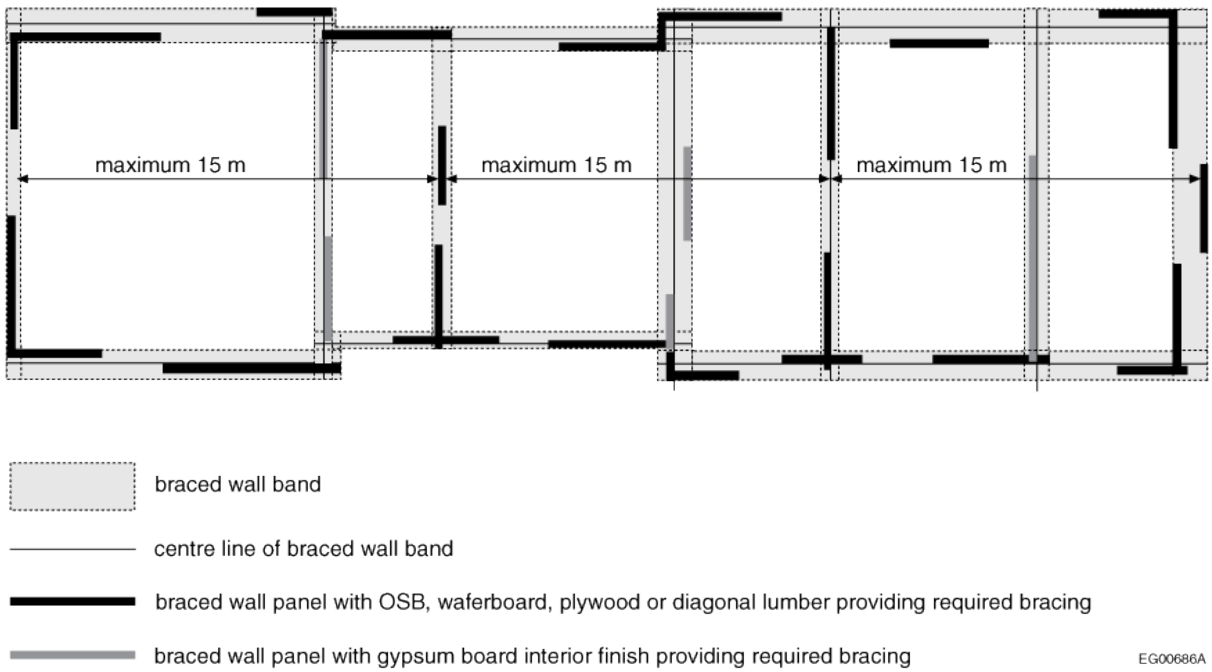
Note A-9.23.13.6.(1) Materials in Braced Wall Panels.

Clause 9.23.13.6.(1)(a)-2025 describes wood-based exterior braced wall panels that are finished on the interior side with gypsum board fastened in accordance with Subsection 9.29.5.; these panels correspond to framing types WSP-A, WSP-B, WSP-C, WSP-D, WSP-E and DWB, with framing type GWB-O on the interior side, as specified in Table 9.23.3.5.-C. Clause 9.23.13.6.(1)(b)-2025 describes exterior braced wall panels that are sheathed with gypsum board only, corresponding to framing types GWB-O, GWB-A, GWB-B, GWB-C and GWB-D, as specified in Table 9.23.3.5.-C. Such panels are typically applied to the interior side of exterior walls to allow the option of not using wood-based structural sheathing on the exterior side of the walls.

Note A-9.23.13.6.(3~~5~~) ~~and (6)~~ Use of Gypsum Board ~~Interior Finish~~ to Provide Required Bracing.

Braced wall panels constructed with gypsum board alone provide less resistance to lateral loads than panels constructed with OSB, waferboard, plywood or diagonal lumber board.~~;~~ ~~Sentence (5)~~Sentence 9.23.13.6.(3)-2025 ~~therefore~~ limits the use of gypsum board ~~to interior walls. Sentence (6) further limits its use~~ to provide the required lateral resistance by requiring that walls in basements and crawl spaces~~not more than 15 m apart~~ be constructed with braced wall panels made of ~~wood or~~ wood-based sheathing at braced wall band spacing intervals of not more than 15 m~~.~~ (s~~S~~ee Figure A-9.23.13.6.(3~~5) and (6~~)).

Figure [A-9.23.13.6.(35) and (6)] A-9.23.13.6.(5) and (6)
Braced wall panels constructed of wood-based ~~material~~sheathing in basements and crawl spaces



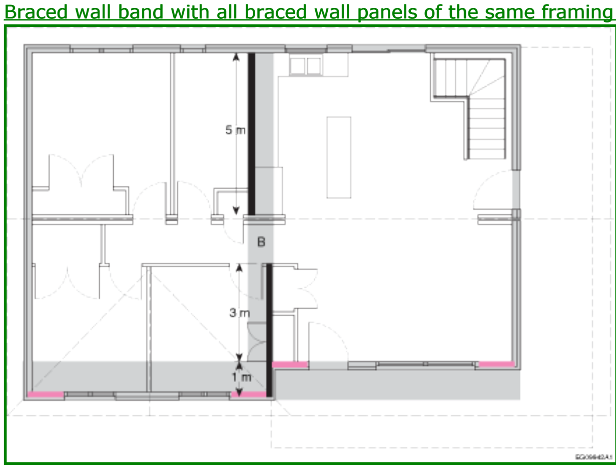
Note A-9.23.13.6.(5) Mixing of Braced Wall Panel Framing Types in Braced Wall Bands.

The primary reason for mixing braced wall panel framing types in braced wall bands is to accommodate situations where an interior panel of a GWB framing type aligns with an exterior panel of a WSP framing type along the same braced wall band. Clause 9.23.13.6.(5)(a)-2025 permits panels of a GWB framing type to be mixed with panels of "low-strength" WSP-A or WSP-B framing type. Mixing of high-strength or very stiff walls with low-strength or less stiff walls requires analysis based on accepted engineering principles (Clause 9.23.13.6.(5)(b)-2025), as this type of mixing has not been sufficiently studied.

The following example is provided to assist in the application of Clause 9.23.13.6.(5)(a)-2025. Figures A-9.23.13.6.(5)-A and A-9.23.13.6.(5)-B illustrate the same braced wall band (B) without and with mixed braced wall panel framing types, respectively.

In Figure A-9.23.13.6.(5)-A, the braced wall band (B) consists of an exterior wall with a length of 1 m, which continues into the building as a first interior wall with a length of 3 m and a second interior wall with a length of 5 m for a total wall length of 9 m. The wall construction along the braced wall band qualifies as braced wall panels of GWB-B framing type. For this example, it is determined according to Article 9.23.13.7. that a total length of braced wall panels of at least 8 m is required for the GWB-B framing type. Therefore, the wall length of 9 m is sufficient to satisfy this requirement.

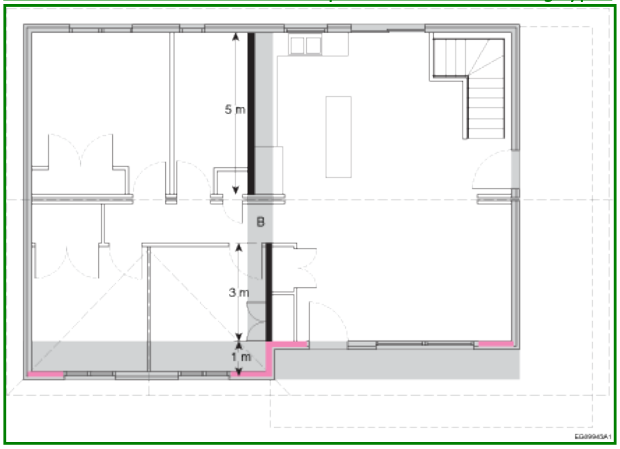
Figure [A-9.23.13.6.(5)-A]
Braced wall band with all braced wall panels of the same framing type



In Figure A-9.23.13.6.(5)-B, the exterior walls are constructed with braced wall panels of WSP-A framing type. The builder would like to substitute WSP-A framing type for GWB-B framing type in the 1 m exterior wall portion of the braced wall band

(B). Clause 9.23.13.6.(5)(a)-2025 permits such a substitution, as long as the total length of braced wall panels is determined based on the GWB-B framing type. As mentioned above, in this example, the required total length of braced wall panels is 8 m for this framing type. Therefore, the total wall length of 9 m (1 m (WSP-A) + 3 m (GWB-B) + 5 m (GWB-B)) is sufficient to meet the requirement.

Figure [A-9.23.13.6.(5)-B]
Braced wall band with braced wall panels of mixed framing types



Note A-9.23.13.7.(3) Alternative Procedure for Calculating L_w.

To facilitate the calculation of the minimum total length of braced wall panels for resistance to wind, L_w, unadjusted minimum total braced wall panel lengths, L_{uw}, are provided in Table 9.23.13.7.-A for various ranges of 1-in-50-year hourly wind pressure (HWP), in kPa. The L_{uw} values are based on the highest HWP in each range and must be adjusted by the factors provided in Table 9.23.13.7.-C.

In lieu of following this procedure, L_w may be calculated directly using the following equation:

$$L_w = C_{Wstorey} K_{Wframe} HWP(K_{exp} K_{roof} K_{Wspacing} K_{Wnumber} K_{gyp} K_{sheath}) \geq BWP_{min}$$

where:

$C_{Wstorey}$	= coefficient for storey location for wind, = 3.84 for braced wall panels supporting a roof only, = 7.89 for braced wall panels supporting a roof and 1 floor, and = 11.93 for braced wall panels supporting a roof and 2 floors,
K_{Wframe}	= framing type adjustment factor for wind, as provided in Table A-9.23.13.7.(3), and
K_{exp}, K_{roof}, $K_{Wspacing}$, $K_{Wnumber}$, K_{gyp}, K_{sheath}, BWP_{min}	= as defined in Sentence 9.23.13.7.(3).

Table A-9.23.13.7.(3) provides framing type adjustment factors for wind and for seismic forces, K_{Wframe} and K_{Sframe}, along with factored shear resistance values based on CSA O86, "Engineering design in wood," for the reference framing types specified in Table 9.23.3.5.-C. This information can be used to calculate the minimum total length of braced wall panels for wind or for seismic forces, L_w or L_s, using the alternative calculation procedure set out in this Note or in Note A-9.23.13.7.(4).

Table [9.23.13.7.(3)] A-9.23.13.7.(3)
Framing Type Adjustment Factors and Factored Shear Resistance Values

Reference Framing Type	K_{Wframe}	K_{Sframe} (1) (2)	Factored Shear Resistance, kN/m (3) (4)
GWB-O (interior side of WSP and DWB framing types)	–	–	0.61
GWB-A	2.85	4.28	1.15
GWB-B	1.65	2.48	1.98
GWB-C	1.23	1.84	2.67
GWB-D	1.00	1.50	3.28

WSP-A	1.00	1.00	3.28
WSP-B	0.53	0.53	6.22
WSP-C	0.46	0.46	7.15
WSP-D	0.42	0.42	7.85
WSP-E	0.38	0.38	8.71
DWB	0.57	0.57	5.77

Notes to Table [9.23.13.7.(3)] A-9.23.13.7.(3):

(1) See Note A-9.23.13.7.(4).

(2) K_{Sframe} accounts for the difference in ductility-related force modification factor, R_d, for WSP (R_d = 3) and GWB (R_d = 2) framing types.

(3) Factored shear resistance values for WSP and DWB framing types include a contribution of 0.61 kN/m from GWB-O installed on opposite side of the *braced wall panel*. The value for the DWB framing type is based on spruce-pine-fir (SPF) studs and northern species diagonal lumber boards. Compared to CSA O86, "Engineering design in wood," the value for the WSP-C framing type was reduced by a factor of 0.20, the value for the WSP-D framing type was reducd by a factor of 0.30, and the value for the WSP-E framing type was reduced by a factor of 0.40, to account for the absence of hold-downs.

(4) Factored shear resistance values for GWB framing types are derived from allowable stress shear resistance values (average peak shear divided by safety factor of 3), soft converted to specified shear resistances, consistent with the practice used in CSA O86, "Engineering design in wood." The resulting factored resistance values are determined in the same way as for WSP framing types, except that a resistance factor of 0.7 is applied for GWB framing types instead of the factor of 0.8 applicable to WSP framing types.

If the value of L_w calculated by either the procedure set out in Sentence 9.23.13.7.(3) or the alternative calculation procedure exceeds the available wall length, a stronger framing type or a closer braced wall band spacing may be considered.

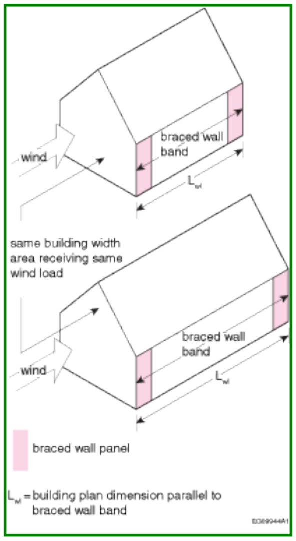
Note A-9.23.13.7.(3) and (4) Factors in Determining L_w and L_s.

Parallel Building Plan Dimension

The equations provided in Sentences 9.23.13.7.(3) and (4)-2025 are used to calculate the minimum total length of braced wall panels, L_w or L_s, within a braced wall band parallel to the direction of the wind or seismic forces.

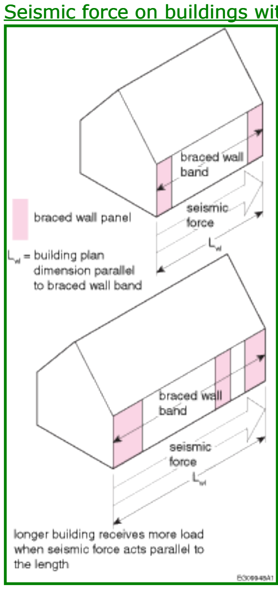
For resistance to wind, the building plan dimension (length) parallel to the direction of the wind is irrelevant to determining the amount of bracing required. As shown in Figure A-9.23.13.7.(3) and (4)-A, a building with a smaller length receives the same wind force as a building of the same width with a larger length. Therefore, in calculating L_w, the braced wall band spacing along the building width needs to be considered, but the building length does not.

Figure [A-9.23.13.7.(3) and (4)-A]
Wind force on buildings with different lengths



In contrast, for resistance to seismic forces, the building plan dimension (length) parallel to the direction of the seismic force is the most important consideration in determining the amount of bracing required. The force demand exerted on a building by seismic motion is directly proportional to the building's mass, which is generally evenly distributed along its length and width. As shown in Figure A-9.23.13.7.(3) and (4)-B, a building with a larger length has more mass—and thus receives greater seismic force—than a building of the same width with a smaller length. Therefore, a longer building will require a larger amount of bracing. The calculated value of L_w is highly dependent on the building length and is less dependent on the building width.

Figure [A-9.23.13.7.(3) and (4)-B]
Seismic force on buildings with different lengths



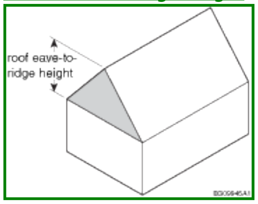
Wind Exposure (L_w only)

K_{exp} accounts for the effects of the local terrain where the building in located. Rough terrain, defined as urban, suburban or wooded terrain extending upwind from the building uninterrupted for a least 1 km, offers a sheltered exposure. A building located in open terrain, defined as level terrain with only scattered trees, buildings or other obstructions, open water or shorelines, will experience a higher wind load than would the same building located in rough terrain and will require a larger amount of bracing.

Roof Eave-to-Ridge Height (L_w only)

K_{roof} accounts for the effects of the roof eave-to-ridge height, as illustrated in Figure A-9.23.13.7.(3) and (4)-C.

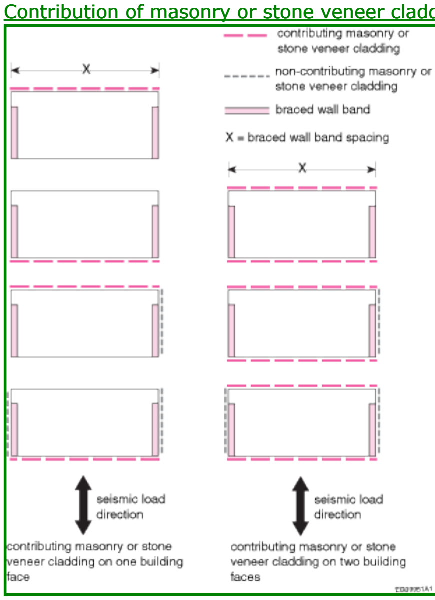
Figure [A-9.23.13.7.(3) and (4)-C]
Roof eave-to-ridge height



Weight of Construction and Cladding (L_s only)

K_{weight} accounts for construction weights higher than normal-weight construction, since heavier buildings generate higher seismic loads. The value of K_{weight} depends on the building's weight of construction and on the presence of masonry or stone veneer cladding on one or two building faces. As illustrated in Figure A-9.23.13.7.(3) and (4)-D, only veneer cladding on building faces perpendicular to the direction of the seismic motion is assumed to contribute to the seismic load.

Figure [A-9.23.13.7.(3) and (4)-D]
Contribution of masonry or stone veneer cladding to seismic loading



Braced wall panels that run perpendicular to masonry- or stone-veneer-clad walls must have a higher lateral strength to resist the increased lateral loading due to the higher mass of the veneer-clad walls. Under seismic action perpendicular to the veneer-clad walls, the lateral load due to the mass of the masonry or stone veneer is transferred into the wall immediately behind the veneer. The load is then transferred, via the load path and diaphragm action, into the roof and floors, and is resisted by the braced wall panels oriented parallel to the seismic motion.

Therefore, only braced wall panels running perpendicular to the masonry- or stone-veneer-clad walls are required to be adjusted by K_{weight}. If the entire building is clad with masonry or stone veneer, all braced wall panels are required to be adjusted by the appropriate K_{weight} value for "both building faces." If only two parallel faces of a four-sided building are clad with masonry or stone veneer, only the two braced wall panels perpendicular to those faces are required to be adjusted by the appropriate K_{weight} value for "both building faces." If only one face of the building is clad with masonry or stone veneer, the two braced wall panels perpendicular to that face are required to be adjusted by the appropriate K_{weight} value for "one building face."

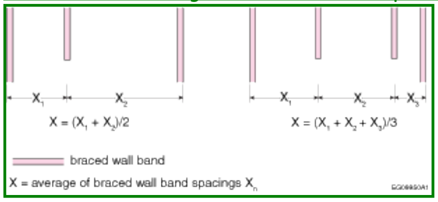
Roof Snow Load (L_s only)

K_{snow} accounts for the effects of a specified roof snow load larger than 2 kPa.

Braced Wall Band Spacing

$K_{Wspacing}$ and $K_{Sspacing}$ account for the effects of the spacing between braced wall bands, X. When the spacing between three or more parallel braced wall bands is not uniform, the average spacing may be used in lieu of the largest spacing for the determination of $K_{Wspacing}$ and $K_{Sspacing}$, as set out in Sentence 9.23.13.7.(5) and illustrated in Figure A-9.23.13.7.(3) and (4)-E.

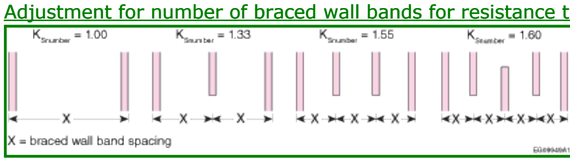
Figure [A-9.23.13.7.(3) and (4)-E]
Calculation of average braced wall band spacing



Number of Parallel Braced Wall Bands

$K_{Wnumber}$ and $K_{Snumber}$ account for the effects of having more than two braced wall bands resist the wind or seismic load, as illustrated for $K_{Snumber}$ in Figure A-9.23.13.7.(3) and (4)-F. Since the total minimum braced wall panel lengths are determined based on the braced wall band spacing, the $K_{Wnumber}$ and $K_{Snumber}$ is needed to account for the actual distribution of loads over the braced wall bands.

Figure [A-9.23.13.7.(3) and (4)-F]
Adjustment for number of braced wall bands for resistance to seismic forces



For example, consider a building 15 m wide with one interior and two exterior braced wall bands at a spacing of 7.5 m. A uniform seismic load of 10 kN/m is applied to the width area of the building. Equally distributing this seismic load to the three braced wall bands results in a force distribution of (10 kN/m × 15 m)/3 = 50 kN per braced wall band. However, based on the braced wall band spacing of 7.5 m, each braced wall band would receive only (10 kN/m × 7.5 m)/2 = 37.5 kN per braced wall band. $K_{Snumber}$ corrects the calculated minimum total braced wall panel length by applying, for 3 braced wall bands, a factor of 50 kN/37.5 kN = 1.33. As the number of braced wall bands increases, the effect diminishes.

The same explanation applies for $K_{Wnumber}$, except that the wind forces are not evenly distributed because the critical load case occurs when the wind blows at an angle to the building. As a result, the $K_{Wnumber}$ values differ slightly from the $K_{Snumber}$ values.

Interior Gypsum Board

K_{gyp} accounts for the effects of omitting gypsum board from the interior side of braced wall panels. If gypsum board is omitted, the minimum total braced wall panel length is increased.

Intermittent Braced Wall Panels

K_{sheath} accounts for the effects of intermittent sheathing of braced wall bands. Where the braced wall band is intermittently sheathed, the minimum total braced wall panel length is increased. In braced wall bands with intermittent braced wall panels, non-structural sheathing may be used for wall segments where bracing is not required (Figure A-9.23.13.7.(3) and (4)-G). The K_{sheath} factor adjusts for the lack of additional resistance that would have been provided by structural sheathing above and below openings and on other wall segments not designated as braced wall panels if the entire braced wall band were continuously sheathed (Figure A-9.23.13.7.(3) and (4)-H).

Figure [A-9.23.13.7.(3) and (4)-G]
Intermittent braced wall panels in braced wall bands

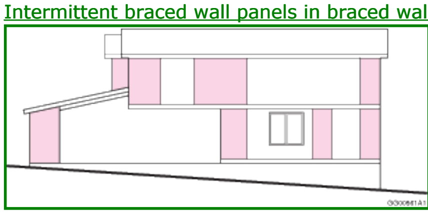
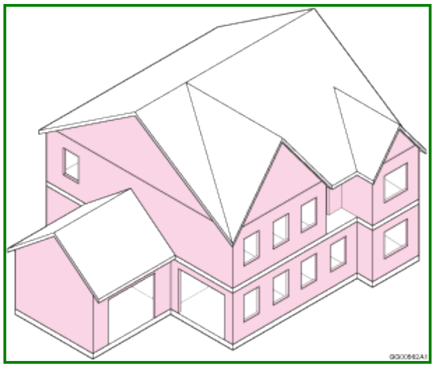


Figure [A-9.23.13.7.(3) and (4)-H]
Continuously sheathed braced wall bands



In continuously wood-sheathed braced wall bands, wall segments not designated as braced wall panels must be constructed with wood sheathing, but must not necessarily be constructed with the same sheathing and fastening as used in the designated braced wall panels. Instead, the non-designated wall segments may be constructed with any of the wood sheathing element options (plywood, OSB, or waferboard) and corresponding fastening as specified in Table 9.23.3.5.-A, anchored in accordance with Sentence 9.23.6.1.(2).

Note A-9.23.13.7.(4) Alternative Procedure for Calculating L_s.

To facilitate the calculation of the minimum total length of braced wall panels for resistance to seismic forces, L_s, unadjusted minimum total braced wall panel lengths, L_{us}, are provided in Table 9.23.13.7.-C for various ranges of seismic design parameter, S_{max}. The L_{us} values are based on the highest S_{max} in each range and must be adjusted by the factors provided in Table 9.23.13.7.-D.

In lieu of following this procedure, L_s, may be calculated directly using the following equation:

$$L_s = (C_{Sstorey} C_{walls} C_{roof} S)(K_{Sframe} S_{max} K_{weight} K_{Sspacing} K_{Snumber} K_{gyp} K_{sheath}) \geq BWP_{min}$$

where:

$C_{Sstorey}$	= coefficient of storey location for seismic forces, = 1 for braced wall panels supporting a roof only, = 3 for braced wall panels supporting a roof and 1 floor, and = 5 for braced wall panels supporting a roof and 2 floors,
C_{walls}	= coefficient accounting for seismic weight based on L_{wl} for walls, as provided in Table A-9.23.13.7.(4),
C_{roof}	= coefficient accounting for seismic weight based on L_{wl} for roofs, as provided in Table A-9.23.13.7.(4),
S	= specified roof snow load, in kPa, as calculated in accordance with Article 9.4.2.2.,
K_{Sframe}	= framing type adjustment factor, as provided in Table A-9.23.13.7.(3), and
K_{weight}, K_{snow}, $K_{Sspacing}$, $K_{Snumber}$, K_{gyp}, K_{sheath}, BWP_{min}	= as defined in Sentence 9.23.13.7.(4).

Table [9.23.13.7.(4)] A-9.23.13.7.(4)
Coefficients for Seismic Forces, C_{walls} and C_{roof}

Building Plan Dimension Parallel to Braced Wall Band, L_{wl}, m	C_{walls} (1)	C_{roof} (1)
3.1	0.38	0.09
6.1	0.60	0.17
9.1	0.83	0.26
12.2	1.06	0.35
15.5	1.29	0.43
18.3	1.52	0.52

Note to Table [9.23.13.7.(4)] A-9.23.13.7.(4):

(1) Linear interpolation between L_{wl} values is permitted.

This alternative calculation procedure may be used to determine L_s for cases designated as "DR" (design required) in Table 9.23.13.7.-C.

If the value of L_s calculated by either the procedure set out in Sentence 9.23.13.7.(4) or the alternative calculation procedure exceeds the available wall length, a stronger framing type or a closer braced wall band spacing may be considered.

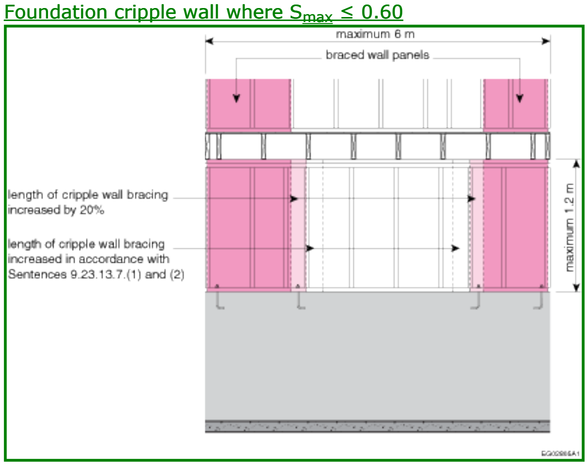
Note A-9.23.13.8. Foundation Cripple Walls.

Cripple walls are also known as "pony walls" or "knee walls." In Section 9.23., the term "cripple walls" refers to short wood-frame stud walls extending from the top of the foundation wall to the underside of the lowest floor framing.

Studies have demonstrated that wood-frame foundation walls with low racking resistance, such as unbraced or insufficiently braced cripple walls, do not have adequate capacity to resist seismic loading. Such walls have led to the failure of buildings in earthquakes. Where cripple walls do not meet the conditions of Sentences 9.23.13.8.(2) to (4)-2025, they need to be considered as an additional storey, or designed in accordance with Part 4 to ensure that they resist both in-plane and out-of-plane forces. Information on cripple walls can be found in the Commentary entitled Design for Seismic Effects in the "Structural Commentaries (User's Guide – NBC 2020: Part 4 of Division B)."

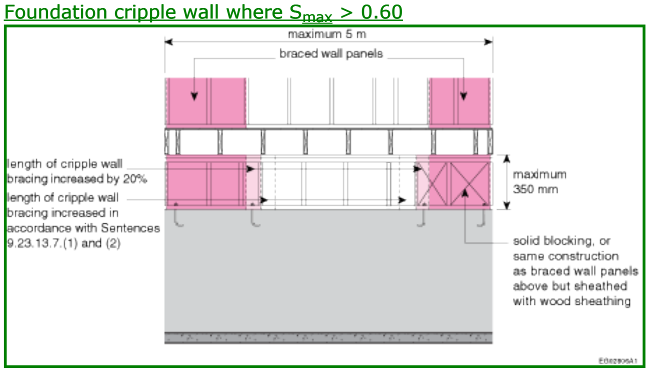
Note A-9.23.13.8.(2) Foundation Cripple Walls Where $S_{max} \leq 0.60$.

Figure [A-9.23.13.8.(2)]
Foundation cripple wall where $S_{max} \leq 0.60$



Note A-9.23.13.8.(3). Foundation Cripple Walls Where $S_{max} > 0.60$.

Figure [A-9.23.13.8.(3).]
Foundation cripple wall where $S_{max} > 0.60$



Note A-9.23.13.9.(1) Cripple Walls in Stepped Foundations.

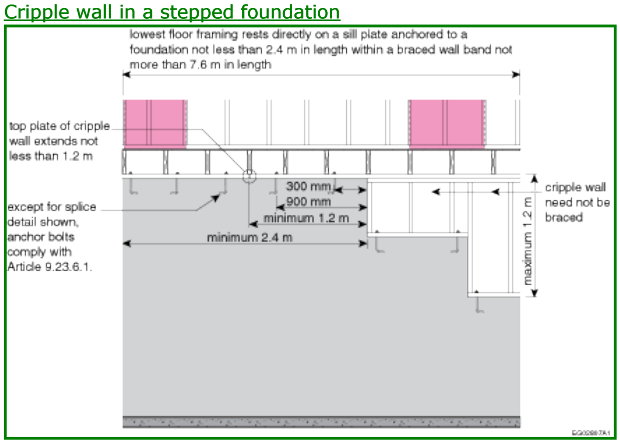
The conditions of Sentence 9.23.13.9.(1) are intended to establish whether the stepped foundation provides sufficient bracing for the braced wall band it supports. If the bracing is not considered to be sufficient, the provisions of Sentences 9.23.13.8.(2) to (4) for the appropriate value of S_{max} apply.

Where the foundation is less than 2.4 m in length, the attachment to the foundation is insufficient to complete the lateral load path for the first-storey braced wall band. In this case, the cripple wall needs to be braced, and there is no need for the top plate to be anchored to the foundation, although it would be good practice.

Where the foundation is at least 2.4 m in length and the top plate of the cripple wall is adequately anchored to the foundation wall, the cripple wall itself does not need to be braced, provided its height does not exceed 1.2 m.

Where the cripple wall exceeds 1.2 m in height, it must be considered as a storey or designed in accordance with Part 4 (see Sentence 9.23.13.8.(1)), regardless of the adequacy of the bracing it provides.

Figure [A-9.23.13.9.(1)]
Cripple wall in a stepped foundation



Note A-9.23.13.10~~5~~.(2~~3~~) Attachment of a Porch Roof to Exterior Wall Framing.

Figure [A-9.23.13.105.(23)-A] A-9.23.13.5.(3)-A
Porch roof framing perpendicular to wall framing between floors

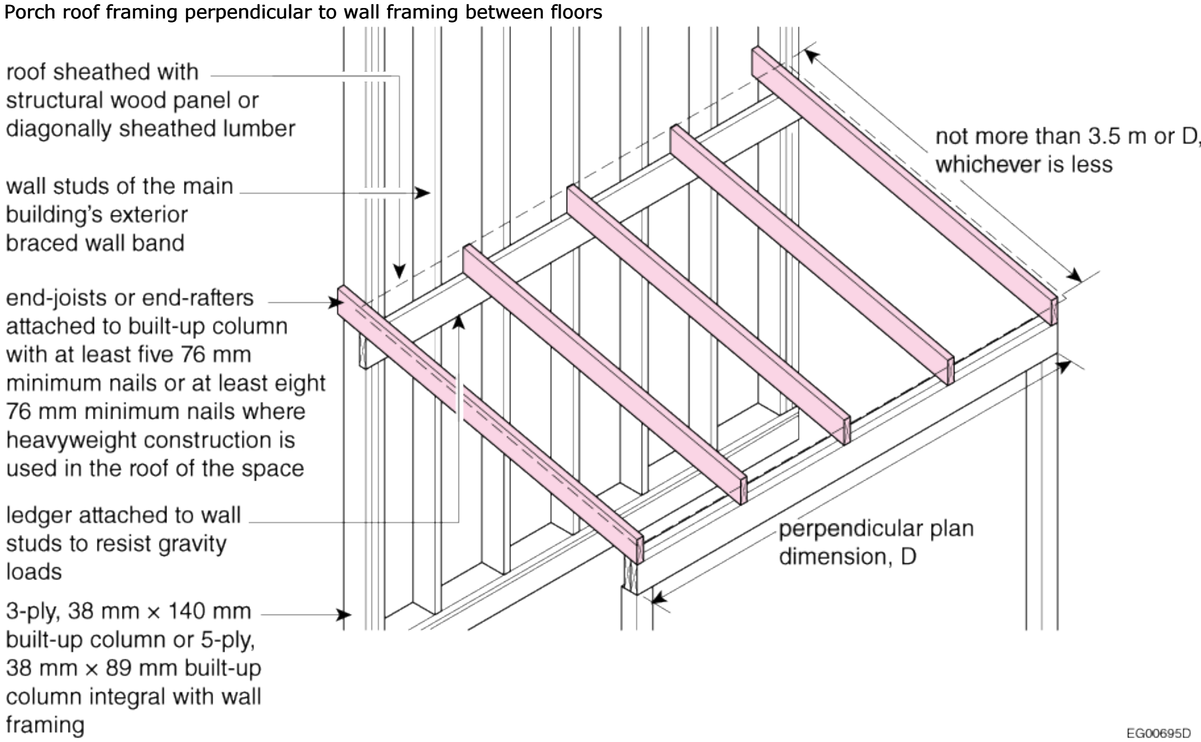
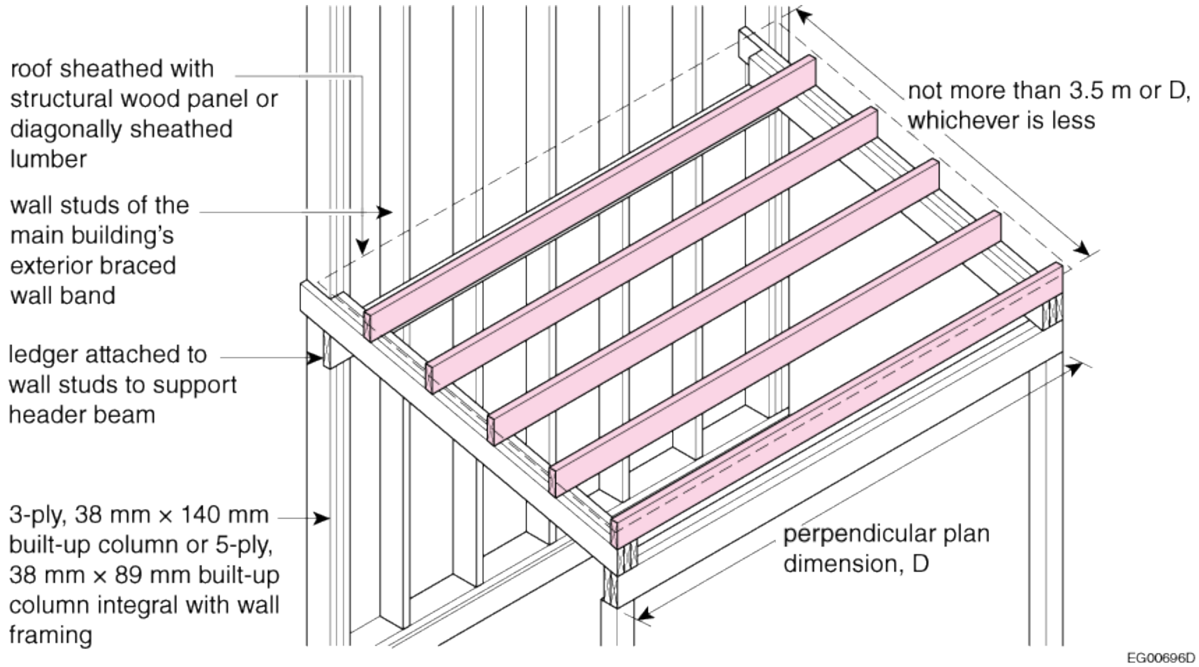


Figure [A-9.23.13.105.(23)-B] A-9.23.13.5.(3)-B
Porch roof framing parallel to wall framing between floors



[9.23.16.1.] 9.23.16.1. Required Roof Sheathing

[1] 1) Except where the 1-in-50-year hourly wind pressure (HWP) is less than 0.8 kPa and the seismic ~~spectral acceleration~~design parameter, ~~$S_a(0.2)$~~S_{max}, for Site Class C is less than or equal to ~~0.70~~0.47, continuous lumber or panel-type roof sheathing shall be installed to support the roofing.

[9.23.16.5.] 9.23.16.5. Lumber Roof Sheathing

[1] 1) Lumber roof sheathing shall not be more than 286 mm wide and shall be applied so that all ends are supported with end joints staggered.

[2] 2) Lumber roof sheathing shall be installed diagonally, where

[a] a) the seismic ~~spectral acceleration~~design parameter, ~~$S_a(0.2)$~~S_{max}, for Site Class C is greater than ~~0.70~~0.47 but not greater than ~~1.2~~0.8, or

[b] b) the 1-in-50-year hourly wind pressure (HWP) is equal to or greater than 0.8~~0~~ kPa but less than 1.2~~0~~ kPa.

[3] 3) Lumber roof sheathing shall be designed according to Part 4, where

[a] a) the seismic ~~spectral acceleration~~design parameter, ~~$S_a(0.2)$~~S_{max}, for Site Class C is greater than ~~1.2~~0.8, or

[b] b) the 1-in-50-year hourly wind pressure (HWP) is equal to or greater than 1.2~~0~~ kPa.

[9.31.6.2.] 9.31.6.2. Equipment and Installation

[1] 3) Where the *building* is in a location where the ~~spectral acceleration~~seismic design parameter, ~~$S_a(0.2)$~~S_{max}, for Site Class C is greater than ~~0.55~~0.37, *service water heaters* shall be secured to the structure to prevent overturning. (See Note A-9.31.6.2.(3).)

[9.33.4.7.] 9.33.4.7. Structural Movement

[1] 2) Where the *building* is in a location where the ~~spectral acceleration~~seismic design parameter, ~~$S_a(0.2)$~~S_{max}, for Site Class C is greater than ~~0.55~~0.37, heating and air-conditioning equipment with fuel or power connections shall be secured to the structure to resist overturning and displacement. (See Note A-9.31.6.2.(3).)

Impact analysis

The impact analysis looks at the cost difference between a base scenario (NBC 2020 lateral loads provisions with the seismic values in Table C-3 of the NBC 2020) and two other scenarios (Scenario A: NBC 2020 lateral loads provisions with updated seismic hazard values; and Scenario B: proposed lateral loads provisions with updated seismic hazard values).

Several iterations of the impact analysis were completed using the seismic design parameters and 1-in-50-year hourly wind pressures for 7 locations (Victoria, BC; Lethbridge AB; Winnipeg, MB; Ottawa, ON; Montréal, QC; St. John's, NL; and Whitehorse, YT). For each of these locations a duplex, stacked town, and bungalow archetypes were used. The costs for various wall assemblies representing braced wall panels from the NBC 2020 and braced wall framing types included in the proposed change were costed using RSMeans software. The cost analysis does not determine the overall wall or building costs; instead it compares the difference in cost between the above-noted scenarios.

The impact analysis (refer to the supporting documents) found that, in general, there will be an increased cost in each of the locations analyzed, with the difference in cost ranging from −0.01% to 0.59% (−$43.60 to $1,142.43) of the average building cost of a home (obtained from Altus Group's 2022 Canadian Cost Guide).

The impact analysis shows how the two types of changes within PCF 1475 affect the cost increase in different ways. Scenario A evaluates how the increase in seismic hazard values impacts construction costs. This impact affects locations like Victoria, which sees a construction cost increase ranging from 0.24% to 1.15% ($1,242.73 to $2,955.67) across the three archetypes. The increase in seismic hazard values also pushes some locations, like Montréal, above the existing lateral loads design trigger value, which is why Montréal sees a construction cost increase ranging from 0.4% to 0.76% ($1,095.89 to $1,525.99) across the archetypes. The other five cities that were analyzed were not pushed above the existing lateral loads design trigger values and therefore do not see an increase in construction cost as a result of the updated seismic hazard values.

PCF 1475 introduces new lateral loads design provisions that are more precise and therefore less conservative than the existing provisions. Consequently, when Scenario B evaluates the construction cost increase associated with updating the seismic hazard values in conjunction with the proposed lateral loads provisions, we see a softening of the increased construction cost for locations that require lateral loads design when subjected to the updated seismic hazard values. Victoria goes from a cost increase range of 0.24% to 1.15% ($1,242.73 to $2,955.67) in Scenario A to a range of −0.01% to 0.25% (−$43.60 to $633.35) in Scenario B. Montréal sees a similar softening of the cost increase in Scenario B relative to Scenario A. The other five cities analyzed see an increase in construction cost ranging from 0.05% to 0.45% ($165.10 to $863.05).

PCF 1475 also includes a Simplified Approach for lateral loads design, which provides conservative minimum braced wall lengths, as evidenced by the resulting construction cost increase of 0.62% ($1,230.03) compared to the 0.41% ($800.81) cost increase for that same location using the normal lateral loads design approach.

Finally, for construction of exterior walls where rigid insulation is used as exterior sheathing in low wind and seismic zones, the impact is greater than typical exterior wall construction, with a difference in construction cost increase range of 0.11% to 0.55% ($352.25 to $1,088.17) compared to that location’s cost increase range of 0.05% to 0.41% ($165.10 to $800.81) when using typical exterior wall construction.

Assumptions:

Where Part 4 design was required, it was assumed that the wall lengths would be increased by 10%, and the cost of hiring a professional engineer was represented as a 1% increase to the construction cost of the home.

Where a city that was analyzed had several options for the type of braced wall panel assembly that could be used, the weakest assembly was selected, unless other portions of that wall façade required another thickness of exterior sheathing, in which case the sheathing thickness dictated the assembly selection.

The Altus Group housing construction data did not include average prices for energy efficient homes, so the cost analysis for an energy efficient home used the cost of normal construction as a comparison.

The labour cost to nail exterior sheathing to the studs was assumed to represent 25% of the overall labour cost to install sheathing (used when data from RSMeans needed to be interpolated).

Limitations:

This is a small subset of all the locations in Canada. The general conclusions above will not necessarily apply everywhere.

Three archetypes were analyzed and the duplex and stacked town archetypes were selected because they included an analysis of a party wall situation, which was meant to represent how a row house could be impacted by PCF 1475.

The analysis was limited to normal weight construction.

The analysis did not examine the benefits of finding a Site Class of A, B, C or D.

National average material costs were used.

To be consistent with the guidelines for impact analysis in Appendix G of the CCBFC Policies and Procedures 2016, this impact analysis did not account for escalation costs (e.g., fluctuations in direct costs for wood materials).

Enforcement implications

This proposed change will require some additional review of building permit applications to ensure that the proper design and construction approach has been taken.

Who is affected

Designers and builders with respect to design, build and construction.

Building owners would bear any increase in costs but would benefit from a reduced probability or degree of property loss in the case of an earthquake.

Supporting Document(s)

Review of Structural Materials and Methods for Home Building in the United States: 1900 to 2000 (review_of_structural_materials_and_methods.pdf)
PCFs 1475 and 1775 on Lateral Loads: Combined Impact Analysis (nbc20_pcfs_1475_and_1775_combined_impact_analysis.pdf)

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[9.4.1.1.] 9.4.1.1. ([1] 1) no attributions

[9.4.1.1.] 9.4.1.1. ([2] 2) no attributions

[9.4.1.1.] 9.4.1.1. ([3] 3) no attributions

[9.4.2.1.] 9.4.2.1. ([1] 1) no attributions

[9.4.2.2.] 9.4.2.2. ([1] 1) [F20-OS2.1,OS2.3] [F22-OS2.3]

[9.4.2.2.] 9.4.2.2. ([1] 1) [F20-OP2.1,OP2.3] [F22-OP2.3]

[9.4.2.2.] 9.4.2.2. ([1] 1) [F22-OH1.1,OH1.2,OH1.3]

[9.4.2.2.] 9.4.2.2. ([2] 2) [F20-OS2.1]

[9.4.2.2.] 9.4.2.2. ([2] 2) [F20-OP2.1]

[9.4.2.2.] 9.4.2.2. ([3] 3) no attributions

[9.4.2.2.] 9.4.2.2. ([4] 4) [F20-OS2.1,OS2.3] [F22-OS2.3]

[9.4.2.2.] 9.4.2.2. ([4] 4) [F20-OP2.1,OP2.3] [F22-OP2.3]

[9.4.2.2.] 9.4.2.2. ([4] 4) [F22-OH1.1,OH1.2,OH1.3]

[9.4.2.2.] 9.4.2.2. ([5] 5) no attributions

[9.4.2.3.] 9.4.2.3. ([1] 1) [F20-OS2.1]

[9.4.2.3.] 9.4.2.3. ([1] 1) [F20-OP2.1]

[9.4.2.4.] 9.4.2.4. ([1] 1) [F20-OS2.1]

[9.4.2.4.] 9.4.2.4. ([1] 1) [F20-OP2.1]

[9.4.2.5.] -- ([1] --) [F20-OS2.1]

[9.4.2.5.] -- ([1] --) [F20-OP2.1]

[9.4.2.5.] -- ([2] --) [F20-OS2.1]

[9.4.2.5.] -- ([2] --) [F20-OP2.1]

[9.20.1.1.] 9.20.1.1. ([1] 1) no attributions

[9.20.1.1.] 9.20.1.1. ([2] 2) no attributions

[9.20.1.2.] 9.20.1.2. ([1] 1) no attributions

[9.20.1.2.] 9.20.1.2. ([2] 2) no attributions

[9.23.1.1.] 9.23.1.1. ([1] 1) no attributions

[9.23.1.1.] 9.23.1.1. ([2] 2) no attributions

[9.23.3.1.] 9.23.3.1. ([1] 1) [F20-OS2.1] [F20,F22-OS2.5] [F20,F22-OS2.3]

[9.23.3.1.] 9.23.3.1. ([1] 1) [F20-OP2.1] [F20,F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.3.1.] 9.23.3.1. ([1] 1) [F20,F22-OS1.2]

[9.23.3.1.] 9.23.3.1. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.3.1.] 9.23.3.1. ([1] 1) [F22-OH4]

[9.23.3.1.] 9.23.3.1. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.3.1.] 9.23.3.1. ([2] 2) [F20-OS2.1] [F20,F22-OS2.5] [F20,F22-OS2.3]

[9.23.3.1.] 9.23.3.1. ([2] 2) [F20-OP2.1] [F20,F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.3.1.] 9.23.3.1. ([2] 2) [F20,F22-OS1.2]

[9.23.3.1.] 9.23.3.1. ([2] 2) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.3.1.] 9.23.3.1. ([2] 2) [F22-OH4]

[9.23.3.1.] 9.23.3.1. ([2] 2) [F22-OS3.1] [F22-OS3.7]

[9.23.3.1.] 9.23.3.1. ([3] 3) [F20-OS2.1] [F20,F22-OS2.5] [F20,F22-OS2.3]

[9.23.3.1.] 9.23.3.1. ([3] 3) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.3.1.] 9.23.3.1. ([3] 3) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.3.1.] 9.23.3.1. ([3] 3) [F20,F22-OS1.2]

[9.23.3.1.] 9.23.3.1. ([3] 3) [F22-OH4]

[9.23.3.1.] 9.23.3.1. ([3] 3) [F22-OS3.1] [F22-OS3.7]

[9.23.3.4.] 9.23.3.4. ([1] 1) [F20-OS2.1] [F20,F22-OS2.5] [F20,F22-OS2.3]

[9.23.3.4.] 9.23.3.4. ([1] 1) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.3.4.] 9.23.3.4. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.3.4.] 9.23.3.4. ([1] 1) [F22-OH4]

[9.23.3.4.] 9.23.3.4. ([1] 1) [F20,F22-OS1.2]

[9.23.3.4.] 9.23.3.4. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.3.4.] 9.23.3.4. ([2] 2) [F20-OS2.1] [F20,F22-OS2.5] [F20,F22-OS2.3]

[9.23.3.4.] 9.23.3.4. ([2] 2) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.3.4.] 9.23.3.4. ([2] 2) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.3.4.] 9.23.3.4. ([2] 2) [F20,F22-OS1.2]

[9.23.3.4.] 9.23.3.4. ([2] 2) [F22-OH4]

[9.23.3.4.] 9.23.3.4. ([2] 2) [F22-OS3.1] [F22-OS3.7]

[9.23.3.4.] 9.23.3.4. ([3] 3) [F20-OS2.1] [F20,F22-OS2.3] [F20,F22-OS2.5]

[9.23.3.4.] 9.23.3.4. ([3] 3) [F20-OP2.1,OP2.5] [F20,F22-OP2.3] [F22-OP2.4,OP2.5]

[9.23.3.4.] 9.23.3.4. ([3] 3) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.3.4.] 9.23.3.4. ([3] 3) [F20,F22-OS1.2]

[9.23.3.4.] 9.23.3.4. ([4] 4) [F20-OS2.1] [F20,F22-OS2.3] [F20,F22-OS2.5]

[9.23.3.4.] 9.23.3.4. ([4] 4) [F20-OP2.1,OP2.5] [F20,F22-OP2.3] [F22-OP2.4,OP2.5]

[9.23.3.4.] 9.23.3.4. ([4] 4) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.3.4.] 9.23.3.4. ([4] 4) [F20,F22-OS1.2]

[9.23.3.5.] 9.23.3.5. ([1] 1) [F22-OH4]

[9.23.3.5.] 9.23.3.5. ([1] 1) [F20,F22-OS1.2]

[9.23.3.5.] 9.23.3.5. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.3.5.] 9.23.3.5. ([1] 1) [F20-OS2.1] [F20,F22-OS2.5] [F20,F22-OS2.3]

[9.23.3.5.] 9.23.3.5. ([1] 1) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.3.5.] 9.23.3.5. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.3.5.] 9.23.3.5. ([2] 2) [F20-OS2.1] [F20,F22-OS2.5] [F20,F22-OS2.3]

[9.23.3.5.] 9.23.3.5. ([2] 2) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.3.5.] 9.23.3.5. ([2] 2) [F20,F22-OH1.1,OH1.2,OH1.3]

~~[9.23.3.5.] 9.23.3.5. ([3] 3) no attributions~~

[9.23.3.5.] 9.23.3.5. ([3] 3) [F22-OS3.7]

[9.23.3.5.] 9.23.3.5. ([3] 3) [F20-OS2.1] [F20,F22-OS2.5] [F20,F22-OS2.3]

[9.23.3.5.] 9.23.3.5. ([3] 3) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.3.5.] 9.23.3.5. ([3] 3) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.3.5.] 9.23.3.5. ([4] 4) no attributions

[9.23.3.5.] 9.23.3.5. ([5] 5) [F20-OS2.1] [F20,F22-OS2.5] [F20,F22-OS2.3]

[9.23.3.5.] 9.23.3.5. ([5] 5) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.3.5.] 9.23.3.5. ([5] 5) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.3.5.] 9.23.3.5. ([5] 5) [F22-OH4]

[9.23.3.5.] 9.23.3.5. ([5] 5) [F20,F22-OS1.2]

[9.23.3.5.] 9.23.3.5. ([5] 5) [F22-OS3.1] [F22-OS3.7]

[9.23.3.5.] 9.23.3.5. ([6] 6) [F20-OS2.1] [F20,F22-OS2.5] [F20,F22-OS2.3]

[9.23.3.5.] 9.23.3.5. ([6] 6) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.3.5.] 9.23.3.5. ([6] 6) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.3.5.] 9.23.3.5. ([6] 6) [F22-OH4]

[9.23.3.5.] 9.23.3.5. ([6] 6) [F20,F22-OS1.2]

[9.23.3.5.] 9.23.3.5. ([6] 6) [F22-OS3.1] [F22-OS3.7]

[9.23.3.5.] 9.23.3.5. ([7] 7) [F20,F22-OS2.1]

[9.23.3.5.] 9.23.3.5. ([7] 7) [F20-OP2.1] [F22-OP2.4]

[9.23.3.5.] 9.23.3.5. ([7] 7) [F22-OH4]

[9.23.3.5.] 9.23.3.5. ([7] 7) [F22-OS3.1]

[9.23.3.5.] 9.23.3.5. ([7] 7) [F20-OS1.2]

~~[9.23.3.5.] 9.23.3.5. ([8] 8) [F20-OS2.1] [F20,F22-OS2.5] [F20,F22-OS2.3]~~

~~[9.23.3.5.] 9.23.3.5. ([8] 8) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]~~

~~[9.23.3.5.] 9.23.3.5. ([8] 8) [F20,F22-OH1.1,OH1.2,OH1.3]~~

[9.23.6.1.] 9.23.6.1. ([1] 1) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]

[9.23.6.1.] 9.23.6.1. ([1] 1) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.6.1.] 9.23.6.1. ([1] 1) [F20-OH1.1,OH1.2,OH1.3]

[9.23.6.1.] 9.23.6.1. ([1] 1) [F22-OH4]

[9.23.6.1.] 9.23.6.1. ([1] 1) [F20-OS3.1]

[9.23.6.1.] 9.23.6.1. ([2] 2) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]

[9.23.6.1.] 9.23.6.1. ([2] 2) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.6.1.] 9.23.6.1. ([2] 2) [F20-OH1.1,OH1.2,OH1.3]

[9.23.6.1.] 9.23.6.1. ([2] 2) [F22-OH4]

[9.23.6.1.] 9.23.6.1. ([2] 2) [F20-OS3.1]

[9.23.6.1.] 9.23.6.1. ([4] 4) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]

[9.23.6.1.] 9.23.6.1. ([4] 4) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.6.1.] 9.23.6.1. ([4] 4) [F20-OH1.1,OH1.2,OH1.3]

[9.23.6.1.] 9.23.6.1. ([4] 4) [F22-OH4]

[9.23.6.1.] 9.23.6.1. ([4] 4) [F20-OS3.1]

~~[9.23.6.1.] 9.23.6.1. ([4] 4) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]~~

~~[9.23.6.1.] 9.23.6.1. ([4] 4) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]~~

~~[9.23.6.1.] 9.23.6.1. ([4] 4) [F20-OH1.1,OH1.2,OH1.3]~~

~~[9.23.6.1.] 9.23.6.1. ([4] 4) [F22-OH4]~~

~~[9.23.6.1.] 9.23.6.1. ([4] 4) [F20-OS3.1]~~

[9.23.6.1.] 9.23.6.1. ([5] 5) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]

[9.23.6.1.] 9.23.6.1. ([5] 5) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.6.1.] 9.23.6.1. ([5] 5) [F20-OH1.1,OH1.2,OH1.3]

[9.23.6.1.] 9.23.6.1. ([5] 5) [F22-OH4]

[9.23.6.1.] 9.23.6.1. ([5] 5) [F20,F22-OS3.1]

~~[9.23.6.1.] 9.23.6.1. ([6] 6) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]~~

~~[9.23.6.1.] 9.23.6.1. ([6] 6) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]~~

~~[9.23.6.1.] 9.23.6.1. ([6] 6) [F20-OH1.1,OH1.2,OH1.3]~~

~~[9.23.6.1.] 9.23.6.1. ([6] 6) [F22-OH4]~~

~~[9.23.6.1.] 9.23.6.1. ([6] 6) [F20-OS3.1]~~

-- (--) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]

-- (--) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

-- (--) [F20-OH1.1,OH1.2,OH1.3]

-- (--) [F22-OH4]

-- (--) [F20-OS3.1]

[9.23.11.4.] 9.23.11.4. ([1] 1) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]

[9.23.11.4.] 9.23.11.4. ([1] 1) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.11.4.] 9.23.11.4. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.11.4.] 9.23.11.4. ([1] 1) [F22-OH4]

[9.23.11.4.] 9.23.11.4. ([1] 1) [F22-OS1.2]

[9.23.11.4.] 9.23.11.4. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.11.4.] 9.23.11.4. ([2] 2) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]

[9.23.11.4.] 9.23.11.4. ([2] 2) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.11.4.] 9.23.11.4. ([2] 2) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.11.4.] 9.23.11.4. ([2] 2) [F22-OH4]

[9.23.11.4.] 9.23.11.4. ([2] 2) [F20,F22-OS1.2]

[9.23.11.4.] 9.23.11.4. ([2] 2) [F22-OS3.1] [F22-OS3.7]

[9.23.11.4.] 9.23.11.4. ([3] 3) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]

[9.23.11.4.] 9.23.11.4. ([3] 3) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.11.4.] 9.23.11.4. ([3] 3) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.11.4.] 9.23.11.4. ([3] 3) [F22-OH4]

[9.23.11.4.] 9.23.11.4. ([3] 3) [F20,F22-OS1.2]

[9.23.11.4.] 9.23.11.4. ([3] 3) [F22-OS3.1] [F22-OS3.7]

[9.23.11.4.] 9.23.11.4. ([4] 4) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]

[9.23.11.4.] 9.23.11.4. ([4] 4) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.11.4.] 9.23.11.4. ([4] 4) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.11.4.] 9.23.11.4. ([4] 4) [F22-OH4]

[9.23.11.4.] 9.23.11.4. ([4] 4) [F20,F22-OS1.2]

[9.23.11.4.] 9.23.11.4. ([4] 4) [F22-OS3.1] [F22-OS3.7]

~~[9.23.11.4.] 9.23.11.4. ([5] 5) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]~~

~~[9.23.11.4.] 9.23.11.4. ([5] 5) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]~~

~~[9.23.11.4.] 9.23.11.4. ([5] 5) [F20,F22-OH1.1,OH1.2,OH1.3]~~

~~[9.23.11.4.] 9.23.11.4. ([5] 5) [F22-OH4]~~

~~[9.23.11.4.] 9.23.11.4. ([5] 5) [F20,F22-OS1.2]~~

~~[9.23.11.4.] 9.23.11.4. ([5] 5) [F22-OS3.1] [F22-OS3.7]~~

[9.23.11.4.] 9.23.11.4. ([5] 5) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]

[9.23.11.4.] 9.23.11.4. ([5] 5) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.11.4.] 9.23.11.4. ([5] 5) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.11.4.] 9.23.11.4. ([5] 5) [F22-OH4]

[9.23.11.4.] 9.23.11.4. ([5] 5) [F20,F22-OS1.2]

[9.23.11.4.] 9.23.11.4. ([5] 5) [F22-OS3.1] [F22-OS3.7]

[9.23.11.4.] 9.23.11.4. ([5] 5) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]

[9.23.11.4.] 9.23.11.4. ([5] 5) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.11.4.] 9.23.11.4. ([5] 5) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.11.4.] 9.23.11.4. ([5] 5) [F22-OH4]

[9.23.11.4.] 9.23.11.4. ([5] 5) [F20,F22-OS1.2]

[9.23.11.4.] 9.23.11.4. ([5] 5) [F22-OS3.1] [F22-OS3.7]

[9.23.11.4.] -- ([7] --) [F20-OS2.1,OS2.5] [F22-OS2.5] [F20,F22-OS2.3]

[9.23.11.4.] -- ([7] --) [F20-OP2.1,OP2.5] [F22-OP2.4,OP2.5] [F20,F22-OP2.3]

[9.23.11.4.] -- ([7] --) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.11.4.] -- ([7] --) [F22-OH4]

[9.23.11.4.] -- ([7] --) [F20,F22-OS1.2]

[9.23.11.4.] -- ([7] --) [F22-OS3.1] [F22-OS3.7]

[9.23.13.1.] 9.23.13.1. ([1] 1) no attributions

[9.23.13.1.] 9.23.13.1. ([2] 2) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.1.] 9.23.13.1. ([2] 2) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.1.] 9.23.13.1. ([2] 2) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.1.] 9.23.13.1. ([2] 2) [F20,F22-OS1.2]

[9.23.13.1.] 9.23.13.1. ([2] 2) [F22-OS3.1] [F22-OS3.7]

[9.23.13.1.] 9.23.13.1. ([2] 2) [F20,F22-OH4]

[9.23.13.2.] 9.23.13.2. ([1] 1) no attributions

[9.23.13.2.] 9.23.13.2. ([2] 2) no attributions

[9.23.13.2.] -- ([3] --) no attributions

[9.23.13.3.] 9.23.13.3. ([1] 1) no attributions

[9.23.13.3.] 9.23.13.3. ([2] 2) no attributions

[9.23.13.4.] 9.23.13.4. ([1] 1) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.4.] 9.23.13.4. ([1] 1) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.4.] 9.23.13.4. ([1] 1) [F20,F22-OS1.2]

[9.23.13.4.] 9.23.13.4. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.13.4.] 9.23.13.4. ([1] 1) [F20,F22-OH4]

[9.23.13.4.] 9.23.13.4. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

~~[9.23.13.4.] 9.23.13.4. ([2] 2) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]~~

~~[9.23.13.4.] 9.23.13.4. ([2] 2) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]~~

~~[9.23.13.4.] 9.23.13.4. ([2] 2) [F20,F22-OH1.1,OH1.2,OH1.3]~~

~~[9.23.13.4.] 9.23.13.4. ([2] 2) [F20,F22-OS1.2]~~

~~[9.23.13.4.] 9.23.13.4. ([2] 2) [F22-OS3.1] [F22-OS3.7]~~

~~[9.23.13.4.] 9.23.13.4. ([2] 2) [F20,F22-OH4]~~

[9.23.13.4.] 9.23.13.4. ([3] 3) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.4.] 9.23.13.4. ([3] 3) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.4.] 9.23.13.4. ([3] 3) [F20,F22-OS1.2]

[9.23.13.4.] 9.23.13.4. ([3] 3) [F22-OS3.1] [F22-OS3.7]

[9.23.13.4.] 9.23.13.4. ([3] 3) [F20,F22-OH4]

[9.23.13.4.] 9.23.13.4. ([3] 3) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OS1.2]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH4]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.5.] 9.23.13.5. ([2] 2) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.5.] 9.23.13.5. ([2] 2) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.5.] 9.23.13.5. ([2] 2) [F20,F22-OS1.2]

[9.23.13.5.] 9.23.13.5. ([2] 2) [F22-OS3.1] [F22-OS3.7]

[9.23.13.5.] 9.23.13.5. ([2] 2) [F20,F22-OH4]

[9.23.13.5.] 9.23.13.5. ([2] 2) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.5.] -- ([3] --) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.5.] -- ([3] --) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.5.] -- ([3] --) [F20,F22-OS1.2]

[9.23.13.5.] -- ([3] --) [F22-OS3.1] [F22-OS3.7]

[9.23.13.5.] -- ([3] --) [F20,F22-OH4]

[9.23.13.5.] -- ([3] --) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.5.] -- ([4] --) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.5.] -- ([4] --) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.5.] -- ([4] --) [F20,F22-OS1.2]

[9.23.13.5.] -- ([4] --) [F22-OS3.1] [F22-OS3.7]

[9.23.13.5.] -- ([4] --) [F20,F22-OH4]

[9.23.13.5.] -- ([4] --) [F20,F22-OH1.1,OH1.2,OH1.3]

~~[9.23.13.5. 9.23.13.10.] 9.23.13.5. ([5 2] 3) no attributions~~

~~[9.23.13.5. 9.23.13.10.] 9.23.13.5. ([6 3] 4) no attributions~~

~~[9.23.13.5. 9.23.13.10.] 9.23.13.5. ([7 4] 5) no attributions~~

[9.23.13.6.] 9.23.13.6. ([1] 1) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.6.] 9.23.13.6. ([1] 1) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.6.] 9.23.13.6. ([1] 1) [F20,F22-OS1.2]

[9.23.13.6.] 9.23.13.6. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.13.6.] 9.23.13.6. ([1] 1) [F20,F22-OH4]

[9.23.13.6.] 9.23.13.6. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.6.] 9.23.13.6. ([8] 4) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.6.] 9.23.13.6. ([8] 4) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.6.] 9.23.13.6. ([8] 4) [F20,F22-OS1.2]

[9.23.13.6.] 9.23.13.6. ([8] 4) [F22-OS3.1] [F22-OS3.7]

[9.23.13.6.] 9.23.13.6. ([8] 4) [F20,F22-OH4]

[9.23.13.6.] 9.23.13.6. ([8] 4) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.6.] 9.23.13.6. ([3] 6) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.6.] 9.23.13.6. ([3] 6) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.6.] 9.23.13.6. ([3] 6) [F20,F22-OS1.2]

[9.23.13.6.] 9.23.13.6. ([3] 6) [F22-OS3.1] [F22-OS3.7]

[9.23.13.6.] 9.23.13.6. ([3] 6) [F20,F22-OH4]

[9.23.13.6.] 9.23.13.6. ([3] 6) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.6.] 9.23.13.6. ([7] 3) no attributions

[9.23.13.6.] 9.23.13.6. ([7] 3) no attributions

~~[9.23.13.6.] 9.23.13.6. ([6] 2) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]~~

~~[9.23.13.6.] 9.23.13.6. ([6] 2) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]~~

~~[9.23.13.6.] 9.23.13.6. ([6] 2) [F20,F22-OS1.2]~~

~~[9.23.13.6.] 9.23.13.6. ([6] 2) [F22-OS3.1]~~

~~[9.23.13.6.] 9.23.13.6. ([6] 2) [F20,F22-OH4]~~

~~[9.23.13.6.] 9.23.13.6. ([7] 3) no attributions~~

~~[9.23.13.6.] 9.23.13.6. ([8] 4) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]~~

~~[9.23.13.6.] 9.23.13.6. ([8] 4) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]~~

~~[9.23.13.6.] 9.23.13.6. ([8] 4) [F20,F22-OS1.2]~~

~~[9.23.13.6.] 9.23.13.6. ([8] 4) [F22-OS3.1] [F22-OS3.7]~~

~~[9.23.13.6.] 9.23.13.6. ([8] 4) [F20,F22-OH4]~~

~~[9.23.13.6.] 9.23.13.6. ([8] 4) [F20,F22-OH1.1,OH1.2,OH1.3]~~

~~[9.23.13.6.] 9.23.13.6. ([9] 5) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]~~

~~[9.23.13.6.] 9.23.13.6. ([9] 5) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]~~

~~[9.23.13.6.] 9.23.13.6. ([9] 5) [F20,F22-OS1.2]~~

~~[9.23.13.6.] 9.23.13.6. ([9] 5) [F22-OS3.1] [F22-OS3.7]~~

~~[9.23.13.6.] 9.23.13.6. ([9] 5) [F20,F22-OH4]~~

~~[9.23.13.6.] 9.23.13.6. ([9] 5) [F20,F22-OH1.1,OH1.2,OH1.3]~~

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OS1.2]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH4]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OS1.2]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH4]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OS1.2]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH4]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OS1.2]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH4]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.7.] -- ([5] --) no attributions

[9.23.13.7.] -- ([5] --) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.7.] -- ([5] --) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.7.] -- ([5] --) [F20,F22-OS1.2]

[9.23.13.7.] -- ([5] --) [F22-OS3.1] [F22-OS3.7]

[9.23.13.7.] -- ([5] --) [F20,F22-OH4]

[9.23.13.7.] -- ([5] --) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OS1.2]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH4]

[9.23.13.8.] -- ([1] --) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.8.] -- ([1] --) [F20-OP2.1,OS2.3,OS2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.8.] -- ([1] --) [F20,F22-OS1.2]

[9.23.13.8.] -- ([1] --) [F22-OS3.1] [F22-OS3.7]

[9.23.13.8.] -- ([1] --) [F20,F22-OH4]

[9.23.13.8.] -- ([1] --) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.8.] -- ([2] --) no attributions

[9.23.13.8.] -- ([2] --) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.8.] -- ([2] --) [F20-OP2.1,OS2.3,OS2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.8.] -- ([2] --) [F20,F22-OS1.2]

[9.23.13.8.] -- ([2] --) [F22-OS3.1] [F22-OS3.7]

[9.23.13.8.] -- ([2] --) [F20,F22-OH4]

[9.23.13.8.] -- ([2] --) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.8.] -- ([3] --) no attributions

[9.23.13.8.] -- ([3] --) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.8.] -- ([3] --) [F20-OP2.1,OS2.3,OS2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.8.] -- ([3] --) [F20,F22-OS1.2]

[9.23.13.8.] -- ([3] --) [F22-OS3.1] [F22-OS3.7]

[9.23.13.8.] -- ([3] --) [F20,F22-OH4]

[9.23.13.8.] -- ([3] --) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.8.] -- ([4] --) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.8.] -- ([4] --) [F20-OP2.1,OS2.3,OS2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.8.] -- ([4] --) [F20,F22-OS1.2]

[9.23.13.8.] -- ([4] --) [F22-OS3.1] [F22-OS3.7]

[9.23.13.8.] -- ([4] --) [F20,F22-OH4]

[9.23.13.8.] -- ([4] --) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.9.] -- ([1] --) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.9.] -- ([1] --) [F20-OP2.1,OS2.3,OS2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.9.] -- ([1] --) [F20,F22-OS1.2]

[9.23.13.9.] -- ([1] --) [F22-OS3.1] [F22-OS3.7]

[9.23.13.9.] -- ([1] --) [F20,F22-OH4]

[9.23.13.9.] -- ([1] --) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.10.] -- ([1] --) no attributions

[9.23.13.5. 9.23.13.10.] 9.23.13.5. ([5 2] 3) no attributions

[9.23.13.5. 9.23.13.10.] 9.23.13.5. ([6 3] 4) no attributions

[9.23.13.5. 9.23.13.10.] 9.23.13.5. ([7 4] 5) no attributions

[9.23.13.10.] 9.23.13.7. ([5] 1) no attributions

[9.23.13.10.] 9.23.13.7. ([6] 2)

[9.23.13.10.] 9.23.13.7. ([7] 3) no attributions

[9.23.13.10.] 9.23.13.7. ([8] 4) no attributions

~~[9.23.13.10.] 9.23.13.7. ([9] 5) no attributions~~

~~[9.23.13.10.] 9.23.13.7. ([10] 6) no attributions~~

~~[9.23.13.10.] 9.23.13.7. ([11] 7) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]~~

~~[9.23.13.10.] 9.23.13.7. ([11] 7) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]~~

~~[9.23.13.10.] 9.23.13.7. ([11] 7) [F20,F22-OS1.2]~~

~~[9.23.13.10.] 9.23.13.7. ([11] 7) [F22-OS3.1] [F22-OS3.7]~~

~~[9.23.13.10.] 9.23.13.7. ([11] 7) [F20,F22-OH4]~~

~~[9.23.13.10.] 9.23.13.7. ([11] 7) [F20,F22-OH1.1,OH1.2,OH1.3]~~

[9.23.13.10.] -- ([1] --) no attributions

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OS1.2]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH4]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OS1.2]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F22-OS3.1] [F22-OS3.7]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH4]

[9.23.13.5.] 9.23.13.5. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

-- (--) no attributions

-- (--) no attributions

-- (--) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

-- (--) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

-- (--) [F20,F22-OS1.2]

-- (--) [F22-OS3.1] [F22-OS3.7]

-- (--) [F20,F22-OH4]

-- (--) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.16.1.] 9.23.16.1. ([1] 1) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.4,OS2.5]

[9.23.16.1.] 9.23.16.1. ([1] 1) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.4,OP2.5]

[9.23.16.1.] 9.23.16.1. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.16.5.] 9.23.16.5. ([1] 1) [F20-OS2.1,OS2.3,OS2.5] [F22-OS2.3,OS2.5]

[9.23.16.5.] 9.23.16.5. ([1] 1) [F20-OP2.1,OP2.3,OP2.5] [F22-OP2.3,OP2.5]

[9.23.16.5.] 9.23.16.5. ([1] 1) [F20,F22-OH1.1,OH1.2,OH1.3]

[9.23.16.5.] 9.23.16.5. ([1] 1) [F20,F22-OS1.2]

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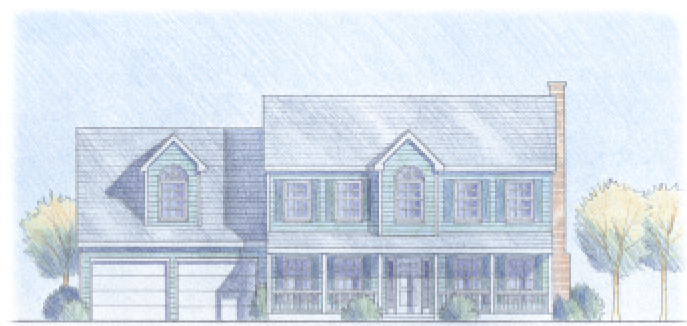
U.S. Department of Housing and Urban Development
Office of Policy Development and Research

REVIEW OF STRUCTURAL MATERIALS AND METHODS FOR HOME BUILDING IN THE UNITED STATES: 1900 to 2000



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REVIEW OF STRUCTURAL MATERIALS AND METHODS FOR HOME BUILDING IN THE UNITED STATES: 1900 to 2000

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Upper Marlboro, MD

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"In dedication to my grandfather, John O. Crandell, Sr., (1904-2000) whose experience in carpentry, home building, and construction stemmed from his desire to work and to provide for his family and others."

Jay H. Crandell
January 16, 2001

NOTICE

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INTRODUCTION

Americans have greater access to better housing today than ever before. While modern housing may be considered to be better than in the past, the process of improving housing value should include periodic evaluation to confirm past successes, consider the ramifications of past decisions, and foster future advancement in the interest of even better housing value.

This paper examines the evolvement of U.S. housing construction during the 20th century. Of particular interest are changes in construction practices associated with the materials and methods used in home building that affect structural performance. The purpose is to benchmark housing structural characteristics (as implied by historic practice), to identify significant changes that have occurred, and to provide an objective resource for discussion and evaluation of structural design implications. Other related interests, such as construction quality, are also considered.

Home building has always been rooted in practical applications of basic technology. Therefore, this study attempts to align the practical aspects of home building and its history with relevant technical data on structural performance. When available, statistics are cited with respect to housing styles, size, materials, and relevant structural aspects. Where reliable statistical data is unavailable, selected documents that define typical practices are used to arrive at reasonable historic profiles of housing construction and structural characteristics. To a limited degree, personal interviews of home builders with experience dating as far back as 1917 were conducted to compare with information found in the literature.

The study focuses on structural aspects of housing construction and breaks them into three periods of time: early 1900s, mid-1900s, and late 1900s. While it is recognized that change usually occurs slowly and that practices vary regionally, an attempt is made to typify relevant housing construction data and practices in each period. The following sections address:

- General Housing Characteristics,
- Design Loads,
- Foundation Construction,
- Wood-Frame Construction, and
- Construction Quality.

Additional information on thermal insulation materials and methods are reported in Appendix A as a matter of special interest.

1.0 GENERAL HOUSING CHARACTERISTICS

Based on *U.S. Census* data, the *Builder Practices Survey*, *Housing at the Millenium: Facts, Figures, and Trends*, and other sources (see Bibliography), a synopsis of American housing in the 20th century may be constructed for each of the following periods:

1.1 EARLY 1900S

The following characteristics describe a typical home and the housing market in 1900:

Population:	76 million (40 percent urban, 60 percent rural)
Median family income:	$490
New home price:	average unknown[1]
Type of purchase:	typically cash
Ownership rate:	46 percent
Total housing units:	16 million
Number of annual housing starts:	189,000 (65 percent single-family)
Average size (starts only):	less than 1,000 sq. ft.
Stories:	One to two stories
Bedrooms:	2 to 3
Bathrooms:	0 or 1

The front elevation and floor plan of a typical home produced in 1900 is shown in Figure 1. Good examples of traditional housing styles and architectural plans in the early 1900s are found in catalogues produced by Sears, Roebuck and Co., a major producer of traditional American kit homes from about 1910 into the early 1930s (see Bibliography). Likewise, it should be recognized that a large portion of the public lived in rural areas that were not subject to municipal building codes, and housing needs were likely fulfilled in a variety of ways that may not be well documented in the popular literature on housing construction. For example, in *Cotton Field's No More* it is stated that "more than half of the farmers lived in one- and two-room shacks that had not been whitewashed or painted for many years, if ever. Many of these houses had holes in the roof, wall, and floor." Further, U.S. Census data for 1900 reports that the value of land and buildings per farm in eleven Southern states ranged from $600 to $2,000. By contrast, the values for Indiana and Kansas were $6,550 and $3,718, respectively. Thus, living conditions and housing varied widely in the early 1900s.

[1] Based on *Housing at the Millenium: Facts, Figures, and Trends*, the average new home cost was less than $5,000. However, this estimate is potentially skewed in that many people could not afford a "house" of the nature considered in the study. Based on Sears, Roebuck, and Co. catalogue prices at the turn of the century, a typical house cost may have ranged from $1,000 to $2,000, including land.

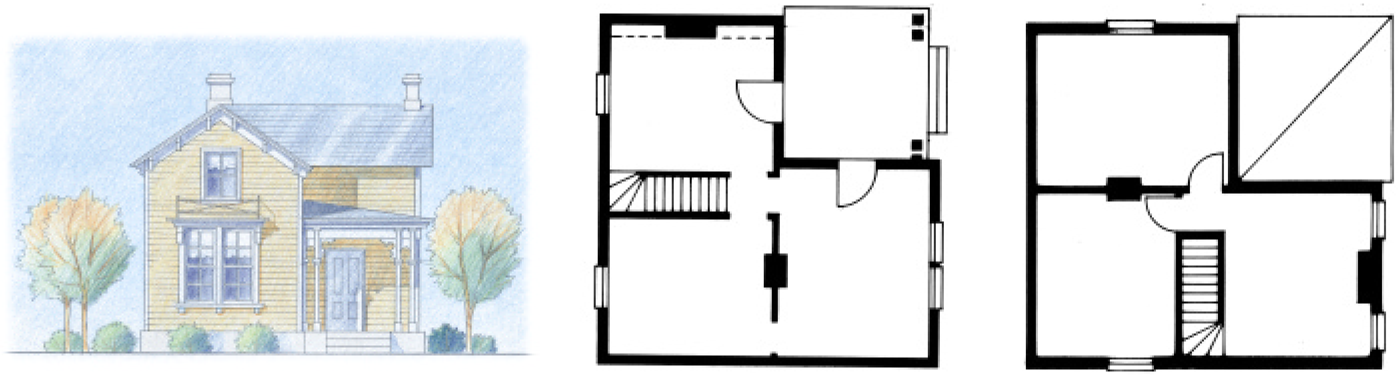

Figure 1. Profile home in 1900 (2 story).[2]

1.2 MID-1900S

The following characteristics describe a typical home and the housing market in 1950:

Population:	150 million (64 percent urban, 36 percent rural)
Median family income:	$3,319
New home price:	$11,000
Type of purchase:	FHA mortgage, 4.25 percent (few options)
Ownership rate:	55 percent
Total housing units:	43 million
Number of housing starts:	1.95 million (85 percent single-family)
Average size (starts only):	1,000 sq.ft.
Stories:	86 percent one story; 14 percent two or more
Bedrooms:	2 (66 percent); 3 (33 percent)
Bathrooms:	1-1/2 or less (96 percent)
Garage:	1 car (41 percent); 0 (53 percent)

The front elevation and floor plan of a typical home produced in 1950 is shown in Figure 2.

[2]First floor plan is similar to size and shape of a small one-story home.

By the mid-1900s, the use of standardized products, materials, and methods of constructing homes had become fairly mature. In particular, lumber grading and sizes had become essentially uniform across the country. Much of the standardization in home building may be attributed to the Federal Housing Administration (current day Department of Housing and Urban Development) with its Minimum Property Requirements (MPRs) which were applied across the country following WWII, and which were eventually superceded by a first edition of the *Minimum Property Standards* (MPS) in 1958. At this point, the older "rules-of-thumb" were giving way to prescriptive construction requirements (e.g., span tables, construction specifications, etc.) that were based on practical as well as basic technical (engineering) criteria. Newer materials such as plywood sheathing were addressed as well as standard construction details. This document was, in the opinion of the author, one of the best organized, instructive, and comprehensive building standards developed in the United States.

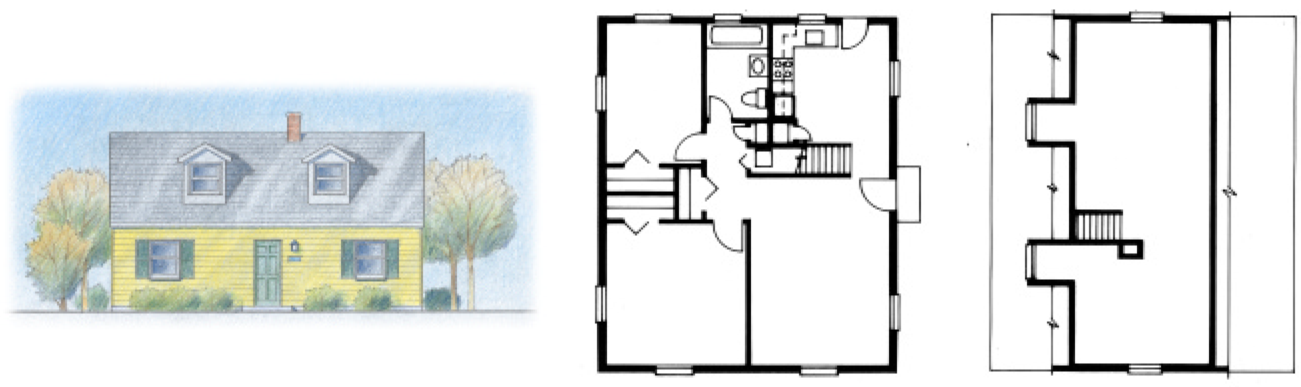

Figure 2. Profile home in 1950 (upper 1/2 story optional).

1.3 Late 1900s

The following characteristics describe a typical home and the housing market in 2000:

Population:	270 million (76 percent urban, 24 percent rural)
Median family income:	$45,000
New home price:	$200,000
Type of purchase:	8 percent (many financing options)
Ownership rate:	67 percent
Total housing units:	107 million (approx. 50 percent single-family)
Number of housing starts:	1.54 million (80 percent single-family)
Average size (starts only):	2,000 sq. ft. or more
Stories:	One story (48 percent); 1-1/2 or 2 story (49 percent)
Bedrooms:	2 or less (12 percent); 3 (54 percent); 4 or more (34 percent)
Bathrooms:	1-1/2 or less (7 percent); 2 (40 percent); 2-1/2+ (53 percent)
Garage:	2 car (65 percent)

The front elevation and floor plan of a typical home produced in 2000 is shown in Figure 3.

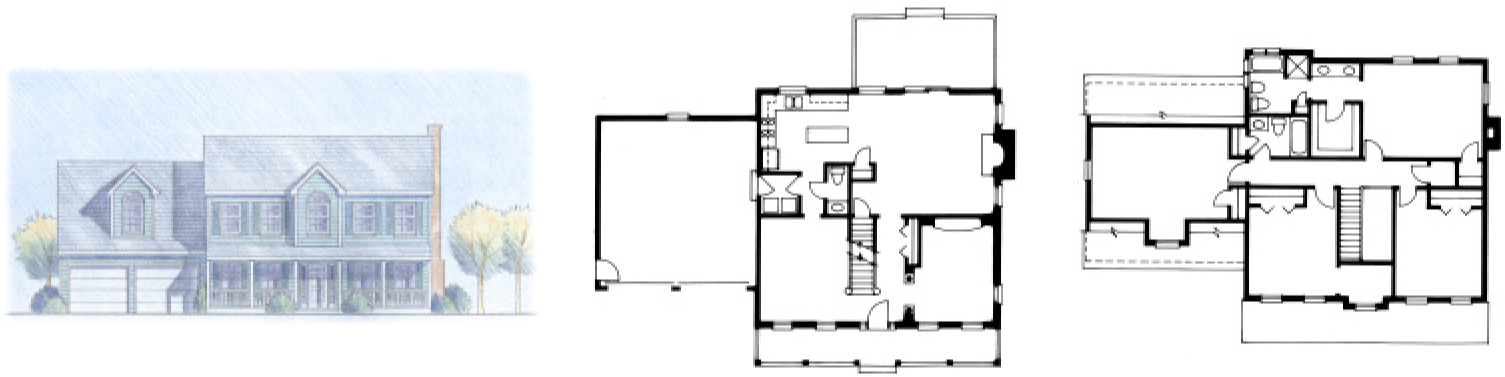

Figure 3. Profile home in 2000 (2 story).

By the late 1900s, detailed statistical data on new housing construction (such as collected by the U.S. Census and the NAHB Research Center's *Builder Practices Survey*) had become readily available. Some basic housing construction statistics related to structural features of homes at this time are summarized in Table 1.

TABLE 1
BASIC NEW HOUSING CONSTRUCTION STATISTICS IN LATE 1900s

Foundation Type:	Basement (34 percent); Crawlspace (11 percent); Slab (54 percent)
Floor Framing:	Type: lumber, 62 percent; wood trusses, 9 percent; wood I-joists, 28 percent Size of Lumber: 2x8, 8 percent; 2x10, 70 percent; 2x12, 21 percent (of lumber floors) Species of Lumber: SYP 39 percent; DF 23 percent; other 37 percent
Floor Sheathing:	37 percent plywood; 30 percent OSB; 6 percent board
Wall Framing:	73 percent 2x4@16"; 5 percent 2x4@24"; 17 percent 2x6@16"; 3 percent 2x6@24"
Wall Sheathing:	11.2 percent plywood; 44.2 percent OSB; 24 percent foam panels; 20.6 percent other
Ceiling Height:	54 percent 8' ceilings; 29 percent 9' ceilings; 8 percent 10' ceilings
Wall Openings:	2.3 ext. doors; 1.2 patio doors; 14.5 windows; 1.2 fireplaces (13 to 15 percent of wall area on average)
Roof Sheathing:	27.6 percent plywood; 71 percent OSB
Roof Framing:	6 percent rafters; 29 percent I-joist; 65 percent wood truss
Roof Pitch:	7 percent 4/12 or less; 63 percent 5/12 to 6/12; 30 percent 7/12 or greater
Roof Shape:	63 percent Gable; 36 percent Hip

Note: Percentages for floor, wall, and roof sheathing and framing are based on total aggregated floor and wall area for housing starts. Other values are given as a percentage of the housing starts.

The species of framing lumber in the late 1900s generally include Douglas Fir, Hem-Fir, Spruce-Pine-Fir, and Southern Yellow Pine. Wall studs are typically Stud Grade lumber; roof and floor framing lumber is typically No. 1 or No. 2 grade when dimension lumber is used. Fasteners are typically pneumatic-driven 0.113 to 0.131 inch diameter nails or staples. Most homes are built following locally adopted and modified national model building codes offered by one of three private code development organizations. These codes include the *Uniform Building Code*, *National Building Code*, and *Standard Building Code*, as well as the *One- and Two-Family Dwelling Code* (OTFDC) developed by CABO, an umbrella for the three national model code organizations.

It is interesting to note that while the cost of housing increased 100-fold or more during the 20th century, family income increased by a factor of about 90. Thus, the cost of a home in 1900 was about 3 times the family income on average while the cost of a home in 2000 was about 4 times the family income on average. Despite this apparent change, the increased availability of private financing options for home purchasers has contributed to a nearly 50 percent increase in the home ownership rate during the past century.

Also of significance is the distribution of age and geographic location of single-family homes in the United States, as shown in Tables 2 and 3. Similar data for the earlier part of the 20th century was not found.

TABLE 2
AGE DISTRIBUTION OF EXISTING U.S. SINGLE-FAMILY HOMES (1995)

AGE OF HOME	PERCENTAGE OF HOUSING STOCK
76 years or older	9
56 to 75 years old	11
25 to 55 years old	35
0 to 24 years old	45

TABLE 3
GEOGRAPHIC DISTRIBUTION OF U.S. SINGLE-FAMILY HOMES BY REGION (1995)

REGION	PERCENTAGE OF HOUSING STOCK
Northeast	19
Midwest	24
South	37
West	20

2.0 DESIGN LOADS

In the early 20th century, structural loads for housing design were not well codified or standardized. Houses and members were largely designed using "rules of thumb" which implicitly considered member strength, stiffness, and loading conditions. By 1923, the U.S. Department of Commerce had formed a Building Code Committee that began to standardize design loads to be used specifically for homes. These loads were later used to formulate various design recommendations such as span tables, footing sizes, and other construction specifications. Recommended live and dead loads published in 1928 are shown in Table 4.

TABLE 4
RECOMMENDED LIVE AND DEAD LOADS
[U. S. Department of Commerce, 1928]

CONDITION	POUNDS PER SQUARE FOOT
Live load, all floors used for living purposes	40
Live load for attic (used for light storage only)	20
Dead weight for average double floor and joists, but without plaster	10
Dead weight of plaster ceiling, including joists on light unfloored attics	10
Roof of light construction, including both live and dead loads	20
Roof of medium construction with light slate or asbestos roofing, including both live and dead loads	30
Roof of heavy construction with heavy slate or tile roofing, including both live and dead loads	40

It is interesting to note that the relationship of live load magnitude to influence area (tributary area) was recognized by the U.S. Department of Commerce at this early time in a rudimentary fashion:

> *"Although a live load of 40 pounds per square foot should be used in selecting all [individual] floor joists, such a load will not occur over a large floor area at the same time. The larger the area, the less chance there is of its being heavily loaded all over. In fact, the building Code Committee of the Department of Commerce, in 1923, after careful investigation, recommended that, in computing the load on girders carrying floors more than 200 square feet in area, a live load of 30 pounds per square foot be used."*

This practical consideration of influence area for dwelling design was subsequently lost in the development of building codes later in the 20th century. Most modern codes do allow a floor live load of 30 psf to be used for bedroom areas; however, this is a separate issue from that of influence area on design live loads.

At the turn of the century, cities that had comprehensive building laws generally specified dwelling floor live loads ranging from 40 to 70 psf. Specified roof loads ranged from 25 to 50 psf depending on the degree that dead, live, and snow loads were included in the values. Snow load reductions based on simple relations to roof slope were sometimes recognized. Wind loads, where specified, ranged from 10 to 30 psf with 20 psf being most common. However, wind loads did not find explicit consideration in housing design until later in the 1900s, even though they were noted throughout the century. For most of the 20th century, it appears that wind loads, when considered, usually used a simple uniform load to be applied to vertical and horizontal projected building surfaces.

In addition, there appears to have been considerable variation in how loads were applied and analyzed. For example, rafter selections were recommended by using horizontal joist span tables produced in the 1930s. Thus, it is unclear as to how various loads were factored into the design of roofs until later in the 20th century when span tables specifically for rafter design considered roof live, dead, and snow loads explicitly. In some cases the actual rafter sloped span was used and wind loads were accounted. However, a lack of standard procedure for analyzing sloped rafters has remained to this day.

By the mid-1900s, the National Bureau of Standards had produced a document titled *Minimum Design Loads in Buildings and Other Structures* (ASA A58.1-1955). In this document, the design floor live load for apartments and first floors of dwellings was set at 40 psf; second floors and habitable attics at 30 psf; and uninhabitable attics at 20 psf.

Throughout the later half of the 1900s, building codes varied in the requirements for building design loads. However, by the end of the century, the major model building codes began to standardize load requirements into a single format with uniform requirements, in most cases based on the American Society of Civil Engineer's standard ASCE 7-98, *Minimum Design Loads for Buildings and Other Structures* (drawn from a later edition of the National Bureau of Standards document ASA A58.1-55).

3.0 FOUNDATION CONSTRUCTION

Foundation construction at the beginning of the 1900s differed significantly from that used by the end of the century. Residential foundations in the early 1900s rarely had separate spread footings; the first course of masonry was often laid directly on subgrade. The following relevant quote was found in *Structural Analysis of Historic Buildings*:

> *"Portland concrete and reinforced spread footings began to appear at about the turn of the century. They were obviously used sparingly at the beginning, as in the application of any new technology."*

When readily available, it is also found that many homes before 1900 used stone masonry for foundation walls or piers, with or without some type of mortar. Special consideration to foundations and soil support was only given to very unique structures or soil conditions. If engineered, building foundation bearing pressures were usually designed with "appropriate dead and live loads" at the beginning of the 20th century. Even then, the techniques were quite arbitrary and relied heavily on experience and judgment of the designer. Most building designs, at best, were based on a manual probing of the soil and reliance on local practice and/or past performance of nearby building foundations.

Typical presumptive (allowable, permissive, or safe) soil bearing values during the 20th century are shown in Table 5. It is noted that presumptive values decreased drastically (became more conservative) in the later half of the 20th century with no compelling reason identified in the literature.

TABLE 5
PRESUMPTIVE SOIL BEARING VALUES BY TIME PERIOD
(pounds per square foot)

EARLY 1900S	MID-1900S	LATE-1900S
Soft/Wet Clay or Sand or Loam (2,000) Firm Earth (2,500 to 3,500) Ordinary Clay/Sand Mix and Sand (4,000) Hard Clay and Firm Course Sand (8,000) Firm Gravel/Sand Mix (12,000) Shale Rock (16,000) Hard Rock (40,000)	Soft Clay (2,000) Firm Clay and Sand/Clay Mix (4,000) Fine dry sand (6,000) Coarse Sand (8,000) Gravel (12,000) Soft Rock (16,000) Hard Rock (80,000)	Clay, Sandy Clay, Silty Clay, and clayey silt (1,000) Sand, silty sand, clayey sand, silty gravel, and clayey gravel (1,500) Sandy gravel and/or gravel (2,000) Sedimentary and foliated rock (2,000) Massive crystalline bedrock (4,000)

By the mid-1900s and throughout the remainder of the century, the use of concrete footings and masonry (block) or concrete walls had become common practice. The introduction of separate spread footings is not well understood, as few documents used in this study spoke directly to this issue. Perhaps, newer wall construction methods and materials allowed the use of thinner foundation walls which brought about concern with bearing area on the foundation soil. Perhaps a greater concern or lower tolerance for settlement and cracking of foundation walls developed over time, as expectations for use of basements increased over the course of the century. Certainly, basement wall cracks are a major source of homeowner complaints or claims in modern homes; however, it does not appear that this was such a concern earlier in the century. Data on modern foundation construction types is reported in Table 1.

4.0 WOOD-FRAME CONSTRUCTION

Prior to the 1900s some significant changes in basic framing practices in the United Sates were set in motion. Up through most of the 19th century, homes were built following traditional timber construction known as *braced framing* adopted from England (see Figure 4). In this manner, homes used heavy squared timber frames and beams with diagonal bracing of 4x or larger timbers. Wood joinery methods were used for heavy connections rather than steel fasteners. Intermediate framing members of smaller dimension were used within the structural frame to provide for attachment of finish materials.

In the mid-1800s a new construction method, known as *balloon framing*, began to be used in the United States. This method used repetitive light framing members, generally 2x4s, made available by the proliferation of sawmills. By the start of the 20th century, balloon framing had practically replaced the traditional heavy braced framing technique. The balloon framing technique is illustrated in Figure 5. In some cases, vestiges of early practices such as the use of 4x corner posts, beams, and sill framing members existed well into the 20th century in combination with balloon framing. Balloon framing persisted until after World War II in some parts of the country.

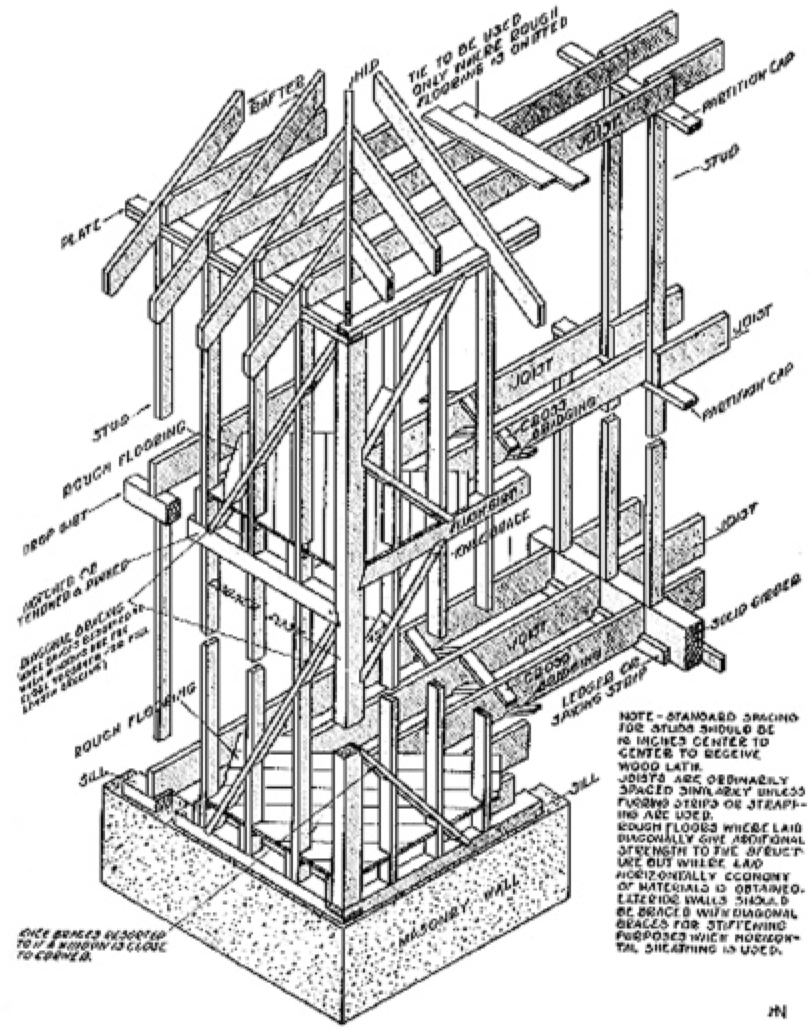

Figure 4. Braced Framing pre-1900.

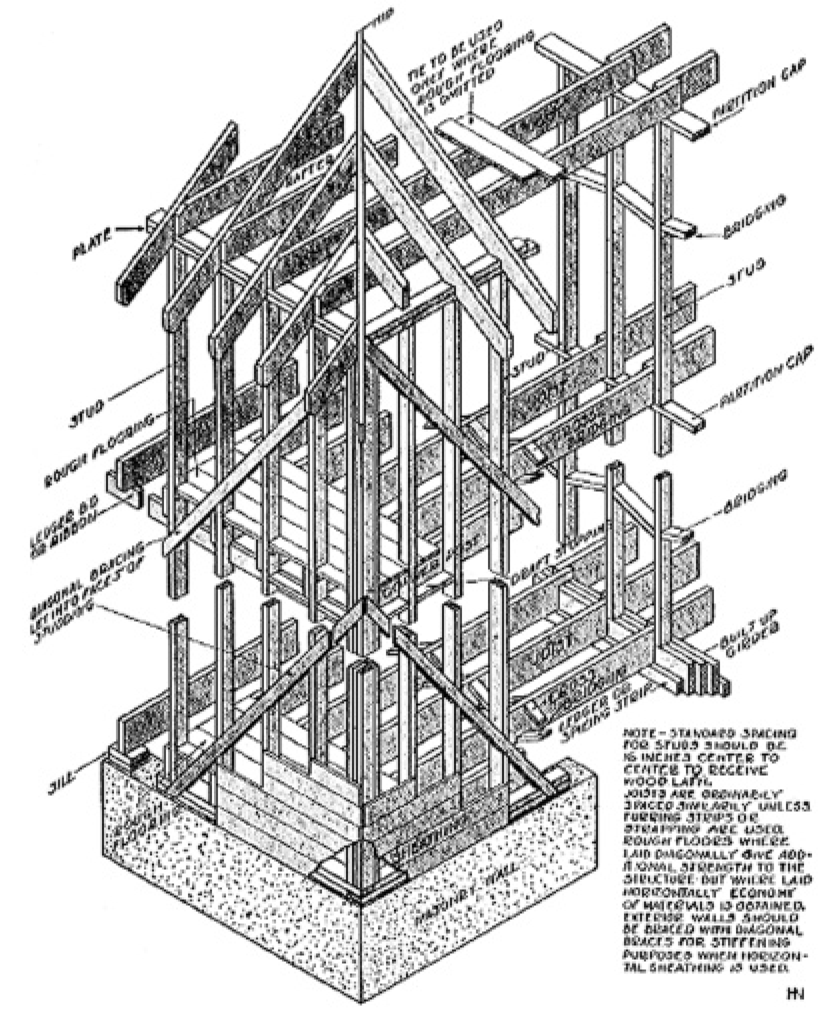

Figure 5. Balloon Framing Technique in Early 1900s.

Variations in application of the balloon framing method also recognized trade-offs between economy and performance. For example, Sears, Roebuck and Co., produced two types of pre-cut structural framing systems: one using the “honor-built” system and the other using the “standard-built” system. In advertising the “honor-built” system, the following features were highlighted:

- Rafters, 2x6 or 2x4 inches (larger where needed), 14-3/8 inches apart (16 inches on center).
- Double plates over doors and windows (as headers and trim nailing base).
- Double studdings at sides of doors and windows (as jamb support and trim nailing base).
- Three studs at corners.
- High grade horizontal wood sheathing boards, 13/16 inch thick with tarred felt overlay between sheathing and wood siding.
- Double floors with heavy building paper between the subfloor and finished floor
- 2x8 inch joists, or 2x10 where needed, 14-3/8 inches apart (16 inches on center).
- Studdings, 2x4 inches, 14-3/8 inches apart (16 inches on center), double plate at top and single at bottom of wall, ceiling height of typically 8 feet-2 inches to 9 feet for above grade stories and as low as 7 feet for basements.
- High quality framing lumber (virgin growth, dense grain, from the Pacific Northwest, Douglas-Fir and Hemlock) specially sorted, stored, and dried at Sears lumber yards.
- Common wire nails of sufficient quantity and variety of sizes.
- Genuine cypress window and door casings (exterior trim), 1-1/8 inches thick, naturally weather resistant.
- 3 coats of guaranteed paint on outside.

The “standard-built” construction was advertised (at the back of the 1928 Sears catalogue) as the “most house per dollar invested” for smaller homes of 1 to 1-1/2 stories. The largest home of this type had four rooms within a 24 feet by 36 feet plan. The following are key specifications of Sears’ “standard-built” homes:

- Rafters, 2x4 inches, 22-3/8 inches apart (24 inches on center); 2x4 ceiling joists at 16 inches on center (for interior finish).
- Single plates over doors and windows (no headers or trim nailing base).
- Single studdings at sides of doors and windows.
- Two studs at corners.
- No wood sheathing (only exterior wood siding of 1x6).
- No sub-floor (finish flooring applied direct to joists).
- Tarred felt under floors and siding.
- 2x8 inch joists placed 22-3/8 inches apart (24 inches on center), spans generally not exceeding 12 feet.
- Studdings, 2x4 inches, 14-3/8 inches apart (16 inches on center), double plate at top and single at bottom of wall; ceiling heights typically 8 feet-3 inches.

- Framing lumber for walls, floors, and roofs uses No. 1 Douglas Fir or Pacific Coast Hemlock (non-Sears standard construction is noted to use lower quality or No. 2 and No. 3 lumber and species such as Tamarak or White Pine).
- Common wire nails of sufficient quantity and variety of sizes.
- Cypress exterior trim.
- All outside paint, two coats.

Sears also advertised cottage style or portable homes with 2x2 No. 1 yellow pine wall framing, 2x3 roof rafters, and post foundations. The largest size had three rooms with overall plan dimensions of 20 feet by 16 feet, plus a 5 foot covered porch. Sears noted that their "standard-built" homes incorporated some improvements over the common practice of that time, such as the use of three-stud corners and doubled 2x4 members at window and door openings for improved finish attachment. It is unknown how many homes of each type were sold by Sears, Roebuck and Co. But, the catalogues give clear evidence that at least two to three distinctly different levels of dwelling construction were recognized in the early 1900s as a matter of economy verses quality.

By the mid-1900s and during the housing “boom” following WWII, the preferred framing practice had evolved to platform framing, a further refinement of balloon framing. Platform framing is shown in Figure 6. This change was driven by economy and practicality. For example, balloon framing required the use of long wall framing members (studs) which were more expensive and less available. Also, balloon framing required fire blocking between wall framing at story levels to comply with modern building codes (initiated in the 1920s). In contrast, platform framing is inherently fire blocked by the use of horizontal wall plates at the top and bottom of each story. In addition, the balloon frame approach was essentially limited to “regular” two-story construction and did not readily allow for newer housing styles that featured story offsets (i.e., floor overhangs) and other “irregularities” in design. Finally, the platform framing technique provides a solid and safe work platform from which to stage construction for upper stories. Platform framing has dominated the housing market since the mid-1900s with a few refinements as follows:

- unnecessary use of bridging between studs and floor joists was eliminated;
- panel products have replaced the use of boards for wall, floor, and roof sheathing;
- wall sheathing no longer laps over the floor perimeter (except in some isolated high wind locales); and
- foundation sill members are anchored to the foundation.

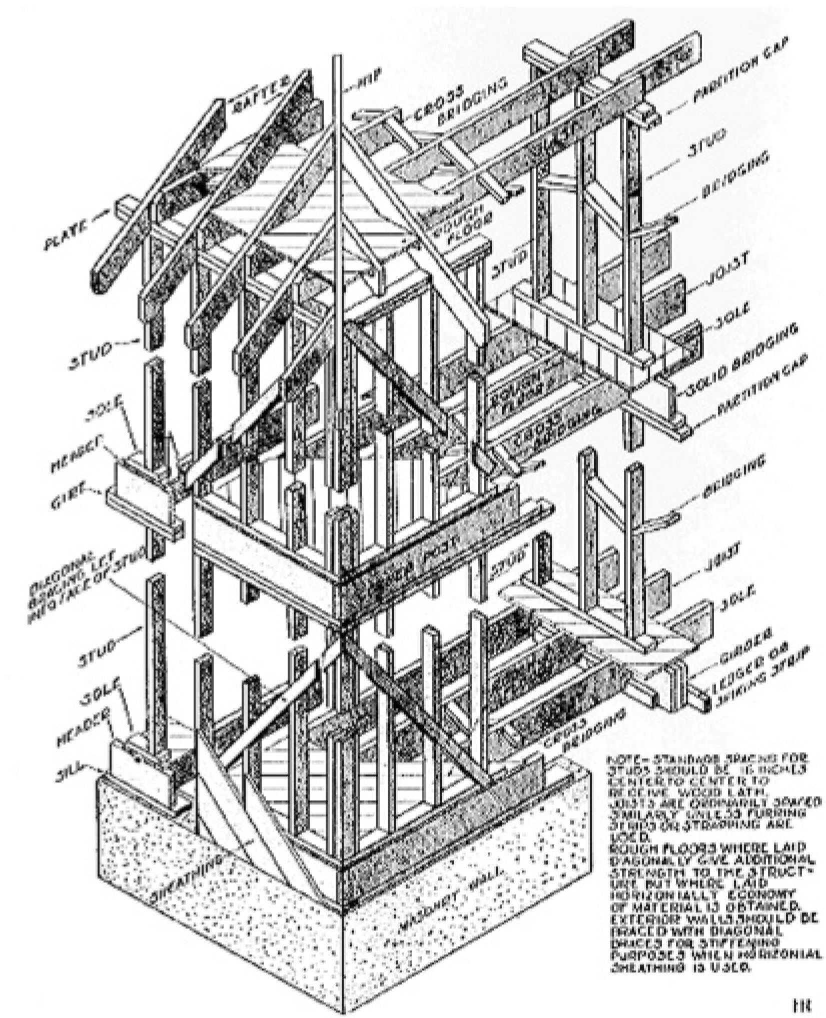

Figure 6. Platform Framing.

Note: Platform framing in Figure 6 is representative of early platform framing. Platform framing in the mid- to late-1900s used panel products in lieu of board sheathing and bridging in floors and walls was eliminated.

Throughout the 20th century, 16 inch on center framing has remained the dominant choice. Interestingly, this practice has been associated with an early concern to provide adequate support for finish materials (i.e., exterior wood siding or sheathing and, particularly, interior lath and plaster finishes). On the other hand, spacing of roof framing members has largely increased from 16 inch on center (early to mid-1900s) to 24 inches on center in the late 1900s. This change is associated with the inception and later dominance of wood roof trusses in the second half of the 20th Century. However, 16 inch on center roof framing still finds limited use today, particularly in complicated roof designs that necessitate rafter framing.

It should be noted that 24 inch on center wall framing has been used throughout the 20th century in at least a small portion of housing construction for reasons of economy and, more recently, for its additional benefits of improved energy efficiency and resource conservation. Changes to panel forms of exterior and interior sheathing materials (including the use of plywood and OSB sheathing panels and gypsum wallboard, as opposed to boards or lath and plaster) have perhaps contributed to a greater use of 24 inch on center framing today than in the early 20th century. Still, 24 inch on center framing is generally used in less than 10 percent of wall area in modern residential construction annually.

Floor construction has also seen some use of alternate spacings such as 19.2 inch and 24 inch. In recent years, increased use of wider spacing for floor framing members may be associated with increased use of engineered wood products such as parallel chord wood trusses and wood I-joists.

4.1 WOOD MATERIALS

4.1.1 Size

Significant changes to sizes of dimension lumber used in balloon framing occurred in the early 1900s. At first, members where often rough sawn (or perhaps only surfaced on two sides) and available in actual (approximate) 2 inch thickness and depths of 4, 6, 8, 10, 12, and even 14 inches. Later, ostensibly to account for surfacing and shrinkage, finished lumber sizes were reduced to 1-3/4 inch thickness with actual depths of 1/4 inch scant of nominal for members up to 4-inch depth and 1/2-inch scant for members over 4-inch depth. Still later, the thickness was reduced to 1-5/8 inch (as in the Sears homes of 1928) and the depth was reduced to 3-5/8, 5-5/8, 7-1/2, 9-1/2, etc. Finally, in the mid-1900s, lumber dimensions were reduced to the standard sizes that are in use today. The nominal size vs. actual size in current use are as follows: 2x4 (1.5 in by 3.5 in), 2x6 (1.5 in by 5.5 inch), 2x8 (1.5 in by 7.25 in), 2x10 (1.5 in by 9.25 in), and 2x12 (1.5 in by 11.25 in).

4.1.2 Type/Species

Over the 20th century, supply and demand has dictated numerous changes in forestry and availability of wood materials in the United States. At the beginning of the 20th century, virgin growth lumber (also known as old growth) was commonly used. As resources of virgin growth lumber diminished, first in the east and then in the west, use of managed forests became more common and practically essential by the mid- to late-1900s. Wood species typically used for framing lumber in residential construction are shown in Table 6 by time period. As seen in the early 1900s many local species were used. However, Sears boasted in being able to ship the best available Douglas Fir and Pacific Coast Hemlock for their framing lumber. By the late 1900s, wood species were organized into 'species groups' each including several species with similar properties.

TABLE 6
TYPICAL FRAMING LUMBER SPECIES BY TIME PERIOD[1]

EARLY 1900S	LATE 1900S
Red Cypress*#	Douglas Fir
Redwood*#	Hem-Fir
Douglas Fir-coastal#	Southern Yellow Pine
Douglas Fir – inland*#	Spruce-Pine-Fir
Pacific Coast Hemlock#	Southern Pine
Western Larch*#	
Eastern Hemlock*#	
Eastern Spruce*#	
California White Pine#	
White Pine (Northern, Idaho, and sugar)#	
Norway Pine#	
Port Orford Cedar#	
White Fir*#	
Tamarack*#	
Long leaf Southern Pine#	
Short Leaf Southern Pine#	
North Carolina Pine#	
Arkansas Soft Pine#	
Southern Yellow Pine#	

[1]Audel's mentions White Pine as the most common framing lumber on the East Coast in the early 1900s, which is also confirmed by similar references in the Sears catalogues.
* Species reported as being appropriate for studs (No. 1 or No. 2 grade recommended)
# Species reported as being appropriate for joists and girders (No. 1 grade recommended)

4.1.3 Structural Properties

For the purpose of this paper, structural quality deals with characteristics that affect the strength of lumber, not factors such as straightness (although there may be relevant correlation between tendency to warp and structural properties). The primary measures of structural quality are the grading methods used for lumber. However, density is perhaps the single most important parameter to consider, as it can be correlated to several structural properties including bending strength and connection capacity. Grading methods have evolved a great deal over the past century. Typical grades in each time period are shown in Table 7 below. As shown, the grade categories of lumber have increased with time. Modern home construction generally uses two or three grades of dimension lumber and three to four different species or species groups.

TABLE 7
TYPICAL LUMBER GRADES BY TIME PERIOD

EARLY 1900S*	MID-1900S**	LATE 1900S**
No. 1	Select Structural	Select Structural
No. 2	No 1 Dense	No 1 Dense
No. 3	No 1	No1
Culls	No 2 Dense	No 2 Dense
	No 2	No2
	Dense Construction	Stud
	Construction	Construction
	Standard	Standard
		Utility

*Audel's describes No 1 as "practically perfect" and No 2 as allowing two sound knots, 1" of sap, and one other blemish. In Light Frame House Construction, No. 2 is noted as OK for economical or temporary construction.
**Grade class designations vary by grading agency and lumber species groupings based on 1962 and 1997 industry design specifications.

By the 1930s, lumber stress values for various species and grades had been used to develop prescriptive span tables for dwelling construction. No. 2 grade lumber was typically recommended for studs while No.1 grade was recommended for joist and rafter framing. The use of No. 2 grade lumber for joists was recognized as a "more economical construction." But, a 2 inch deeper member was recommended for use with span tables based on No. 1 grade lumber. However, in the 1960s, many builders reported using construction grade lumber for floor joists.

Evidently, little analytical concern was placed on structural capacity prior to the 1900s except by way of practical experience, although limited discussions and test data related to structural properties of some commonly used wood species may be found in the literature prior to 1900. However, because of the limited tests conducted, the experimenters often reported different structural property values and used different terminology in describing results. One of the better examples of wood engineering data was produced in 1913 by Carnegie Steel (Table 8) who used timber for the purpose of railroad trestle design. While a larger safety margin of about 5 was used for railroad design, a safety factor of 4 was typically recommended for general use where engineering was applied. The safety factors were typically applied to average ultimate strength values from limited testing to develop allowable or working stress design values.

TABLE 8
EARLY ENGINEERING DATA FOR STRUCTURAL TIMBERS
(Carnegie Steel Co., 1913)

Unit Stresses (psi)													
Kind of Timber	**Bending**			**Shearing**				**Compression**					
	Extreme Fiber Stress		Modulus of Elasticity	Parallel to the Grain		Longitudinal Shear in Beam		Perpendicular to the Grain		Parallel to the Grain		Working Stresses for Columns	
	Average Ultimate	Working Stress	Average	Average Ultimate	Working Stress	Average Ultimate	Working Stress	Elastic Limit	Working Stress	Average Ultimate	Working Stress	Length under 15 x d	Length over 15 x d
Douglas fir	6,100	1,200	1,510,000	690	170	270	110	630	310	3,600	1,200	900	1,200(1-*l*/60*d*)
Longleaf pine	6,500	1,300	1,610,000	720	180	300	120	520	260	3,800	1,300	975	1,300(1-*l*/60*d*)
Shortleaf pine	5,600	1,100	1,480,000	710	170	330	130	340	170	3,400	1,100	825	1,100(1-*l*/60*d*)
White pine	4,400	900	1,130,000	400	100	180	70	290	150	3,000	1,000	750	1,000(1-*l*/60*d*)
Spruce	4,800	1,000	1,310,000	600	150	170	70	370	180	3,200	1,100	825	1,100(1-*l*/60*d*)
Norway pine	4,200	800	1,190,000	590	130	250	100		150	2,600	800	600	800(1-*l*/60*d*)
Tamarack	4,600	900	1,220,000	670	170	260	100		220	3,200	1,000	750	1,000(1-*l*/60*d*)
Western hemlock	5,800	1,100	1,480,000	630	160	270	100	440	220	3,500	1,200	900	1,200(1-*l*/60*d*)
Redwood	5,000	900	800,000	300	80			400	150	3,300	900	675	900(1-*l*/60*d*)
Bald Cypress	4,800	900	1,150,000	500	120			340	170	3,900	1,100	825	1,100(1-*l*/60*d*)
Red Cedar	4,200	800	800,000					470	230	2,800	900	675	900(1-*l*/60*d*)
White Oak	5,700	1,100	1,150,000	840	210	270	110	920	450	3,500	1,300	975	1,300(1-*l*/60*d*)
From Carnegie Steel Co. 1913, 310 (as reported in *Structural Analysis of Historic Buildings*).													

As discussed later, many wood members for light building construction were probably sized or designed by intuitive “rules of thumb” passed down through years of experience. For example, there were no records found of engineering calculations or test data in the origins of balloon framing techniques in the mid- to late-1800s. However, this outcome is not to suggest that no structural consideration or verification testing was performed, since “proof testing” has historically been a common practice to validate new construction techniques. For example, modern roof trusses were developed using engineering tests and data in the mid-1900s. Proof testing of actual truss constructions (i.e., stacking weights on a trussed roof) was often done to verify performance to a skeptical audience. In essence, the concept of “seeing is believing” has played a significant role in the adoption of new construction technologies.

In summary, it appears that two methods of wood construction verification were emerging in the United States in the late 1800s and early 1900s. The first relied on experience with constructed systems for specific applications (i.e., balloon framing of buildings). The second and newer method relied on engineering analysis of special structures (i.e., railroad trestles) based on evaluation of stresses on individual members using quantified structural properties of various wood species. By the 1920s, allowable stresses for various species and two grades (No.1 and No.2) of structural timbers had been published (see Table 9). Later in the 1920s and 1930s, allowable stresses for structural lumber and timber for dry uses had been published (see Table 10). The following quotation from *Light Frame House Construction* describes the use of the data in Table 10 in the 1930s:

> *"In Table [10] is given a list of various softwoods used for building construction, with allowable unit working stresses for each species and grade. The species in the upper half of the list are manufactured in structural grades as shown. Definite working stresses have been assigned to all these grades by the manufacturers. For the species in the lower half of the table, structural grades are seldom manufactured as such. Nevertheless, timbers from these species, if carefully selected as to influence of defects, may be rated as 'select structural,' and timbers of lower grade as 'common structural.' The working stresses shown may then be applied."*

It is apparent that the application of grading standards was in its infancy in the 1930s. The common lumber grades (No. 1 and No. 2) were loosely defined in practice and may have varied substantially at the local level of supply. While published bending properties varied by grade and species, they did not differ much according to size of member. Similarly, modulus of elasticity values tended to vary by species, but not by grade.

Early tests of lumber density are not readily found in the available literature. Because of the lack of grading standards at that time, the lack of standard terminology, and the frequent use of locally grown and milled timber, it is difficult to determine the range of lumber densities typifying residential and other building construction earlier in the 1900s. However, in 1885 the data in Table 11 was reported.

By the 1930s, stress values for many popular wood species, and typically two grades each, were available from lumber grading agencies that followed grading standards. Through the mid- to late-1900s structural data on a wide variety of wood species grew rapidly. By the second half of the 20th century, grading rules and agencies were in full swing, and numerous design values were published in wood industry specifications such as the *National Design Specification for Wood Construction* and its supplement of wood design values. While dimension lumber dominated the housing market through most of the 20th century, the late 1990s saw a dramatic increase in the use of engineered wood members such as trusses, wood I-joists, and engineered wood panel products (see Table 1).

TABLE 9
ALLOWABLE STRESSES FOR STRUCTURAL TIMBERS
(Voss and Varney, 1926)

SPECIES	GRADE	ALLOWABLE STRESSES (PSI)				
		Bending		Compression		Modulus of Elasticity
		Extreme Fiber	Horizontal Shear	Parallel to Grain "Short Columns"	Perpendicular to Grain	
Cedar, western red	1	900	80	700	200	1,000,000
	2	600	53	467	200	
Cedar, northern white	1	750	70	550	175	800,000
	2	500	47	384	175	
Chestnut	1	950	90	800	300	1,000,000
	2	633	60	533	300	
Cypress	1	1,300	100	1,100	350	1,400,000
	2	867	67	733	350	
Douglas fir	1	1,500	90	1,100	325	1,600,000
	2	1,000	60	750	300	
Douglas fir (Rocky Mountain)	1	1,100	85	800	275	1,200,000
	2	767	57	533	275	
Fir, balsam	1	900	70	700	150	1,000,000
	2	600	47	467	150	
Gum, red	1	1,100	100	800	300	1,200,000
	2	767	67	533	300	
Hemlock, western	1	1,300	75	900	300	1,400,000
	2	867	50	600	300	
Hemlock, eastern	1	1,000	70	700	300	1,100,000
	2	667	47	467	300	
Larch, western	1	1,200	100	1,100	325	1,300,000
	2	800	67	733	325	
Maple, sugar or hard	1	1,500	150	1,200	500	1,600,000
	2	1,000	100	800	500	
Maple, silver or soft	1	1,000	100	800	350	1,100,000
	2	667	67	533	350	
Oak, white or red	1	1,400	125	1,000	500	1,500,000
	2	933	83	667	500	
Pine, southern yellow	1	1,500	110	1,100	325	1,600,000
	2	1,000	70	750	300	
Pine, eastern white, western white, and western yellow	1	900	85	750	250	1,000,000
	2	600	57	500	250	
Pine, Norway	1	1,100	85	800	300	1,200,000
	2	733	57	533	300	
Spruce, red, white, and Sitka	1	1,100	85	800	250	1,200,000
	2	733	57	533	250	
Spruce, Engelman	1	750	70	600	175	800,000
	2	500	47	400	175	
Tamarack, eastern	1	1,200	95	1,000	300	1,300,000
	2	800	63	667	300	

From Voss and Varney 1926, 8 (as reported in *Structural Analysis of Historic Buildings* without notation regarding safety margins and characteristic structural property data used to derive the working stress design values). Modulus of elasticity is assumed to represent an average characteristics, but does not differentiate between grades.

TABLE 10
ALLOWABLE UNIT STRESSES FOR STRUCTURAL LUMBER AND TIMBER
(all sizes, dry locations)
(HEW, 1931)

SPECIES OF TIMBER	GRADE	ALLOWABLE UNIT STRESS (PSI)		
		Extreme Fiber in Bending		Modulus of Elasticity
		Joist and Plank Sizes; 4 inches and less in thickness	Beam and stringer sizes; 5 inches and thicker	
WORKING STRESSES FOR MANUFACTURERS' ASSOCIATION STANDARD COMMERCIAL GRADES				
Douglas fir, coast region	Dense superstructural	2,000	2,000	1,600,000
	Superstructural and dense structrual	1,800	1,800	1,600,000
	Structural	1,600	1,600	1,600,000
	Common structural	1,200	1,400	1,600,000
Douglas fir, inland empire	Dense superstructural	2,000	2,000	1,600,000
	Dense structural	1,800	1,800	1,600,000
	No.1 common dimension and timbers	1,135	1,135	1,500,000
Larch, western	No.1 common dimension and timbers	1,135	1,135	1,300,000
Pine, southern yellow	Extra dense select structural	2,300	2,300	1,600,000
	Select structural	2,000	2,000	1,600,000
	Extra dense heart	2,000	2,000	1,600,000
	Dense heart	1,800	1,800	1,600,000
	Structural square edge and sound	1,600	1,600	1,600,000
	Dense No. 1 common	1,200	1,200	1,600,000
Redwood	Superstructural	2,133	1,707	1,200,000
	Prime structural	1,707	1,494	1,200,000
	Select structural	1,280	1,322	1,200,000
	Heart structural	1.024	1,150	1,200,000
WORKING STRESSES FOR STRUCTURAL LUMBER AND TIMBER GRADED UNDER THE STRUCTURAL GRADE EXAMPLES OF THE AMERICAN LUMBER STANDARDS				
Cedar, Alaska	Select structural	1,100	1,100	1,200,000
	Common structural	880	880	1,200,000
Cedar, northern and southern white	Select structural	750	750	800,000
	Common structural	600	600	800,000
Cedar, Port Orford	Select structural	1,100	1,100	1,200,000
	Common structural	880	880	1,200,000
Cedar, western red	Select structural	900	900	1,000,000
	Common structural	720	720	1,000,000
Cypress, southern	Select structural	1,300	1,300	1,200,000
	Common structural	1,040	1,040	1,200,000
Douglas fir, Rocky Mountain region	Select structural	1,100	1,100	1,200,000
	Common structural	880	880	1,200,000
Fir, balsam	Select structural	900	900	1,000,000
	Common structural	720	720	1,000,000

TABLE 10
ALLOWABLE UNIT STRESSES FOR STRUCTURAL LUMBER AND TIMBER
(all sizes, dry locations)
(HEW, 1931)
(continued)

SPECIES OF TIMBER	GRADE	ALLOWABLE UNIT STRESS (PSI)		
		Extreme Fiber in Bending		Modulus of Elasticity
		Joist and Plank Sizes; 4 inches and less in thickness	Beam and stringer sizes; 5 inches and thicker	
WORKING STRESSES FOR STRUCTURAL LUMBER AND TIMBER GRADED UNDER THE STRUCTURAL GRADE EXAMPLES OF THE AMERICAN LUMBER STANDARDS				
Fir, golden, Noble, silver, white (commercial white)	Select structural	1,100	1,100	1,100,000
	Common structural	880	880	1,100,000
Hemlock, eastern	Select structural	1,100	1,100	1,100,000
	Common structural	880	880	1,100,000
Hemlock, west coast	Select structural	1,300	1,300	1,400,000
	Common structural	1,040	1,040	1,400,000
Oak, commercial white and red	Select structural	1,400	1,400	1,500,000
	Common structural	1,120	1,120	1,500,000
Pine, California, Idaho, and northern white, lodgepole, Pondosa, sugar	Select structural	900	900	1,000,000
	Common structural	720	720	1,000,000
Pine, Norway	Select structural	1,100	1,100	1,200,000
	Common structural	880	880	1,000,000
Spruce, Englemann	Select structural	750	750	800,000
	Common structural	600	600	800,000
Spruce, red, white, Sitka	Select structural	1,100	1,100	1,200,000
	Common structural	880	880	1,200,000
Tamarack, eastern	Select structural	1,200	1,200	1,300,000
	Common structural	960	960	1,300,000
Note: The source document (HEW, 1931) did not indicate the margin of safety or characteristic structural property values used to derive the above working stress values. The table values were used to create joist, rafter, and girder span tables in the source document based on a stated extreme fiber working stress.				

TABLE 11
EARLY DATA ON WOOD SPECIFIC GRAVITY

DESCRIPTION OF WOOD	SPECIFIC GRAVITY
White spruce (Canadian)	0.465
White pine (American)	0.455
Black spruce (American)	0.490
Southern pine (American)	0.872
From Mahon 1885, 125 (as reported in *Structural Analysis of Historic Buildings*).	

While difficult to quantify, the references used in the study indicate that a general decline in the structural quality of lumber has occurred. This reduction may be related to the increased use of managed growth lumber, which implies the use of younger, faster growing trees. Based on available reports of lumber density and species usage, it is the authors' judgment that framing (dimension) lumber density has dropped from a typical range of 0.4 to 0.65 earlier in the 20^{th} century to a range of 0.35 to 0.55 by the end of the 20^{th} century – approximately a 10 percent reduction in lumber density. A similar change in the grade quality of lumber may also be inferred. This trend would affect member properties as well as connection properties that are discussed later. While these apparent changes are amply treated in wood engineering specifications and structural property data, the affect on conventional practices suggests the need for re-examination of rules of thumb that are still in use today, particularly with respect to system connections and system performance. On the other hand, it should be noted that many engineered wood products that use laminated veneers and similar methods to create entire members or parts of composite members tend to offset the apparent reduction in dimension lumber quality.

4.2 FLOOR FRAMING

In the early 1900s, floor joists were typically 2x8 with spans in the range of 12 feet to 14 feet spaced on 16 inch centers (though 24 inch on center placement was indicated for "economical floor construction" when a plaster ceiling was not supported by the joists). For spans of more than 14 feet, 2x10s were recommended when No. 1 grade lumber was used or 2x12 if No. 2 lumber was used. (It was generally recommended that joists be 2 inches deeper or 1 inch wider when lower grade material was used.) One early rule of thumb for sizing joists and beams from *Audel's* states that "Joists longer than 12 times their width [depth] used without intermediate supports are apt to crack plastered ceilings." Obviously, the concern here was with serviceability rather than safety. Rules of thumb for strength were not found in the reviewed literature, but some general guidelines have been passed down. For example, a span to depth ratio limit of 21 is commonly considered as a practical design limitation when beams or joists are laterally supported to prevent twisting. This rule of thumb would allow a 2x8 (1920s actual size 1-5/8" x 7-1/2") to span about 13 feet.

By the 1930s, standardized lumber grades and stress values (see Table 10) were used to specify maximum spans based on engineering analysis of strength limits. A deflection limit of 1/360 of span was used to produce span tables for joists supporting plaster ceilings. Tables were also used to specify maximum horizontal spans for sloped roof rafters. Some examples of maximum spans are shown in Table 12.

TABLE 12
MAXIMUM SPANS FOR JOISTS AND RAFTERS (feet-inches)
(HEW, 1931)

LIVE LOAD (psf)	**JOIST SPACING (inches)**	**2x8 (1-5/8” x 7-1/2”)**	**2x10 (1-5/8” x 9-1/2”)**	**2x12 (1-5/8” x 11-1/2”)**
Plastered ceiling below (deflection not over 1/360 of span)				
10	16	15-4	19-4	23-4
	24	14-6	17-3	20-7
20	16	13-11	17-6	21-1
	24	12-3	15-6	18-7
30	16	12-11	16-3	19-6
	24	11-4	14-4	17-3
40	16	12-1	15-3	18-5
	24	10-4	13-1	15-9
No plastered ceiling below				
30	16	15-6	19-5	23-3
	24	12-10	16-2	19-5
40	16	13-11	17-4	20-11
	24	11-5	14-5	17-5

By the mid-1900s and throughout the remainder of the century, building codes used span tables similar to Table 12; however, the 1/360 of span deflection limit was eventually applied to all floor joists with design loads of 30 psf or 40 psf. Separate tables were eventually created for the selection of roof rafters using different deflection limits (see Section 4.4). In modern codes, deflection limits–not strength limits–control most floor joist selections. The rationale associated with the elimination of the option to design a floor without a deflection limit when no interior finish was supported was to improve the “feel” of the floor (i.e., floor vibration or bounce) and also to minimize long-term deflection (creep). However, affordable homes well into the mid-1900s can be found with 2x8 floor joist at 16 inch centers spanning as much as 14 to 15 feet over unfinished space. Starting in the 1960s, 2x10 floor joists became as popular as 2x8 joists (both comprising a total of 75 percent of the practice and usually of a "construction" grade lumber). Engineered wood joists such as parallel chord wood trusses and I-joists came into use starting in the 1980s (see Table 1). Modern span tables and manufacturer data are readily available for engineered wood products. Because of differences in “feel” and because of greater spans (up to 20 feet and more), many engineered wood I-joist manufacturers recommend a deflection limit of 1/480 of the span.

4.3 WALL FRAMING

4.3.1 Studding

Over the 20th century, actual vs. nominal framing member sizes have decreased somewhat and wall framing methods have changed from balloon to platform frame. By far, the most common stud spacing throughout the 20th century was 16 inches on center; however, 24 inches on center has also been used primarily for single stories. In the early 1900s, it is clear that 16 inches on center framing was considered necessary for the support of lath and plaster interior finishes. While 2x4 studding is exclusively mentioned in the earlier parts of the century for typical dwelling construction, 2x6 studs are sometimes used in modern homes to allow for thicker wall cavity insulation (see Table 1). Because of their greater structural capacity and cost, 2x6 studs are sometimes spaced 24 inches on center where 2x4's would be spaced 16 inches on center.

In the early 1900s, 2x4s spaced 16 inches on center were considered adequate for use in buildings up to three stories in height and for ceiling heights not exceeding 12 to 15 feet. This limit was related to the weak axis of the stud being braced by wall finishes and a maximum stud height to stud depth ratio of 50. For buildings over three stories in height, 2x6s or 3x4s were recommended in the lower stories. In modern codes with 2x4s of smaller standard dimension spaced 16 inches on center, building height is limited to two stories and the maximum 2x4 stud wall height is limited to 10 ft. For buildings over two stories in height, 2x6s or 3x4s are required for the lower stories. Preferred ceiling heights have also changed somewhat over time (see Table 1)which affects the selection of stud lengths.

4.3.2 Plates

While balloon framing generally used single plates at the top and bottom of walls, “standard” modern platform frame construction has adopted the use of double top plates (discussed earlier in Sears’ “standard-built” homes). However, single plates are still permitted, and are used occasionally, in modern affordable platform framed homes, specifically in non-load bearing walls or where loads are transferred directly down through studs.

4.3.3 Corners

Three stud corners have been typical throughout the 20th century. A 4x4 corner post was sometimes used in older homes as a hold-over from the 19th century braced frame construction. Two stud corners were also used and are still permitted.

4.3.4 Headers

In the early 1900s, headers were usually considered unnecessary above typical window and door openings because of the load distributing effects in the walls and floor members above the opening. Thus, only a single or double 2x4 flat-wise was used. Doubled 2x4 stud framing at window and door openings was considered as an enhancement to allow for better trim attachment and more sturdy support. Regarding headers in platform frame construction, the following 1923 quote was found in *Audel's*:

> *"It [platform framing] made the formation of openings for windows and doors easier: a simple header (flat-wise 2x4) could be utilized because the platform above spreads loads from an upper floor or roof uniformly to the stud walls below."*

For framing above larger than normal doors and windows, truss framing using diagonal blocking with cripple studs was recommended, though extensive use of this recommended practice is doubtful. Framing requirements above window and door openings in the early 1900s are summarized in Table 13.

TABLE 13
RECOMMENDED FRAMING ABOVE OPENINGS
(HEW, 1931)

OPENING WIDTH	RECOMMENDED HEADER FRAMING
3' or less	2-2x4 edgewise in load bearing walls 1-2x4 flatwise in non-load bearing walls
3' to 6'	use a trussed header
greater than 6'	use a girder (built-up header)

During the last half of the 1900s, built-up headers ranging in size up to two 2x12s for large openings were provided in span tables in building codes based on various engineering assumptions and loading conditions with disregard for "load spreading" recognized earlier in the century. No clear reason (practical or technical) for this was found in the reviewed literature. It does appear that recognition of different header requirements in load bearing vs. non-load bearing conditions existed throughout the century, although confusion in the field often resulted in the use of headers in either case.

4.3.5 Bracing

Wall bracing includes not only the presence of designated bracing members, but also the contribution of various sheathing and finish materials applied to interior and exterior surfaces. In addition, housing style (i.e., amount and size of openings and plan configuration) can have significant effects on the amount and type of lateral bracing provided.

In the early 1900s, wall bracing followed one or more of the following reported practices:

- no bracing (relying solely on interior lath and plaster finish and exterior wood siding);
- 1x4 diagonal bracing (let-in or cut-in); or
- horizontal or diagonal board sheathing.

The following 1931 quote from *Wood Frame House Construction* explains the recommendation for wall bracing when no sheathing is used:

> *"Where sheathing is omitted, the wall should be braced, at each corner and beside each doorway, with let-in strips [1x4] running diagonally from the floor line above to the plate or sill below, and nailed strongly at the upper and lower ends as well as at each intervening stud…Drop siding is more suitable than bevel or common siding for direct application to studs without sheathing…While rabbeted siding serves to brace the building to some extent, it does not add sufficient strength to serve in lieu of other forms of bracing. For this reason the building should be braced, or the bracing effect needed should be supplied in some other way, as by wood lath and plaster, diagonal sheathing, or let-in bracing."*

Based on the above quote, it is apparent that interior finishes (wood lath and plaster) were considered as an adequate primary wall bracing mechanism in the 1930s and earlier. However, it was also recognized that other practices, such as the use of let-in braces or diagonal board sheathing provided enhanced bracing.

The Forest Products Laboratory conducted in-plane shear tests in 1929 on various wall systems representative of the above practices. These tests were conducted to determine the effectiveness of different bracing because "no one knew the relative values of different methods." The bracing tested ranged from horizontal sheathing of green lumber to wood lath and plaster without sheathing. Walls were either solid, framed with a single window opening, or framed with a window and door opening. The standard wall construction was designated as horizontal 1x6 board sheathing of seasoned lumber fastened to each stud with two 8d common wire nails (without interior lath and plaster finish). It was assigned a relative value of 100 percent (i.e., strength and stiffness factors of 1.0). Wall height and length dimensions included two conditions: 9 feet by 14 feet and 7 feet 4 inches by 12 feet. The walls were tested under sufficient vertical restraint (load) to prevent overturning from occurring. The test results for the various solid wall constructions are shown in Table 14; results for walls with openings are shown in Table 15. It is apparent that results varied substantially.

TABLE 14
EARLY SHEAR WALL TEST DATA
[Forest Products Laboratory, 1929]

SIZE OF PANEL	DESCRIPTION	LOAD (pounds)	STRENGTH FACTOR	STIFFNESS FACTOR	REMARKS
9’ x 14’	8-inch horizontal sheathing, two 8d nails, no braces				
7’-4” x 12’	“	2,588	1.0	1.0	No. 20 vibrated 50,000 cycles
7’-4” x 12’	“				
9’ x 14’	“				
9’ x 14’	8-inch diagonal sheathing, two 8d nails, no braces, boards in tension	--	over 8	4.3	Test stopped at 20,000 lb load
7’-4” x 12’	“	17,100	6.6	4.3	
9’ x 14’	“	--	over 8	2.8	Test stopped at 20,000 lb load
9’ x 14’	“	20,100	7.8	7.3	
9’ x 14’	8-inch horizontal sheathing, two 8d nails, herringbone or bridge 2x4 braces	2,800	1.1	1.3	
9’ x 14’	“ “ , cut-in 2x4 braces	3,700	1.4	1.6	
9’ x 14’	“ “ , let-in 1x4 braces, first arrangement	9,250	3.6	2.6	
9’ x 14’	“ “ , cut-in 2x4 braces, second arrangement	9,000	3.5	4.2	
9’ x 14’	8-inch horizontal sheathing, three 8d nails, no braces	2,330	0.9	1.0	
9’ x 14’	“ , four “ “	3,550	1.4	1.4	
9’ x 14’	8-inch diagonal sheathing, three 8d nails, no braces, boards in tension	--	over 8	5.2	Test stopped at 20,000 lb load
9’ x 14’	“ , four “ “ “	--	over 8	7.5	Test stopped at 20,000 lb load
9’ x 14’	8-inch horizontal sheathing, two 10d nails, no braces	3,500	1.4	1.5	
9’ x 14’	“ , two 12d nails, “	2,800	1.1	1.3	
9’ x 14’	8-inch diagonal sheathing, two 10d nails, no braces, boards in tension	--	over 8	7.5	Test stopped at 20,000 lb load
9’ x 14’	6-inch horizontal sheathing, two 8d nails, end and side matched, no braces	2,550	1.0	1.0	
9’ x 14’	Plaster on wood lath, no sheathing	11,400	4.4	7.2	First plaster crack at 10,600 lb
9’ x 14’	“ , 8-inch horizontal sheathing, two 8d nails, no braces	14,500	5.6	7.9	“ “ “ “ 9,900 lb
9’ x 14’	“ , 8-inch diagonal sheathing, “ , “	20,300	7.8	9.2	“ “ “ “ 12,200 lb
9’ x 14’	“ , studs and horizontal sheathing, green lumber then seasoned one month	12,700	4.9	6.0	“ “ “ “ 8,200 lb
9’ x 14’	8-inch horizontal green sheathing, two 8d nails, no braces, panel seasoned one month	1,700	0.7	0.5	
7’-4” x 12’	“ “ “ “ “ “ “	1,800	0.7	0.7	Vibrated one million cycles
9’ x 14’	“ diagonal “ “ “ “ “	--	--	1.7	
7’-4” x 12’	“ “ “ “ “ “ “	--	--	1.7	
9’ x 14’	8-inch horizontal sheathing, two 8d nails, no braces, alt. sunshine and rain one month	2,175	0.8	0.7	

Note: Panel frames consisted of 2x4 upper and lower plates, vertical studs spaced 16 inches, and triple end posts.

TABLE 15
EARLY SHEAR WALL TEST DATA FOR 9’ X 14’ WALLS WITH OPENINGS
[Forest Products Laboratory, 1929]

OPENINGS	DESCRIPTION	LOAD (pounds)	STRENGTH FACTOR	STIFFNESS FACTOR	REMARKS
window	8-inch horizontal sheathing, 1x4 let-in brace	6,500	2.5	3.0	
“	“ diagonal “ , no braces, broads in tension	13,000	5.0	3.1	
window and door	8-inch horizontal sheathing, no braces	2,100	0.8	0.7	
“	“ diagonal “ “ , boards in tension	10,240	4.0	1.4	
“	“ “ “ “ “ “	10,150	3.9	1.4	
“	“ “ “ “ “ compression	3,250	1.3	0.8	
“	“ “ “ “ “ “	3,400	1.3	1.2	
“	8-inch horizontal sheathing, 1x4 let-in braces	5,650	2.2	1.5	
“	8-inch horizontal sheathing, no braces, 6-inch bevel siding	3,400	1.3	1.1	
“	“ “ diagonal “ “ , boards in compression, 6-inch bevel siding	8,500	3.3	2.0	
“	“ “ “ “ “ , “ tension , “	13,900	5.4	3.3	
“	“ “ horizontal “ 1x4 let-in braces, 6-inch bevel siding	8,880	3.4	2.7	
“	Plaster on wood lath, no sheathing	4,200	1.6	2.3	First plaster crack at 1,300 lb
“	“ “ “ , 8-inch horizontal sheathing, no braces	5,800	2.2	2.4	“ “ “ 800 lb
“	“ “ “ , “ diagonal “ “	11,300	4.4	2.8	“ “ “ 800 lb
“	“ “ “ , “ horizontal “ , 1x4 let-in braces	9,360	3.6	4.1	“ “ “ 1,500 lb

Notes: 1. Panel frames consisted of 2x4 upper and lower plates, vertical studs spaced 16 inches, and triple end posts.
2. Window rough openings were approximately 33” x 57” and door openings approximately 33” x 76”. Therefore, the total wall area was 126 square feet, the window area was 13 square feet, and the door area was 17.4 square feet.

Interestingly, the “no bracing” condition (with lath and plaster only) provided 440 percent more shear capacity than the horizontal board sheathing without lath and plaster used as a comparative baseline. Diagonal board sheathing also provided significant racking strength for solid walls, but, when the diagonal boards were loaded in compression in walls with window and door openings, the shear capacity was less than that achieved with lath and plaster with the same window and door openings. Findings for walls with openings showed that any of the bracing methods that included a 1x4 brace, diagonal sheathing, or plaster and wood lath provided more shear capacity than for the solid wall with horizontal sheathing only.

With the introduction of 4x8 plywood sheathing panels in the mid-1900s, interest in wall bracing using wood sheathing panels was initiated. However, the standard affordable construction apparently remained with the use of 1x4 let-in braces and non-structural sheathing. Later, designated bracing was provided by wood structural panels (i.e., plywood) placed continuously or intermittently (i.e., at corners and at 25’ intervals along each wall). Also, a significant number of modern homes used proprietary wall bracing panels such as medium density fiber board, and others. By the end of the century, 7/16-inch-thick oriented strand board (OSB) was commonly used to fully sheath exterior walls. Some statistics on the use of exterior sheathing/bracing are included in Table 1. Various sources of test data on shear resistance of wall materials are summarized in the *Residential Structural Design Guide – 2000 Edition* (HUD, 2000). Approximate ultimate shear values for various modern wall constructions based on research from the mid- to late-1900s are shown in Table 16.

TABLE 16
ULTIMATE SHEAR VALUES FOR TYPICAL MODERN WALL CONSTRUCTIONS

1x4 Let-in brace	>600 lbs/ea (tension) 2,000 lbs/ea (compression)
Metal T-brace (tension only)	1,400 lbs/ea
1/2” Gypsum Wall Board (single side, min. 4d cooler nails at 12”oc)	100 plf
3/8” Plywood or 7/16” OSB (G=0.5, 8d pneumatic nails at standard 6/12 spacing)	650 plf
Exterior 7/8” PC stucco and metal lath w/nails w/staples	 500-750 plf 750-1,580 plf

It is evident that the interior finish material, which is not considered explicitly as bracing, actually was the most significant determinant of bracing capacity in many homes built during the first half of the 20th century. During the mid-1900s the preference for interior finishes switched from wood lath and plaster to gypsumboard, 2 foot wide gypsum “lath” that was finished with a skim coat of plaster. Soon thereafter, the preferred practice became gypsum wallboard using 4 foot wide panels with taped and finished joints. This practice has remained a standard through the end of the 20th century. It is noted that older lath and plaster interior finishes may provide up to 8 times more shear capacity than typical gypsum board wall finishes used in modern homes (i.e., 100 plf vs. 800 plf). However, all modern homes use either structural panel or let-in/metal braces in addition to support provided by interior finishes.

Since dwelling lateral (shear) capacity is to some degree dependent on interior finishes, it is important to consider changes in the average size of houses as depicted in Table 1, in amounts of interior wall relative to area, and in dead load (relative to seismic or wind design loads). Data on interior wall linear footage per story level as a function of square feet of floor area on a given story level are shown in Table 17. These data are based on a limited sample of house plans that are considered to be representative of a range of home styles constructed in each period. The decrease in the relative amounts of interior walls over the course of the past century is notable. While this trend tends to show a decrease in the amount of ancillary bracing provided by interior walls in newer homes, the lineal footage of exterior walls relative to floor area tend to increase in the newer homes. Thus, the overall bracing impact (considering the changes to interior and exterior walls) may be somewhat offset by these two countervailing trends. Uncertainty in the effects of increased irregularity in plan configuration of newer homes must also be considered relative to possible impact on resistance to lateral loads. However, one recent study of homes following the Northridge Earthquake seems to indicate that irregularities in wall line offsets cannot be directly associated with any noticeable trend in performance of single family homes (HUD, 1999). The data summarized in this section is provided to suggest the need for a more detailed and thorough evaluation of changes in bracing found in homes over the past century. Thus, the simple comparisons as suggested in this report are not absolute or complete treatments of this subject.

TABLE 17
INTERIOR WALL AMOUNTS
[lin. ft. as a percent of floor area of story]

OLDER HOMES (early 1900s)[1]		MODERN HOMES (late 1900s)[2]	
1 story	9 percent ± 1 percent	1st floor of 1 to 2 story	4.3 percent ± 1 percent
1st floor of 2 story	6 percent ± 1 percent	2nd floor of 2 story	7.9 percent ± 1 percent
2nd floor of 2 story	9 percent ± 1.5 percent		

Notes:
[1]Values based on a small sample of traditional house plans in Sears Catalogues (1910 – 1926) including affordable and more expensive construction of 1 and 2 stories.
[2]Values based on a small sample of representative modern home plans (1990s) including economy and move-up construction (no luxury homes).

4.4 ROOF FRAMING

4.4.1 Rafters

As noted earlier, roof rafters were typically 2x4 or 2x6 in the early 1900s. The horizontal span of rafters and the rules of thumb mentioned previously for joists were typically used for rafter members as well. For hip and valley rafters, the following rule of thumb from *Light Frame House Construction* was apparently in use in the early part of the 20th century:

- up to 12 foot horizontal span use a single hip rafter 2 inches deeper or 1 inch thicker than rafters; and
- over 12 foot horizontal span use a doubled rafter for the hip rafter.

Since engineering methods have failed to offer reasonably accurate explanations of the system effects related to hip or valley rafter design, similar rules of thumb are still in practice today (unless an engineered design is required). By the mid-1900s, rafter framing (and also floor joists) were commonly provided in engineered span tables using certain design assumptions and methods of analysis considering single elements and not systems. Newer span tables are based on updated lumber properties, but engineering assumptions similar to those used earlier in the century are found in all modern building codes for residential construction. During the mid-1900s, engineered wood roof trusses were introduced and by the late-1900s were used in a great majority of new homes (see Table 1).

4.4.2 Roof Sheathing

In the early 1900s, roof sheathing of 1x6 or 1x8 boards, or minimum 1x3 furring (spaced sheathing) spaced according to weather exposure of wood shingles (up to 6 inches on center) was typical. A minimum of two 8d common wire nails were typically used to fasten random-length boards to each roof rafter. In the mid-1900s plywood roof sheathing entered the market and soon became the standard. By the late 1900s, most roofs were sheathed with some form of wood structural panel sheathing, primarily 7/16-inch-thick OSB (see Table 1); board sheathing methods had become practically extinct. Nailing requirements and types of fasteners changed to accommodate the panels and newer tools, such as pneumatic nail guns.

4.5 FASTENERS AND CONNECTIONS

Trends in the treatment of connections in housing during the 20th century provide important insights into changes in the structural characteristics of homes. This section reviews some of the changes in fastening practices and materials. Where found in the literature, data on structural characteristics of various fasteners or connections are summarized.

Wire nails have been the predominant fastener for wood framing connections throughout the 20th century. Up to the 20th century, the most common nails used were wrought iron or cut nails, which were preceded by the use of wooden pegs and special heavy timber connection details (i.e., wood joinery). Cut nails were quickly replaced by common wire nails in the earliest parts of the 20th century. However, it is worth noting that *Audel's* reports test data indicating that cut nails provide as much as 2 to 3 times the "holding capacity" of common wire nails of similar size. The tests were conducted with several repetitions and wood species, including hardwoods and soft woods and dense soft woods. It is presumed that the difference in withdrawal capacity can be explained by the wedging action created by the tapered shank of a cut nail. Cut nails continued to see infrequent use for some applications such as hardwood flooring, but eventually they became obsolete. In early framing practice, specifications often called for heavier loaded joints or thicker materials to be "securely spiked together." Spikes are similar to common wire nails, but are larger in diameter and greater in length than common wire nails. However, from the literature surveyed, it appears that for home building in the early 1900s, spikes may have been considered to be 20d common wire nails. Rules of thumb for nail selection in the early 1900s are paraphrased as follows from *Audel's*:

> *"Use one penny size for each 1/8-inch of thickness for typical wood density. For softer wood use up to two penny-weights larger, and for harder/denser wood use one to two penny-weights smaller to prevent cracking of wood."*

In the last half of the 1900s, box nails with a smaller shank diameter and a resin coating to increase holding were used to some unknown extent. By the late 1900s, pneumatic fasteners dominated the market. Various fastener sizes and types are addressed in the *Residential Structural Design Guide – 2000 Edition* (HUD, 2000) and other wood design or technology references.

Early requirements for nailing were as much a result of constructability considerations as for structural reason, and varied depending on a particular connection and its perceived role in the structural system. Often, the older requirements for connections used vague terms such as “spike securely” or “adequately nail.” Perhaps this subjective approach was in realization that the fastening practice, material choices, and framing methods of the early 1900s were sufficiently conservative and simple as to not require exact specification. While connection requirements for modern residential wood framing can be found in building codes, no data is available that quantifies the variation in actual fastening techniques or practices used in the field. Observation tends to suggest that the variation is quite large. Very little technical data is available to explain the actual performance of various fastener and material choices found in modern home construction practice, particularly when considered at a system level (e.g., multiple joints and fasteners in a load path). Some studies of this nature are summarized in the *Residential Structural Design Guide – 2000 Edition* (HUD, 2000).

The following connection requirements or practices are excerpted and summarized from sources reviewed in this study. They are based on recommendations provided in various framing guidelines and early code documents and, therefore, may not represent actual field practice during the different time periods or in different locales.

4.5.1 Early 1900s

Sill to Foundation - Indicated as “desireable” to anchor sill to foundation (especially if high wind is possible); recommend 3/4 inch bolts extending 18 inches into concrete foundation wall with OG washer and nut. Recommendations for sill bolt spacing ranged from 6 feet to 12 feet on center. Evidently, anchoring was not a required or common practice for typical construction at the beginning of the 20th century.

Joist to Sill or Wall (depending on type of framing) - (1) Balloon and braced framing: *spike securely* to side of studs (two near bottom and enough at top to hold in place during construction). (2) Platform framing: joists should be *securely toe-nailed* to plate with not less that 8d or 10d nails; box headers should be *spiked securely* into ends of joists with 20d nails (remember, the box header or band joist was treated as a continuous header above all openings in walls below).

Built-up Girders - Use 10d common wire nails at 12 inches on center top and bottom (staggered) to keep individual members from buckling separately or failing independently.

Joist Headers for Floor Openings - End nail through inside trimmer (if doubled trimmer joists) into end grain of each single or built-up header member with two 20d spikes for 2x6; 3 for 2x8 and 2x10; or 4 for 2x12 and 2x14.

Stud to Top and Bottom Plates - “Desirable” to endnail using two 20d common wire nails.

Ribband to Stud - Let-in 1x6 into studs to support joists in balloon framing; secure ribband to each stud with two 8d common wire nails.

Rafter to Ceiling Joists or Collar Beams (cross ties) - "Solidly nail" rafters to joists; connect a ceiling joist to every rafter if shallow slope roof or to every second or third rafter for steep roofs. Some old construction drawings suggest that 3 to 5 nails may have been used for this connection.

Rafters to Ridge Board - Toenail or endnail rafter to ridge board; "not of great significance structurally," but required to hold in place during construction.

Rafters to Wall Plate - Toe nailing was common practice; however, nail sizes and numbers were not shown or reported in any of the literature surveyed. Like foundation anchor bolts, it appears that anchoring of roofs was left to the realm of "accepted construction practice."

Valley and Hip Rafter to Ridge - Provide "adequate fastening to ridge to prevent pulling apart."

Sheathing Boards to Wall or Roof Framing - Two 8d common nails per board up to 1x8; three 8d common nails for greater than 1x8. In the early 1900s cut nails were still frequently used for this connection.

4.5.2 Late 1900s

The mid-1900s can be considered as a transition period in fastening technology. During this period, pneumatic fasteners began to be used (discussed below). Box nails were also used in place of common nails, but to an unknown degree. Other changes that affected fastener specification included the introduction of plywood sheathing, and the use of metal plate connected wood trusses in place of traditional rafter and joist framing. Special metal connectors, such as joist hangers, also came into use for certain connections or conditions.

By the late 1900s, pneumatic fasteners were used predominantly in the home building industry for framing purposes. The requirements for pneumatic fasteners (nails and staples) were provided in a code evaluation report (NER 272). However, connection schedules in codes still addressed primarily common wire nails. Thus, the connection requirements for specific fastener types in common use or approved for use are not consolidated. This condition may explain the variations in actual practice that may fall above or below the minimums implied by or explicitly defined in modern building codes.

5.0 CONSTRUCTION QUALITY

No reliable source of data was found regarding trends in construction quality over the course of the 20th century. However, it should be noted that complaints and concerns with shoddy construction in the references used in this study seem to indicate that it was just as much a concern at the beginning of the century as the end. Unfortunately, the significance of such concerns remain in the realm of anecdotal evidence, which serves to confirm that quality problems existed, but does not allow a quantitative assessment of the degree, frequency, or implications of such problems as related to structural performance in newer or older homes. It appears that the tradespeople of yesterday were just as subject to human error as they are today.

However, assuming no significant change in construction quality, certain changes in construction materials and methods may justify a greater concern in modern times on the basis that the techniques are less "forgiving" of mistakes or tolerances implicit to reasonable standards of workmanship. For example, modern framing members are somewhat smaller and require greater precision in fastener installation. Pneumatic fastening methods and panelized sheathing products tend to create situations where "blind" connections are made to underlying framing members without as close a control as inherent with hand-driven nails to secure boards. While such problems can be avoided with appropriate controls, newer materials and methods (including more varieties and options than in the past) do seem to place the burden of a greater standard of care on the tradesperson.

6.0 SUMMARY AND CONCLUSIONS

Significant changes to construction materials and methods have occurred over the past century that affect the economy and structural performance of homes. In some cases it appears that change has increased structural performance while, in other cases structural performance was reduced. It also appears that different levels of value (i.e., balancing of cost versus performance) have been applied throughout the century to meet varied housing needs or desires in the nation. As a result, minimums based on a compelling need for affordable housing have co-existed with "up-grades" used in homes sold to more affluent buyers. In such a manner, housing supply has served a diverse demand with needed flexibility in establishing an appropriate definition of value based on individual buyers or market segments.

Some significant changes to housing construction methods and materials discussed in this report are summarized as follows:

- Separate concrete spread footings, introduced in early 1900s, are found on nearly all homes by the end of the century. In fact, several enhancements to foundation construction have occurred over the past century.

- Framing method switched from balloon to platform frame technique.

- In 1900, lumber was ungraded and largely reliant on locally available species and “sorts”. Later, lumber grades were standardized and resources became more dependent on managed forests and fewer species.

- Lumber size was originally based on full dimensions (i.e., actual size of a 2x4 was 2 inches by 4 inches). During the 1900s, the sizes of “finished” dimension lumber were reduced in several stages to a standard thickness of 1.5 inches and standard widths of 3.5, 5.5, 7.25, 9.25, and 11.25 inches for nominal 2x4, 2x6, 2x8, 2x10, and 2x12 dimension lumber, respectively.

- At the end of the 20th century, engineered wood products quickly gained acceptance as alternatives to dimension lumber used primarily in sheathing, floor framing, and floor girder applications.

- A complete change from boards to engineered wood structural panels (i.e., OSB and plywood) happened relatively quickly early in the second half of the 20th century.

- Headers for windows and doors have seen significant change. At the beginning of the century structural headers, as such, were not normally used over openings; instead there was acknowledgement of system effects in distributing loads over wall openings. By the end of the 20th century, header requirements became more complicated requiring different tables to be considered under various conditions. For unspecified reasons, the earlier acknowledgment of system effects was abandoned. In addition, the apparent desire to simplify construction in the field has often resulted in the “worst-case” condition being applied to all headers in order to eliminate confusion.

- Wall bracing has apparently seen little change in effective capacity required by standardized testing of wall segments, though materials have changed during the course of the 20th century. Specific bracing requirements were implemented in the last half of the century. However, interior finishes have changed from lath and plaster to gypsum wallboard which has the effect of lowering the “reserve capacity” found in older homes relative to newer homes. Changes in house style, size, and design of interior space have also affected the “reserve capacity.” However, more recent trends toward total sheathing with structural material such as OSB can readily compensate for other "losses."

- Fasteners changed, first from cut nails to common wire nails, then to pneumatic fasteners. Box or sinker nails were also used. However, little quantitative information is available to determine the functional or performance rationale for connections found in the historic practice or in building codes (not to suggest that data from various single fastener tests do not exist in large quantity). The withdrawal capacity of an 8d cut nail used at the beginning of the 20th century for sheathing was as much as 2 to 3 times more than a comparable 8d common wire nail according to early tests. The 8d common wire nail, in turn, provides greater withdrawal capacity when compared to most 8d (0.113 inch diameter) pneumatic nails commonly used at the end of the 20th century, but only when adhesive coatings on pneumatic nails are not considered. Thus, withdrawal capacity of nails for certain joints may have changed dramatically depending on the effectiveness of adhesives on newer coated nails. Changes in the shear capacity of certain joints, such as sheathing connections, also occurred as a result of the general reduction in nail diameters.

- Construction quality has been a concern through the 20th century with little evidence to suggest that any substantial change (good or bad) has occurred. However, there are some obvious changes in materials and tools that require more precision in construction; thus, there is a greater potential for error, particularly in connections. This problem is not helped by the numerous choices for fasteners (including staples, etc.) now on the market, and the lack of simplicity and uniformity in the regulations that govern connection requirements in modern construction practice.

7.0 RECOMMENDATIONS

The findings and conclusions of this study suggest that certain modern house construction practices should be carefully evaluated in view of changes in historic practice. Some specific recommendations include:

1. Re-evaluate, simplify, and prepare specific details for connections that balance structural needs with the intuition and capability of the tradesperson. For example, can two specific sizes of pneumatic nails be successfully used to specify all or most framing connections in a typical house?

2. Wall bracing practices should be re-assessed based on changes in the style, size, and interior finishes used in modern homes as compared to older homes (early 1900s).

3. Practices for header sizing and engineering analysis of homes in general should incorporate more efficient system-based design principles that were inherently understood in the design and framing practices in the early 1900s.

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APPENDIX A
THERMAL INSULATION

Very little mention of any requirement for energy efficiency such as thermal insulation was found in the historical sources reviewed (see Bibliography). For example, no information on thermal insulation was found in the Sears catalogues, which were considered an exhaustive catalogue for building materials, although the use of tarred felt paper underneath flooring to prevent draftiness and under the siding for rot protection was mentioned.

Tarred paper was also recognized as an air barrier to prevent air leakage through walls in “poorly built” homes in a University of Wisconsin study in the early 1900s. This study reported various infiltration rates through frame walls and found that “air infiltration through frame wall construction, containing building paper or plaster properly applied, is negligibly small (0.1 to 0.3 cubic feet per hour with a 15 mph wind-induced pressure difference). It is also reported that the United States Bureau of Standards had conducted tests on the strength, rate of air penetration, and moisture proof properties of building papers. Asphalt impregnated papers were reported to weigh from 66 to 163 pounds per 1,000 square feet. It was noted that building paper “must be selected and put on much more carefully than is ordinarily done.”

One 1930s framing guide (HEW, 1931) encouraged the use of exterior board sub-sheathing for its structural bracing benefits and for comfort benefits in cold or hot climates since “wood is one of the best natural insulators.” In addition, one drawing of roof framing did indicate “insulation material” placed between ceiling joists, which may suggest the relative importance placed on insulation in roofs as compared to other locations. The same guide later describes air leakage and thermal conduction as primary sources of heat loss, and encourages the use of thermal insulation and weather striping of doors to save on the rising cost of coal as well as other sources of heating energy (fuel oil, electric, etc.), and percent reductions in air leakage were cited for practices such as weather stripping and tightly fitting doors.

The National Bureau of Standards (Journal of Research, Vol.6, No.3), reported fuel savings for combinations of weather-stripped doors, insulation, and double (storm) windows. The savings were reported to range from 10 to 60 percent. The higher values were reported for use of 1-inch insulation (probably exterior wood sheathing) and double windows. It is noted that if tarred paper is not placed over sheathing (i.e., board sheathing is omitted) it is probably not worth installing because of air leakage between laps in the building paper. It is not clear that the function of moisture protection was considered reason enough to justify the use of building paper.

In general, energy efficiency did not become a serious consideration in home construction until later in the 1900s. The Minimum Property Standards (HUD, 1958) gave requirements for insulation based on a rudimentary calculation method. By the late 1900s, more sophisticated energy codes had been developed and relatively high levels of insulation were required in virtually every new home. The availability of materials to enhance energy efficiency also flourished (e.g., double glazed windows, various insulation types with high thermal resistivity, sealing and weather-stripping technologies, etc.). In addition to energy codes that addressed new construction, tax incentive programs were introduced in the 1970s to encourage insulation of older homes. In addition, credits were offered through energy efficient mortgage financing programs and demand-management programs offered by various utility companies.

Submit a comment

Proposed Change 1390

Code Reference(s):	NPC20 Div.B 2.4.9.2. (first printing)
Subject:	Drainage Systems
Title:	Size of Drainage Pipes Serving Water Closets
Description:	This proposed change deletes Sentences 2.4.9.2.(2) and (3), which set minimum sizes for branch and building drains, and soil-or-waste stacks, respectively.
Related Code Change Request(s):	CCR 1242

This change could potentially affect the following topic areas:

- [ ] Division A
- [x] Division B
- [ ] Division C
- [ ] Design and Construction
- [ ] Building operations
- [ ] Housing
- [x] Small Buildings
- [x] Large Buildings
- [ ] Fire Protection
- [ ] Occupant safety in use
- [ ] Accessibility
- [ ] Structural Requirements
- [ ] Building Envelope
- [ ] Energy Efficiency
- [ ] Heating, Ventilating and Air Conditioning
- [x] Plumbing
- [ ] Construction and Demolition Sites

Problem

The current Article 2.4.9.2. of Division B of the NPC restricts the nominal pipe size (NPS) of branch or building drains and soil-or-waste stacks that serve water closets. A branch or building drain serving three or more water closet fixtures is required to be not less than NPS 4 in size. Likewise, a soil-or-waste stack that serves more than six water closets is required to be not less than NPS 4 in size.

These restrictions on pipe size could lead to the oversizing of pipes, which could lead to insufficient flow velocity, as well as insufficient carrying capacity, which in turn could contribute to blockage issues and lead to unsanitary conditions and harm to persons.

Justification

The sizing of drainage pipes serving water closets should solely be based on the hydraulic load in fixture units, where "fixture unit" is defined in Article 1.4.1.2. of Division A of the NPC "(as applying to drainage systems) [as] the unit of measure based on the rate of discharge, time of operation and frequency of use of a fixture that expresses the hydraulic load that is imposed by that fixture on the drainage system."

According to Table 2.4.9.3., water closets with flush tanks have a hydraulic load of 4 fixture units drained (FUD) and water closets with direct flush valves have a hydraulic load of 6 FUD.

According to Table 2.4.10.6.-B, a maximum hydraulic load of 27 FUD is permitted to drain to an NPS 3 branch. Therefore, six water closets with flush tanks or four water closets with direct flush valves are permitted to discharge into an NPS 3 branch.

According to Table 2.4.10.6.-A, a maximum hydraulic load of 18 FUD per storey is permitted to drain into an NPS 3 soil-or-waste stack. Therefore, four water closets with flush tanks or three water closets with direct flush valves per storey are permitted to discharge into an NPS 3 stack.

To prevent the oversizing of pipes, this proposed change would remove the restrictions on pipe size in Sentences 2.4.9.2.(2) and (3) in favour of using the applicable NPC Tables to determine the appropriate pipe size by hydraulic load.

PROPOSED CHANGE

[2.4.9.2.] 2.4.9.2. Serving Water Closets

[1] 1) Drainage pipes that serve a water closet shall be not less than *NPS* 3.

~~[2] 2) *Branch* and *building drains* downstream of the third water-closet *fixture drain* connection shall be not less than *NPS* 4.~~

~~[3] 3) *Stacks* that serve more than 6 water closets shall be not less than *NPS* 4.~~

[4] 4) Discharge pipes serving a macerating toilet system shall be not less than *NPS* ¾.

Impact analysis

This proposed change would reduce plumbing installation costs while ensuring that the Code objectives and functional statements continue to be met. This proposed change would favour the use of the hydraulic loads in applicable NPC Tables to ensure that water closets discharge into a pipe of a size that is appropriate for the number of water closets, which would limit the likelihood that persons would be exposed to an unacceptable risk of illness due to unsanitary conditions.

Enforcement implications

This proposed change would facilitate the enforcement of Section 2.4. by building officials and regulators.

Who is affected

Designers, plumbers, regulators, engineers, building owners, and contractors.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[2.4.9.2.] 2.4.9.2. ([1] 1) [F81-OH2.1]

~~[2.4.9.2.] 2.4.9.2. ([2] 2) [F81-OH2.1]~~

~~[2.4.9.2.] 2.4.9.2. ([3] 3) [F81-OH2.1]~~

[2.4.9.2.] 2.4.9.2. ([4] 4) [F81-OH2.1]