Comment **Commentaires**

Document	NBC 2005	Document
Provision	Appendix C	Exigence
Committee	Structural Design • Calcul des structures	Comité
Minutes	pcf Appendix C,2005-06.13	Procès-verbaux

EXISTING PROVISION

Appendix C
Climatic and Seismic Information for Building Design in Canada

Introduction

The great diversity of climate in Canada has a considerable effect on the performance of buildings; consequently, building design must reflect this diversity. This Appendix briefly describes how climatic design values are computed and provides recommended design data for a number of cities, towns, and smaller populated locations. Through the use of such data, appropriate allowances can be made for climate variations in different localities of Canada and the National Building Code can be applied nationally.

[…]

Changing and Variable Climates

Climate is not static. At any location, weather and climatic conditions vary from season to season, year to year, and over longer time periods (climate cycles). This has always been the case. When estimating climatic design loads, this variability can be considered using appropriate statistical analysis, data records spanning sufficient periods, and meteorological judgement. The analysis generally assumes that the past climate will be representative of the future climate.

Past and ongoing modifications to atmospheric chemistry (from greenhouse gas emissions and land use changes) are expected to alter most climatic regimes in the future. As a result, it can no longer be safely assumed that the climate of the past few decades will be a sufficient guide to the climate of the next few decades. While average climatic conditions may be changing, the frequency and magnitude of extreme climatic events may also be changing in unknown ways. Although consensus is emerging on the long-term trends for some climatic elements, there is no agreement as yet on the changes expected in climatic variability.

January Design Temperatures

A building and its heating system should be designed to maintain the inside temperature at some pre-determined level. To achieve this, it is necessary to know the most severe weather conditions under which the system will be expected to function satisfactorily. Failure to maintain the inside temperature at the pre-determined level will not usually be serious if the temperature drop is not great and if the duration is not long. The outside conditions should, therefore, not be the most severe in many years, but should be the somewhat less severe conditions that are occasionally but not greatly exceeded.

The January design temperatures are based on an analysis of January air temperatures only. Wind and solar radiation also affect the inside temperature of most buildings and may need to be considered for energy-efficient design.

The January design temperature is defined as the lowest temperature at or below which only a certain small percentage of the hourly outside air temperatures in January occur. In the past, a total of 158 stations with records from all or part of the period 1951-66 formed the basis for calculation of the 2.5 and 1% January temperatures. Where necessary, the data were adjusted for consistency. Since most of the temperatures were observed at airports, design values for the core areas of large cities could be 1 or 2°C milder, although the values for the fringe areas are probably about the same as for the airports. No adjustments were made for this urban heat island effect. The design values for the next 20 to 30 years probably will differ from these tabulated values due to year-to-year climate variability and global climate change resulting from human modifications to atmospheric chemistry.

A review of the design temperatures was undertaken for the 1995 issue of this Appendix using hourly temperature observations from 265 stations for the length of record up to 1993. Where needed, hourly temperatures were supplemented with correlated record minimum temperatures from 1449 long-term stations. The results from the recent analysis indicated reasonable consistency with the previous recommendations. Consequently, the January design temperatures remain unchanged from previous issues of the Supplement to the National Building Code of Canada.

The 2.5% January design temperature is the value ordinarily used in the design of heating systems. In special cases, when the control of inside temperature is more critical, the 1% value may be used. Other temperature-dependent climatic design parameters may be considered for future issues of this document.

July Design Temperatures

A building and its cooling and dehumidifying system should be designed to maintain the inside temperature and humidity at certain pre-determined levels. To achieve this, it is necessary to know the most severe weather conditions under which the system is expected to function satisfactorily. Failure to maintain the inside temperature and humidity at the pre-determined levels will usually not be serious if the increases in temperature and humidity are not great and the duration is not long. The outside conditions used for design should, therefore, not be the most severe in many years, but should be the somewhat less severe conditions that are occasionally but not greatly exceeded.

The summer design temperatures in this Appendix are based on an analysis of July air temperatures and humidities. Wind and solar radiation also affect the inside temperature of most buildings and may, in some cases, be more important than the outside air temperature. More complete summer and winter design information can be obtained from Environment Canada.

In the past, two datasets formed the basis for calculation of the July 2.5% dry-bulb temperatures. The first dataset was based on temperature frequency distributions for 33 stations and an empirical relationship between design temperatures and the mean annual maximum temperature. The second dataset consisted of hourly data summaries for 109 stations based on records from 1957 to 1966. Results from the two datasets were averaged and adjusted for consistency. The July 2.5% wet-bulb temperatures were obtained in a similar way, using the two datasets, but without the use of an empirical relationship for the first dataset.

A review of the July design temperatures was undertaken for the 1995 issue of this Appendix. Design dry-bulb temperatures were analyzed using hourly temperature observations from 264 stations for the length of record up to 1993. Where needed, hourly dry-bulb temperatures were supplemented with correlated record maximum temperatures from 1450 long-term stations. The July 2.5% coincident wet-bulb temperatures were obtained by averaging wet-bulb temperatures for all hours when the dry-bulb temperature was within 0.2°C of the July design dry-bulb temperature. A comparison of the results indicated reasonable consistency for design dry-bulb temperatures but some differences for design wet-bulb temperatures that will be investigated for future issues. The July design temperatures remain unchanged for this issue.

Heating Degree-Days

The rate of consumption of fuel or energy required to keep the interior of a small building at 21°C when the outside air temperature is below 18°C is roughly proportional to the difference between 18°C and the outside temperature. Wind speed, solar radiation, the extent to which the building is exposed to these elements and the internal heat sources also affect the heat required and may have to be considered for energy-efficient design. For average conditions of wind, radiation, exposure, and internal sources, however, the proportionality with the temperature difference generally still holds.

Since the fuel required is also proportional to the duration of the cold weather, a convenient method of combining these elements of temperature and time is to add the differences between 18°C and the mean temperature for every day in the year when the mean temperature is below 18°C. It is assumed that no heat is required when the mean outside air temperature for the day is 18°C or higher.

Although more sophisticated computer simulations using other forms of weather data have now almost completely replaced degree-day-based calculation methods for estimating annual heating energy consumption, degree-days remain a useful indicator of relative severity of climate and can form the basis for certain climate-related code requirements.

The degree-days below 18°C have been computed day by day for 1030 stations for the length of record available from the period 1961 to 1990. The average annual degree-day values were then interpolated from analyzed maps. When observations with 20 years or more of record were available, recommendations for those locations were weighted towards the observed value.

A difference of only one Celsius degree in the mean annual temperature will cause a difference of 250 to 350 in the Celsius degree-days. Since differences of 0.5 of a Celsius degree in the mean annual temperature are quite likely to occur between two stations in the same town, heating degree-days cannot be relied on to an accuracy of less than about 100 degree-days.

Heating degree-day values for the core areas of larger cities can be 200 to 400 degree-days less (warmer) than for the surrounding fringe areas. The observed degree-days, which are based on daily temperature observations, are often most representative of rural settings or the fringe areas of cities.

Snow Loads

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Rainfall Intensity

Roof drainage systems are designed to carry off rainwater from the most intense rainfall that is likely to occur. A certain amount of time is required for the rainwater to flow across and down the roof before it enters the gutter or drainage system. This results in the smoothing out of the most rapid changes in rainfall intensity. The drainage system, therefore, need only cope with the flow of rainwater produced by the average rainfall intensity over a period of a few minutes, which can be called the concentration time.

In Canada, it has been customary to use the 15-minute rainfall that will probably be exceeded on an average of once in 10 years. The concentration time for small roofs is much less than 15 minutes and hence the design intensity will be exceeded more frequently than once in 10 years. The safety factors in the National Plumbing

Code of Canada 2005 will probably reduce the frequency to a reasonable value and, in addition, the occasional failure of a roof drainage system will not be particularly serious in most cases.

The rainfall intensity values tabulated in previous editions of this information were based on measurements of the annual maximum 15-minute rainfalls at 139 stations with 7 or more years of record. They were the 15-minute rainfalls that would be exceeded once in 10 years on average, or the values that had 1 chance in 10 of being exceeded in any one year. The values were analyzed using a Gumbel extreme value distribution.(1)

It is very difficult to estimate the pattern of rainfall intensity in mountainous areas, where precipitation is extremely variable and rainfall intensity can be much greater than in other types of areas. Many of the observations for these areas were taken at locations in valley bottoms or in extensive, fairly level areas.

One-Day Rainfall

If for any reason a roof drainage system becomes ineffective, the accumulation of rainwater may be great enough in some cases to cause a significant increase in the load on the roof. In previous editions of this information, it had been common practice to use the maximum one-day rainfall ever observed for estimating the additional load. Since the length of record for weather stations in Canada is quite variable, the maximum one-day rainfall amounts in previous editions often reflected the variable length of record at nearby stations as much as the climatology. As a result, the maximum values often differed greatly within relatively small areas where little difference should be expected. The current values have been standardized to represent the one-day rainfall amounts that have 1 chance in 50 of being exceeded in any one year or the 1-in-50-year return value one-day rainfalls.

The one-day rainfall values in the Table were based on measurements of the annual maximum one-day rainfalls for 2051 stations with 10 years or more of record. These 1-in-50–year values were obtained using a Gumbel extreme value distribution fitted using the method of moments.(1)

Rainfall frequency observations can vary considerably over time and space. This is especially true for mountainous areas, where elevation effects can be significant. In other areas, small scale intense storms or local influences can produce significant spatial variability in the data. As a result, the analysis incorporates some spatial smoothing.

Moisture Index (MI)

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Wind Effects

All structures need to be designed to ensure that the main structural system and all secondary components, such as cladding and appurtenances, will withstand the pressures and suctions caused by the strongest wind likely to blow at that location in many years. Some flexible structures, such as tall buildings, slender towers and bridges, also need to be designed to minimize excessive wind-induced oscillations or vibrations.

At any time, the wind acting upon a structure can be treated as a mean or time-averaged component and as a gust or unsteady component. For a small structure, which is completely enveloped by wind gusts, it is only the peak gust velocity that needs to be considered. For a large structure, the wind gusts are not well correlated over its different parts and the effects of individual gusts become less significant. The User's Guide – NBC 2005, Structural Commentaries (Part 4 of Division B) evaluates the mean pressure acting on a structure, provide appropriate adjustments for building height and exposure and for the influence of the surrounding terrain and topography (including wind speed-up for hills), and then incorporate the effects of wind gusts by means of the gust factor, which varies according to the type of structure and the size of the area over which the pressure acts.

The wind speeds and corresponding velocity pressures used in the Code are regionally representative or reference values. The reference wind speeds are nominally one-hour averages of wind speeds representative of the 10 m height in flat open terrain corresponding to Exposure A or open terrain in the terminology of the User's Guide – NBC 2005, Structural Commentaries (Part 4 of Division B). The reference wind speeds and wind velocity pressures are based on long-term wind records observed at a large number of weather stations across Canada.

In the past, reference wind velocity pressures in the Code have been calculated from hourly averaged wind speed observations measuring the number of miles of wind passing a wind anemometer cup in one hour. The pressures derived from these measurements were representative of true hourly wind pressures. When wind pressures were last calculated in the early 1960s, the hourly averaged wind speeds were the records most commonly available for statistical analysis. Since that time, the majority of the principal observation stations, including the major airports, have converted their observation programs to aviation-type wind speed measurements or spot readings of wind speed.(5) These one-minute averaged wind speeds (later converted to two-minute averages) were observed just before the hour. True one-hour averaged wind speed records from over 100 stations for periods from 10 to 22 years formed the basis for most of the wind pressures provided in the Table. The wind velocity pressures, q, were calculated in Pascals using the following equation:

$$q = \frac{1}{2}\rho V^2$$

where ρ is an average air density for the windy months of the year and V is wind speed in metres per second. While air density depends on both air temperature and atmospheric pressure, the density of dry air at 0°C and standard atmospheric pressure of 1.2929 kg/m^3 was used as an average value for the wind pressure calculations. As explained by Boyd(6), this value is within 10% of the monthly average air densities for most of Canada in the windy part of the year.

Hourly wind speeds that have 1 chance in 10 and 50* of being exceeded in any one year were analyzed using the Gumbel extreme value distribution fitted using the method of moments with correction for sample size. Values of the 1-in-30-year wind speeds for locations in the Table were estimated from a mapping analysis of wind speeds. The 1-in-10- and 1-in-50-year speeds were then computed from the 1-in-30-year speeds using a map of the dispersion parameter that occurs in the Gumbel analysis.(1)

Table C-1 has been arranged to give pressures to the nearest one-hundredth of a kPa and their corresponding wind speeds. The value of "q" in kPa is assumed to be equal to 0.00064645 V^2, where V is given in m/s.

Table C-1
Wind Speeds

q kPa	V m/s	q kPa	V m/s	q kPa	V m/s	q kPa	V m/s
0.15	15.2	0.53	28.6	0.91	37.5	1.29	44.7
0.16	15.7	0.54	28.9	0.92	37.7	1.30	44.8
0.17	16.2	0.55	29.2	0.93	37.9	1.31	45.0
0.18	16.7	0.56	29.4	0.94	38.1	1.32	45.2
0.19	17.1	0.57	29.7	0.95	38.3	1.33	45.4
0.20	17.6	0.58	30.0	0.96	38.5	1.34	45.5
0.21	18.0	0.59	30.2	0.97	38.7	1.35	45.7
0.22	18.4	0.60	30.5	0.98	38.9	1.36	45.9
0.23	18.9	0.61	30.7	0.99	39.1	1.37	46.0

0.24	19.3	0.62	31.0	1.00	39.3	1.38	46.2
0.25	19.7	0.63	31.2	1.01	39.5	1.39	46.4
0.26	20.1	0.64	31.5	1.02	39.7	1.40	46.5
0.27	20.4	0.65	31.7	1.03	39.9	1.41	46.7
0.28	20.8	0.66	32.0	1.04	40.1	1.42	46.9
0.29	21.2	0.67	32.2	1.05	40.3	1.43	47.0
0.30	21.5	0.68	32.4	1.06	40.5	1.44	47.2
0.31	21.9	0.69	32.7	1.07	40.7	1.45	47.4
0.32	22.2	0.70	32.9	1.08	40.9	1.46	47.5
0.33	22.6	0.71	33.1	1.09	41.1	1.47	47.7
0.34	22.9	0.72	33.4	1.10	41.3	1.48	47.8
0.35	23.3	0.73	33.6	1.11	41.4	1.49	48.0
0.36	23.6	0.74	33.8	1.12	41.6	1.50	48.2
0.37	23.9	0.75	34.1	1.13	41.8	1.51	48.3
0.38	24.2	0.76	34.3	1.14	42.0	1.52	48.5
0.39	24.6	0.77	34.5	1.15	42.2	1.53	48.6
0.40	24.9	0.78	34.7	1.16	42.4	1.54	48.8
0.41	25.2	0.79	35.0	1.17	42.5	1.55	49.0
0.42	25.5	0.80	35.2	1.18	42.7	1.56	49.1
0.43	25.8	0.81	35.4	1.19	42.9	1.57	49.3
0.44	26.1	0.82	35.6	1.20	43.1	1.58	49.4
0.45	26.4	0.83	35.8	1.21	43.3	1.59	49.6
0.46	26.7	0.84	36.0	1.22	43.4	1.60	49.7
0.47	27.0	0.85	36.3	1.23	43.6	1.61	49.9
0.48	27.2	0.86	36.5	1.24	43.8	1.62	50.1
0.49	27.5	0.87	36.7	1.25	44.0	1.63	50.2
0.50	27.8	0.88	36.9	1.26	44.1	1.64	50.4
0.51	28.1	0.89	37.1	1.27	44.3	1.65	50.5
0.52	28.4	0.90	37.3	1.28	44.5	1.66	50.7

Seismic Hazard

The parameters used to represent seismic hazard for specific geographical locations are the 5%-damped horizontal spectral acceleration values for 0.2, 0.5, 1.0, and 2.0 second periods and the horizontal Peak Ground Acceleration value that have a 2% probability of being exceeded in 50 years. The four spectral parameters are deemed sufficient to define spectra closely matching the shape of the Uniform Hazard Spectra (UHS). Hazard values are 50th percentile (median) values based on a statistical analysis of the earthquakes that have been experienced in Canada and adjacent regions.[(7)(8)] The median was chosen over the mean because the mean is affected by the amount of epistemic uncertainty incorporated into the analysis. It is the view of the Geological Survey of Canada and the members of the Canadian National Committee on Earthquake Engineering that the estimation of the epistemic uncertainty is still too incomplete to adopt into the Code.

Further details regarding the representation of seismic hazard can be found in the Commentary on Design for Seismic Effects in the User's Guide – NBC 2005, Structural Commentaries (Part 4 of Division B).

References

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(2) Newark, M.J., Welsh, L.E., Morris, R.J., and Dnes, W.V., Revised Ground Snow Loads for the 1990 NBC of Canada. Can. J. Civ. Eng., Vol. 16, No. 3, June 1989.
(3) Newark, M.J., A New Look at Ground Snow Loads in Canada. Proceedings, 41st Eastern Snow Conference, Washington, D.C., Vol. 29, pp. 59-63, 1984.
(4) Bruce, J.P. and Clark, R.H., Introduction to Hydrometeorology. Pergammon Press, London, 1966.
(5) Yip, T.C. and Auld, H., Updating the 1995 National Building Code of Canada Wind Pressures. Proceedings, Electricity '93 Engineering and Operating Conference, Montreal, paper 93-TR-148.
(6) Boyd, D.W., Variations in Air Density over Canada. National Research Council of Canada, Division of Building Research, Technical Note No. 486, June 1967.
(7) Basham, P.W. et al., New Probabilistic Strong Seismic Ground Motion Source Maps of Canada: a Compilation of Earthquake Source Zones, Methods and Results. Earth Physics Branch Open File Report 82-33, p. 205, 1982.
(8) Heidebrecht, A.C. et al., Engineering Applications of New Probabilistic Seismic Ground-Motion Maps of Canada. Can. J. Civ. Eng., Vol. 10, No. 4, pp. 670-680, 1983.
(9) Skerlj, P.F. and Surry, D. A Critical Assessment of the DRWPs Used in CAN/CSA-A440-M90. Tenth International Conference on Wind Engineering, Wind Engineering into the 21st Century, Larsen, Larose & Livesay (eds), 1999 Balkema, Rotterdam, ISBBN 90 5809 059 0
(10) Cornick, S., Chown, G.A., et al. Committee Paper on Defining Climate Regions as a Basis for Specifying Requirements for Precipitation Protection for Walls. Institute for Research in Construction, National Research Council, Ottawa, April 2001.

Table C-2
Design Data for Selected Locations in Canada

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PROPOSED CHANGE

Replace text in Appendix C as follows:

Other Code Provisions Affected: Table C-2

Appendix C
Climatic and Seismic Information for Building Design in Canada

Introduction

The great diversity of climate in Canada has a considerable effect on the performance of buildings; consequently, building design must reflect this diversity. This Appendix briefly describes how climatic design values are computed and provides recommended design data for a number of cities, towns, and ~~smaller~~lesser populated locations. Through the use of such data, appropriate allowances can be made for climate variations in different localities of Canada and the National Building Code can be applied nationally.

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Changing and Variable Climates

Climate is not static. At any location, weather and climatic conditions vary from season to season, year to year, and over longer time periods (climate cycles). This has always been the case. In fact, evidence is mounting that the climates of Canada are changing and will continue to change significantly into future. When estimating climatic design loads, this variability can be considered using appropriate statistical analysis, data records spanning sufficient periods, and meteorological judgement. The analysis generally assumes that the past climate will be representative of the future climate.

Past and ongoing modifications to atmospheric chemistry (from greenhouse gas emissions and land use changes) are expected to alter most climatic regimes in the future~~. As a result, it can no longer be safely assumed that the climate of the past few decades will be a sufficient guide to the climate of the next few decades. While average climatic conditions may be changing, the frequency and magnitude of extreme climatic events may also be changing in unknown ways. Although consensus is emerging on the long-term trends for some climatic elements, there is no agreement as yet on the changes expected in climatic variability.~~ despite the success of the most ambitious greenhouse gas mitigation plans.[(10)] Some regions could see an increase in the frequency and intensity of many weather extremes, which will accelerate weathering processes. Consequently, many buildings will need to be designed, maintained and operated to adequately withstand ever changing climatic loads. The assumption that the average and extreme conditions of the past will represent climate conditions affecting the structure over its lifespan is no longer valid.

Similar to global trends, the last decade in Canada was noted as the warmest in instrumented record. Canada has warmed, on average, at almost twice the rate of the global average increase, while the western Arctic is warming at a rate that is unprecedented over the past 400 years.[(10)] Mounting evidence from Arctic communities indicates that rapid changes to climate in the North have resulted in melting permafrost and impacts from other climate changes have affected nearly every type of built structure. Furthermore, analyses of Canadian precipitation data shows that many regions of the country have, on average, also been tending towards wetter conditions.[(10)] In the United States, where the density of climate monitoring stations is greater, a number of studies have found an unambiguous upward trend in the frequency of heavy to extreme precipitation events, with these increases coincident with a general upward trend in the total amount of precipitation. Climate change model results, based on an ensemble of global climate models worldwide, project that future climate warming rates will be greatest in higher latitude countries such as Canada.[(11)]

January Design Temperatures

A building and its heating system should be designed to maintain the inside temperature at some pre-determined level. To achieve this, it is necessary to know the most severe weather conditions under which the system will be expected to function satisfactorily. Failure to maintain the inside temperature at the pre-determined level will not usually be serious if the temperature drop is not great and if the duration is not long. The outside conditions used for design should, therefore, not be the most severe in many years, but should be the somewhat less severe conditions that are occasionally but not greatly exceeded.

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The January design temperature is defined as the lowest temperature at or below which only a certain small percentage of the hourly outside air temperatures in January occur. In the past, a total of 158 stations with records from all or part of the period 1951-66 formed the basis for calculation of the 2.5 and 1% January temperatures. Where necessary, the data were adjusted for consistency. Since most of the temperatures were observed at airports, design values for the core areas of large cities could be 1 or 2°C milder, although the values for the ~~fringe~~outlying areas are probably about the same as for the airports. No adjustments were made for this urban ~~heat~~ island heat effect. The design values for the next 20 to 30 years ~~probably~~ will probably differ from these tabulated values due to year-to-year climate variability and global climate change resulting from the impact of human activities ~~modifications~~ ~~to~~on atmospheric chemistry.

~~A review of t~~The design temperatures ~~was~~were ~~undertaken~~reviewed and updated ~~for the 1995 issue of this Appendix~~ using hourly temperature observations from ~~265~~480 stations for ~~the length of record up to 1993~~a 25-year period up to 2006 with at least 8 years of complete data. ~~Where needed, hourly temperatures were supplemented with correlated record minimum temperatures from 1449 long-term stations. The results from the recent analysis indicated reasonable consistency with the previous recommendations. Consequently, the January design temperatures remain unchanged from previous issues of the Supplement to the National Building Code of Canada.~~ These data are consistent with data shown for Canadian locations in the 2009 Handbook of Fundamentals[12] published by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). The most recent 25 years of record were used to provide a balance between accounting for trends in the climate and the sampling variation owing to year-to-year variation. The 1% and 2.5% values used for the design conditions represent percentiles of the cumulative frequency distribution of hourly temperatures and correspond to January temperatures that are colder for 8 and 19 hours, respectively, on average over the long term.

The 2.5% January design temperature is the value ordinarily used in the design of heating systems. In special cases, when the control of inside temperature is more critical, the 1% value may be used. Other temperature-dependent climatic design parameters may be considered for future issues of this document.

July Design Temperatures

A building and its cooling and dehumidifying system should be designed to maintain the inside temperature and humidity at certain pre-determined levels. To achieve this, it is necessary to know the most severe weather conditions under which the system is expected to function satisfactorily. Failure to maintain the inside temperature and humidity at the pre-determined levels will usually not be serious if the increases in temperature and humidity are not great and the duration is not long. The outside conditions used for design should, therefore, not be the most severe in many years, but should be the somewhat less severe conditions that are occasionally but not greatly exceeded.

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~~between design temperatures and the mean annual maximum temperature. The second dataset consisted of hourly data summaries for 109 stations based on records from 1957 to 1966. Results from the two datasets were averaged and adjusted for consistency. The July 2.5% wet-bulb temperatures were obtained in a similar way, using the two datasets, but without the use of an empirical relationship for the first dataset.~~

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Heating Degree-Days

The rate of consumption of fuel or energy required to keep the interior of a small building at 21°C when the outside air temperature is below 18°C is roughly proportional to the difference between 18°C and the outside temperature. Wind speed, solar radiation, the extent to which the building is exposed to these elements and the internal heat sources also affect the heat required and may have to be considered for energy-efficient design. For average conditions of wind, radiation, exposure, and internal sources, however, the proportionality with the temperature difference generally still holds.

Since the fuel required is also proportional to the duration of the cold weather, a convenient method of combining these elements of temperature and time is to add the differences between 18°C and the mean temperature for every day in the year when the mean temperature is below 18°C. It is assumed that no heat is required when the mean outside air temperature for the day is 18°C or higher.

Although more sophisticated computer simulations using other forms of weather data have now almost completely replaced degree-day-based calculation methods for estimating annual heating energy consumption, degree-days remain a useful indicator of relative severity of climate and can form the basis for certain climate-related Code requirements.

The degree-days below 18°C ~~have been computed~~ were compiled ~~day by day~~ for ~~1030~~1300 stations for the ~~length of record available from the period 1961 to 1990~~ 25-year period ending in 2006. ~~The average annual degree-day values were then interpolated from analyzed maps. When observations with 20 years or more of record were available, recommendations for those locations were weighted towards the observed value.~~ This analysis period is consistent with the one used to derive the design temperatures described above and with the approach used by ASHRAE.[12]

A difference of only one Celsius degree in the mean annual temperature will cause a difference of 250 to 350 in the Celsius degree-days. Since differences of 0.5 of a Celsius degree in the mean annual temperature are quite likely to occur between two stations in the same town, heating degree-days cannot be relied on to an accuracy of less than about 100 degree-days.

Heating degree-day values for the core areas of larger cities can be 200 to 400 degree-days less (warmer) than for the surrounding fringe areas. The observed degree-days, which are based on daily temperature observations, are often most representative of rural settings or the fringe areas of cities.

Climatic Data for Energy Consumption Calculations

The climatic elements tabulated in this Appendix represent commonly used design values but do not include detailed climatic profiles, such as hourly weather data. Where hourly values of weather data are needed for the purpose of simulating the annual energy consumption of a building, they can be obtained from multiple sources, such as Environment Canada, Natural Resources Canada, the Regional Conservation Authority and other such public agencies that record this information. Hourly weather data are also available from public and private agencies that format this information for use with annual energy consumption simulation software; in some cases, these data have been incorporated into the software.

Snow Loads

[…]

Rainfall Intensity

Roof drainage systems are designed to carry off rainwater from the most intense rainfall that is likely to occur. A certain amount of time is required for the rainwater to flow across and down the roof before it enters the gutter or drainage system. This results in the smoothing out of the most rapid changes in rainfall intensity. The drainage system, therefore, need only cope with the flow of rainwater produced by the average rainfall intensity over a period of a few minutes, which can be called the concentration time.

In Canada, it has been customary to use the 15-minute rainfall that will probably be exceeded on an average of once in 10 years. The concentration time for small roofs is much less than 15 minutes and hence the design intensity will be exceeded more frequently than once in 10 years. The safety factors in the National Plumbing Code of Canada 2005 will probably reduce the frequency to a reasonable value and, in addition, the occasional failure of a roof drainage system will not be particularly serious in most cases.

The rainfall intensity values ~~tabulated in previous editions of this information were based on measurements of the~~ were updated for the 2010 edition of the Code using observations of annual maximum 15-minute rainfall~~s~~ amounts ~~at 139~~from 485 stations with ~~7~~10 or more years of record, including data up to 2007 for some stations. ~~They were~~ Ten-year return period values—the 15-minute rainfall~~s that would be exceeded once in 10 years on average~~having a probability of 1-in-10 of being exceeded in any year—~~or the values that had 1 chance in 10 of being exceeded in any one year. The values~~ were ~~analyzed~~calculated by fitting the annual maximum values to the ~~using a~~ Gumbel extreme value distribution~~.~~[1] using the method of moments. The updated values are compiled from the most recent short-duration rainfall intensity-duration-frequency (IDF) graphs and tables available from Environment Canada.

It is very difficult to estimate the pattern of rainfall intensity in mountainous areas, where precipitation is extremely variable and rainfall intensity can be much greater than in other types of areas. Many of the observations for these areas were taken at locations in valley bottoms or in extensive, fairly level areas.

One-Day Rainfall

If for any reason a roof drainage system becomes ineffective, the accumulation of rainwater may be great enough in some cases to cause a significant increase in the load on the roof. In previous editions of this information, it had been common practice to use the maximum one-day rainfall ever observed for estimating the additional load. Since the length of record for weather stations in Canada is quite variable, the maximum one-day rainfall amounts in previous editions often reflected the variable length of record at nearby stations as much as the climatology. As a result, the maximum values often differed greatly within relatively small areas where little difference should be expected. The current values have been standardized to represent the one-day rainfall amounts that have 1 chance in 50 of being exceeded in any one year or the 1-in-50-year return value one-day rainfalls.

The one-day rainfall values~~ in the Table~~ were ~~based on measurements of the~~updated using ~~annual maximum one-day~~ daily rainfall~~s~~ observations ~~for 2051 stations~~from more than 3500 stations with 10 years or more of record, including data up to 2008 for some stations. The~~se~~ ~~1-in-~~50–year return period values were ~~obtained~~calculated by~~using the Gumbel extreme value distribution fitted~~ fitting the annual maximum one-day rainfall observations to the Gumbel extreme value distribution using the method of moments.[(1)]

Rainfall frequency observations can vary considerably over time and space. This is especially true for mountainous areas, where elevation effects can be significant. In other areas, small-scale intense storms or local influences can produce significant spatial variability in the data. As a result, the analysis incorporates some spatial smoothing.

Moisture Index (MI)

[…]

Wind Effects

All structures need to be designed to ensure that the main structural system and all secondary components, such as cladding and appurtenances, will withstand the pressures and suctions caused by the strongest wind likely to blow at that location in many years. Some flexible structures, such as tall buildings, slender towers and bridges, also need to be designed to minimize excessive wind-induced oscillations or vibrations.

At any time, the wind acting upon a structure can be treated as a mean or time-averaged component and as a gust or unsteady component. For a small structure, which is completely enveloped by wind gusts, it is only the peak gust velocity that needs to be considered. For a large structure, the wind gusts are not well correlated over its different parts and the effects of individual gusts become less significant. The User's Guide – NBC 2005, Structural Commentaries (Part 4 of Division B) evaluates the mean pressure acting on a structure, provide appropriate adjustments for building height and exposure and for the influence of the surrounding terrain and topography (including wind speed-up for hills), and then incorporate the effects of wind gusts by means of the gust factor, which varies according to the type of structure and the size of the area over which the pressure acts.

The wind speeds and corresponding velocity pressures used in the Code are regionally representative or reference values. The reference wind speeds are nominally one-hour averages of wind speeds representative of the 10 m height in flat open terrain corresponding to Exposure A or open terrain in the terminology of the User's Guide – NBC 2005, Structural Commentaries (Part 4 of Division B). The reference wind speeds and wind velocity pressures are based on long-term wind records observed at a large number of weather stations across Canada.

In the past, rReference wind velocity pressures in previous versions of the Code since 1961 have beenwere calculated from hourly averagedbased mostly on wind speed observations measuring the number of miles of wind passing a wind anemometer cup in one hour. The pressures derived from these measurements were representative of true hourly wind pressures. When wind pressures were last calculated in the early 1960s, the hourly averaged wind speeds were the records most commonly available for statistical analysis. Since that time, the majority of the principal observation stations, including the major airports, have converted their observation programs to aviation-type wind speed measurements or spot readings of wind speed.(5) These one-minute averaged wind speeds (later converted to two-minute averages) were observed just before the hour. True one-hour averaged wind speed records from over 100 stations for periodsof hourly averaged wind speeds (i.e. the number of miles of wind passing an anemometer in an hour) from over 100 stations with from 10 to 22 years of observations ending in the 1950sformed the basis for most of the wind pressures provided in the Table. The wind pressure values derived from these measurements represented true hourly wind pressures.

The reference wind velocity pressures were reviewed and updated for the 2010 edition of the Code. The primary data set used for the analysis comprised wind records compiled from about 135 stations with hourly averaged wind speeds and from 465 stations with aviation (one- or two-minute average) speeds or surface weather (ten-minute average) speeds observed once per hour at the top of the hour; the periods of record used ranged from 10 to 54 years. In addition peak wind gust records from 400 stations with periods of record ranging from 10 to 43 years were used. Peak wind gusts (gust durations of approximately 3 to 7 seconds) were used to supplement the primary once-per-hour observations in the analysis.

Several steps were involved in updating the reference wind values. Where needed, speeds were adjusted to represent the standard anemometer height above ground of 10 m. The data from years when the anemometer at a station was installed on the top of a lighthouse or building were eliminated from the analysis since it is impractical to adjust for the effects of wind flow over the structure. (Most anemometers were moved to 10 m towers by the 1960s.) Wind speeds of the various observation types—hourly averaged, aviation, surface weather and peak wind gust—were adjusted to account for different measure durations to represent a one-hour averaging period and to account for differences in the surface roughness of flat open terrain at observing stations.

The annual maximum wind speed data was fitted to the Gumbel distribution using the method of moments [1] to calculate hourly wind speeds having the annual probability of occurrence of 1-in-10 and 1-in-50 (10-year and 50-year return periods). The values were plotted on maps, then analyzed and abstracted for the locations in Table C-2.

The wind velocity pressures, q, were calculated in Pascals using the following equation:

$$q = \frac{1}{2}\rho V^2$$

where ρ is an average air density for the windy months of the year and V is wind speed in metres per second. While air density depends on both air temperature and atmospheric pressure, the density of dry air at 0°C and standard atmospheric pressure of 1.2929 kg/m³ was used as an average value for the wind pressure calculations. As explained by Boyd[6], this value is within 10% of the monthly average air densities for most of Canada in the windy part of the year.

As a result of the updating procedure, the 1-in-50 reference wind velocity pressures remain unchanged for most of the locations listed in Table C-2; both increases and decreases were noted for the remaining locations. Many of the decreases resulted from the fact that anemometers at most of the stations used in the previous analysis were installed on lighthouses, airport hangers and other structures. Wind speeds on the tops of buildings are often much higher compared to those registered by a standard 10 m tower. Eliminating anemometer data recorded on the tops of buildings from the analysis resulted in lower values at several locations.

Hourly wind speeds that have 1 chance in 10 and 50* of being exceeded in any one year were analyzed using the Gumbel extreme value distribution fitted using the method of moments with correction for sample size. Values of the 1-in-30-year wind speeds for locations in the Table were estimated from a mapping analysis of wind speeds. The 1-in-10- and 1-in-50-year speeds were then computed from the 1-in-30-year speeds using a map of the dispersion parameter that occurs in the Gumbel analysis.([1])

Table C-1 has been arranged to give pressures to the nearest one-hundredth of a kPa and their corresponding wind speeds. The value of "q" in kPa is assumed to be equal to 0.00064645 V^2, where V is given in m/s.

Table C-1
Wind Speeds

q kPa	V m/s	q kPa	V m/s	q kPa	V m/s	q kPa	V m/s
0.15	15.2	0.53	28.6	0.91	37.5	1.29	44.7
0.16	15.7	0.54	28.9	0.92	37.7	1.30	44.8
0.17	16.2	0.55	29.2	0.93	37.9	1.31	45.0
0.18	16.7	0.56	29.4	0.94	38.1	1.32	45.2
0.19	17.1	0.57	29.7	0.95	38.3	1.33	45.4
0.20	17.6	0.58	30.0	0.96	38.5	1.34	45.5
0.21	18.0	0.59	30.2	0.97	38.7	1.35	45.7
0.22	18.4	0.60	30.5	0.98	38.9	1.36	45.9
0.23	18.9	0.61	30.7	0.99	39.1	1.37	46.0
0.24	19.3	0.62	31.0	1.00	39.3	1.38	46.2
0.25	19.7	0.63	31.2	1.01	39.5	1.39	46.4
0.26	20.1	0.64	31.5	1.02	39.7	1.40	46.5
0.27	20.4	0.65	31.7	1.03	39.9	1.41	46.7
0.28	20.8	0.66	32.0	1.04	40.1	1.42	46.9
0.29	21.2	0.67	32.2	1.05	40.3	1.43	47.0
0.30	21.5	0.68	32.4	1.06	40.5	1.44	47.2
0.31	21.9	0.69	32.7	1.07	40.7	1.45	47.4
0.32	22.2	0.70	32.9	1.08	40.9	1.46	47.5
0.33	22.6	0.71	33.1	1.09	41.1	1.47	47.7
0.34	22.9	0.72	33.4	1.10	41.3	1.48	47.8
0.35	23.3	0.73	33.6	1.11	41.4	1.49	48.0
0.36	23.6	0.74	33.8	1.12	41.6	1.50	48.2
0.37	23.9	0.75	34.1	1.13	41.8	1.51	48.3

0.38	24.2	0.76	34.3	1.14	42.0	1.52	48.5
0.39	24.6	0.77	34.5	1.15	42.2	1.53	48.6
0.40	24.9	0.78	34.7	1.16	42.4	1.54	48.8
0.41	25.2	0.79	35.0	1.17	42.5	1.55	49.0
0.42	25.5	0.80	35.2	1.18	42.7	1.56	49.1
0.43	25.8	0.81	35.4	1.19	42.9	1.57	49.3
0.44	26.1	0.82	35.6	1.20	43.1	1.58	49.4
0.45	26.4	0.83	35.8	1.21	43.3	1.59	49.6
0.46	26.7	0.84	36.0	1.22	43.4	1.60	49.7
0.47	27.0	0.85	36.3	1.23	43.6	1.61	49.9
0.48	27.2	0.86	36.5	1.24	43.8	1.62	50.1
0.49	27.5	0.87	36.7	1.25	44.0	1.63	50.2
0.50	27.8	0.88	36.9	1.26	44.1	1.64	50.4
0.51	28.1	0.89	37.1	1.27	44.3	1.65	50.5
0.52	28.4	0.90	37.3	1.28	44.5	1.66	50.7

Seismic Hazard

The parameters used to represent seismic hazard for specific geographical locations are the 5%-damped horizontal spectral acceleration values for 0.2, 0.5, 1.0, and 2.0 second periods and the horizontal Peak Ground Acceleration (PGA) value that have a 2% probability of being exceeded in 50 years. The four spectral parameters are deemed sufficient to define spectra closely matching the shape of the Uniform Hazard Spectra (UHS). Hazard values are 50th percentile (median) values based on a statistical analysis of the earthquakes that have been experienced in Canada and adjacent regions.~~[7][8]~~[13][14][15][16] The median was chosen over the mean because the mean is affected by the amount of epistemic uncertainty incorporated into the analysis. It is the view of the Geological Survey of Canada and the members of the ~~Canadian National Committee on Earthquake Engineering~~ Standing Committee on Earthquake Design that the estimation of the epistemic uncertainty is still too incomplete to adopt into the Code.

The seismic hazard values were updated for the 2010 edition of the Code by replacing the quadratic fit that generated the NBC 2005 values with an 8-parameter fit to the ground motion relations used for earthquakes in eastern, central and north-eastern Canada. In 2005, it was recognized that, while the quadratic fit provided a good approximation in the high-hazard zones, it was rather conservative at short periods for the low-hazard zones; however, as the design values are small in the low-hazard zones, the approximation was accepted. The 8-parameter fit gives a good fit across all zones. In general, PGA and short-period spectral values are reduced, while long-period values are slightly increased. The 2010 values have the following engineering implications: geotechnical design levels (based on PGA values) are reduced, the design forces for short-period buildings are reduced, and the design forces for tall buildings are increased. Since zones of low seismicity cover a large part of the country, the climatic information for about 550 of the 650 localities listed in Table C-2 has changed (often in a minor way); only some western localities are unaffected.

Further details regarding the representation of seismic hazard can be found in the Commentary on Design for Seismic Effects in the User's Guide – NBC 2005, Structural Commentaries (Part 4 of Division B).

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Table C-2
Design Data for Selected Locations in Canada

[…]

RATIONALE

Problem

The climatic data in Table C-2 is outdated.

Justification - Explanation

Update the climatic data and revise the explanatory material in Appendix C accordingly.

Cost implications

Cost implications have been assessed for the revision to the seismic hazard values only. The change to the other climatic values is due to updating of the data.

The 20% reduction in $S_a(0.2)$ values results in a decrease in the cost of construction of approximately \$4.30/ft^2 from a total of \$156.60/ft^2 (2.7%). The 30% increase in long-term spectral acceleration results in an increase to the cost of construction of approximately \$4.00/ft^2 from a total of \$154.50/ft^2 (2.6%). As there are (conservatively) at least 3 times as many low-rise buildings built as high-rise ones, the net result is a savings in construction cost of \$2.22/ft^2 from a total cost of construction of \$156.08/ft^2 (1.4%).

The decrease in PGA will not directly affect the cost of construction other than for retaining walls. Rather, the reduction in PGA will make more sites viable when analyzed for slope instability.

Enforcement implications

None.

Who is affected

Designers, builders.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISION

Provision: Appendix C **Analysis: N/A**

Attributions

Objective

[Comment](#) [Commentaires](#)