What is a Site specific Wind Assessment?

The design of tall structures such as communication towers requires knowledge of the design pressure, both at the surface level (10 m) and as a profile with height above ground. The Building Codes which the engineer follows provide maps or tabulations of derived wind or pressure at the surface level (Basic Wind) with prescriptions for accounting for terrain characteristics, topographic effects, and vertical wind profiles.

Due to the large areas covered by the maps in the US or Canada encompassing many types of local meteorological effects which are not included in the maps, the codes recognize that such information and procedures are not adequate for producing credible wind pressure estimates for special wind zones and local meteorological situations. The codes then recognize the need for a Site Specific assessment of such situations, which are presumed to include recourse to local meteorological data and application of recognized procedures for deriving the wind profile for the tower.

If the engineer then decides to obtain a site-specific wind for a tower site, he finds that the product denoted as “Site-Specific Wind and Ice Assessment” is interpreted differently by organizations which supply site specific studies, although the Building and Tower codes such as ASCE7 (in Section 26.5.3) and TIA 222 (Section 2.64 and explicitly in topographic category 5) require the use of meteorological data obtained at a nearby site and analysis using accepted statistical methods in the literature in order to treat them as site specific assessments. For example if the basic wind from the ASCE maps is used and the user calculates and applies the 4 profile factors specified in the pressure formula per the code prescription, then the user would not call it a site specific assessment.

ICE Inc. obtains hourly wind and other meteorological data from a nearby airport with 30 or more years of record, as well as supporting meteorological data such as precipitation, temperature, humidity, and observations such as gust, freezing precipitation, cloud ceiling, and weather type codes. ICE then performs the statistical analysis to determine the extreme wind speed for any return period required by the user, applies the topographic and terrain corrections using the Simple Guidelines, and models the icing for each event in order to provide vertical profiles of wind for the extreme event, freezing rain and in-cloud icing dependent on tower height, location, and the elevation of the tower site.

Environment Canada uses as its starting point the mapped wind from the NBCC (National Building Code of Canada) in tabular form and applies an equation derived from the Simple Guidelines for topographic influences on the wind profile. Icing accumulation due to freezing rain is per NBCC table, and no rime icing estimate is produced. EC provides a service on this basis which it calls Site Specific.

The Checkwind software from Revolutio (Australia) interpolates the ASCE7 Map or other code wind map to a specific location and performs for the user the topographic and terrain corrections provided in the code. It also calls this a site specific wind.

The ATC (Applied Technology Council) Hazards by Location web site provides wind values by interpolating the ASCE7 wind maps for a specific geographic location, and the user is expected to apply the terrain and topographic correction factors to obtain a wind in accord with the code. They call this a Site Specific wind as well, although there is no charge for obtaining the interpolated wind from the web site presumably in recognition of the fact that the user can do the map interpolation on his own.

Ultimately it is up to the design engineer to decide which product serves his client’s needs. It is easy to see why the engineer would be uneasy about having to make the decision, given that he does not have the full picture of what these procedures entail. This is then compounded by the fact that the same name "Site Specific Wind" is being used for totally different products. As ICE is familiar with the EC data and procedures through numerous comparisons and discussions, the following sets out some of the differences between the ICE service and the EC service and the implications of the two approaches in practice. A more detailed discussion of the differences is provided in a paper available on our web site at ice-inc.co.

As a basic requirement, when different data and methods are compared it is important to establish the basis for comparison. This is particularly critical in the case of the return value for wind speed, because this is not a quantity that is measurable except by indirect statistical inference. In the design process the specifics of the derivation of the wind speed and profile of wind speed with height are essential, so that a comparison of the single value at 10 m is not sufficient to compare available alternatives.

There are several differences between the ICE and EC site specific approach which often produce large differences in the results provided to the engineer.

Basic Wind

The winds tabulated in the NBCC were mostly derived 20 years ago from about 250 stations across Canada with available data of less than 15 years at many of the stations. In preparing the 50 year return values for the stations it was then assumed that all locations had a similar extreme statistic apart from the mean, in other words the Gumbel distribution was used with a uniform variance across Canada to derive the 50 year return wind.

In preparing the maps, it was necessary to standardize the winds by using information about the airport surrounding terrain. Stations that were on the shore of large water bodies or marine based stations were not standardized. It was also decided to set a lower bound of 76 km/h on the return period wind speed for any station (apparently for structural integrity of the tower). This set of return period winds was then mapped by straight interpolation without taking into account the effect of exposure in reducing winds inland from the shoreline, or the intervening topographic variation.

Winds currently available at the Canadian Airports and Climate Sites have many more sites of available data and an additional 20 years of data for most of the original stations. Studies carried out by Environment Canada researchers using more current data have shown that the NBCC Table winds are on average 15% greater than winds derived from the new data and analysis.

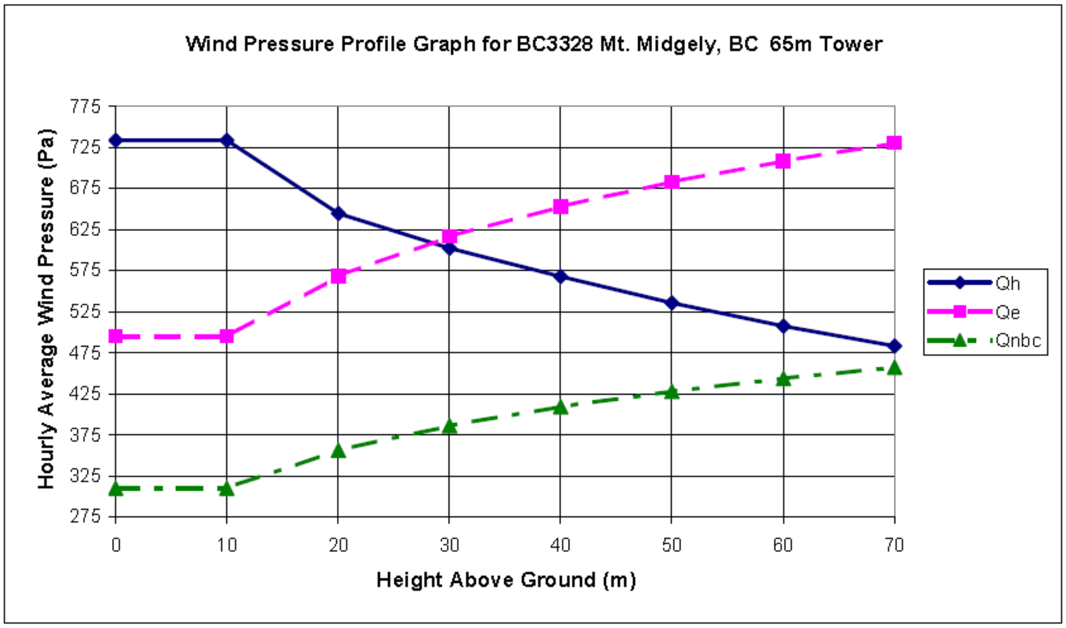
As an example of a large disparity between the basic wind tabulation and actual data, the Hope airport which is located in a valley in British Columbia is listed as having a Basic Wind for 50 year return of 105 km/hr (pressure of 550 Pa). The last 37 years of hourly observations show a 50 year return wind of 72 km/hr (pressure of 254 Pa), or less than half the EC derived pressure.

Wind Profile

Both EC and ICE use a continuous description of the terrain in terms of roughness length, and both use the logarithmic profile for wind speed. ICE applies the Taylor Lee Simple Guidelines topographic adjustment, and so does EC. The difference is that EC develops a single equation for the topographic and terrain exposure adjustment to the profile using the logarithmic profile, but then converts to a power law profile for the wind, with a profile exponent selected for different exposure conditions.

In the process there is a mismatch created in one of the terms in the equation which creates non-physical profiles in situations where there is a transition in surface roughness near the top of a topographic feature. In particular in the case where there is a tower on top of a forested hill, with a clearing of 100 m surrounding the tower, the EC produces a wind profile that decreases with height above tower base, usually for the entire height of the tower.

The EC report shows such a situation for the Mt. Midgely Tower in BC, as reproduced below.



Here the Qh profile is the result of applying the formula specific for this tower as shown in the following extract from the report.

BC3328 Mt. Midgely, BC 65m Tower

Site Specific Hourly Wind Pressure Documentation Sheet

Site Information:

Name:	BC3328 Mt. Midgely, BC
Latitude:	49° 9' 52.3" N
Longitude:	116° 40' 53.5" W
Tower Height (m):	65
Elevation MSL (m):	1739

UTM Coordinates:

Zone:	11
Easting (m):	523217
Northing (m):	5445795

Results:

Q_e (Pa):	495
Uncertainty of Q_e:	[20%, -25%]
Q_{nbc} (Pa):	320
Icing:	**Rime Icing May Occur***
Return Period:	30

Wind Pressure Formula (for z in metres and result in Pa):

For Z ≤ 22.7 metres: $Q_h = 0.12919 \{[0.9241\ e^{(-0.0173 z)} + 0.5686\ ln(z/0.0500) / ln(z/0.7000)]\ 39.44\}^2\ (z/10)^{0.2}$

For Z > 22.7 metres: $Q_h = 0.12919 \{[1 + 0.9241\ e^{(-0.0173 z)}]\ 39.44\}^2\ (z/10)^{0.2}$

Profile Formula General Form:

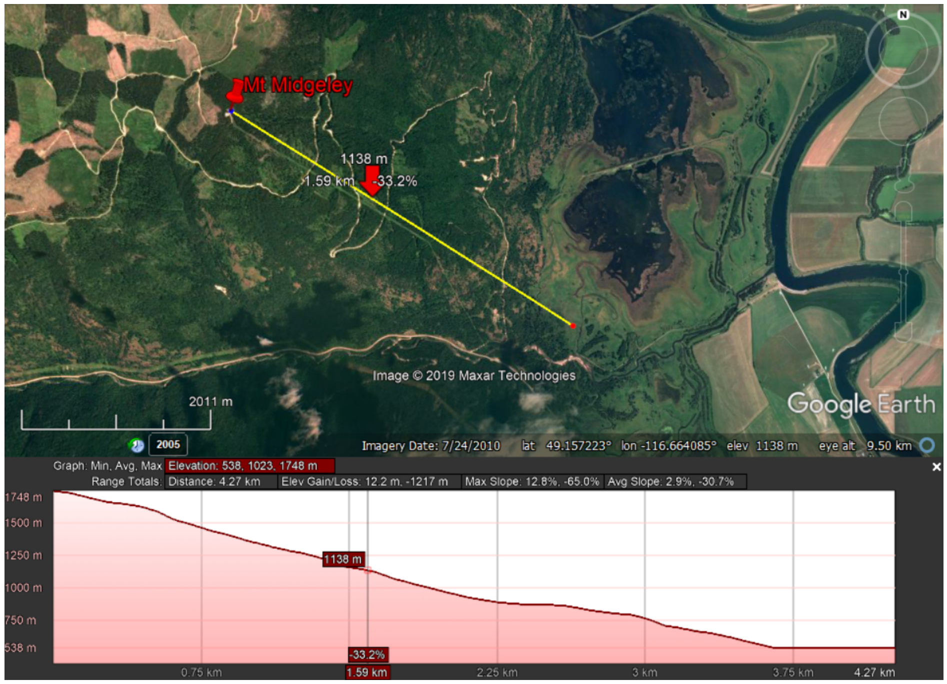
$$Q_h = 0.12919 \{[a_1\ e^{(-a2\ z)} + a_3\ \ln(z/z_h) / \ln(z/z_{01})]\ v_{01}\}^2\ (z/10)^{0.2}$$

Site Values of Coefficients:

For Z ≤ 22.7 metres: $a_1 = 0.9241$, $a_2 = 0.0173$, $a_3 = 0.5686$, $z_h = 0.0500$, $z_{01} = 0.7000$, $v_{01} = 39.44$ mph

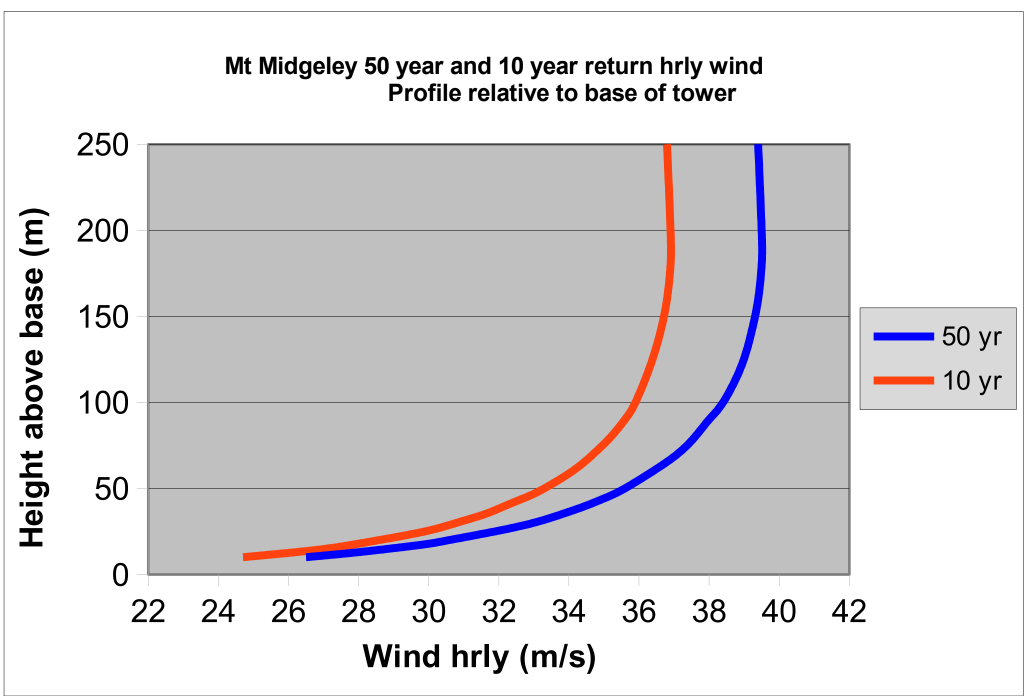
For Z > 22.7 metres: $a_1 = 0.9241$, $a_2 = 0.0173$, $a_3 = 1.0000$, $z_h = 0.7000$, $z_{01} = 0.7000$, $v_{01} = 39.44$ mph

The ICE procedure starts from determining the 50 year return wind using the Creston airport data, which shows a basic value of 47km/hr (21 mph) compared to the 39.4 mph basic wind which EC derived by interpolation from the Table.



The height, slope and L value are derived for the direction which would produce the maximum speed up by the hill using Google Earth.

The projected wind profile at the tower site is shown in the following, with the 50 yr return pressure at the 10 m level of the tower of 442 Pa compared to the EC value of 730 Pa.



At the 70 m level (top of the tower) the ICE pressure is 895 Pa whereas the EC value is predicted to drop down to 480 Pa.

This kind of inversion of the wind profile is not physical, and in fact examination of the equation in the EC report above clearly shows that the factor inside the brackets in the EC equation in this case decreases with height to the 22 m level and up to the top of the tower.

The developers of the equation were clearly aware of this failing, which is why the presented the results as the curve Qe (in red), where they determined a mean value of the wind and then applied the power law profile which they anticipated for this site. The Qe formulation is no longer provided in the EC reports, and the power law exponent is now set to a higher value based on the surface roughness of the site. This has partly corrected some of the recent profiles; however, the exponent selected is not appropriate for the hourly average wind speed so in many cases the power law profile is still not adequate in overcoming the problem with the equation.

The paper “Ice Site Specific vs EC.pdf” available on the ice-inc.co website discusses the details of the two derivations in this case and should be consulted for more information.