CLIMATIC LOADS 2A
DETERMINATION OF WIND LOADS

Determination of wind loads applied to structures should be carried out in accordance with EN 1991-1-4:2005 [1, 2] with consideration to the National Annex applicable to the country in which the structure is being constructed.

This document is not intended to provide comprehensive guidance, only a brief understanding of the elements that will influence wind loads. EN 1991-1-4:2005 should be followed when assessing characteristic wind loadings on a structure.

When determining wind loadings, there are two key aspects; wind pressure and wind action. Wind pressure will be dependent on the height of the building and the surrounding terrain. The wind actions use the wind pressure to determine, based on building size and shape, the wind loadings acting on surfaces and elements.

DETERMINATION OF WIND VELOCITY AND VELOCITY PRESSURE

Various factors will influence the fundamental basic wind load incident on a building, in order to determine the peak wind pressures.

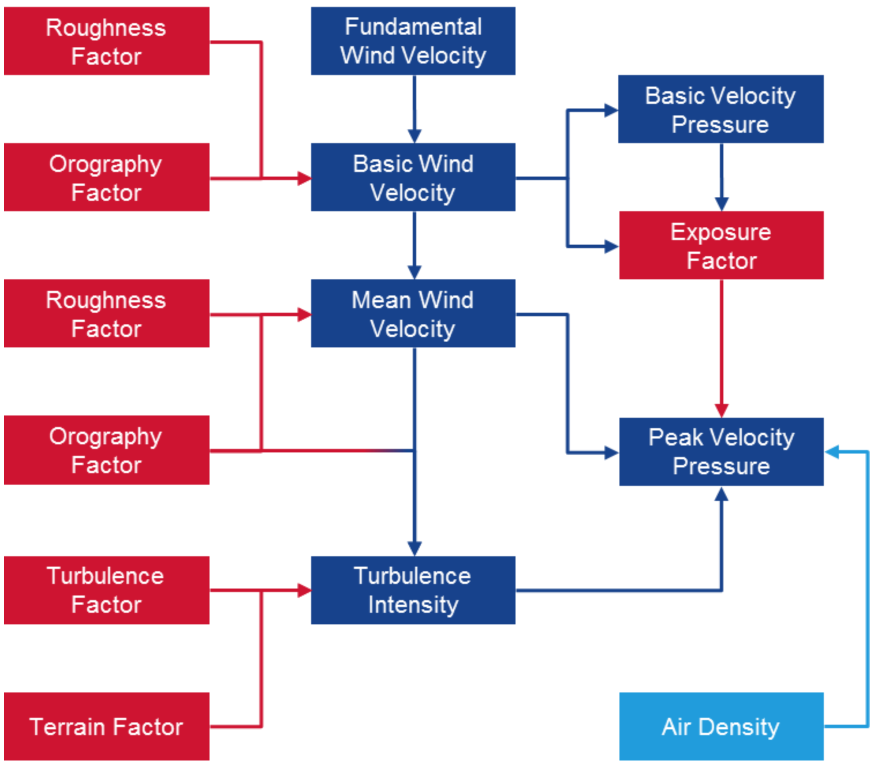

Figure 1 - Overview of Wind Load Determination

BASIC WIND VELOCITY

Within the UK, the basic wind speed is generated in conjunction with the National Annex with a combination of fundamental wind speeds from a map ($v_{b,map}$) and altitude factors.

Data is also available, which provides the basic wind speed, without altitude adjustment, at locations east and north of a datum point. The following image provides an illustration of the wind speed bands generated from this data. This image is not intended to replace Figure NA.1 from NA to BS EN 1991-1-4:2005, which should be used for the determination of map wind speed.

The fundamental basic wind speeds are characteristic of strong gales or storms (9 or 10 on the Beaufort scale) to account for potential worst case conditions.

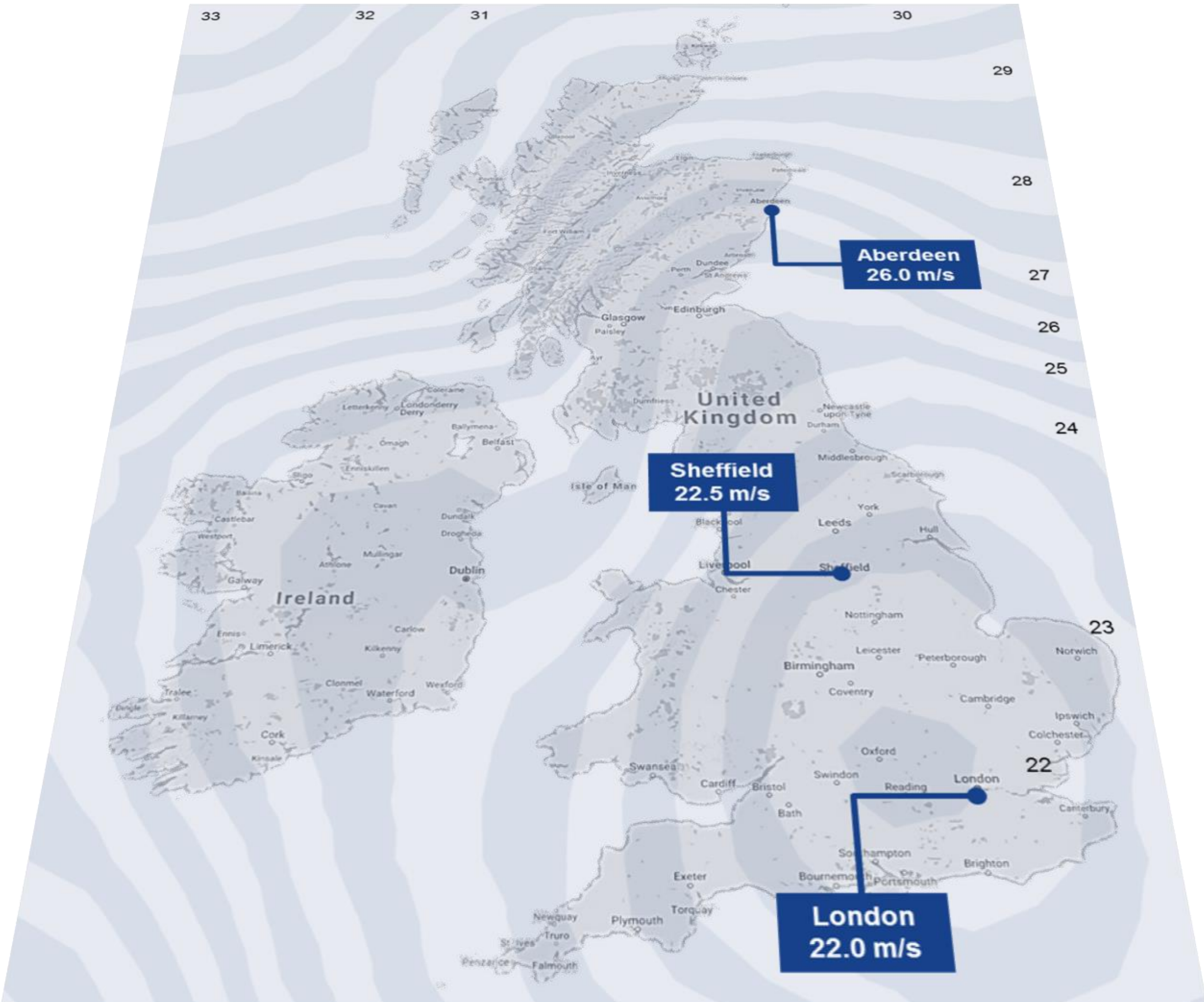

Figure 2 - Basic Wind Speed Zones

By ignoring the effects of building height, altitude can be conservatively factored (c_{alt}) as a direct function of height above mean sea level (A). This can then be used to provide the location specific fundamental wind velocity ($v_{b,0}$).

$$c_{alt} = 1 + 0.001 \cdot A$$

$$v_{b,0} = v_{b,map} \cdot c_{alt}$$

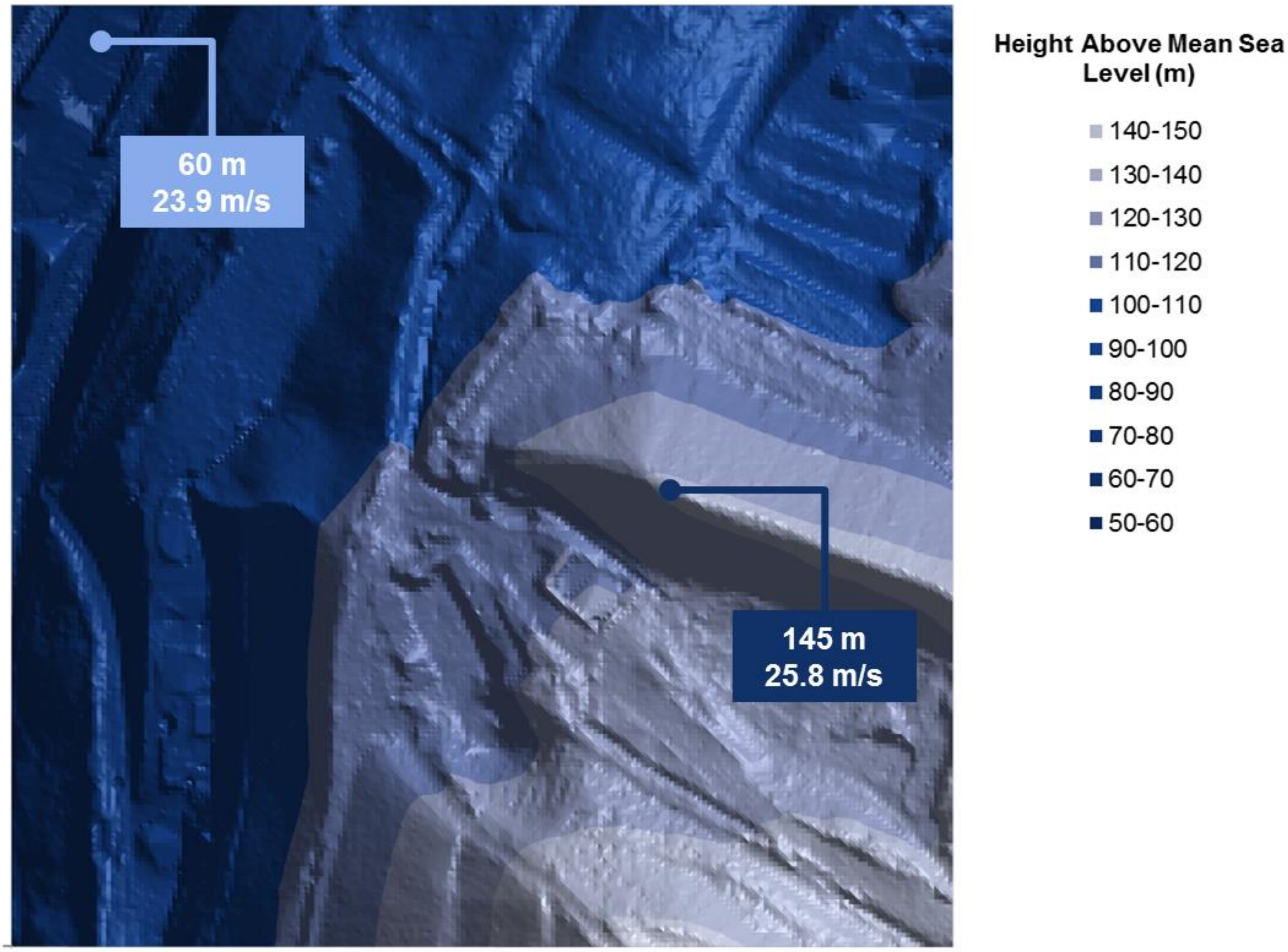

Figure 3 - Illustration of Altitude

To finalise the basic wind velocity (v_b), directional (c_{dir}) and seasonal (c_{season}) factors can be taken into account, however, these are typically considered to be 1.0 for a conservative approach.

$$v_b = v_{b,0} \cdot c_{dir} \cdot c_{season}$$

MEAN WIND VELOCITY

Mean wind velocity is determined for a height above the terrain, and is dependent on roughness ($c_r(z)$) and orography ($c_o(z)$) factors, as below;

$$v_m(z) = v_b \cdot c_r(z) \cdot c_o(z)$$

Roughness is dependent on the terrain type, with the UK National Annex considering three categories; sea, country and town.

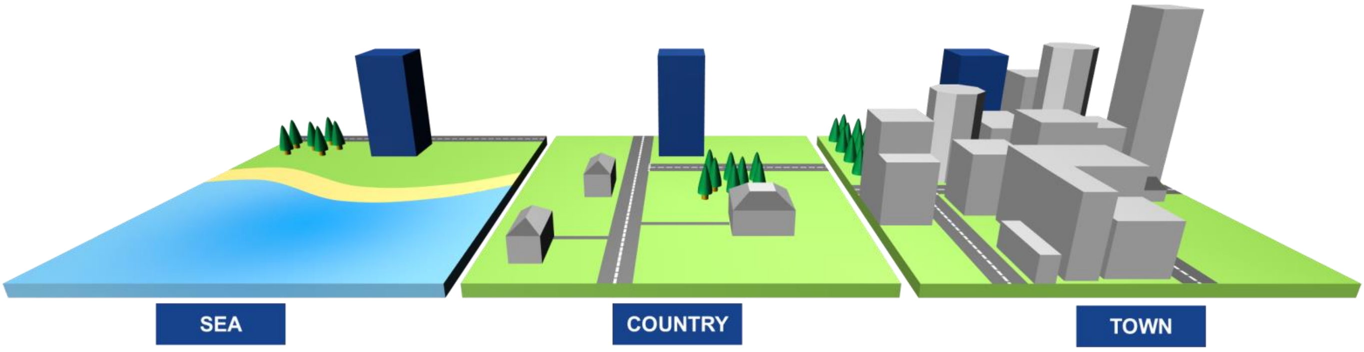

Figure 4 - Illustration of Terrain Categories

For sea and country categories, the roughness factor is dependent on the distance from the shore, and within towns, the distance from shore, factored by the distance within the town area. The closer to the shore or the edge of a town, the greater the roughness factor, and consequently, the lower the mean wind speed.

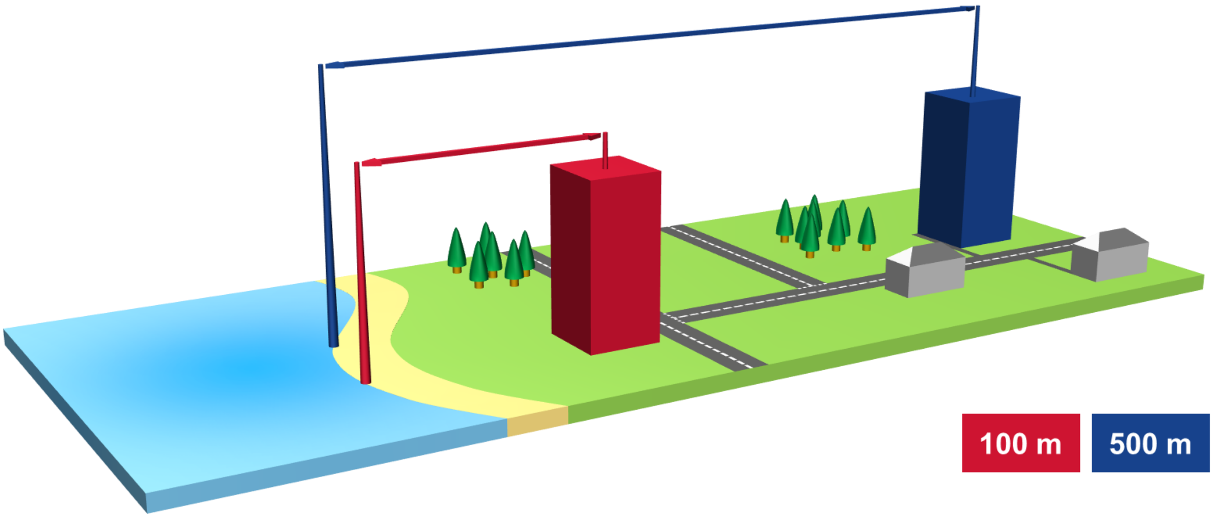

Figure 5 - Illustration of Distance to Shoreline

For example, with the same elevation and displacement height, the red building closer to the shoreline would be subjected to an increased mean wind velocity, than the blue building an additional 400 m inland.

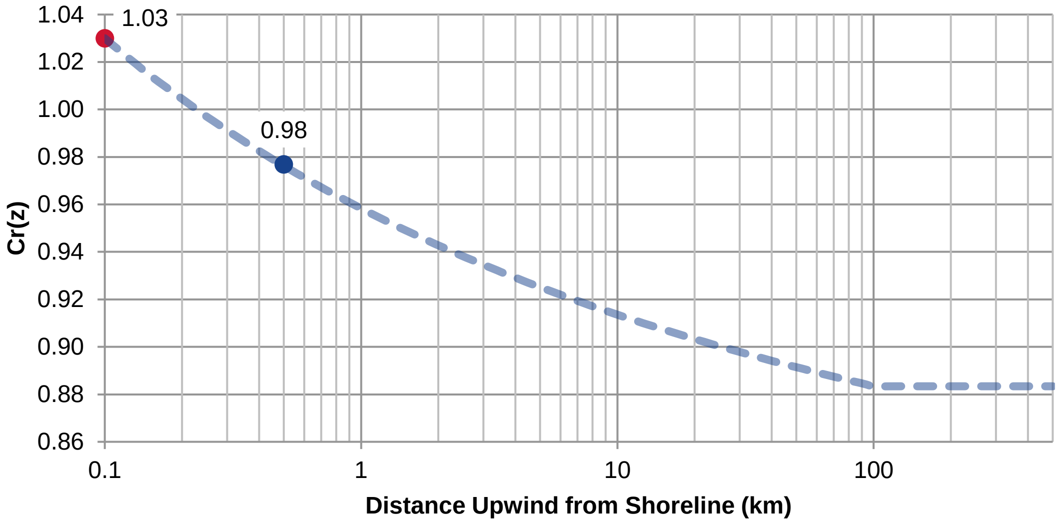

Figure 6 - Distance to Shoreline, Infleunce on Cr(z)

The orography factor is dependent on the surrounding terrain, specifically hills, ridges and escarpments. Detailed calculations can be carried out in accordance with Annex A.3 of EN 1991-1-4.

PEAK VELOCITY PRESSURE

In addition to terrain effects, the influence of surrounding buildings can also be considered by Annex A.4 and Annex A.5 of EN 1991-1-4. This includes analysis based on the height of surrounding structures as well as the spacing of surrounding structures.

Annex A.4 allows nearby taller structures to be considered, and their influence on wind pressures. Effectively, when near to significantly larger structures, buildings are designed based on being at a higher effective height.

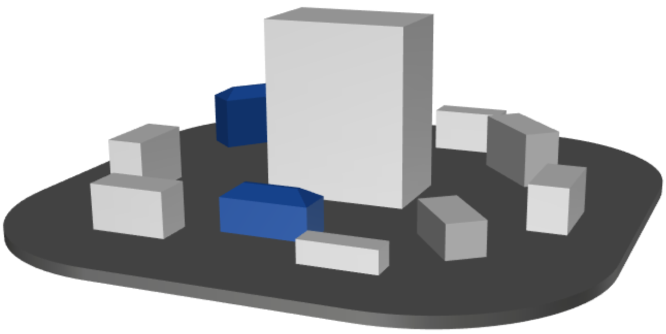

Figure 7 - Illustration of Surrounding Building Height

Annex A.5 considers the influence of nearby buildings to determine the displacement height, which can be considered as the effective ground level, but also influences the roughness height.

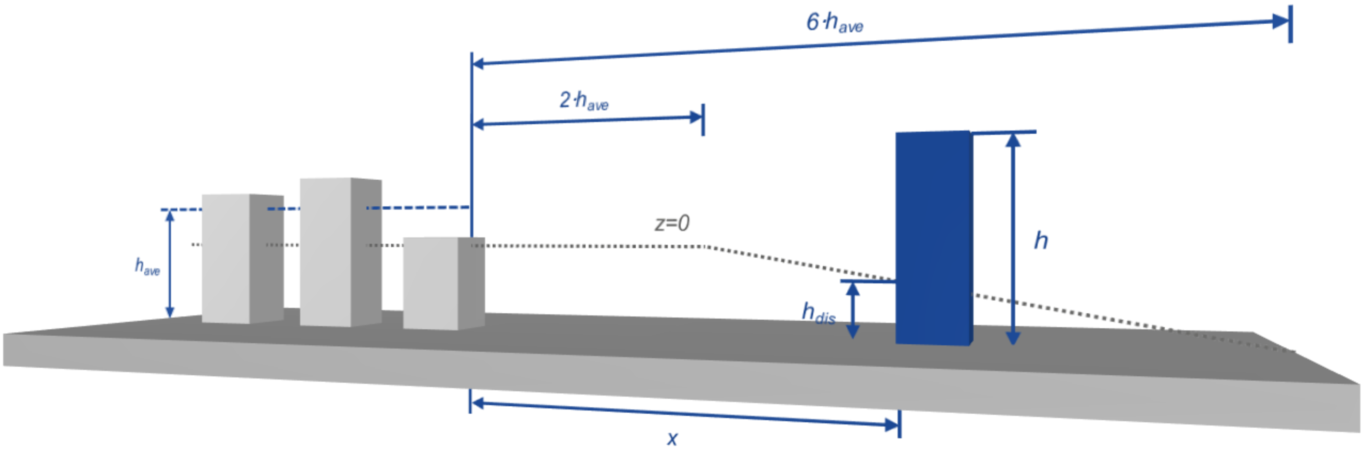

Figure 8 - Illustration for Upwind Building Distance

These factors allow the derivation of factors relating to turbulence, and exposure, which ultimately allow the determination of the peak velocity pressure.

WIND ACTIONS

The wind actions will result from the wind peak pressure, and are dependent on the size and shape of the building under assessment.

The net pressure on a roof or wall element will be the summation of the external and internal pressures on the surface, factored by external and internal pressure coefficients and the structural factor.

STRUCTURAL FACTOR

The structural factor will depend on the building size and shape and considers two effects, influence from the buildings size on the potential for the non-simultaneous occurrence of peak wind actions and vibrations of the structure due to turbulence.

EN 1991-1-4 and the UK National Annex should be considered when assessing these parameters.

PRESSURE & FORCE COEFFICIENTS

Pressure and force coefficients will vary across a wall or roof area, and will also be dependent on the aspect ratio of the building. Where the height exceeds the width, the elevation under assessment will be subjected to greater variations in the wind loadings.

Depending on building size, and roof shape, the wind loading will be considered across different areas and factored according to the standard. The example below shows the typical areas for a flat roof, where the side parallel to the wind is less than twice the height or the crosswind dimension.

Once appropriately factored, each façade area will have a characteristic wind load.

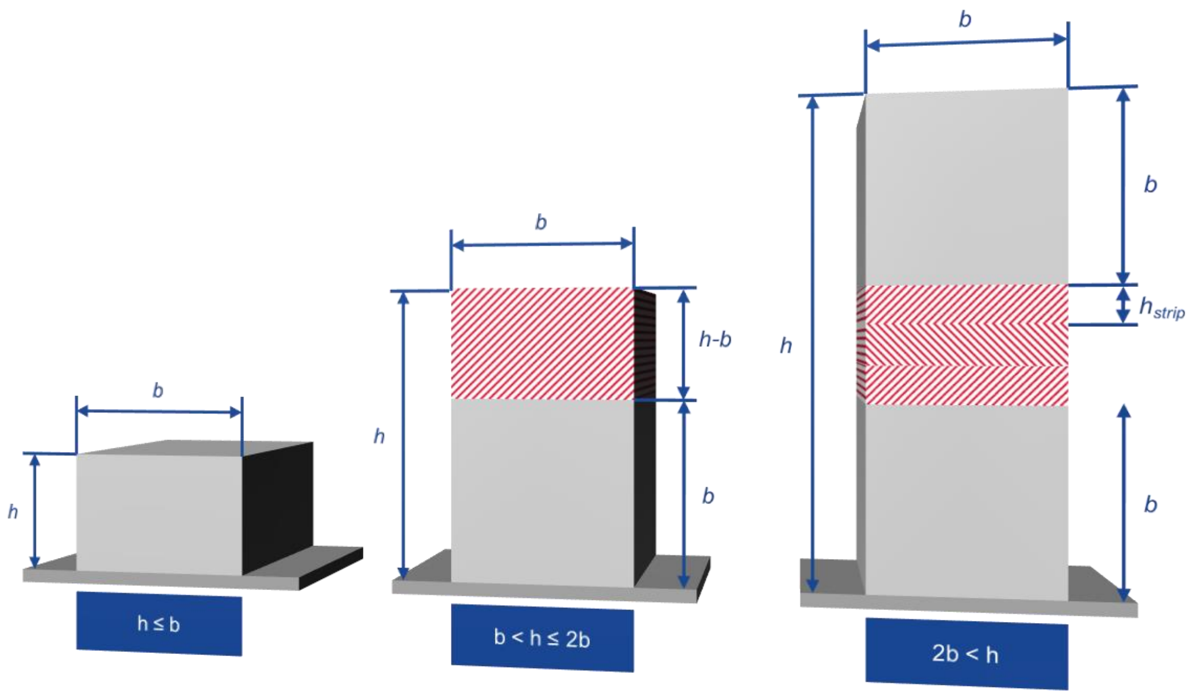

Figure 9 - Building Height Zones

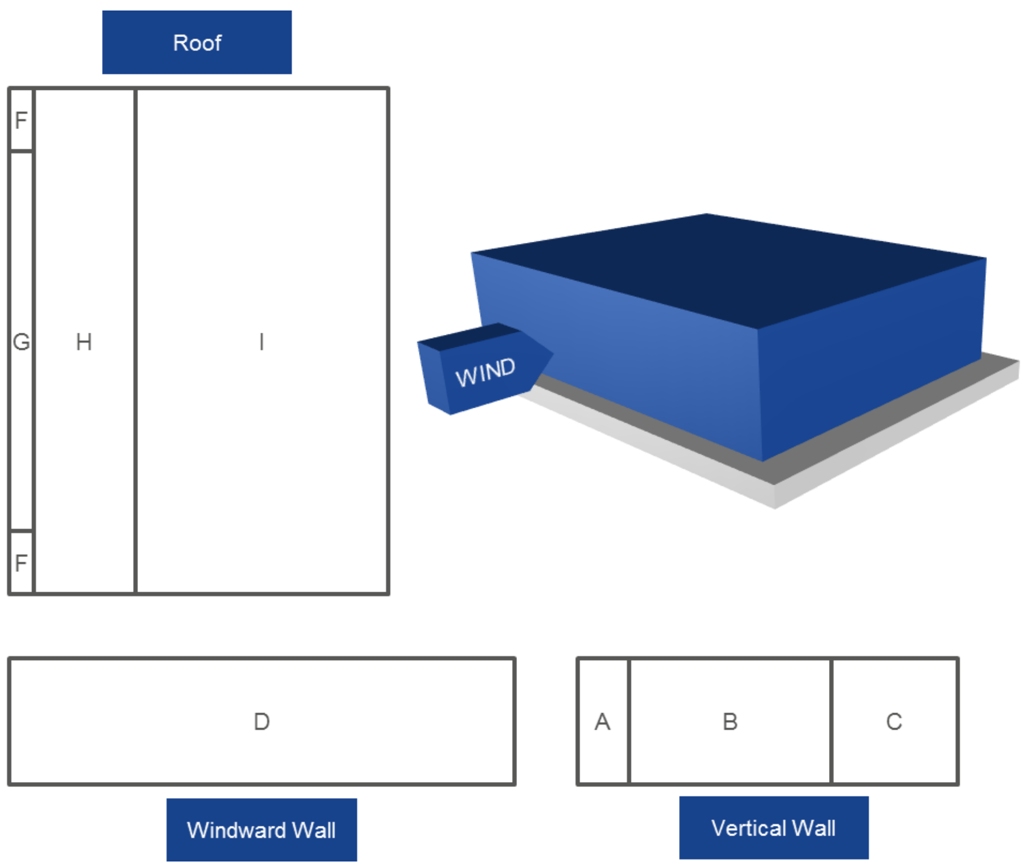

Figure 10 - Building Wall and Roof Zones

REQUIREMENTS FOR ASSESSMENT

In order to fully assess glazing under wind loading, the characteristic relevant wind loads must be obtained for all elevations. Once these loadings have been obtained, they can then be used as part of a combined load scenario, as per EN 1990:2002 [3, 4].

ALTERNATIVE STANDARDS

BS 6262-3:2005 [5] remains a current British Standard, and contains a highly simplified method for determining wind loadings, and can be used where accepted by relevant certifying authorities.

BS 6399-2:1997 [6] is also commonly referenced, including by BS 6262-3. This standard contains a calculation method similar to EN 1991-1-4, however, it should be noted that this standard is withdrawn, and has been replaced by EN 1991-1-4 and the UK National Annex.

REFERENCES

[1] European Committee for Standardization, *EN 1991-1-4:2005+A1:2010 - Eurocode 1. Actions on structures. General actions. Wind actions,* CEN, 2005/2010.

[2] European Committee for Standardization, NA to BS EN 1991-1-4:2005+A1:2010 - UK National Annex to Eurocode 1. Actions on structures. General actions. Wind actions, CEN, 2005/2010.

[3] European Committee for Standardization, *EN 1990:2002 - Basis of structural design,* CEN, 2002.

[4] European Committee for Standardization, *NA to BS EN 1990:2002+A1:2005 - UK National Annex for Eurocode - Basis of structural design,* BSI, 2002.

[5] British Standards Institute, *BS 6262-3:2005 - Glazing for buildings. Code of practice for fire, security and wind loading,* BSI, 2005.

[6] British Standards Institute, *BS 6399-2:1997 - Loading for buildings. Code of practice for wind loads,* BSI, 1997.