The Building Envelope Authority

Guidance Documents

DECEMBER 2023

GD 41 WIND LOADING FOR METAL ROOFING & CLADDING - PROTOCOL FOR CALCULATIONS

1.0 INTRODUCTION

As a leading association within the metal building envelope industry, MCRMA is responsible for providing a range of in-depth guidance documents and training courses for people involved in various aspects of the construction process. It is crucial that every aspect of a building envelope is considered, including the protocol for wind loading calculations.

A key factor in the design of roof and wall systems is the resistance to wind loading. This must be calculated for each building and correlate the result with the specified profile load/span tables and specified fastener capacity, type, location and spacing.

The magnitude of wind loads can surprise a non-engineer. For example, consider a distribution building 20m high by 40m wide and 80m long, near Manchester Airport with a finished 4° pitched roof, on the outskirts of a built-up area.

For this example, the roof is treated as a flat roof and the maximum local wind load is negative 2.09kN/m^2 in the perimeter zones and negative 0.86kN/m^2 in the field areas (away from building edges). The maximum wall load is negative 1.33kN/m^2 and positive 1.05kN/m$^{2.}$.

The calculations indicate that the roof loads are all negative, i.e., suction or uplift and the wall loads are both negative (suction) and positive (pressure) depending upon the zone.

NOTE negative 2.09kN/m^2 in the perimeter roof zones equates to negative 213kg/m^2.

In simple terms, wind loads are the result of differential air pressures over a roof or wall, caused by airflow over the building. If the air pressure is lower externally than the internal pressure, there is a pressure difference resulting in an uplift load, and the construction attachment should be designed to resist this.

Note that if a roof is poorly installed and has, for example, a loose flashing that stands proud and faces the wind, it can act as a sail and become ripped off, making the roof construction vulnerable.

This document gives guidance to the person undertaking a wind load calculation and assists with the interpretation of results.

The correct calculation methodology for UK Building Regulations compliance is defined by the relevant standard BS EN 1991-1-4:2005+A1:2010 (incorporating National Amendment A1 of January 2011). This document does not reproduce the Eurocode but provides supplementary guidance for the specific application of these standards for calculation of wind load acting on flat and pitched roofs.

BRE Documents PD 6688-1-4: 2015 and Digest 436 (parts 1, 2 & 3) Revised 2015 give further information.

Note that for property protection reasons, certain insurance companies such as Factory Mutual, may require an enhanced wind uplift performance of roofs to that indicated by EN 1991-1-4:2005+A1:2010 alone.

There are two main parts to the estimation of wind loads: -

- The building height and locations lead to the peak velocity pressure qp
- The building shape and roof/wall construction affect the external and internal coefficients (Cpe and Cpi) to use.

The wind load calculation is qp*(Cpe-Cpi)

2.0 CALCULATION SOFTWARE AND COMPETENCY

The software used to undertake a wind load calculation must be suitable for use in flat and pitched roof applications. It must comply with the requirements of BS EN 1991-1-4:2005+A1:2010 and supplemented with the UK National Annex (NA) incorporating National Amendment A1 dated January 2011. The person undertaking the calculation should have a thorough knowledge of the calculation procedure, be trained in the use of the appropriate software, and be covered by appropriate PI insurance.

3.0 ESSENTIAL INPUT DATA

It is essential for those who are producing the calculation to fully understand the shape of the building, its location and other parameters which could influence the results of the calculation.

3.1 LOCATION

Always ensure that the location used for the building is correct. Should the wind load design software use an appropriate database, the correct grid reference or site location must be used as this will automatically select the terrain category.

For users without such software, take time to check that the terrain category selected is correct and applicable to one of the 3 types available. For example, if the building is located in a seaside town, on the seafront, only select 'Sea or coastal area exposed to the open sea'. If the building is within the town boundary, then 'Country' terrain or 'Town' terrain may be appropriate.

Should a postcode be provided for the location, ensure that the position of the building requiring the calculation is accurately determined. Rural postcodes in particular can cover a significant area and therefore every effort should be made to ensure that the site altitude, distance to sea, distance to town and exposure factor are correctly defined.

In all cases ensure that the correct distance to the sea is input as part of the location to reflect this position. Note that the UK National Annex refers to 3 terrain categories in contrast to the 5 categories in Eurocode1. If the terrain type is not given assume 'Country' terrain. BRE Digest 436 part 1 gives guidance on determining terrain categories.

Site altitude and the topographic relief of elevated terrain (orography) are also important for the accuracy of the calculation and will significantly affect the resulting wind load. Ensure the correct altitude is used.

The orography factor in software will usually default to 1.0. If the orography factor is provided by the Structural Engineer, this value should be used. Examples of locations where the orography factor will influence the wind load include where the project is located upwind or downwind of the slope of hills, ridges, cliffs or escarpments.

Ideally the project structural engineer, who is far more familiar with the building location and terrain, will provide the peak velocity pressure (qp) to be used on the project. This would avoid a sub-contractor having to make assumptions and ensure wind loadings are not underestimated.

3.2 CALCULATION OF ROOF PERIMETER ZONES

Local wind load zones are shown in appendix A along with zone sizes.

Should the roof being assessed be joined to other roof areas, the complete building footprint should be considered for the calculation of the perimeter and corner zones and not just the roof being considered in isolation. If roofs are treated in isolation of the whole building this would generally produce a conservative (potentially overdesigned) result.

3.2.1 Adjacent structures

Separate roofs built off or adjacent to the roof being assessed should be considered as part of the calculation process. Shadow zones of adjacent higher buildings should be taken into consideration when determining the appropriate roof zones.

The effect of separate adjacent buildings on perimeter zones and wind loads should be taken into consideration in accordance with the guidance provided by PD 6688-1-4:2015, Published Document: ‘Background information to the National Annex to BS EN 1991-1-4:2005+A1:2010 and additional guidance’. Guidance is additionally provided within BRE document Digest 436 (parts 1, 2 & 3) Revised 2015.

3.3 ROOF TYPE

It is important to input the correct roof type, flat roof (<=5º), mono pitched (>5º), duo pitched (>5º), barrel vaulted etc. because this will affect the locations and magnitude of the appropriate roof zones see Appendix A. NOTE that a roof <=5º, be it mono, duo, curved or hipped, is treated as a flat roof.

3.4 BUILDING HEIGHT AND PARAPET WALLS

The wind load on roofs increases with building height. The reference height should be taken as the highest roof point above ground level, and this dimension should include the parapet wall height should this be higher than the ridge at any point of the roof being evaluated.

The effect of parapet walls on the external pressure coefficients for roofs (Cpe) should also be considered and in this respect, Table NA5 of BS NA EN 1991-1-4 (2010): UK National Annex to Eurocode 1. Actions on structures. 'General actions' will provide further guidance and the calculated wind load of the adjacent roof corner zone may be assumed

For parapet walls higher than 1100mm refer to clause 7.4.1 of the standard. When dealing with the boundary of an inset storey, this should be treated as a wall and not a parapet. The external pressure coefficients (Cpe) acting on the walls of inset stories are detailed in PD 6688 section 3.3.2.

APPENDIX A

Metal Roofing and Cladding Systems

A.1 Size Effect factor should be taken as 1.0

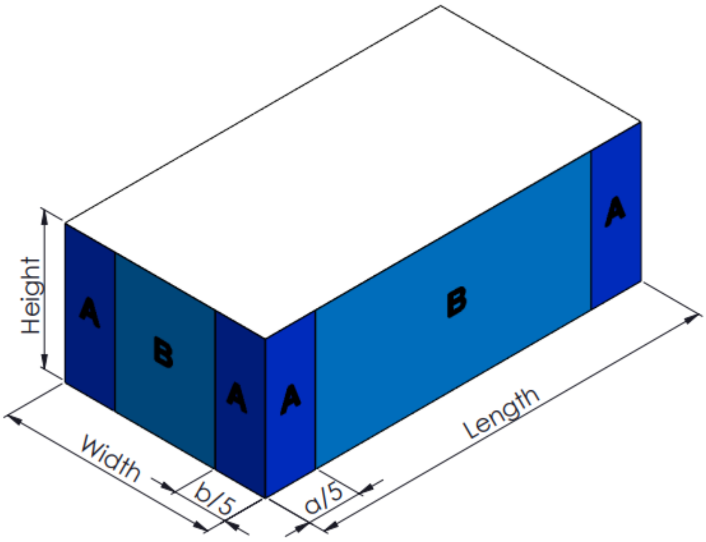
A.2 External Pressure Coefficients (Cpe) and Zones

The following is based on information given BS EN 1991-1-4:2005+A1:2010

Walls: Cpe values

	Isolated			**Funnelling**		
Walls	**Zone A**	**Zone B**		**Zone A**	**Zone B**	
	-1.20	-0.80	0.80	-1.60	-0.90	0.80

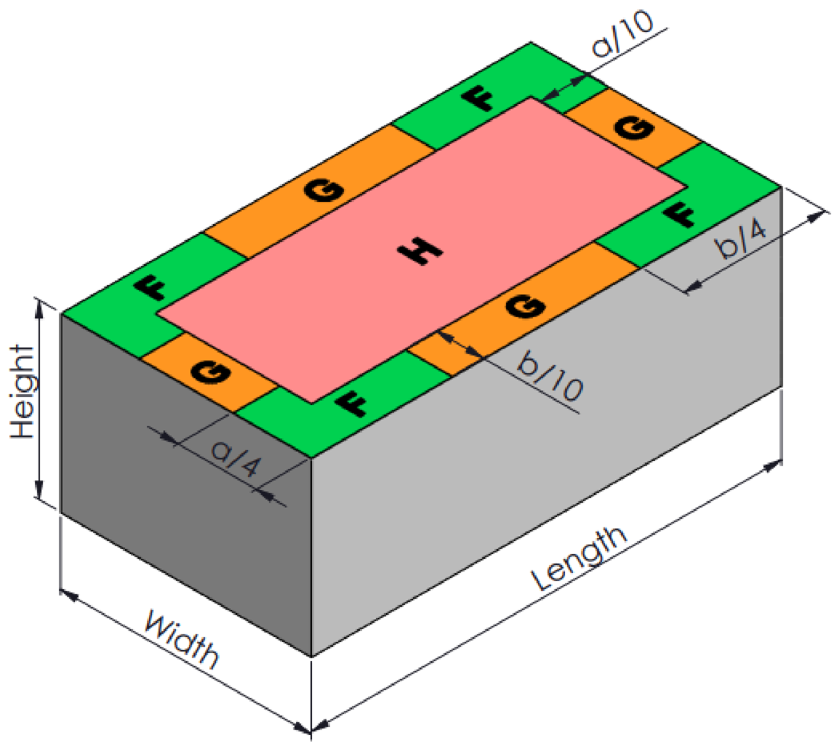
Details where Funnelling should be used is given in NA.2.27



a = Width or 2 x Building Height whichever is the smaller
b = Length or 2 x Building Height whichever is the smaller

Flat Roof: Cpe values

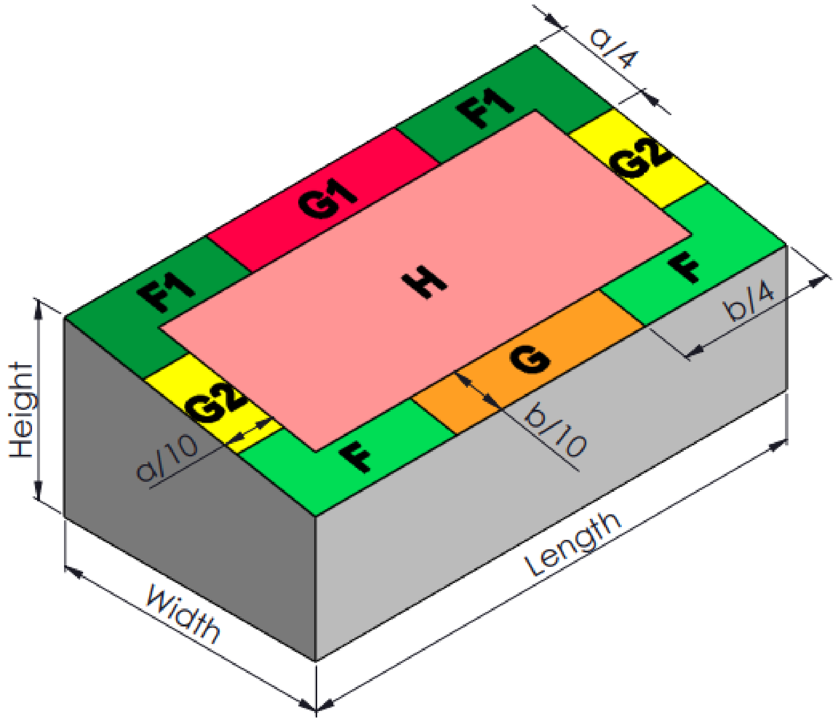
Flat Roof	Zone F	Zone G	Zone H
	-2.00	-1.40	-0.70



a = Width or 2 x Building Height whichever is the smaller
b = Length or 2 x Building Height whichever is the smaller

Mono Pitch Roofs: Cpe values

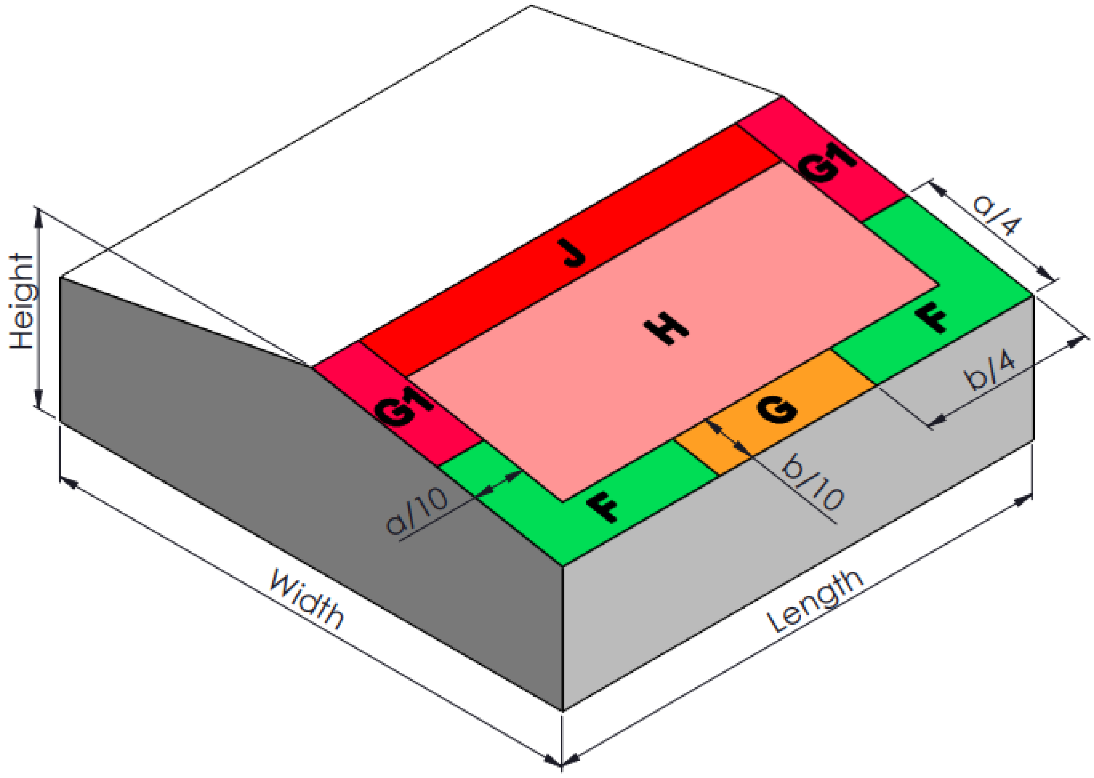
Pitch	Zone F	Zone G	Zone H	Zone F1	Zone G1	Zone G2
5	-2.10	-1.20	-0.80	-2.40	-1.10	-1.10
10	-1.90	-1.00	-0.90	-2.50	-1.10	-1.10
15	-1.60	-0.90	-0.90	-2.60	-1.00	-1.10
20	-1.50	-0.90	-0.90	-2.30	-1.00	-1.10
25	-1.40	-1.00	-1.00	-2.00	-1.00	-1.20
30	-1.30	-1.00	-1.00	-1.70	-1.00	-1.20
45	-1.30	-1.00	-1.00	-1.50	-1.00	-1.20
60	-1.20	-0.70	-0.70	-1.20	-0.70	-1.20
75	-1.20	-0.70	-0.70	-1.20	-0.70	-1.20



a = Width or 2 x Building Height whichever is the smaller
b = Length or 2 x Building Height whichever is the smaller

Duo Pitch Roofs: Cpe values

Pitch	Zone F	Zone G	Zone H	Zone G1	Zone J
5	-2.00	-1.20	-0.60	-1.10	-0.90
10	-1.80	-1.00	-0.60	-1.30	-1.10
15	-1.60	-0.80	-0.60	-1.50	-1.30
20	-1.50	-0.70	-0.60	-1.40	-1.20
25	-1.30	-0.60	-0.60	-1.20	-1.00
30	-1.20	-0.60	-0.60	-1.10	-0.90
45	-1.20	-0.60	-0.60	-1.20	-0.60
60	-1.20	-0.70	-0.70	-1.20	-0.70
75	-1.20	-1.20	-1.20	-1.20	-1.20

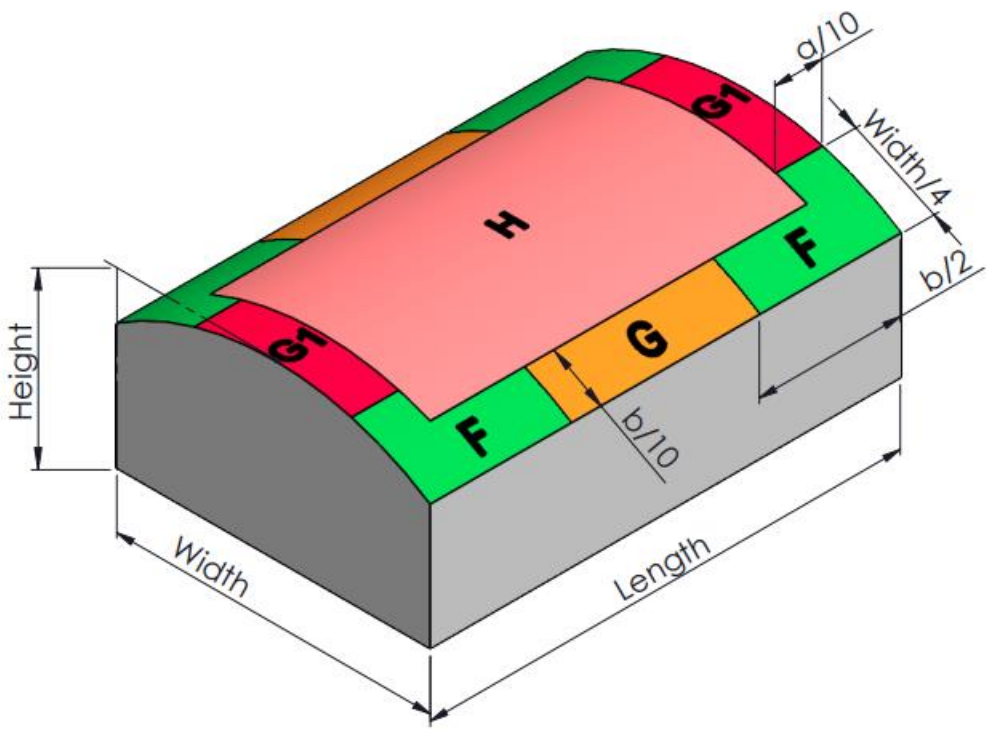


a = Width or 2 x Building Height whichever is the smaller
b = Length or 2 x Building Height whichever is the smaller

Barrel Vault Roofs: Cpe values

Pitch	Zone F	Zone G	Zone H	Zone G1
5	-2.00	-1.20	-0.70	-1.40
10	-1.80	-1.00	-0.70	-1.40
15	-1.60	-0.80	-0.70	-1.40
20	-1.50	-0.70	-0.70	-1.40
25	-1.30	-0.70	-0.70	-1.40
30	-1.20	-0.70	-0.70	-1.40
45	-1.20	-0.70	-0.70	-1.40
60	-1.20	-0.70	-0.70	-1.40
75	-1.20	-1.20	-1.20	-1.40

NOTE pitch is maximum pitch at eaves.



a = Width or 2 x Building Height whichever is the smaller
b = Length or 2 x Building Height whichever is the smaller

A.3 Internal Pressure Coefficients

Building with normal openings Cpi = 0.20

Building with dominant openings Cpi = 0.72

APPENDIX B SAFETY FACTORS

B.1 WIND LOAD CALCULATION SAFETY FACTOR γ_q (γ_f)

Partial safety factors must be applied to the wind suction loads, thereby increasing them in accordance with Tables A1.1 and A1.2 of EN 1990:2002. For the wind suction load the partial safety factor is normally 1.5.

B.2 MATERIAL SAFETY FACTOR γ_m

Material safety factors are given in BS 5427:2016+A1:2017 code of practice for the fasteners used with profiled metal sheet for roof and wall cladding on buildings and relevant ones are reproduced below.

Pull-through: 1.33

Pull-out from steel ≥1.5 mm: 1.33

Pull-out from aluminium ≥2.0 mm: 1.33

Pull out from timber: 2.0

Pull out from masonry/concrete: 2.67

Spacer assembly: 1.33

Secret fix fixing assembly: 2.0

MCRMA recommend that where appropriate for thinner metals a safety factor of 2.0 is used for steel < 1.5mm and Aluminium < 2.0mm, instead of factor 1.33 as shown above.

Adoption by industry of the guidance outlined in this document will lead to better and more consistent standards of metal roofing and cladding construction. Failure to comply with the advice contained in this document could also void any warranty provided by a manufacturer or supplier of systems, products or materials and those involved in the design of the building and the construction and installation on the building.

MCRMA member companies can advise on the suitability and performance of materials, systems, and assemblies. Manufacturers are best placed to offer advice about their particular products and any variation from their published data during the design or construction process could result in the component or system failing prematurely or not complying with the guarantee or warranty conditions.

In addition, design information can be obtained from any of the independent roofing and cladding inspectors featured on the MCRMA web site at www.mcrma.co.uk

REFERENCES

BS EN 1991-1-4:2005+A1:2010 Actions on structures. General actions. Wind actions + National Annex NA to BS EN 1991-1-4:2005 + A1:2010 (incorporating National Amendment A1 of January 2011)
BRE Document PD 6688-1-4:2015 Background information to the National Annex to BS EN 1991-1-4 and additional guidance
BRE Document Digest 436 (parts 1, 2 & 3) Revised 2015
BS EN 1990:2002+A1:2005 Eurocode. Basis of structural design
BS 5427:2016+A1:2017 Code of Practice for the use of profiled sheet for roof and wall cladding on buildings

DISCLAIMER

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