Guidance document GD 16 **December 2014**

Amended 26/08/16

GUIDANCE FOR SNOW LOADING ON CLADDING

INTRODUCTION

Metal cladding that has been specified as self-supporting must be capable of supporting its own weight plus any loading applied to it. For typical roof cladding, the loading is likely to include the cladding self-weight, access for maintenance, snow loading (including snow drift) and wind loading, not to mention the weight of photovoltaic arrays in many cases.

While winters in the UK are often relatively mild and severe snow falls rare, it is not uncommon for heavy snow to result in damage to buildings, including roofs and their supporting structures. Due to the mild climate, the snow that causes these collapses is often regarded as exceptional. However, the reality is that most of the recent snow falls in the UK have been within the design values predicted by the codes and standards, so should not have caused the damage that they did.

Good building design in terms of resistance to snow loading starts with the correct specification of the roof cladding and its supporting structure. This in turn depends on the accurate determination of the likely magnitude of snow loading appropriate for the location and geometry of the building. Snow loading is normally calculated by suitably qualified engineers using the latest codes of practice and software. However, all construction professionals need to be aware of the basic principles of snow loading to ensure that they play their part in specifying and delivering a safe building.

SNOW LOADING ON BUILDINGS

When designing a building for snow loading, it is important to distinguish between the two fundamental types of snow load:

- Uniform snow loading
- Snow drift

Snow falling vertically onto a roof without obstructions will be distributed evenly over the whole area of the roof, giving rise to a uniformly distributed load. The intensity of this load (kN/m^2) is likely to be small, but the effects may be severe due to the large area involved.

By contrast, snow drifting occurs when there are obstructions against which the snow could accumulate, such as parapets or walls. While the intensity of snow drift loading is usually much higher than uniform snow load, it is limited to a relatively small area of roof. A similar situation may arise on buildings that are susceptible to snow sliding off a neighbouring roof, causing a very high local load where it lands.

Uniform snow loading and snow drift both cause bending effects in the roof cladding and, in extreme cases, may cause structural failure of the cladding profile. The loading must ultimately be transferred to the foundations via the purlins and primary building structure, so it is essential that a safe load path is provided that permits the transfer of this load without damage to the building envelope. This means the correct specification not only of the cladding, but also the spacer system (in the case of built-up roofs), fasteners and purlin system (including anti-sag rods where required). The issue of load paths is discussed in greater detail later.

It is common practice for the structural engineer with overall responsibility for the building design to calculate the building snow loads as part of the structural design process. However, the snow loading calculated for the design of the frame may ignore high local forces experienced by small areas of the building envelope, such as those areas of roof under the deepest snow drift. (The building structural engineer is primarily interested on the total load acting on each frame, so may consider the average snow drift between frames, rather than the highest local load). It may therefore be necessary to perform snow loading calculations specifically for the building envelope in addition to those undertaken by the structural engineer.

FACTORS AFFECTING SNOW LOADING

Snow loading is dependent on several factors relating to the location of the site and the geometry of the building. For this reason, snow loading is site and building specific, so must be calculated for each new building. Deriving the size and location of snow drift should be provided by the structural engineer and provided to the roof system specifier, be that the architect, roof system manufacturer or installer. This avoids the effects of snow drift being overlooked or wrongly calculated, and keeps those who may be specifying or tendering for work to use the same design criteria.

The main factors that influence snow load are:

- Location
- Altitude
- Parapets and obstructions
- Neighbouring roofs

Location

Some parts of the country are more susceptible to snowfall than others. A number of meteorological factors influence the depth and frequency of snow fall at a given location, beyond the expertise of a typical structural engineer. Fortunately, the available meteorological data has been analysed to produce simplified guidance in the form of a snow map and a simple equation to allow for site altitude.

Both are published in the National Annex to the BS EN 1991-1-3. The snow map, which has been reproduced in Figure 1, divides the country into a number of zones, according to the predicted intensity of the 1 in 50 year snow event. It should come as no surprise that the highest snow loading occurs in Scotland and eastern areas of England.

Altitude

The depth of snow fall naturally increases with altitude. This is catered for in the Eurocode by a simple equation that gives site snow load in terms of site altitude and snow zone (taken from the map reproduced on page 4).

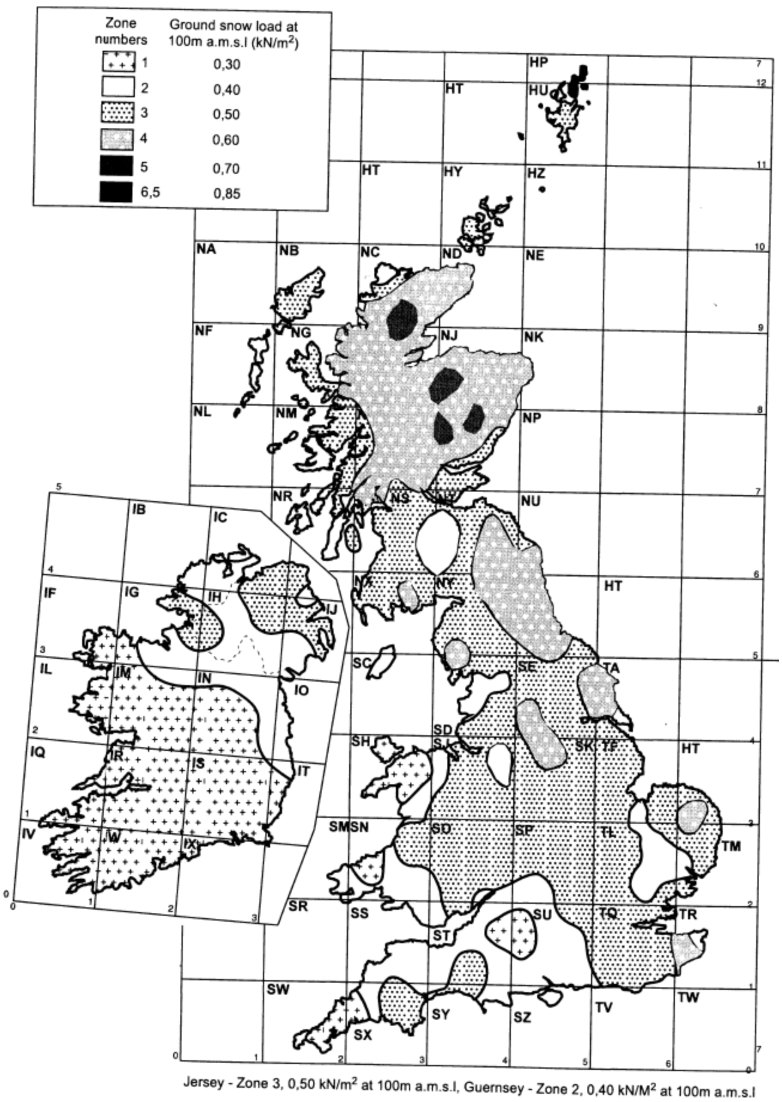

Figure 1: Characteristic ground snow load map taken from UK NA to BS EN 1991-1-3

Parapets and obstructions

Parapets and other obstructions against which the snow may accumulate cause snow drifts resulting in localised high snow loads well in excess of the uniform snow load. These need to be taken into account in the design of the roof cladding and its supporting structure and may require additional strengthening of the roof (for example, purlins at closer centres). Typical snow drift situations are shown in Figure 2. As with the uniform snow load, BS EN 1993-1-3 contains recommendations and guidance on calculating snow drift loads on buildings.

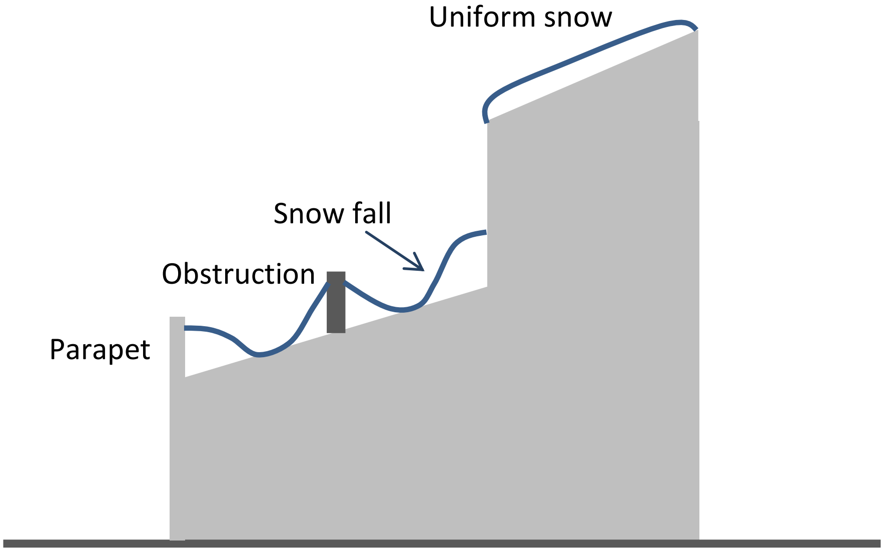

Figure 2: Typical situations in which snow drifting may arise on a roof

Neighbouring roofs

Where a new building is erected adjacent to an existing taller one, designers should be aware of the possibility of snow falling off the higher roof onto the lower building causing local overloading of the roof cladding and supporting structure, as shown in Figure 3. In this case, the snow load will depend on the roof slope area of the taller building and the area of the lower roof onto which the snow is likely to fall (that is, the size of the heap formed on the lower roof). If there is a significant height difference between the two roofs, there is also the risk of impact loading due to the momentum of the snow as it hits the lower roof. This loading is likely to be far greater than the equivalent static load.

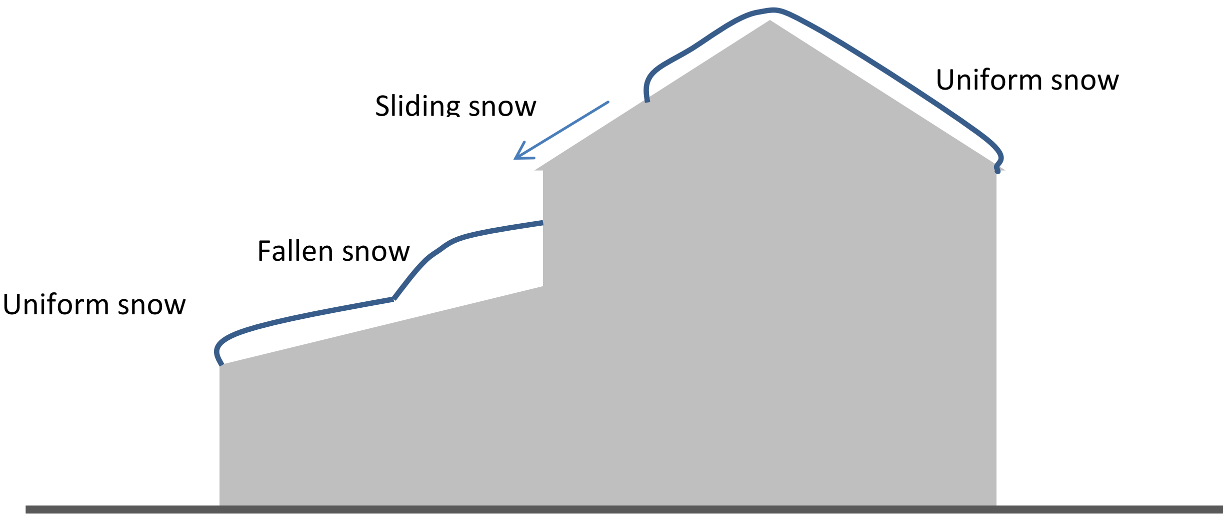

Figure 3: Snow falling off a neighbouring roof

LOAD PATHS

The weight of the snow on a roof must ultimately be transferred safely to the building foundations through the cladding, secondary steelwork and primary frames. On flat roof buildings, all gravity loading is resisted by bending and shear in the roof deck and supporting beams. However for pitched roofs, the matter is complicated by the existence of several alternative load paths which are:

1. Through the spacer and along the purlin
2. Down slope to the eaves
3. Up slope to the ridge
4. Diaphragm action to the rafters (via brackets and purlin cleats)

These are illustrated in figure 4 below

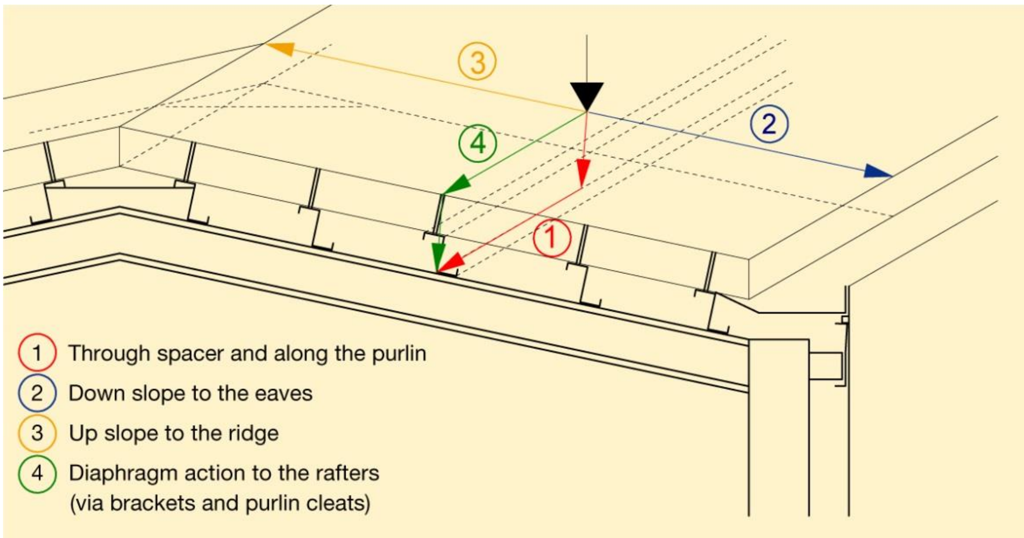

Figure 4: Load paths on a pitched roof

A large proportion of the load will be carried by the cladding in bending and, in the case of a built-up roof, will be taken via the spacer system to the purlins. However, if the roof is sufficiently steep, a significant amount of load may be taken in axial tension and compression to the ridge and gutters respectively. Some load will also be taken in diaphragm action through the cladding directly to the rafters. In practice, the distribution of load between the various load paths is dependent on the relative stiffness of each path. This will depend on the stiffness of the individual components (for example, axial stiffness of the cladding compared to its bending stiffness) and the detailing of the connections and fasteners.

SNOW LOADING CALCULATIONS

In order to specify the roof cladding correctly, it is necessary to estimate the maximum magnitude of snow loading that the building is likely to encounter over its life. This should be achieved using a recognised code of practice (British Standard or Eurocode). Until March 2010, the code of practice for snow loading in the UK was BS 6399-3, but this has since been replaced by BS EN 1991-1-3 (although the former is still widely used).The latter standard is one of the structural Eurocodes and is applicable across the European Union, although each member state has its own National Annex that must be used when designing for that country.

As noted above, the snow loading on the ground at a particular site is a function of the snow zone (see map in Figure 1) and the site altitude and is relatively straightforward to calculate. The uniformly distributed snow loading on the roof is obtained by multiplying the ground snow load by the appropriate snow load shape coefficient (see section 5.3 of BS EN 1991-1-3 and Annex B of BS EN1991-1-3). Having calculated the uniform snow load, designers should consider whether there is a risk of snow drift due to the presence of parapets or other obstructions and should also consider the possibility of snow falling off neighbouring roofs. Where appropriate the snow drift loading should be calculated following the guidance in section 5.2(3) of BS EN 1991-1-3.

When designing to the Eurocodes, the snow loading is combined with the dead load (for example, self-weight) and any positive (downward) wind loading, all multiplied by the appropriate safety factors to give the factored loading for the roof. Access for maintenance (imposed load) is considered as a separate load case and is combined with the dead load only. This means that the snow loading must always be considered, even if it is lower in magnitude than the imposed load. By contrast, in BS 6399-3 the imposed load was treated as a minimum snow load, so designers only needed to consider the actual snow load where it exceeded this minimum value (usually 0.6 kN/m^2). In both codes, snow drift loading is considered separately and is treated as an accidental load case.

BS EN 1991-1-3 aims to calculate the snow loading corresponding to the 1 in 50 year snow fall, so cladding and buildings designed to this standard should be able to withstand the typical winter weather with ease. Furthermore, when checking the ultimate resistance of cladding sheets, the design loads include a safety factor to provide an additional margin against failure.

Therefore, if designed properly, no cladding should fail due to snow loading, except in the most extreme of cases. The use of the 1 in 50 year event and safety factors does not mean that the roof is 'over designed' and should not be used as an excuse for reducing the cladding loads; the margin of safety engineered into the calculations is essential to ensure with reasonable probability that the building envelope will not fail during its design life.

Cladding manufacturers typically publish their technical data in the form of load span tables. In producing these tables, it is common practice to divide the resistance (strength) of the cladding profile by the appropriate safety factor to give a 'safe working load'. When using these tables, specifiers should compare the published resistance values against the 'unfactored' snow, downward wind and imposed loads (snow + wind as one case and imposed load as a separate case).

The spanning capability of a cladding profile is dependent on the precise geometry of the profile and the gauge and strength of the steel or aluminium from which it is made. It is therefore essential that specifiers refer to the appropriate load tables or other design data published by the manufacturer of the profile under consideration (rather than referring to tables for a similar product produced by someone else). The load tables should be produced using BS EN 1993-1-3.

CONCLUSIONS

Snow loading varies from site to site and building to building due to variations in the depth of snowfall with location and altitude and localised variations in snow load due to drifting behind parapets and other obstructions. The calculation of snow loading is less complicated than that of wind load, but is still best performed by a qualified engineer. If not properly accounted for, snow loading can cause significant damage to buildings. However, by following the recommended calculation procedures and specifying the cladding and supporting structure accordingly, building designers can ensure that the roofs of their buildings do not collapse due to snow loading even in the harshest of winters.

MCRMA member companies can advise on the suitability and performance of materials, systems and assemblies to ensure that the snow loading is calculated properly for every building and that the cladding and fasteners are specified accordingly. In addition, snow loading and roofing 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

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ACKNOWLEDGMENT

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Published December 2014 Amended 26/08/16