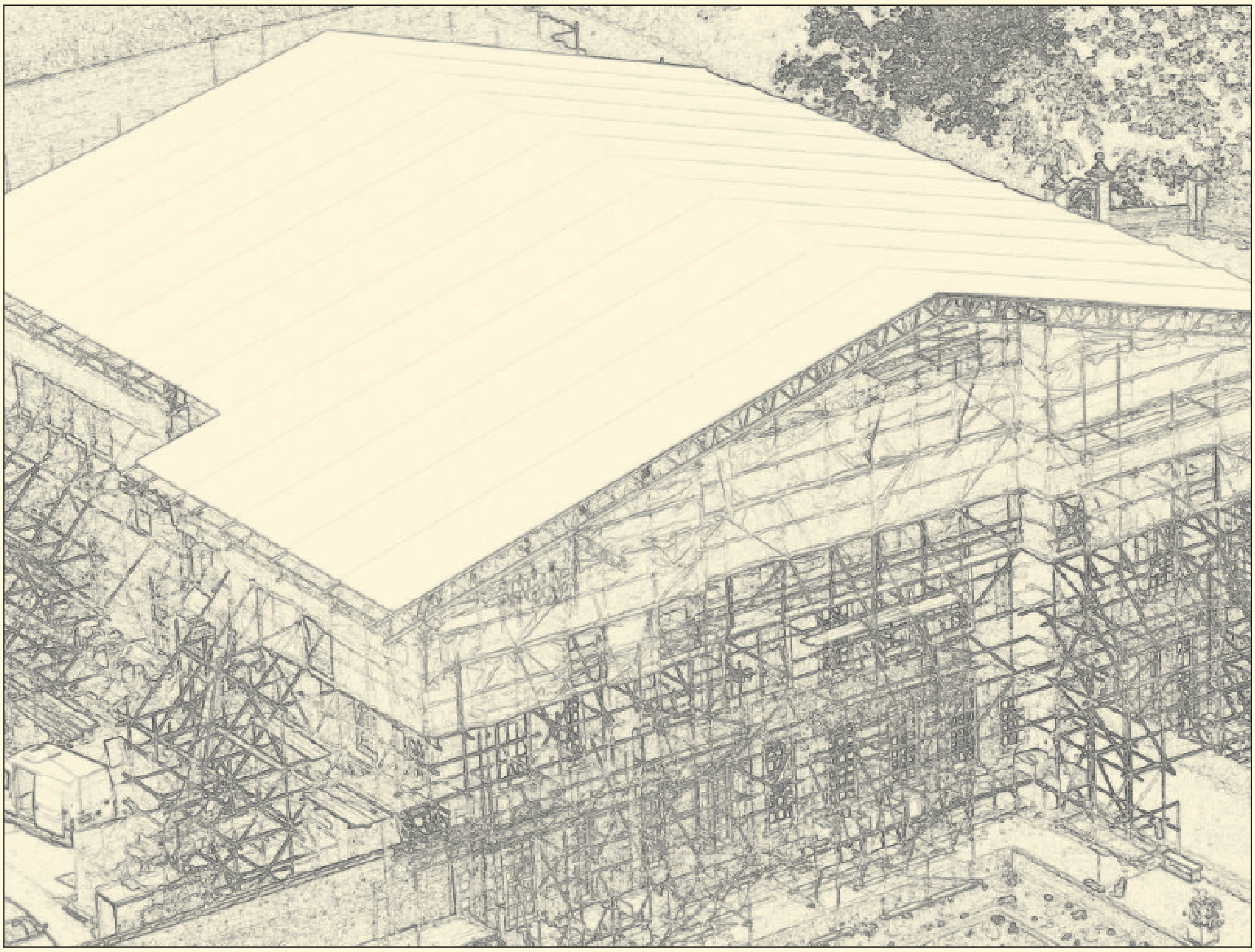
TG9:18

Guide to the design and construction of temporary roofs and buildings

NASC
NATIONAL ACCESS & SCAFFOLDING CONFEDERATION



NASC

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1. INTRODUCTION

A temporary roof or building is a sheeted structure designed to provide cover over an area from the effects of weather, dust, etc. It may stand on the ground or on top of a building or be an extension of a scaffold round a building. It may have fully sheeted walls and roof or only a roof or a roof with skirts.

This guide is intended to give design and construction information to designers and suppliers of temporary roofs and buildings constructed with scaffolding materials.

It is not a comprehensive design guide but covers some of the more basic requirements and considerations that should be made to provide an economical, but safe, completed temporary structure.

The usual types of sheeting employed for temporary buildings are as follows:

a) corrugated steel or corrugated aluminium;

b) flexible plastics;

c) flexible plastics covered panels.

For welding screens and other places where there is a fire hazard, corrugated steel sheeting should be used.

For structures with a very limited life, for example: at sports arenas and exhibitions, fixing cords of known breaking strength may be used with flexible sheeting to cater for excessive gust wind speeds.

This guide replaces all previous versions of TG9 and takes into consideration BS EN 16508.

2. SCOPE

This guide is intended for the design and construction of;

- a temporary roof which is supported by an existing building
- a temporary roof which is supported by scaffolding
- a temporary roof which is supported by another temporary construction (for example: a steel frame)
- a complete temporary construction including roof and walls (temporary building).

This guide excludes;

- roofing for stages
- roofing for grandstands
- inflatable structures

Whilst excluded from this guide, these structures will still require specialist design considerations.

3. MANAGEMENT CONSIDERATIONS

A Full Risk Assessment and Method Statement should be prepared for all installations.

The work must be in compliance with Work at Height Regulations.

Where a temporary roof is standing on an existing roof or anchored to building, the principle contractor must ensure that the structure can adequately withstand the additional imposed loads.

Check for hidden services that are likely to cause a problem with loads from standards or kentledge.

Where anchoring to a building is not permitted, ensure that sufficient space is available for buttressing.

The safe method of moving materials to site and to the actual place of installation.

The method of access to the place of the installation for erecting/dismantling and inspection.

Any requirement for water management is to be agreed with client.

Any requirement for snow management is to be agreed with client.

The management and protection for members of the public and the workforce of other contractors.

The choice of covering medium

> If Steel sheets are used, then ensure that a safe system of work is practicable. If rigid panels are used, then ensure that a safe system of work is practicable.
>
> If tracked sheeting is used, then provide adequate safe, working platforms for inserting and removing sheets.

Roof cover

> 100%
>
> Partial cover – Re-erect or rolling
>
> Sections requiring opening for lowering in of materials etc.

Training of workforce

> Ensure that specific training is carried out for the selected roofing system and method of erecting and dismantling.

Job specific design

> Working construction design drawing and calculations corresponding to manufacturer's loading data and current codes of practice.

4. TYPES OF CONSTRUCTION

4.1 Structural framework

The most common method of providing temporary roofing is by the use of prefabricated beams manufactured from steel or aluminium alloy.

They are available in various lengths, depths and strengths.

The beams can be joined together by differing methods.

The spacings of the beams may be adjusted to suit the span and loading conditions to give the optimum design.

The roof structure may be constructed in various forms.

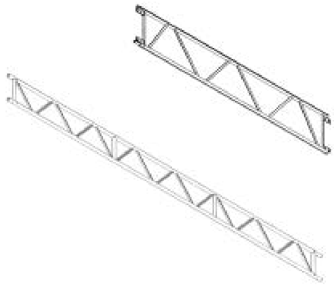


Figure 1

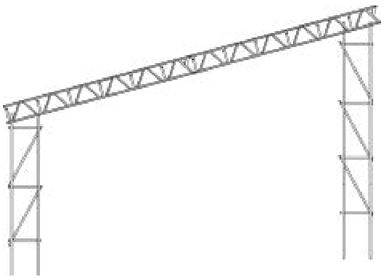


Figure 2
Simple mono-pitched roof

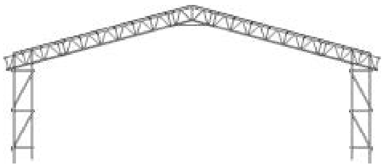


Figure 3
Apex (pitched) roof

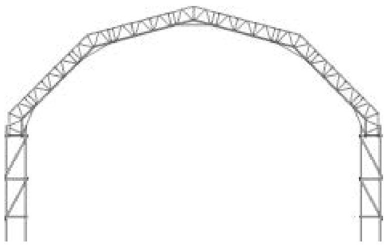


Figure 4
Multi-pitched roof

Any of the above types of structure, may be constructed as static structures, mobile or as 'telescopic' arrangements (one roof passing over another)

4.2 Roof covering

A number of covering methods are commonly used;

Rigid / Semi-rigid sheets

- Corrugated Steel or Composite
- Proprietory Panels (also known as Cassettes) with Steel, Aluminium Alloy or plastic sheeting

Flexible Sheeting

- Purpose-made sheeting (PVC, Polythene etc) which may be fixed down to beams by various methods or pulled through and retained by a purpose-made slot in the roof beams (commonly known as 'keder')

4.3 Water management

The roof drainage arrangements should be agreed between the designer and the user. Gutters should have a fall of not less than 1 vertical to 100 horizontal. The rain water pipes should be in agreed locations and tied securely to the structure.

5. COMPONENTS

5.1 Prefabricated beams

5.1.1 Steel beams

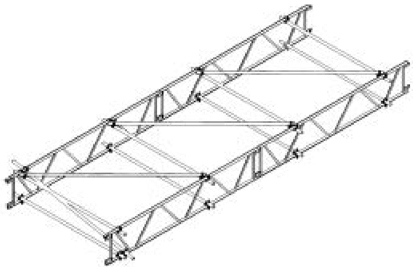


Figure 5

Prefabricated steel beams are generally warren trusses with 48.3mm diameter chords at approximately 600mm centres. They are available in various standard unit lengths and are connected end to end by 2 or 3 bolts and a spigot at each gusset joint.

The load carrying capacity depends mainly on the frequency of restraint to the compression chord. Guidance should be sought from the beam supplier for the actual load carrying capacities. Generally, if chords are tied at the node positions (1.2m approx. intervals) then the maximum bending moment is normally in the range of 12 to 27 kN.m.

It is important that lateral restraint in the form of bracing is provided. Generally this bracing will be required every 5th bay.

Note: depending on the loading conditions, the compression chord may be either top or bottom chord.

It is also important to tie the tension chords together.

Figure 5 illustrates the use of bracing to achieve stability for groups of prefabricated beams. Generally this bracing will be required in every 5th bay.

5.1.2 Aluminium alloy beams

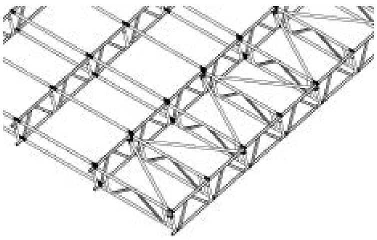


Figure 6 – This is indicative of a system roof

These beams range from 400mm to in excess of 1000mm in depth.

Lacing and bracing may be effected by the use of system components or tube & couplers.

The load carrying capacity largely depends on the frequency and type of restraint to the compression chords.

Guidance should be sought from the supplier/manufacturer for the actual capacities prior to carrying out detail design.

It is important that lateral restraint in the form of bracing is provided. Generally this bracing will be required every 5th bay.

Note depending on the loading conditions, the compression chord may be either top or bottom chord.

It is also important that tension chords are laced together.

Since there is a wide range of this type of beam, with a wide range of properties, it is recommended that the designer **clearly indicates the specific beam used in the design drawing**.

5.2 Covering – Rigid sheeting

5.2.1 Corrugated steel

Corrugated steel sheets are normally placed and fixed in-situ at roof level with the appropriate safety measures in place to minimise the risk and consequences of a fall.

For normal use, the recommended sheeting is 22 gauge or 24 gauge thickness. Under no circumstances should sheeting of thickness less than 26 swg be used.

See Appendix B for further details.

The design should indicate positions of purlins and overlay tubes and their corresponding couplers. Particular attention should be paid to those areas subject to increased wind pressures etc.

Recommended minimum roof slope is 5°.

5.2.2 Proprietary sheeting panels – also known as cassettes

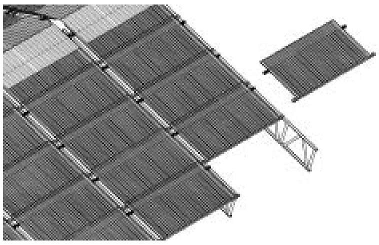


Figure 7

These may be constructed from steel, aluminium alloy or GRP sheet materials, mounted on a framework with a means of secure attachment to the roof trusses.

During erection, the panels should provide the necessary support for the placement of subsequent panels.

The panels may be man-handled into position or lifted by crane depending on the item weight and circumstances.

Recommended minimum roof slope is 5°.

5.3 Covering – Flexible sheeting

5.3.1 Plastic sheeting supported by proprietary purlins

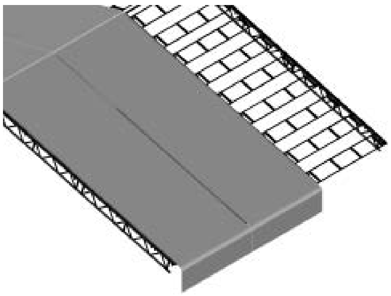


Figure 8

Using this method, the sheets are stretched taut and securely fixed through the sheeting to the roof beams. The purlin frames fitted between the roof beams prevent ponding.

Care should be taken when considering the safe erection of this type of roof covering.

It is not normally permissible to walk on the sheeting.

Recommended minimum roof slope is 10°.

5.3.2 Plastic sheeting in track – commonly known as 'keder'

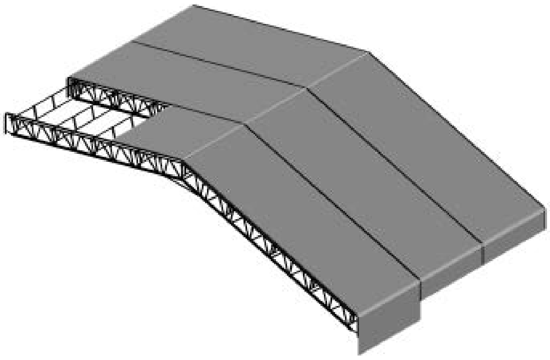


Figure 9

When using this method, channels are provided, either within the truss beam itself or by separate track components.

The sheets are drawn through the slots from one side of the roof to the other.

This method allows the sheet to be fitted without the need to access the roof structure.

In order to prevent ponding, it is essential that the sheets are tensioned at their ends.

It is not normally permissible to walk on the sheeting.

Recommended minimum roof slope is 10°.

6. DESIGN METHODS

Requirement for structural design

6.1 Basic requirements

All temporary roof and temporary building structures should be individually designed.

The structure should be designed in accordance with recognized engineering principles and should take into account the variability of materials, workmanship, site conditions and construction tolerances.

Temporary works systems should be designed with regard to the ease and safety of erection and dismantling. The designers and suppliers should provide appropriate guidance on the sequence of erection and dismantling of their design.

The designer will be expected to have considered the buildability of the structure and the design should take account of the methods of construction. The designer should also provide the relevant information – with regard to the significant risks involved in its construction.

The layout of the structure should be such that there is a well-defined system for transferring the loads to the ground. When the form of the design has been chosen, the various structural elements and joints should be designed and constructed so that the elements themselves and the rigidity of the joints between them are adequate for their purposes and are used in accordance with the manufacturer's recommendations.

The assembly as a whole should be stable against sliding and sway due to wind forces with a **factor of safety of 1.3** and against overturning with a **factor of safety of 1.2**. Wind loads should be calculated.

The cross fall of the roof should be such that rain water will be readily shed. The lateral thrusts derived from arched or ridged roofs should be taken into consideration in the design and construction. In the case of steeper ridged roofs, ties designed and inserted for this purpose should take the thrust.

The roof drainage arrangements should be agreed between the designer and the user. Gutters should have a fall of not less than 1 vertical to 100 horizontal. The rain water pipes should be in agreed locations and tied securely to the structure.

The load resulting from transverse wind forces may be taken account of by the incorporation of suitably stiff framing and by a means for transferring the local wind loading to it.

The overturning of the structure as a whole may be prevented by ground anchors or kentledge round the perimeter or by guys and anchors.

If the forces in the knee bracing and in the braces to tube and fittings trusses are too large to be resisted by one coupler, then supplementary couplers should be added or the fittings pinned with shear pins. When couplers interfere with the sheeting, a secondary rafter and raised purlins should be added above the truss to carry the sheeting.

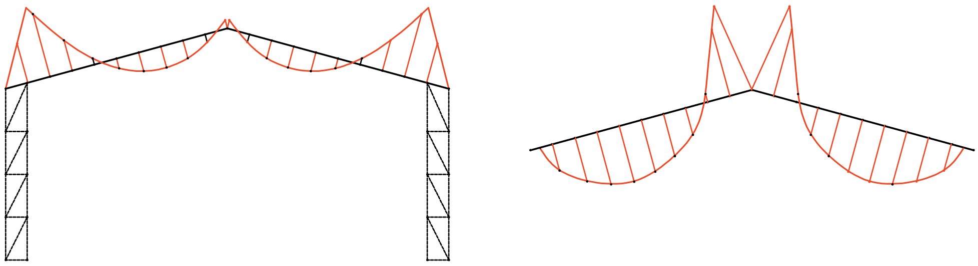
Longitudinal bracing should be inserted in the long walls and transverse bracing in the end walls or end gable. Plan bracing should be inserted in the roof structure.

When the temporary building is an extension to an access scaffold, the bracing and tying of this access scaffold should be supplemented as necessary. The effect of the horizontal forces on the walls of the building should be considered.

When a temporary building or roof is constructed on the top of an existing building, the anchor points should be suitable to resist the loads imposed upon them.

6.2 Method of design

It is not recommended that the roof structure is designed in isolation from the supporting structure. This can lead to inaccurate assessment of the forces at the ends of the roof trusses. It is preferable, and more accurate, to consider the complete structural arrangement.



a) Total structure model

b) Roof in isolation
assuming ends of roof beams held in position

Figure 10 – Effect of supporting structure on bending moment distribution

The overall roof and the side support scaffolds could be subjected to uplift and joints in the uprights and knee braces may need to be strengthened by lapping. If the scaffolding structure is of insufficient self weight to resist the uplifts, as may be the case in a low height, long span roof, then additional resistance must be provided by anchors, tubes under window heads, kentledge or similar. Overturning and side sway of the total structure must also be considered to determine the worst combinations of loads.

Any untied, free standing structure may need a buttressed scaffold system with anchors at foundation level on any buttress lines and should be the subject of detailed design.

Particular attention should be given to the design and detail of the anchors. Refer to NASC Guidance TG4 (Anchorage systems for scaffolding) and TG16 (Anchoring to the ground).

6.3 Factors of safety

All elements of the structure shall be designed with a factor of safety not less than 1.65.

6.4 Applied loadings

The conditions of loading which must be considered are:

- Q_1 Permanent Actions
- $Q_2 - Q_4$ Variable Imposed Loads
  - Q_2 Access and service loads
  - Q_3 Other imposed loads (eg effects of lifting operations etc)
  - Q_4 Service load on roof
- Q_5 Max. snow loading
- Q_6 Reduced snow loading
- Q_7 Minimum vertical loading
- Q_8 Maximum wind loading
- Q_9 Accidental loads

To ensure that servicabilty limits are not exceeded, these loads must be considered in the most onerous combinations to produce the worst effect on an element or on the structure as a whole.

Note: these loads should be applied in their true directions;
ie. wind loads should be applied perpendicular to the surface,
gravity loads can only act vertically downwards.

Mobile temporary structures may be subject to an overall uplift due to wind pressure. Consideration should therefore be given to providing kentledge or other means of tying down such structures.

6.4.1 Q_1 Dead loads

The dead load relates to the self weight of all the components forming the structure. These weights should be obtained from the manufacturers data sheets or brochures. Other dead loads (eg overlay tubes, working and/or erection platforms, lifting beams, lighting etc) should also be considered.

6.4.2 Q_2 Working Load

The effects of specified live loading on decked platforms for various trades.

6.4.3 Q_3 Other imposed loads

This would include effects of lifting operations etc.

Note: The initial design and construction should avoid contained water.
eg. sheets should be sufficiently stretched to prevent excessive sag and ponding to occur.
Where the roof slope is too shallow, natural deflection may allow ponding to develop.

6.4.4 Q_4 Service load on roof

For the effect due to erection, dismantling or maintenance, the structural elements should be designed for two concentrated loads of 1 kN not less than 2m apart, at the most onerous positions.

Each load area should be 200 x 200mm.

The load, Q4, shall not be combined with other loading conditions.

6.4.5 Q_5 Maximum Snow loading

BS EN 1991-1-3 provides the method of calculating the expected maximum snow loads in the UK.
See Appendix D for details

If there is no risk of snow for the period that the temporary roof or building is to be provided then snow loads may be ignored. However, Q7 should be used in this case.

6.4.6 Q_6 Reduced Snow loading

The maximum loading should only be reduced if the Designer is aware of a practical snow management method for the proposed roofing system agreed by Contractor and Client.

BS EN 1991-1-3 provides the method of calculating the expected maximum snow loads in the UK.
See Appendix D for details

6.4.7 Q_7 Minimum vertical loading

If there is no risk of snow for the period that the temporary roof or building is to be provided then snow loads may be ignored. However, a minimum vertical loading of 0.1 kN/m^2 should be applied.

6.4.8 Q_8 Wind loading

All structures require individual design.

Wind loading should be evaluated using the information available in BS EN 1991-1-4 and take into account the effects of the building shape and wind flow.
See Appendix E for details

6.4.9 Q_9 Accidental loading

Anchor points for fall arrest devices must be capable of withstanding a vertical force of 6 kN during the erection and dismantling of the framework and cladding.

Note: when retractable fall arrest devices are used, horizontal forces may be in excess of 6 kN.

6.4.10 Loading combinations

The designer should consider which of the applied loads would occur within the lifetime of the structure and the probability of any combination of these loads occurring at the same time.

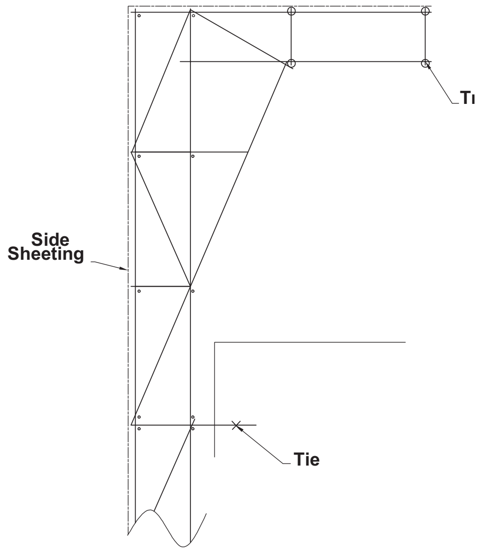
Table 6.1 – Load combination factors, ψi

	LC 1	LC 2	LC 3	LC 4	LC 2a	LC 2b	LC 3a	LC 3b	LC 4a
Q_1 Dead loads	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Q_2 Working loads	–	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Q_3 Other imposed loads	–	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Q_5 Max. snow load	–	1.0	–	–	0.5	1.0			
Q_6 Reduced snow load	–	–	1.0	–	–	–	0.5	1.0	
Q_7 Min. vertical	–	–	–	1.0	–	–			1.0
Q_8 Max. wind load	1.0	–	–	–	1.0	0.5	1.0	0.5	1.0
Note: Q_4 is not included within these combinations.									

6.5 Special considerations – gable ends

The gable ends of a temporary roof are often overlooked. The gable end will be subjected to significant wind pressures and coefficients, and must therefore be designed.

(a) A gable **end** of a building where a scaffold is built from the ground.



(b) A gable end **where** the supporting scaffold is not available or is unnecessary.

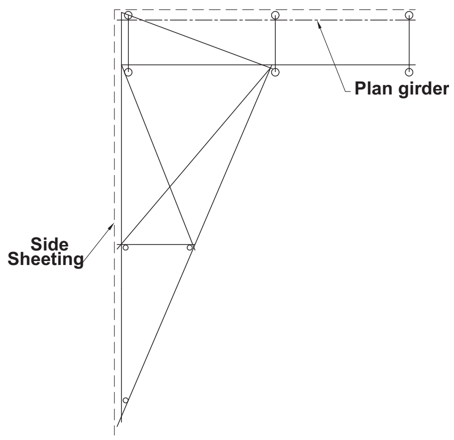


Figure 11 – Gable ends

7. DESIGN & CONSTRUCTION CHECK LISTS

7.1. Design

(A) Has a feasibility study been carried out from a site visit?

(B) Is the designer fully familiar with the product being used in the design?

(C) Is there a full job specific design complete with working drawing and calculations?

(D) Is the design compliant with TG9?
(Guide to the design and construction of temporary roofs)

(E) Does the design meet with contract requirements, e.g.

(i) total cover?

(ii) partial cover?

(iii) static roof?

(iv) mobile/rolling roof?

(v) ability to create openings?

(F) Does the design confirm specifications and origin of authorised manufacturer's loading data for components used?

(G) Do the proprietary system components used meet with the NASC Code of practice for the hire, sale and use of system scaffolds?

(H) Can the designed structure be built/dismantled in accordance with manufacturer's recommended safe system of work? (User guide)

(I) Has a Design Check been carried out?
See Appendix F

(J) Has a Design Risk Assessment been carried out and documented to identify significant hazards, in particular, those associated with overall stability of the structure during the erection/dismantling stages and minimizing risks of working at height.

7.2. Construction

7.2.1 Method statement

State method for:

(A) For erecting (and dismantling) by trained operatives?

(B) Raising and lowering equipment?

(C) Movement of men and materials to work face?

(D) Precautions to be taken when weather conditions may prevent safe working?

(E) Erection/dismantling procedures if different from manufacturer's recommendations?

(F) Repositioning of roof (erect/dismantle/move) or mobile?

(G) Rescue procedures?

7.2.2 Competency of workforce

(A) Leading hand should be an advanced scaffolder, and the entire team should have appropriate training and experience for the task.

(B) Have scaffolders received manufacturer’s training?

(C) Proof of training (current methods)? (Record scheme)

7.2.3 Documentation on site

(A) Copy of the approved working design drawing.

(B) Current copy of manufacturer's user guide, where appropriate.

(C) Copy of site specific method statement & risk assessment

(D) Copy of site specific rescue plan

(E) Evidence of a briefing of operatives in design drawing(s), site specific method statement and risk assessment.

7.2.3 Risk assessment and work at height regulations (WAHR)

(A) Has the WAHR hierarchy of avoid, prevent or mitigate falls been used in the risk assessment process for both the design, erection and dismantling of the structure?

(A1) AVOID
Can the roof be erected at ground level and lifted into place?

(A2) PREVENT
Is it possible/practicable to erect work platforms on 3 sides of the supporting scaffold?

(A3) PREVENT
Can the roof be erected bay-by-bay from a work platform and rolled into position?

(A4) PREVENT / MITIGATE
Can the roof be erected bay-by-bay from a work platform and walked out?

(B) FALL ARREST

If Fall Arrest measures are specified,

(B1) Can a work restraint arrangement be used rather than fall arrest?

(B2) Are the anchor points adequate, secure and to a specified/approved strength?

(B3) Describe the anchor points.

(B4) Is minimum practicable lanyard length used ?

(B5) Are double lanyards used to ensure worker is attached at all times?

(B6) Can operatives be anchored to separate components ?

(B7) Is there sufficient clearance with no obstructions below the workers at all times to allow the fall arrest to deploy safely?

(B8) Are rescue procedures specified to safely rescue a fallen worker?

(B9) Is there a statement of P.P.E. equipment to be used?

See Appendix A for safe systems of work

7.2.4 Other Issues

(A) Criteria for routine inspection?

(B) Access/egress for inspections?

(C) Maintenance of structure?

(D) If corrugated steel sheeting is used:

- It must be able to support a person's weight
- It should be secured to prevent displacement of sheeting

APPENDIX A: SAFE SYSTEMS OF WORK FOR TEMPORARY ROOFS

With the introduction of the work at height regulations in 2005 (WAHR) have come new duties and responsibilities affecting many aspects of scaffolding and access. The methods employed to build temporary roofs are coming under increasing scrutiny in view of the high risk element involved with all of these structures.

The WAHR Hierarchy

AVOID WORK at HEIGHT	This is unlikely to be an entire solution but there may be scope for reducing the amount of working at height. eg. Assembling sections on the ground and lifting into position.
PREVENT FALL BY COLLECTIVE EQUIPMENT	1. Can the roof be erected entirely from fully guarded platforms? 2. Can the roof be built using MEWPs or independent towers? 3. Can the roof design be chosen where *most* of the work can be carried out from fully guarded platforms, rather than relying on harnesses? eg. A system roof where the covering can be pulled across from the scaffold platforms, rather than a CI roof which has to be worked on in order to install the sheets.
PREVENT FALL BY PERSONAL WORK EQUIPMENT	If personal fall protection equipment has to be relied on, consider the use of lanyards which would provide work restraint rather than a fall arrest system (ie it stops the person actually reaching an open edge at all). Location and adequacy of anchor points need careful consideration. Operatives must be anchored to separate components.
MITIGATE THE EFFECT OF FALL BY USING COLLECTIVE MEASURES	eg. Nets below the working areas (if suitable anchor points are available and the nets themselves can be fitted safely)
MITIGATE THE EFFECT OF FALL BY USING PERSONAL MEASURES	This is the **last resort**, and includes fall arrest lanyards. A detailed, job-specific method statement should be prepared: the risks are high and demand a proportionate level of planning, training and supervision. The location and adequacy of anchor points need careful consideration. The type of lanyard should be suitable eg. twin lanyards for traversing beams (see SG4). Harness inspection regimes should be robust (see HSE leaflet INDG367). Rescue procedure should be in place. Adequate supervision to ensure personal fall protection equipment is used correctly. Operatives must be anchored to separate components.

The effect of the Regulations is not to exclude particular methods but they do put pressure on those traditional methods to justify a compliant safe method of building in-situ compared to more modern proprietary systems. This can be demanding.

For details of Safe Systems of Work the appropriate Safety Guidance should be followed.

Four methods for constructing temporary roofs are:

1. Building the roof progressively from a protected platform and rolling out.
2. Building the components on the ground in sections and lifting into position by crane. Whilst this reduces working at height, it also often involves a need to provide working platforms to access the beam lines to connect lifted sections and there can be difficulties weather-proofing joints.
3. Constructing a movable access platform(s) to act as a protected platform for assembly and dismantling.
4. Erecting and dismantling components in-situ from the beams or other roof components.

However, there are other issues that influence the ability to build temporary roofs safely, which include:

- Job specific risk assessment
- A job-specific design aimed at eliminating/reducing the risk of fall and other hazards identified by the risk assessment.
- Scaffolders should be fully trained in the equipment used, with proof of training.
- The designer should be fully familiar with the equipment selected.
- For proprietary temporary roof systems, erection / user guides on the selected method should be provided by the supplier.
- If personal fall arrest is utilised, with twin lanyards, job-specific rescue plan must be provided. Anchor points should be determined for adequacy.
- A materials handling plan should outline the procedure for getting the materials to the workplace, both to the scaffold working platform and their final fixed position on the roof.
- A job specific method statement developed from the above.

Corrugated steel sheeting

B.1 Properties

Pitch of corrugations	Sheet thickness	Unit weight including laps	Approx. I_{NA} per 300mm width	Approx. Z per 300mm width	Bending stress	M.R. per 300mm width
mm	mm (swg)	N/m^2	mm^4	mm^3	N/mm^2	kN.m
76.2	0.5 (26) 0.6 (24) 0.7 (22)	60 75 95	8190 10240 12700	855 1081 1339	86.9 91.72 96.53	0.074 0.099 0.129

Table B1

B.2 Lapping of corrugated sheets

Generally sheets are overlapped at their ends by a minimum of 150mm, but on exposed sites where there is a higher risk of leakage, end laps should be increased to 230mm or in severe cases 300mm.

When a specification requires a fully watertight roof, it may be necessary to seal the joints with suitable mastic or sealing strip.

Side laps are usually 1½ to 2 corrugations wide, and as with end laps, may require some form of mastic or sealant when a watertight roof is specified. It may be necessary to consider having various sheet widths available (10/3 & 12/3) to overcome overlay tube sheeting couplers clashing with roof beam purlin fixings.

At the edges of the roof where the pressure co-efficient is high, it may be necessary to stitch the side laps together. This can be carried out using either pop rivets, self tapping screws, blind fixings or as a last resort nuts and bolts. These fixings would normally be placed at 450mm c/c.

B.3 Gutterings and downpipes

The drainage arrangements should be agreed between the designer and the user. Early discussion can save a great deal of time and argument, particularly where discharge points need to be varied through the contract.

B.4 Translucent sheeting

Sheets should be *non-fragile* – must be capable of bearing the load imposed by the operatives.

Some contracts may specify the requirement for the provision of natural light whilst also remaining waterproof.

Natural lighting can be achieved using translucent sheeting where the corrugation sizes are compatible with those of the steel sheets.

When using this form of sheeting, either by itself or in conjunction with steel sheeting, it will be necessary to check the following points:

Compatibility with the steel sheeting used for the remainder of the roof.

Durability – Effects from sunlight etc.

Strength – This should be looked at in two ways:

- Span between purlin members – It may be necessary to reduce the spacing between the purlins.

- Fixings – Frequency and type.

All of the above points should be checked with the sheet supplier to ensure that the sheeting is suitable for the specific application.

B.5 Sheeting connectors

Examples of sheeting connectors:

Hook or J bolts.
Roof bolts and screws.
Roofing couplers.

B.5.1 Hook or J bolt

Bolts less than 10mm diameter are not recommended due to their tendency to straighten under wind load oscillation.

Where the bolt passes through the sheeting, it should always be located on the crest of a corrugation. This positioning avoids the possibility of leakage, particularly from a bolt located at the bottom of a corrugation which forms the normal run off flow line.

The hole through the sheet can be waterproofed using either of the following two methods:

(a) Diamond shaped steel washers curved to take up the sheet profile, sandwiching a diamond shaped bitumastic washer on to the sheet face.

or

(b) A proprietary plastic washer with either a loose or captivated nut that forms a seal with the sheet face as the nut is tightened down.

For the safe working load of bolts refer to the manufacturers information as it will vary depending on:

The grade of steel used.
The method of threading.
The method of manufacture.
The thickness of the steel sheet.

It must be borne in mind when designing bolt groups that it is not always the bolts that provide the weak link. In many instances the sheeting is weaker than the bolt and can collapse or tear under load.

B.5.2 Roofing couplers

These couplers enable the roof sheets to be fixed without the need for drilled holes. They connect to the purlin tubes and secure the sheets and overlay tubes.

Figure B.1

B.5.3 Roof bolts and screws

These should be installed in accordance with the recommendations of the sheet manufacturers.

B.5.4 Other forms of connection are possible. For example:

U. Bolts – these again are usually fabricated from M8 or M10 diameter steel rod with either cut or rolled threads. The design load on this type of connector is much higher than the J bolt because the limitation on load carrying capability is now the bar or thread diameter and not the straightening of the hook.

When using this type of connector, it would be the failure of the sheet which would be the deciding factor rather than failure of the bolt.

B.6 Purlins

In temporary roof systems these are usually scaffold tubes which are fixed to the main supporting members (or rafters.)

Where the main supporting member is some form of I beam or lattice structure then in order to reduce the effect of lateral buckling, restraint must be provided. Here the purlin takes on the dual role of a sheet support and lateral restraint member.

The safe bending Moment of Resistance of a new standard scaffold tube 48.3mm dia. x 4mm wall thickness = 1.12 kN.m.

In axial compression, the allowable loads should be as shown in NASC TG20, "Guide to good practice for scaffolding with tubes and fittings".

B.6.1 Purlin connectors

The purlin connector is the final link in the chain before considering the main rafter members.

This particular connector needs to be of the type that will carry the required load but will not interfere with the sheeting line.

Of the scaffold connectors currently on the market, the following fulfil these objectives:

B.6.1.1 Band & plate coupler

Figure B.2

This is a combined parallel and right angle coupler.

This coupler will adequately cope with the slip load required to laterally restrain the rafter.

The major load from uplift created by the wind forces will be adequately coped with by this fitting, because the load is at right angles to its normally loaded mode.

B.6.1.2 Putlog couplers

Figure B.3

This is not a fully load bearing coupler, but in accordance with BS 1139 Part 2-1991 must be tested for slip and should be able to sustain a design load of 0.63 kN.

At right angles, normal to the roof surface, this fitting can safely be rated at 1.75 kN.

APPENDIX C: DESIGN EXAMPLE

General arrangement

Site location Slough
(80km from coast)

Roof span = 22m
Roof length = 28m
Max height = 11m
Roof pitch = 15°
Period = 9 months

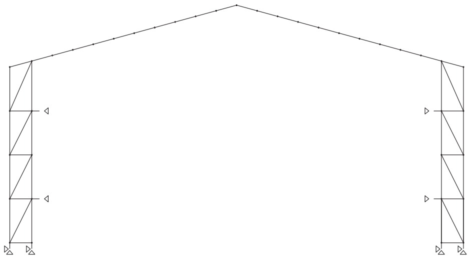


Figure C.1

Design loading

a) Dead loading

Self-Weight of roof structure (from manufacturer's data)
= **0.25 kN/m** run along beam

b) Service loading

Two concentrated load of 1 kN placed 1m each side of ridge.

c) Imposed loading

c.1) Snow loading (Appendix D)

Ground snow load = 0.4 kN/m^2 – from BS EN 1991-1-3 (Slough – Zone 2)
Altitude = 145m
Characteristic snow load = 0.2 + 0.1 Zone + (145-100)/525 = 0.48 kN/m^2
Shape coefficient = 0.8
Design snow load = **0.38 kN/m^2** **= 0.95 kN/m** @ 2.5m crs

c.2) Wind loadings (Appendix E)

Map wind speed, Vb = 21 m/s – from BS EN 1991-1-4 (Slough)
Altitude = 145m
Altitude factor, calt = 1 + 145/1000 = 1.145
Basic wind speed, Vb = 21 x 1.145 = 24.05 m/s
C_{prob} = 1.0, C_{dir} = 1.0, C_{season} = 1.0
T_{wind} (topographical factor) = 1.0

Basic wind pressure, q_b = 0.613 x V_{b2} / 1000 = 0.35 kN/m^2

Combined exposure factor, C_c = 2.08

Peak wind pressure, qp = 0.7 x 0.35 x 2.08 = **0.51 kN/m^2**

Basic loading cases

Self weight – Case 1

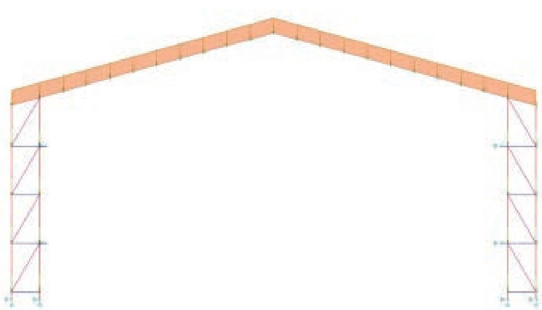


Figure C.2

Snow – Case 2

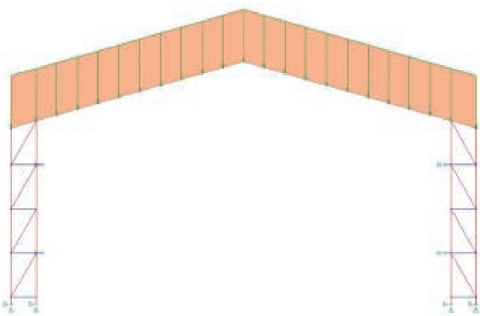


Figure C.3

Normal wind type A – Case 3

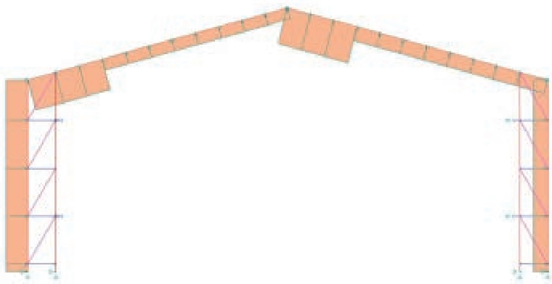


Figure C.4

Normal wind type B – Case 4

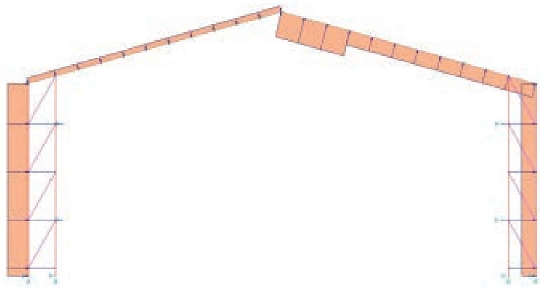


Figure C.5

Parallel wind – Case 5

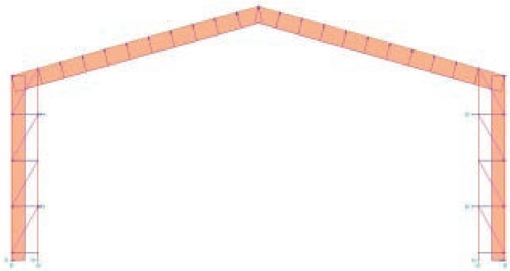


Figure C.6

Internal pressure (+ve) – Case 6

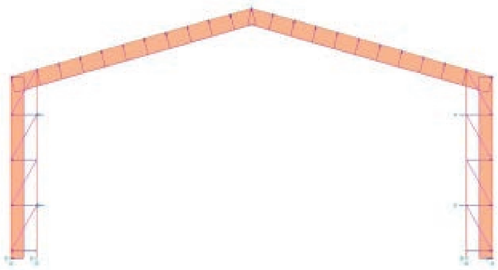


Figure C.7

Internal pressure (-ve) – Case 7

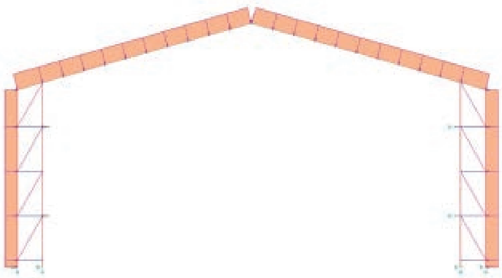


Figure C.8

Parallel wind – Case 8

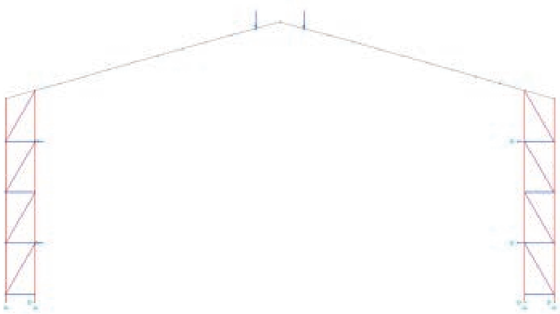


Figure C.6

Design loading cases

self + snow	= 1 + 2
self + wind A	= 1 + 3
self + wind B	= 1 + 4
self + wind B	= 1 + 4
self + parallel wind	= 1 + 5
self + wind A + Internal –ve	= 1 + 3 + 6
self + wind A + Internal +ve	= 1 + 3 + 7
self + wind B + Internal –ve	= 1 + 4 + 6
self + wind B + Internal +ve	= 1 + 4 + 7
self + parallel + Internal –ve	= 1 + 5 + 6
self + parallel + Internal +ve	= 1 + 5 + 7
self + service load	= 1 + 8

Combination loading cases

self + snow + wind A	= 1 + (0.5 x 2) + 3
self + snow + wind A	= 1 + 2 + (0.5 x 3)
self + snow + wind B	= 1 + (0.5 x 2) + 4
self + snow + wind B	= 1 + 2 + (0.5 x 4)
self + snow + wind parallel	= 1 + (0.5 x 2) + 5
self + snow + wind parallel	= 1 + 2 + (0.5 x 5)
self + snow + wind A -ve	= 1 + (0.5 x 2) + 3 + 6
self + snow + wind A -ve	= 1 + 2 + 0.5 (3 + 6)
self + snow + wind B -ve	= 1 + (0.5 x 2) + 4 + 6
self + snow + wind B -ve	= 1 + 2 + 0.5 (4 + 6)
self + snow + wind parallel -ve	= 1 + (0.5 x 2) + 5 + 6
self + snow + wind parallel -ve	= 1 + 2 + 0.5 (5 + 6)
self + snow + wind A +ve	= 1 + (0.5 x 2) + 3 + 7
self + snow + wind A +ve	= 1 + 2 + 0.5 (3 + 7)
self + snow + wind B +ve	= 1 + (0.5 x 2) + 4 + 7
self + snow + wind B +ve	= 1 + 2 + 0.5 (4 + 7)
self + snow + wind parallel +ve	= 1 + (0.5 x 2) + 5 + 7
self + snow + wind parallel +ve	= 1 + 2 + 0.5 (5 + 7)

for overturning – for design of kentledge etc only (FoS 1.2)

self + wind A	= 1 + 3 x 1.2
self + wind B	= 1 + 4 x 1.2
self + wind A + Internal -ve	= 1 + (3 + 6) x 1.2
self + wind A + Internal +ve	= 1 + (3 + 7) x 1.2
self + wind B + Internal -ve	= 1 + (4 + 6) x 1.2
self + wind B + Internal +ve	= 1 + (4 + 7) x 1.2
self + wind parallel + Internal –ve	= 1 + (5 + 6) x 1.2
self + wind parallel + Internal +ve	= 1 + (5 + 7) x 1.2

APPENDIX D: SNOW LOADING

Snow loading should be taken from BS EN 1991-1-3

Method:

Determine ground snow load or zone
Determine altitude
Determine shape coefficient for roof pitches **not greater than 30° = 0.8**
Combine for design loadings

Useful tips:

For determination of altitude

google earth – can determine altitude anywhere in world;
– may be downloaded from www.google.com

Design snow load, Sd, is given by;

Sk x μ Where,

Sk = Characteristic ground snow load (kN/m^2)

= S_{map} + (A-100) / 525

Where S_{map} = Ground snow load at 100m (kN/m^2) from Fig. D.1

A = altitude of the site in metres above sea level

μ = Shape Coefficient

Snow load shape coefficients	
Angle of pitch (α)	**Shape coefficient**
≤ 30°	0.8
30° < α < 60°	$0.8\left(\frac{60-\alpha}{30}\right)$

10°	0.8
15°	0.8
20°	0.8
25°	0.8
30°	0.8
45°	0.4

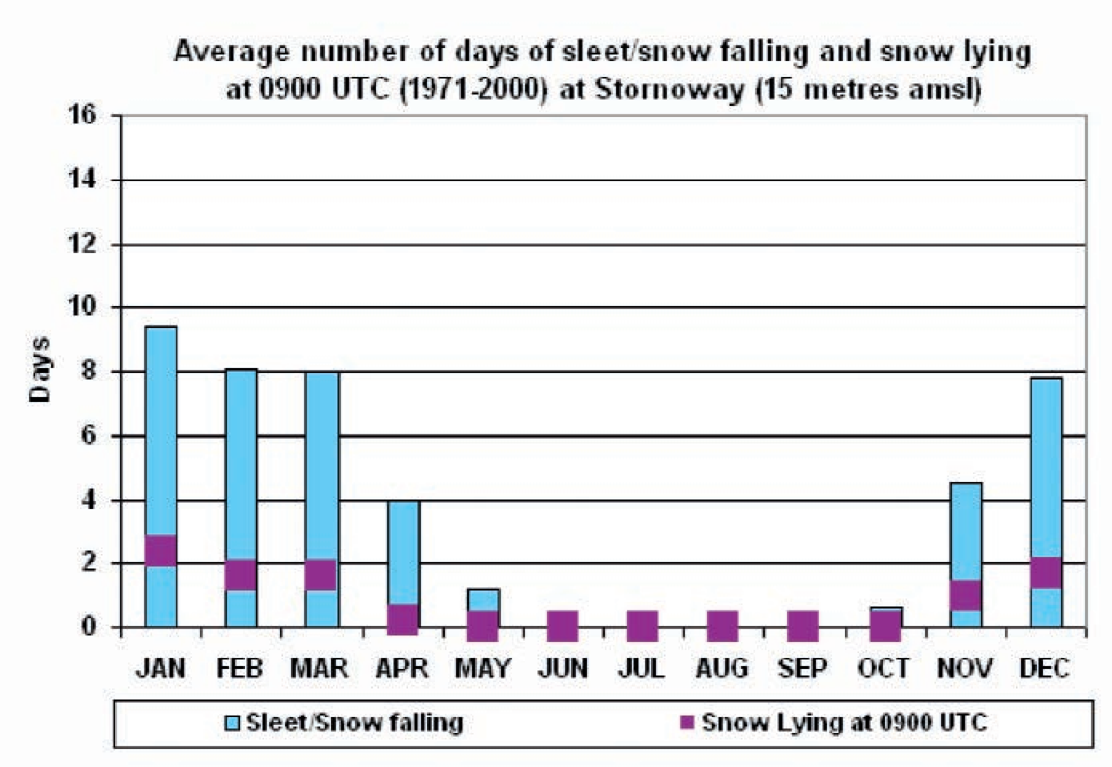
Table D.1

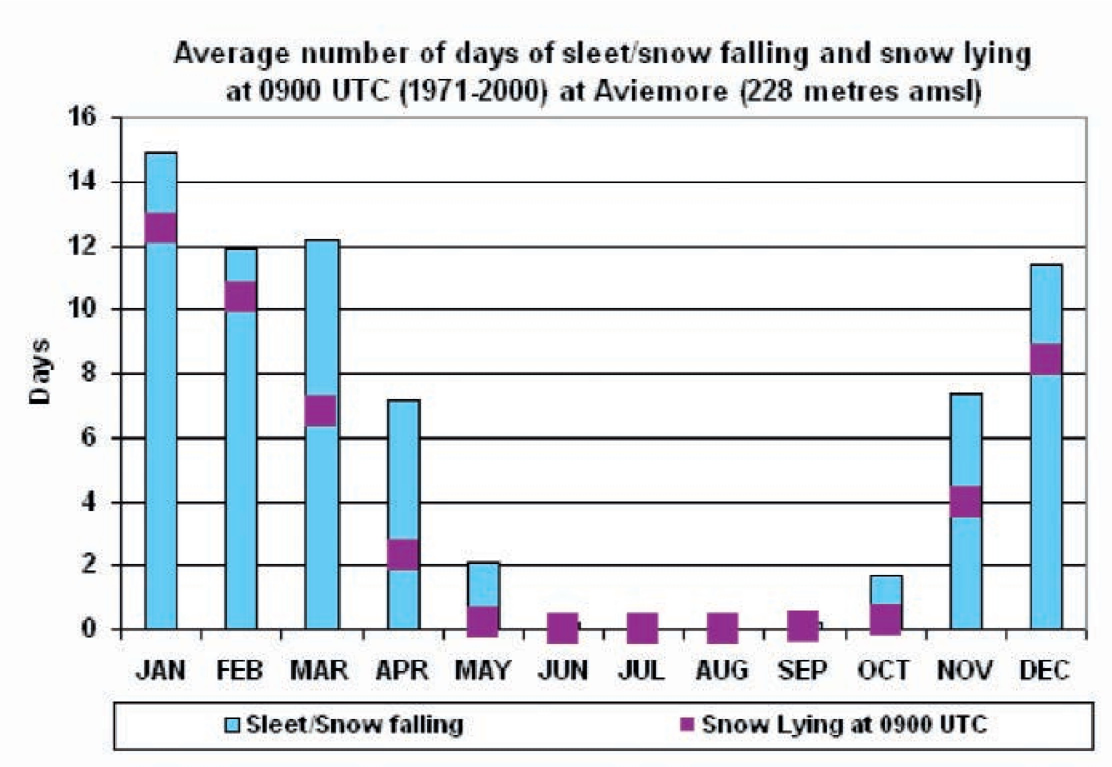
Figure D.1 – Basic snow loading, S_{map} (kN/m^2)

AVERAGE NUMBER OF DAYS OF SLEET/SNOW FALLING AND SNOW LYING

Northern Scotland

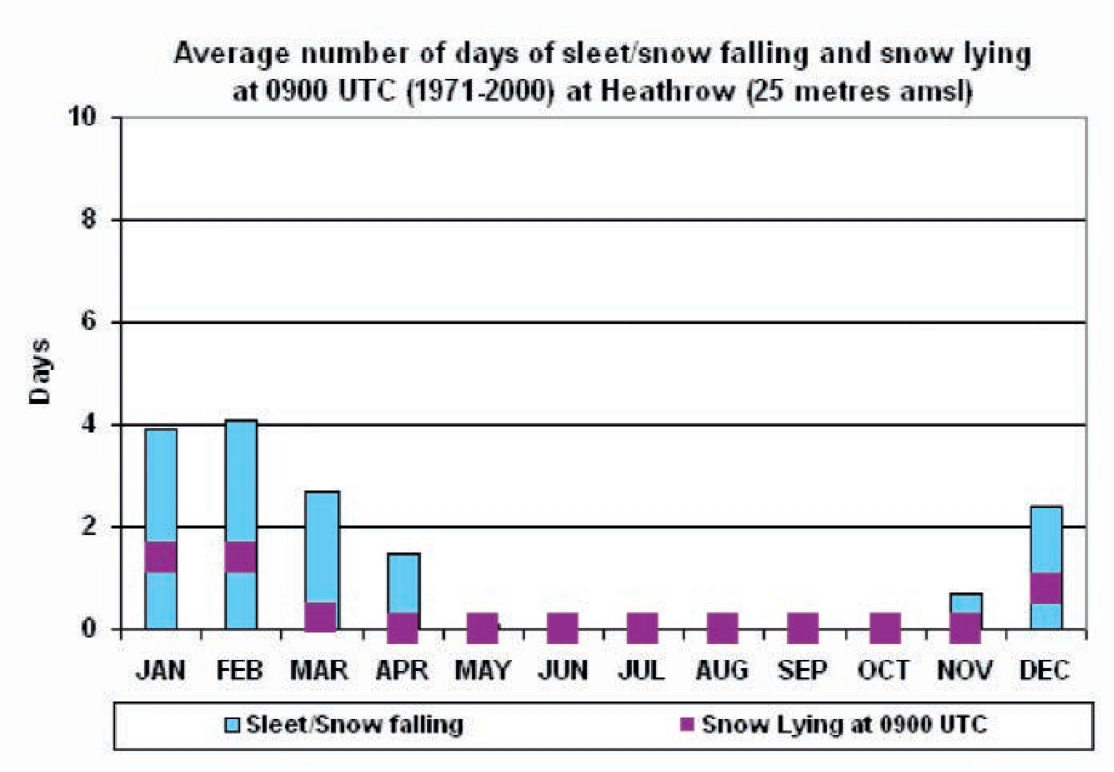
On average, the number of days with snow falling varies from less than 40 per year along the west coast to over 100 days over the Grampians. The number of days with snow lying has a similar distribution, with less than 6 over the westernmost islands, about 20 in Shetland and more than 50 days over the higher ground. On the highest summits, such as Ben Nevis, snow cover typically persists for 6 or 7 months each year.

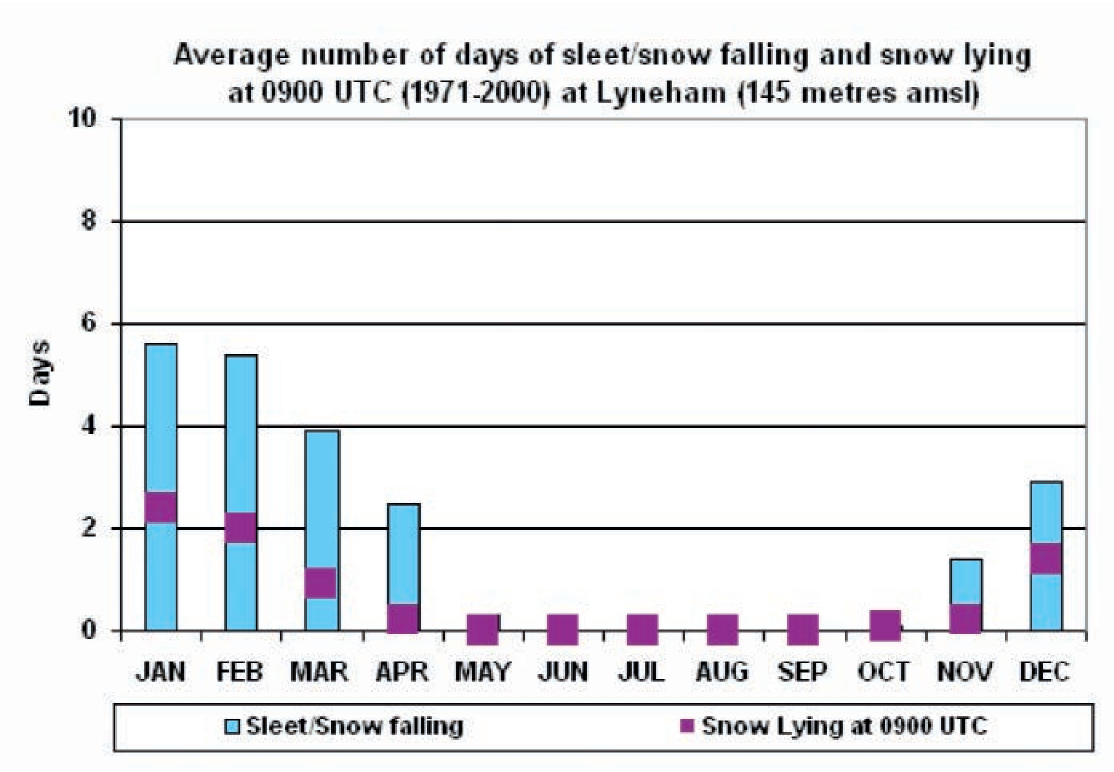




Southern England

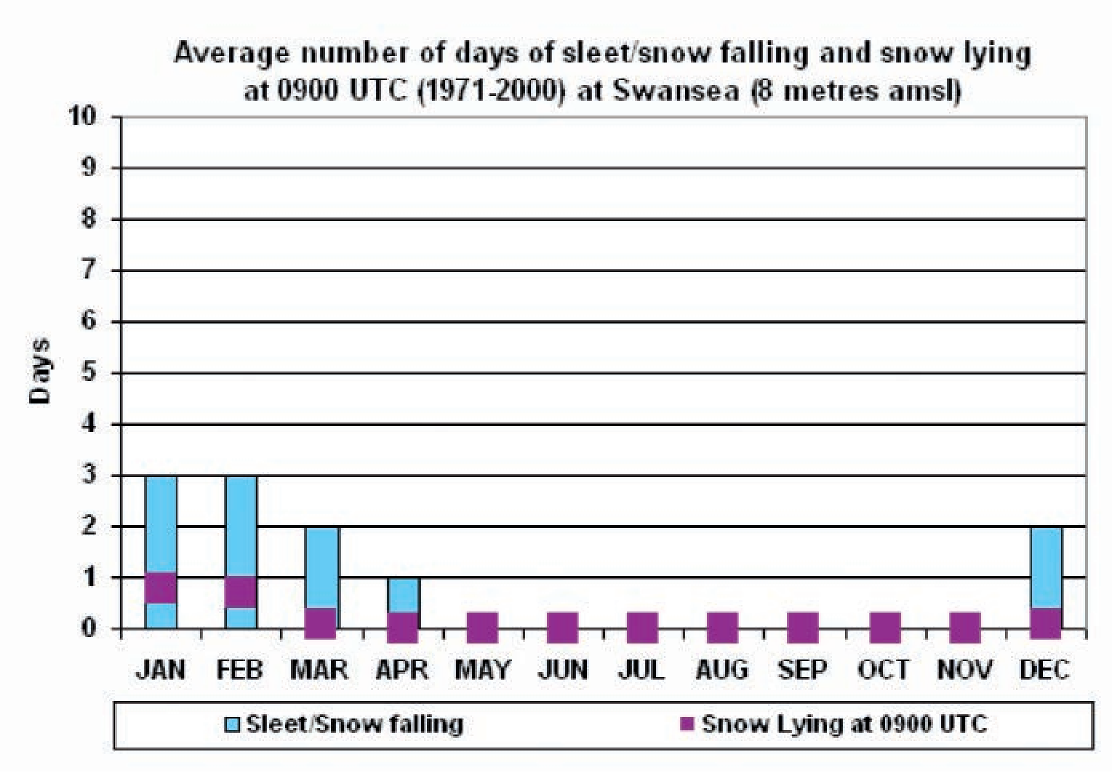
On average, the number of days with snow falling is about 12-15 per year over the lower lying areas but about 20 days over the higher ground of the Chilterns, North Downs and Weald. The least snow-prone places are those close to the English Channel, with less than 10 days.

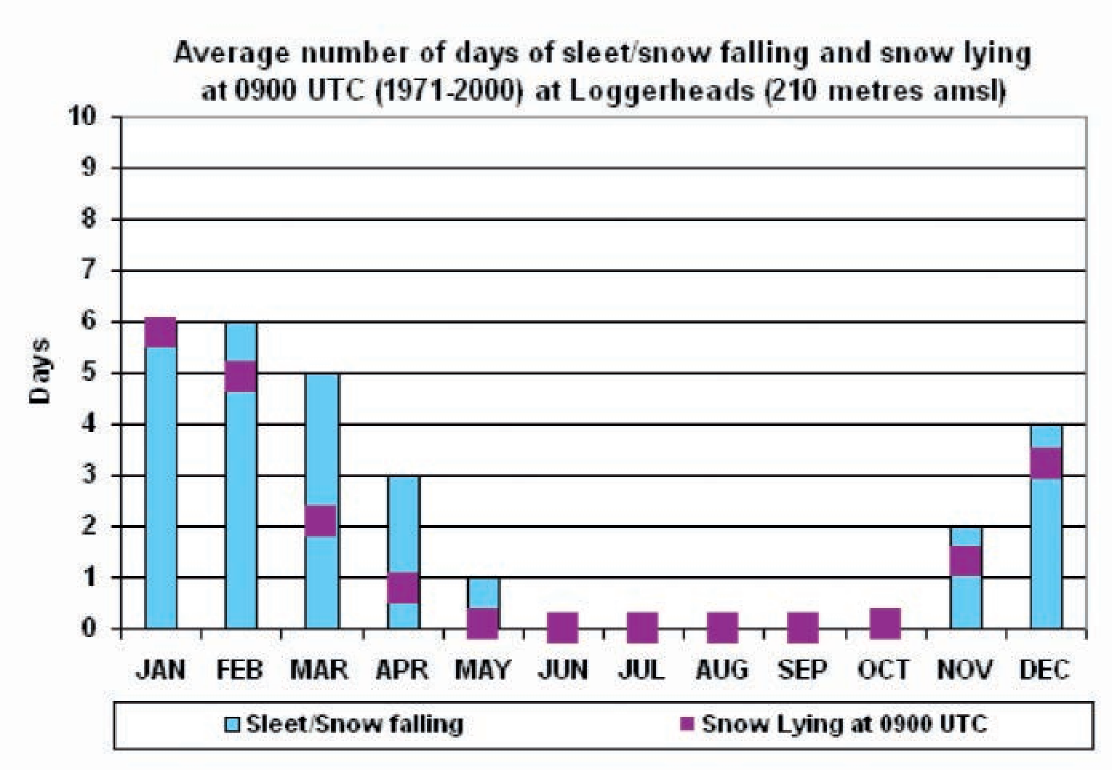




Wales

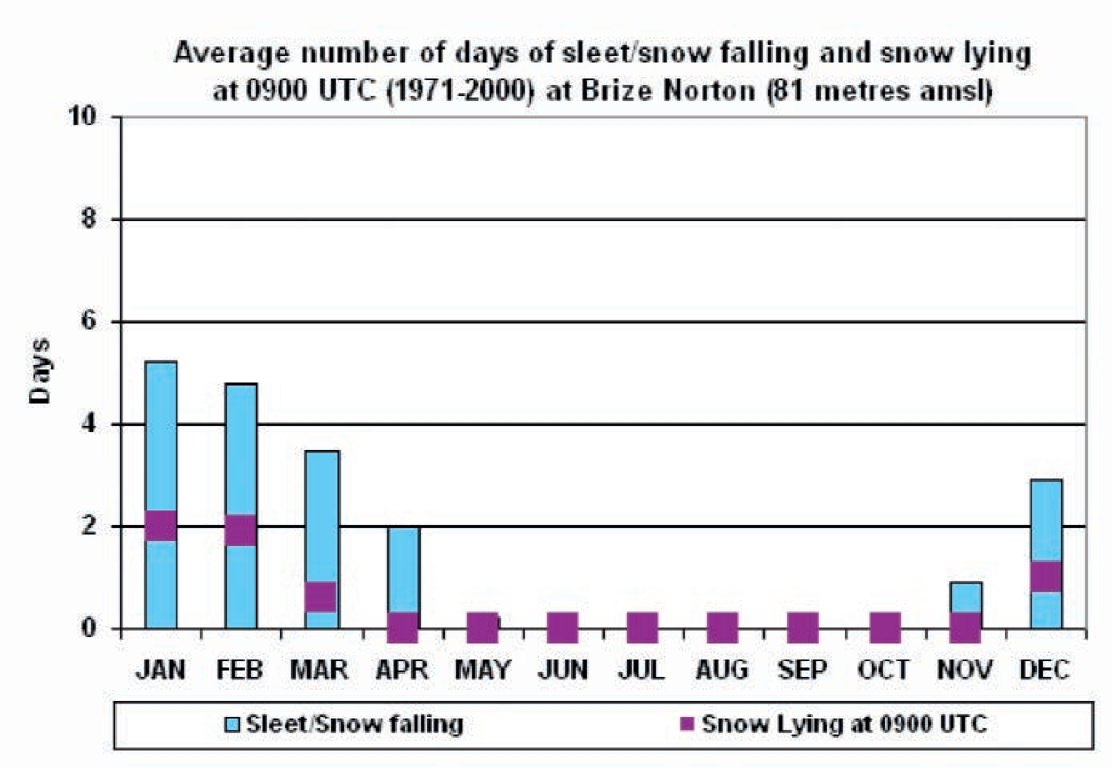
The average number of days each year when sleet or snow falls varies from 10 or less in south-western coastal areas to over 40 in Snowdonia. Snow rarely lies on the ground at sea level before December or after March, and the average number of days with snow lying in Wales varies from 5 or less around the coasts to over 30 in Snowdonia.

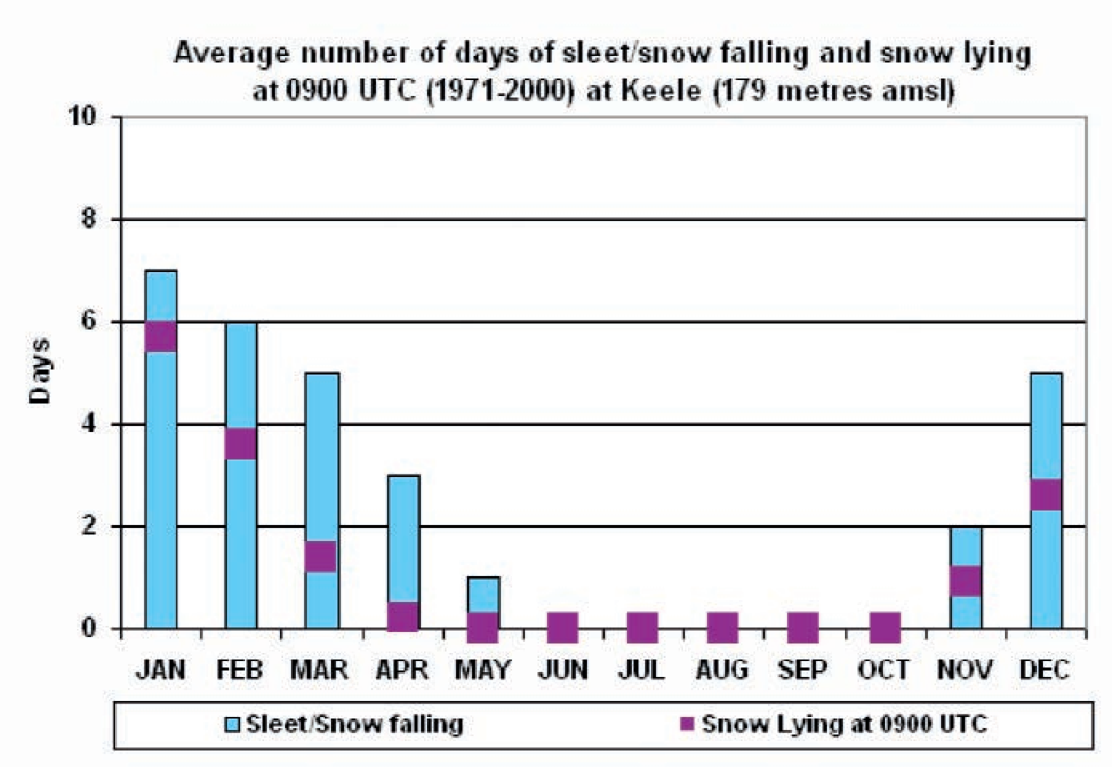




Midlands

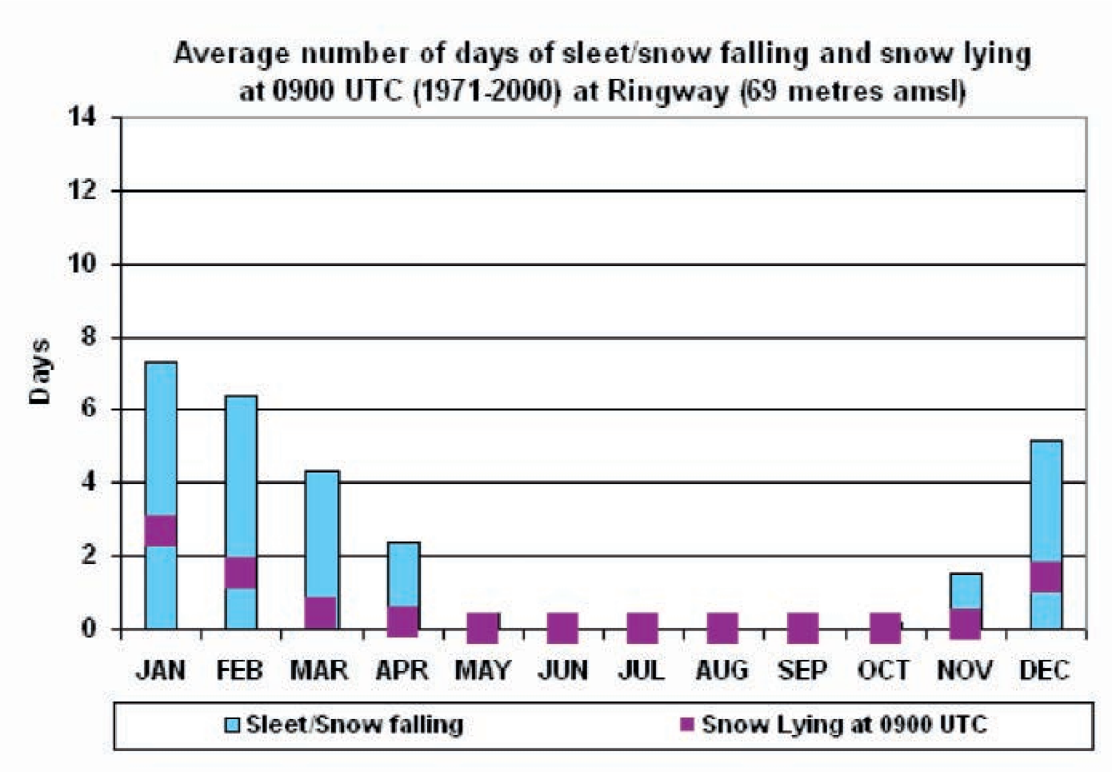
On average, the number of days with snow falling is about 20 per winter in the lower lying areas, particularly the lower Severn valley. An average of about 35 days is typical of upland areas in the north and near the Welsh border. An average increase of about 5 days of snow falling per year per 100 metres increase in altitude has been found typical.

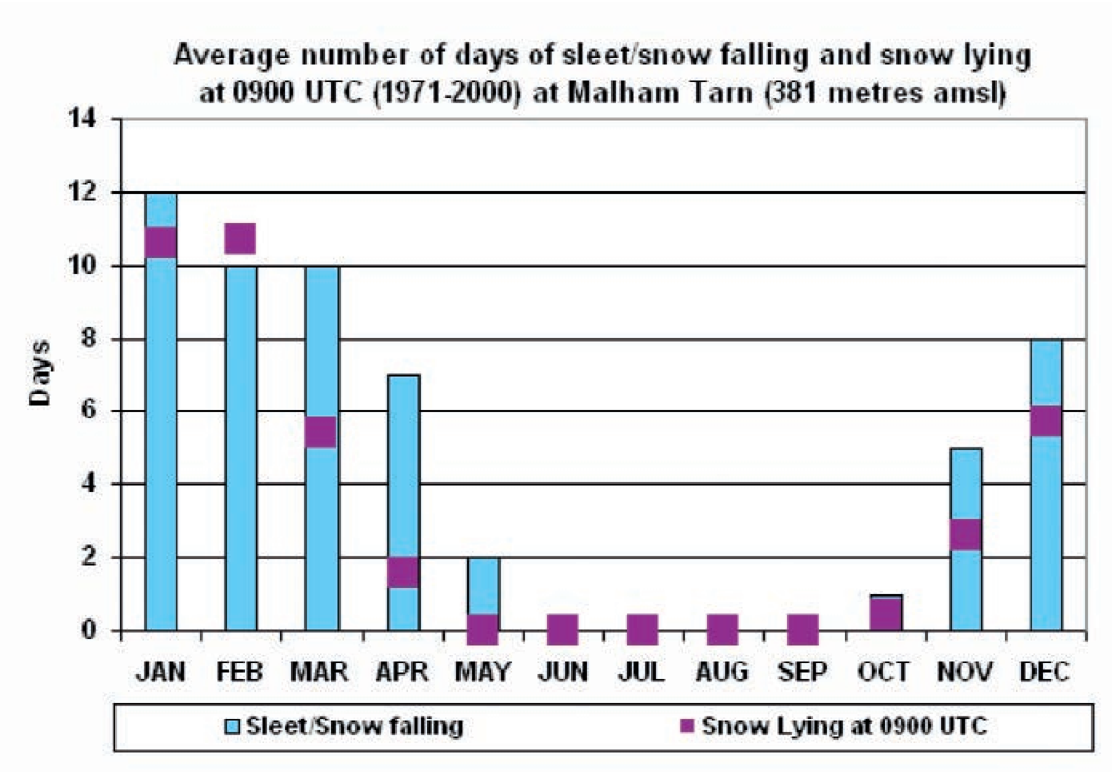




Northern England

On average, the number of days with snow falling is about 15-20 per year on the Isle of Man and from 20 to 30 days in lower-lying parts of the mainland but as much as 60 days over the highest ground. An average increase of about 5 days of snow falling per year per 100 m increase in altitude has been found typical.





APPENDIX E: WIND LOADING

The basic data for the design of structures to resist wind forces are contained in BS EN 1991-1-4 and the UK National Annex to BS EN 1991-1-4. Additional background information is given in PD 6688-1-4.

Information required by designer

The following information is necessary for calculation of the wind forces

(a) Location of site – distances to the edge of town and to the sea.

(b) Topography of site, considered in all directions, e.g. nominally flat, on moderate or steep hill, on moderate or steep escarpment etc.

(c) Altitude of the site (in m above sea level)

(d) Duration of the temporary structure operations and use. (If the structure is expected to be erected for no more than 2 years, a reduction in total wind loading may be applied.)

Peak wind pressure for temporary structures

In order to take account of the temporary nature of a falsework structure erected for a period not exceeding two years, the peak wind pressure may be modified by a temporary works factor (twf) of not less than 0.7 in accordance with the note to Clause 8.2.4.1 of BS EN12812. This value is equivalent to using a probability factor of 0.84 (0.842 = 0.7). Either the twf of 0.7 OR a probability factor of 0.84 may be used, but, they should NOT BOTH be applied in the same wind pressure calculation.

The peak wind pressure is given by:

$$\mathbf{q_p = 0.613 \times C_c \times S_{wind}^2} \qquad \mathrm{N/m^2}$$

where q_p is the peak wind pressure ($\mathrm{N/m^2}$)
S_{wind} is the wind factor
C_c is the combined exposure factor – see Table E.1
Note: this is a combination of exposure factor, $C_e(z)$ and town correction factor, $C_{e,T}$

The wind factor, S_{wind}, is given by:

$$\mathbf{S_{wind} = T_{wind} \times V_{map} \times (1 + 0.001\,A) \times C_{prob} \times C_{dir} \times C_{season}}$$

where v_{map} is the basic wind speed for the site in m/s – see Fig. E.1
T_{wind} is the topographical factor – see Fig. E.2
A is the altitude of the site (in m above sea level)
C_{prob} is the probability factor
= 1.0 for periods **exceeding 2 years**
= 0.84 for periods **not exceeding 2 years** (providing twf NOT applied)
C_{dir} is the directional factor (normally 1.0)
C_{season} is the seasonal factor (normally 1.0)

Topography factor, T_{wind}

Where the ground is nominally flat, i.e. the average slope is less than 1:20 and at the base of steeper slopes, the value of the topography factor is unity, T_{wind} = 1.00.

Where there are hills or slopes the wind profile changes and the topography, known as “orography” in BS EN 1991-1-4, can become significant. The values for the topography factor T_{wind} for falsework erected up to 50m in height for other conditions of hills or escarpments are shown in Fig. E.2.

Values for topography factor appropriate for the site should be considered for the wind acting in ALL directions, and not just the orientation of the falsework structure.

Displacement height, h_{dis}

The BS EN 1991-1-4 method calculates the wind pressure at a height, z, in metres above ground level.

For a temporary structure erected on the ground the value of z would be taken as the height from the ground to the top of the structure.

When considering the forces on the temporary structure, the value for z should be taken as the actual height of the structure. However, if the temporary structure is erected in an elevated position above the surrounding ground level, for instance at the top of a tall structure, the reference height z, would be measured from the ground, although the actual structure affected by the wind would only be its own storey height.

An allowance can be made for the effect of surrounding general buildings, such as housing or woodlands, by using a height displacement (h_{dis}). The displacement height is the lesser of the value in the following two equations:

	h_{dis}	$= 0.8\ h_{ave}$
or	h_{di}	$= 0.6\ h$
where	h_{dis}	is the displacement height (m)
	h_{ave}	is the average obstruction height in the area (m)
	h	is the height of the considered structure for calculating z.

Where the temporary structure is spaced more than six times the average obstruction height away from the nearest obstruction, the full height of structure is used and hdis = 0.

Values may be interpolated. See Figure E.3.

The effective height of the structure for wind calculations is $z - h_{dis}$

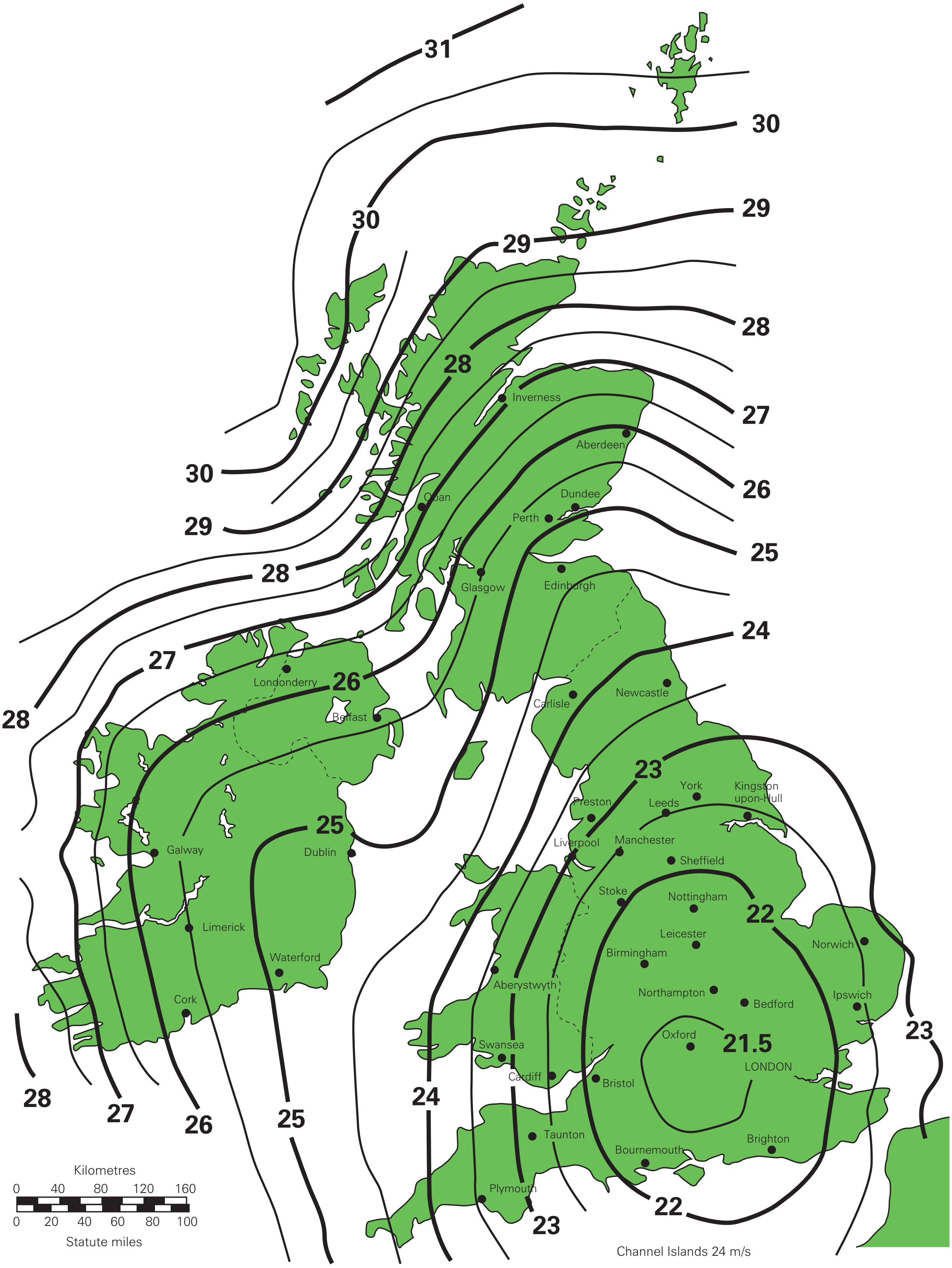


Figure E.1 – Wind speed, V_{map} (m/s)

Table E1: Combined exposure factor, Cc

Height $Z - h_{dis}$ ** (m)	Site in country or adjacent to sea				Site in town, more than 2 km from the edge of the town		
	Closest distance to the shoreline (km)				Distance to shoreline (km)		
	≤ 0.1	2	10	≥ 100	≥ 2	10	≥ 100
≤ 2	1.90	1.60	1.50	1.40	1.07	1.01	0.94
3	2.15	1.84	1.73	1.62	1.32	1.25	1.17
4	2.31	2.03	1.90	1.78	1.54	1.44	1.35
5	2.43	2.18	2.05	1.90	1.72	1.62	1.50
10	2.82	2.65	2.50	2.32	2.33	2.20	2.04
15	3.07	3.02	2.85	2.67	2.81	2.65	2.48
20	3.20	3.05	2.98	2.78	2.90	2.83	2.64
30	3.42	3.43	3.27	3.04	3.40	3.24	3.01
50	3.68	3.68	3.62	3.39	3.68	3.62	3.39
100	3.98	3.98	3.98	3.80	3.98	3.98	3.80
Notes: (1) Interpolation may be used in this table (2) Based on Figure NA.7 and Figure NA.8 in the NA to BS EN 1991-1-4							

Note: Town values are to be considered if more than 2 km inside the edge of the town.
** for h_{dis} see Figure E.3

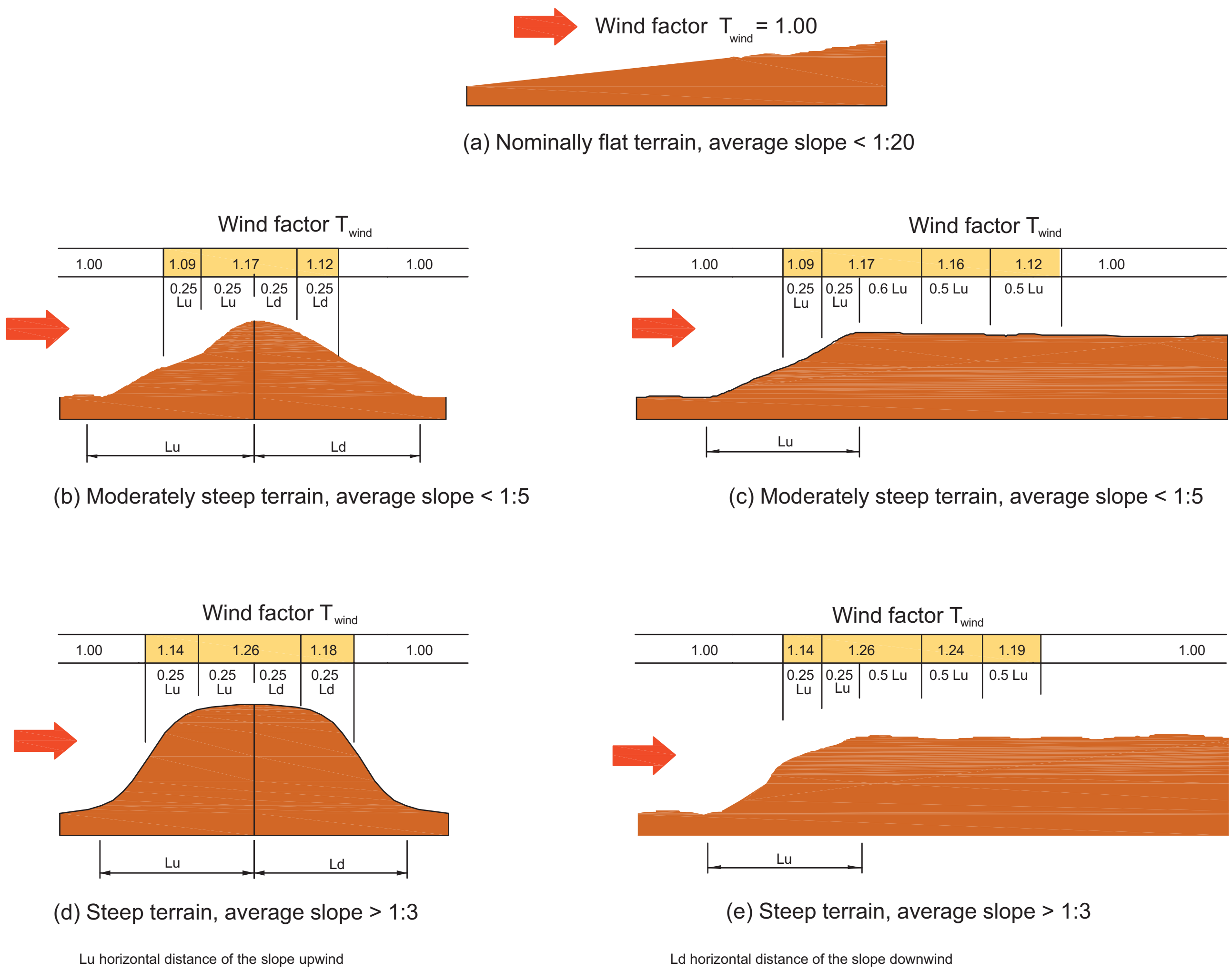


Figure E.2 – Topography factor, T_{wind}

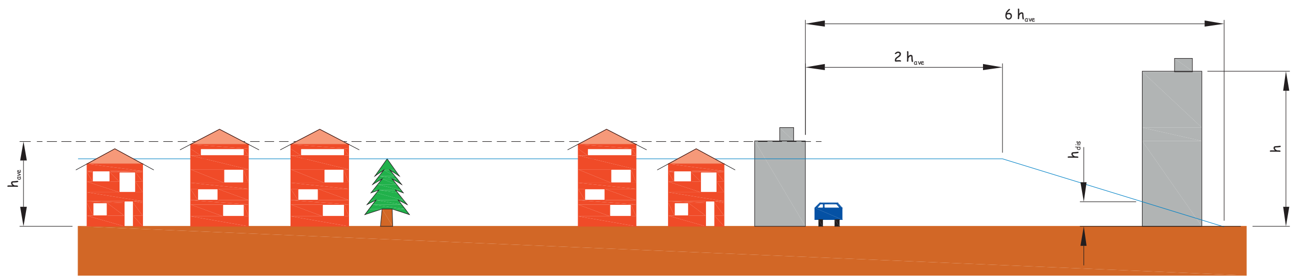
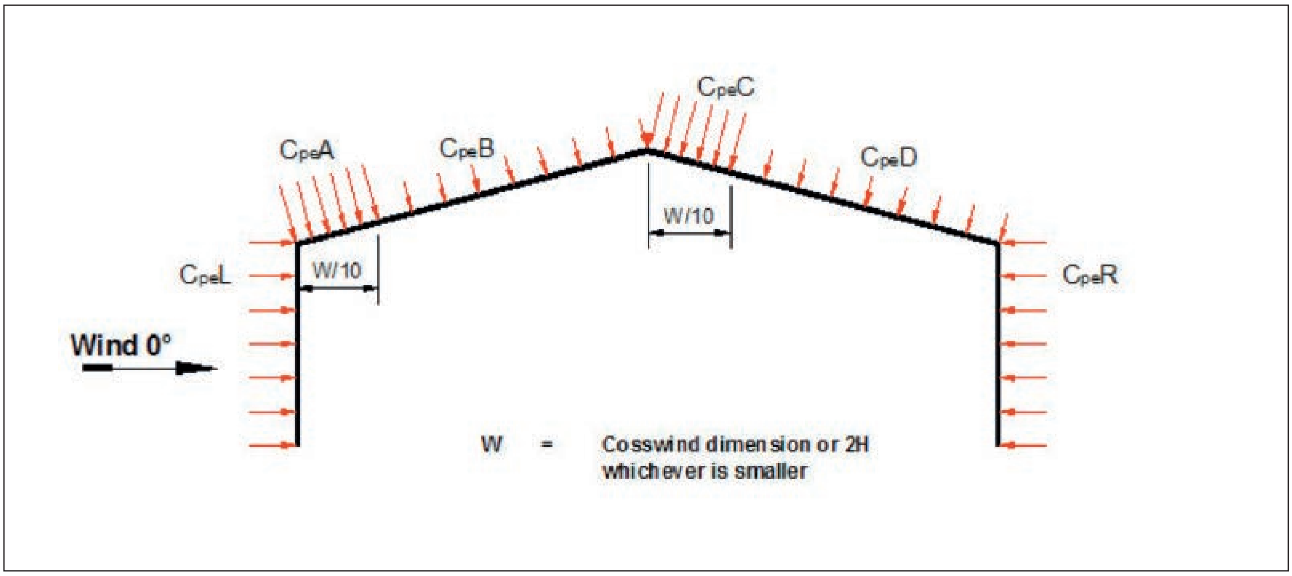


Figure E.3 – Displacement height

External pressure coefficients

Note: beware of increased C_{ps} at all edges.

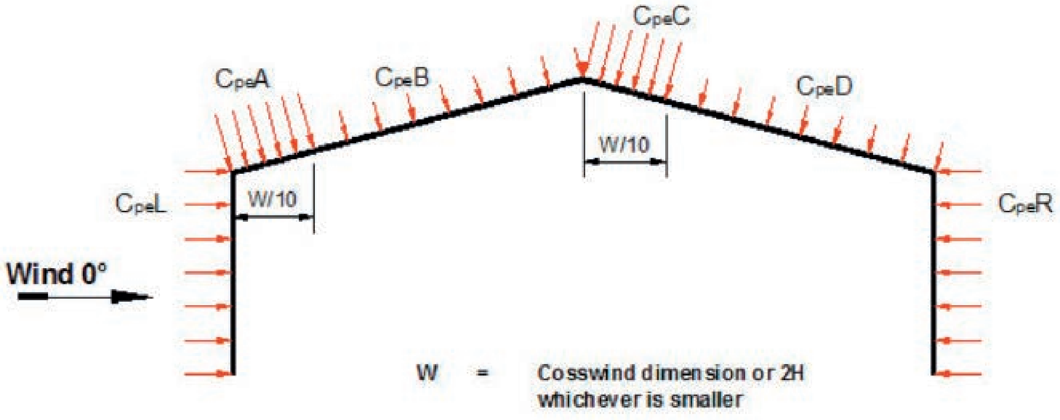
Table E.4a: C_{pe} for Duo-Pitched Roofs – Central Sections



Pitch Angle, α°	Wind Direction, θ = 0° (& reversed, θ=180°)						Wind Direction, θ = 90°					
	$C_{pe}A$	$C_{pe}B$	$C_{pe}C$	$C_{pe}D$	$C_{pe}L$	$C_{pe}R$	$C_{pe}A$	$C_{pe}B$	$C_{pe}C$	$C_{pe}D$	$C_{pe}L$	$C_{pe}R$
10	-1.02 0.12	-0.60 0.00	-0.22 -0.37	-0.52 -0.37	0.8	-0.5	-0.65	-0.65	-0.65	-0.65	-0.5	-0.5
12	-0.95 0.16	-0.48 0.09	-0.39 -0.28	-0.49 -0.28	0.8	-0.5	-0.63	-0.63	-0.63	-0.63	-0.5	-0.5
15	-0.80 0.20	-0.43 0.13	-1.00 0.00	-0.40 0.00	0.8	-0.5	-0.60	-0.60	-0.60	-0.60	-0.5	-0.5
18	-0.74 0.30	-0.30 0.20	-0.90 0.00	-0.40 0.00	0.8	-0.5	-0.64	-0.64	-0.64	-0.64	-0.5	-0.5
22.5	-0.65 0.45	-0.28 0.24	-0.75 0.00	-0.40 0.00	0.8	-0.5	-0.70	-0.70	-0.70	-0.70	-0.5	-0.5
30	-0.50 0.70	-0.25 0.30	-0.50 0.00	-0.40 0.00	0.8	-0.5	-0.80	-0.80	-0.80	-0.80	-0.5	-0.5
37.5	-0.25 0.70	-0.10 0.50	-0.40 0.00	-0.30 0.00	0.8	-0.5	-0.83	-0.83	-0.83	-0.83	-0.5	-0.5
45	0.00 0.70	-0.20 0.40	-0.30 0.00	-0.20 0.00	0.8	-0.5	-0.90	-0.90	-0.90	-0.90	-0.5	-0.5
60	0.70	0.00	-0.30	-0.20	0.8	-0.5	-0.80	-0.80	-0.80	-0.80	-0.5	-0.5
	G	H	J	I			H	H	H	H		

BS EN 1991-1-4 Figure 7.8 Zones

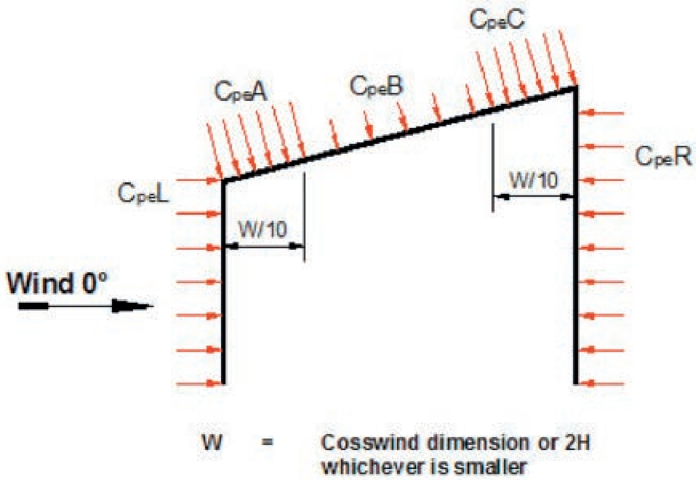
Table E.4b: C_{pe} for Duo-Pitched Roofs – Edge Sections



Pitch Angle, α°	Wind Direction, θ = 0° (& reversed, θ=180°)						Wind Direction, θ = 90°					
	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}D	C_{pe}L	C_{pe}R	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}D	C_{pe}L	C_{pe}R
10	-1.36 0.12	-0.48 0.09	-0.22 -0.37	-0.52 -0.37	0.8	-0.5	-1.45	-1.30	-1.45	-1.45	-0.5	-0.5
12	-1.23 0.16	-0.43 0.13	-0.39 -0.28	-0.49 -0.28	0.8	-0.5	-1.39	-1.30	-1.30	-1.39	-0.5	-0.5
15	-0.90 0.20	-0.30 0.20	-1.00 0.00	-0.40 0.00	0.8	-0.5	-1.30	-1.30	-1.30	-1.30	-0.5	-0.5
18	-0.82 0.30	-0.28 0.24	-0.90 0.00	-0.40 0.00	0.8	-0.5	-1.26	-1.32	-1.32	-1.26	-0.5	-0.5
22.5	-0.70 0.45	-0.25 0.30	-0.75 0.00	-0.40 0.00	0.8	-0.5	-1.20	-1.35	-1.35	-1.20	-0.5	-0.5
30	-0.50 0.70	-0.20 0.40	-0.50 0.00	-0.40 0.00	0.8	-0.5	-1.10	-1.40	-1.40	-1.10	-0.5	-0.5
37.5	-0.25 0.70	-0.10 0.50	-0.40 0.00	-0.30 0.00	0.8	-0.5	-1.03	-1.25	-1.25	-1.03	-0.5	-0.5
45	0.00 0.70	0.00 0.60	-0.30 0.00	-0.20 0.00	0.8	-0.5	-1.10	-1.40	-1.40	-1.10	-0.5	-0.5
60	0.70	0.70	-0.30	-0.20	0.8	-0.5	-1.10	-1.20	-1.20	-1.10	-0.5	-0.5
	F	H	J	I			F	G	G	F		

BS EN 1991-1-4 Figure 7.8 Zones

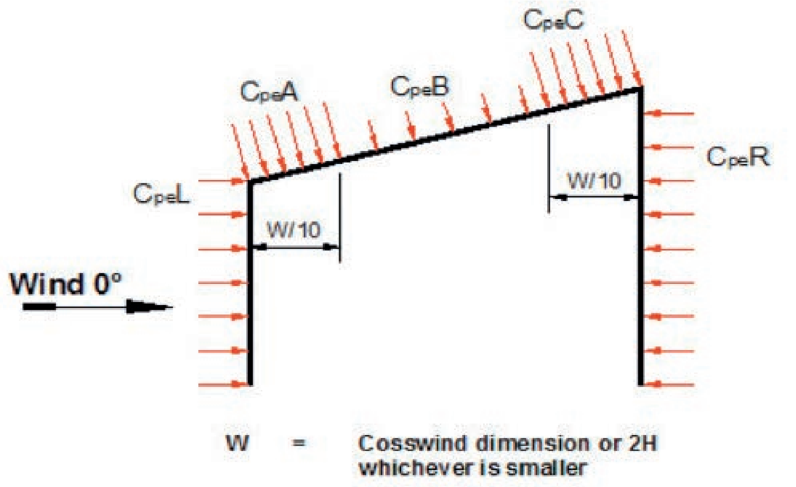
Table E.5a: C_{pe} for Mono-Pitched Roofs – Central Sections



Pitch Angle, α°	Wind Direction, θ = 0°					Wind Direction, θ = 180°					Wind Direction, θ = 90°				
	$C_{pe}A$	$C_{pe}B$	$C_{pe}C$	$C_{pe}L$	$C_{pe}R$	$C_{pe}A$	$C_{pe}B$	$C_{pe}C$	$C_{pe}L$	$C_{pe}R$	$C_{pe}A$	$C_{pe}B$	$C_{pe}C$	$C_{pe}L$	$C_{pe}R$
10	-1.26 0.10	-1.01 0.10	-1.01 0.10	0.8	-0.5	-0.85 -0.85	-0.85 -0.85	-1.30 -1.3	-0.5	0.8	-0.70	-0.70	-0.70	-0.5	-0.5
12	-1.07 0.14	-0.72 0.14	-0.72 0.14	0.8	-0.5	-0.87 -0.87	-0.87 -0.87	-1.30 -1.3	-0.5	0.8	-0.74	-0.74	-0.74	-0.5	-0.5
15	-0.80 0.20	-0.30 0.20	-0.30 0.20	0.8	-0.5	-0.90 -0.90	-0.90 -0.90	-1.30 -1.3	-0.5	0.8	-0.80	-0.80	-0.80	-0.5	-0.5
18	-0.74 0.30	-0.28 0.24	-0.28 0.24	0.8	-0.5	-0.88 -0.88	-0.88 -0.88	-1.20 -1.2	-0.5	0.8	-0.84	-0.84	-0.84	-0.5	-0.5
22.5	-0.65 0.45	-0.25 0.30	-0.25 0.30	0.8	-0.5	-0.85 -0.85	-0.85 -0.85	-1.05 -1.05	-0.5	0.8	-0.90	-0.90	-0.90	-0.5	-0.5
30	-0.50 0.70	-0.20 0.40	-0.20 0.40	0.8	-0.5	-0.80 -0.80	-0.80 -0.80	-0.80 -0.8	-0.5	0.8	-1.00	-1.00	-1.00	-0.5	-0.5
37.5	-0.25 0.70	-0.10 0.50	-0.10 0.50	0.8	-0.5	-0.75 -0.75	-0.75 -0.75	-0.65 -0.65	-0.5	0.8	-1.00	-1.00	-1.00	-0.5	-0.5
45	-0.0 0.70	-0.0 0.60	-0.0 0.60	0.8	-0.5	-0.7 -0.7	-0.7 -0.7	-0.50 -0.5	-0.5	0.8	-1.00	-1.00	-1.00	-0.5	-0.5
60	0.70	0.70	0.70	0.8	-0.5	-0.50	-0.50	-0.50	-0.5	0.8	-1.00	-1.00	-1.00	-0.5	-0.5
	G	H	H			H	H	G			H	H	H		

BS EN 1991-1-4 Figure 7.8 Zones

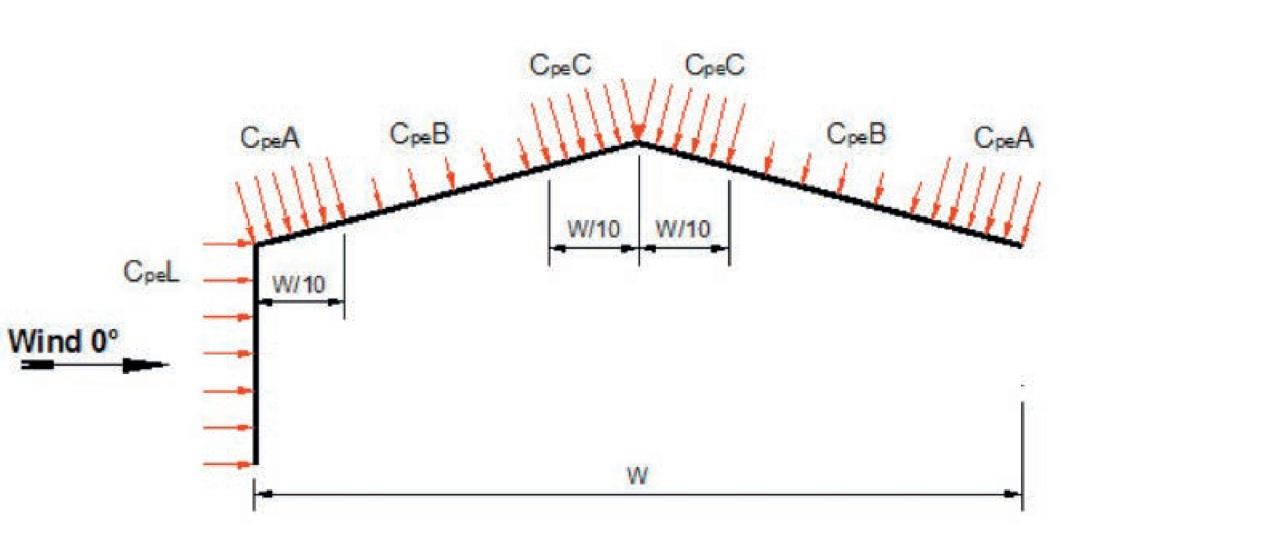
Table E.5b: C_{pe} for Mono-Pitched Roofs – Edge Sections



Pitch Angle, α°	Wind Direction, θ = 0°					Wind Direction, θ = 180°					Wind Direction, θ = 90°				
	$C_{pe}A$	$C_{pe}B$	$C_{pe}C$	$C_{pe}L$	$C_{pe}R$	$C_{pe}A$	$C_{pe}B$	$C_{pe}C$	$C_{pe}L$	$C_{pe}R$	$C_{pe}A$	$C_{pe}B$	$C_{pe}C$	$C_{pe}L$	$C_{pe}R$
10	-1.30 0.10	-1.01 0.10	-1.01 0.10	0.8	-0.5	-0.85 -0.85	-0.85 -0.85	-2.40 -2.4	-0.5	0.8	-1.85	-1.85	-2.25	-0.5	-0.5
12	-1.14 0.14	-0.72 0.14	-0.72 0.14	0.8	-0.5	-0.87 -0.87	-0.87 -0.87	-2.44 -2.44	-0.5	0.8	-1.75	-1.87	-2.31	-0.5	-0.5
15	-0.90 0.20	-0.30 0.20	-0.30 0.20	0.8	-0.5	-0.90 -0.90	-0.90 -0.90	-2.50 -2.5	-0.5	0.8	-1.60	-1.90	-2.40	-0.5	-0.5
18	-0.82 0.30	-0.28 0.24	-0.28 0.24	0.8	-0.5	-0.88 -0.88	-0.88 -0.88	-2.22 -2.22	-0.5	0.8	-1.54	-1.82	-2.34	-0.5	-0.5
22.5	-0.70 0.45	-0.25 0.30	-0.25 0.30	0.8	-0.5	-0.85 -0.85	-0.85 -0.85	-1.80 -1.80	-0.5	0.8	-1.45	-1.70	-2.25	-0.5	-0.5
30	-0.50 0.70	-0.20 0.40	-0.20 0.40	0.8	-0.5	-0.80 -0.80	-0.80 -0.80	-1.10 -1.1	-0.5	0.8	-1.30	-1.50	-2.10	-0.5	-0.5
37.5	-0.25 0.70	-0.10 0.50	-0.10 0.50	0.8	-0.5	-0.75 -0.75	-0.75 -0.75	-0.85 -0.85	-0.5	0.8	-1.30	-1.45	-1.80	-0.5	-0.5
45	-0.0 0.70	-0.0 0.60	-0.0 0.60	0.8	-0.5	-0.7 -0.7	-0.7 -0.7	-0.6 -0.6	-0.5	0.8	-1.30	-1.40	-1.50	-0.5	-0.5
60	0.70	0.70	0.70	0.8	-0.5	-0.50	-0.50	-0.50	-0.5	0.8	-1.20	-1.20	-1.20	-0.5	-0.5
	F	H	H			H	H	F			F low	G	F up		

BS EN 1991-1-4 Figure 7.7 Zones

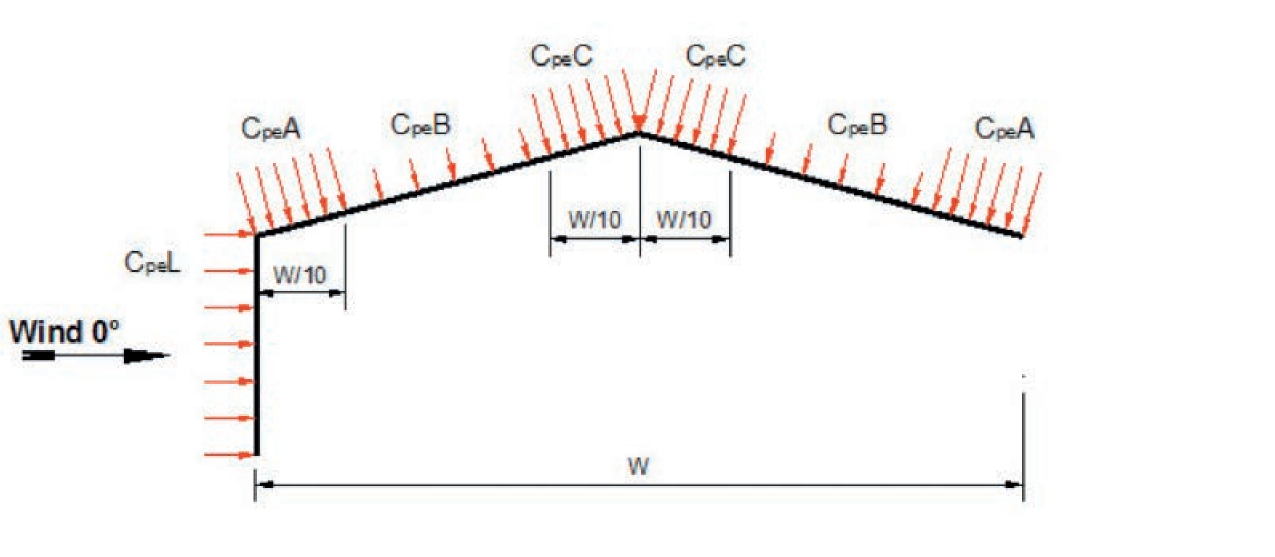
Table E.6a: C_{pe} for Duo-Pitched Canopies – Central Sections – with Side Wall



Pitch Angle, α°	(Minimum ϕ = 1)							
	Wind Direction, θ = 0° (& reversed, θ=180°)				Wind Direction, θ = 90°			
	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}L	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}D
5	-1.80	-1.30	-1.50	-0.5	-2.00	-1.50	-2.00	-0.5
10	-1.80	-1.30	-1.80	-0.5	-2.00	-1.80	-2.00	-0.5
15	-1.60	-1.30	-2.10	-0.5	-2.20	-2.10	-2.20	-0.5
20	-1.60	-1.40	-2.10	-0.5	-2.20	-2.10	-2.20	-0.5
25	-1.50	-1.40	-2.00	-0.5	-2.00	-2.00	-2.00	-0.5
30	-1.40	-1.40	-2.00	-0.5	-1.80	-2.00	-1.80	-0.5
	C	A	D		B	D	B	

BS EN 1991-1-4 Table 7.7 Zones

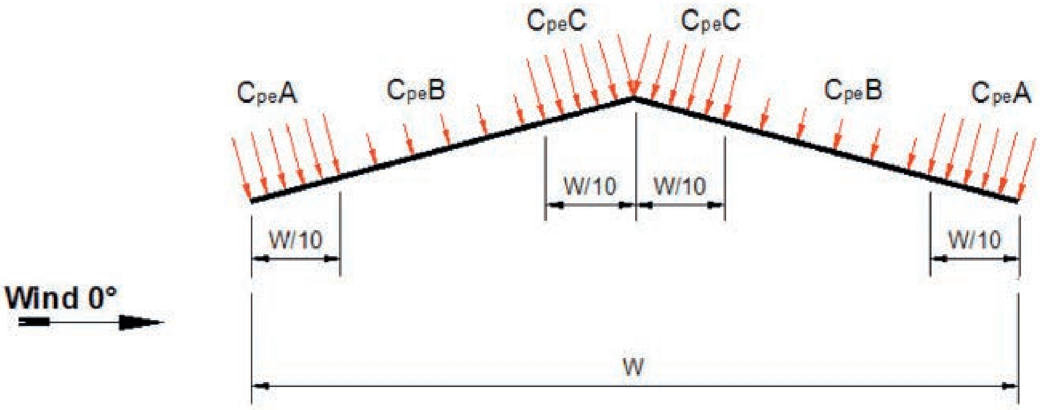
Table E.6b: C_{pe} for Duo-Pitched Canopies – Edge Sections – with Side Wall



Pitch Angle, α°	(Minimum ϕ = 1)							
	Wind Direction, θ = 0° (& reversed, θ=180°)				Wind Direction, θ = 90°			
	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}L	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}D
5	-1.80	-1.30	-1.50	-0.5	-2.00	-1.50	-2.00	-0.5
10	-1.80	-1.30	-1.80	-0.5	-2.00	-1.80	-2.00	-0.5
15	-1.60	-1.30	-2.10	-0.5	-2.20	-2.10	-2.20	-0.5
20	-1.60	-1.40	-2.10	-0.5	-2.20	-2.10	-2.20	-0.5
25	-1.50	-1.40	-2.00	-0.5	-2.00	-2.00	-2.00	-0.5
30	-1.40	-1.40	-2.00	-0.5	-1.80	-2.00	-1.80	-0.5
	C	A	D		B	D	B	

BS EN 1991-1-4 Table 7.7 Zones

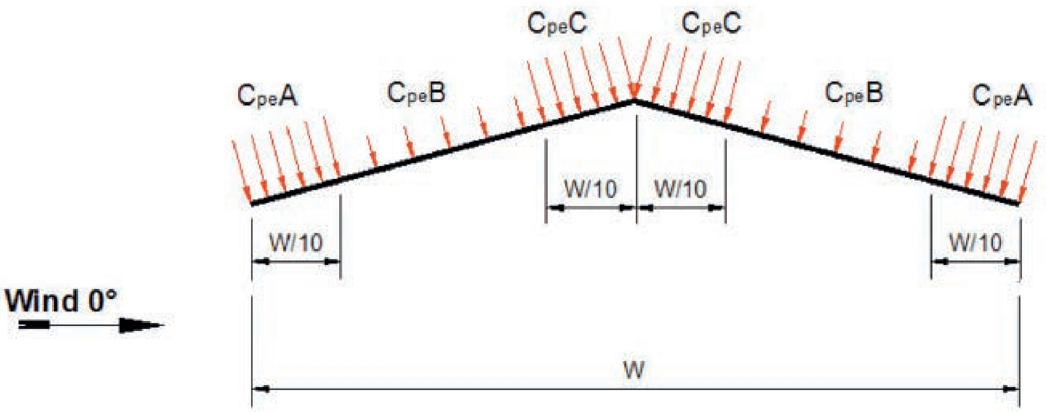
Table E.7a: C_{pe} for Duo-Pitched Canopies – Central Sections – without Side Wall



Pitch Angle, α°	(Minimum ϕ = 0)					
	Wind Direction, θ = 0° (& reversed, θ=180°)			Wind Direction, θ = 90°		
	$C_{pe}A$	$C_{pe}B$	$C_{pe}C$	$C_{pe}A$	$C_{pe}B$	$C_{pe}C$
5	-1.40	-0.60	-1.10	-1.40	-1.10	-1.40
10	-1.40	-0.70	-1.40	-1.50	-1.40	-1.50
15	-1.40	-0.90	-1.80	-1.70	-1.80	-1.70
20	-1.40	-1.20	-2.00	-1.80	-2.00	-1.80
25	-1.40	-1.40	-2.00	-1.90	-2.00	-1.90
30	-1.40	-1.40	-2.00	-1.90	-2.00	-1.90
	C	A	D	B	D	B

BS EN 1991-1-4 Table 7.7 Zones

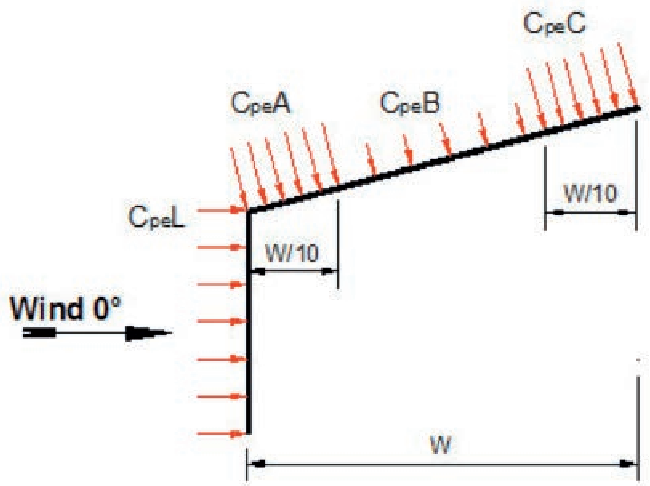
Table E.7b: C_{pe} for Duo-Pitched Canopies – Edge Sections – without Side Wall



Pitch Angle, α°	(Minimum ϕ = 0)					
	Wind Direction, θ = 0° (& reversed, θ=180°)			Wind Direction, θ = 90°		
	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}A	C_{pe}B	C_{pe}C
5	-1.40	-0.60	-1.10	-1.40	-1.10	-1.40
10	-1.40	-0.70	-1.40	-1.50	-1.40	-1.50
15	-1.40	-0.90	-1.80	-1.70	-1.80	-1.70
20	-1.40	-1.20	-2.00	-1.80	-2.00	-1.80
25	-1.40	-1.40	-2.00	-1.90	-2.00	-1.90
30	-1.40	-1.40	-2.00	-1.90	-2.00	-1.90
	C	A	D	B	D	B

BS EN 1991-1-4 Table 7.7 Zones

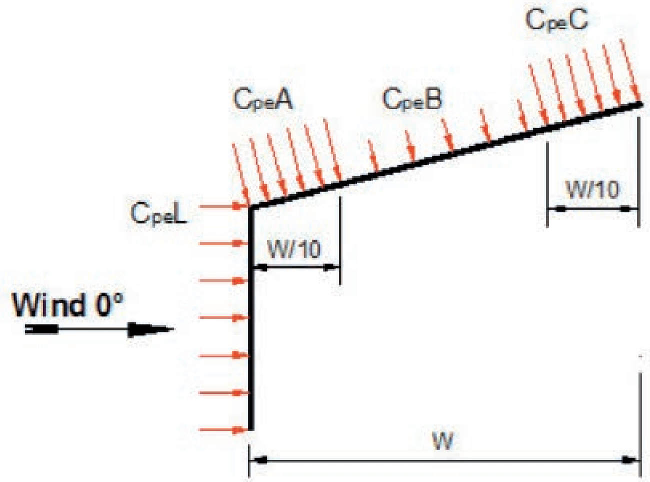
Table E.8a: C_{pe} for Mono-Pitched Canopies – Central Sections – with Side Wall



Pitch Angle, α°	(Minimum ϕ = 1)							
	Wind Direction, θ = 0° (& reversed, θ=180°)				Wind Direction, θ = 90°			
	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}L	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}D
5	-2.50	-2.20	-2.50	-0.5	-2.20	-1.60	-2.20	-0.5
10	-2.70	-2.60	-2.70	-0.5	-2.60	-2.10	-2.60	-0.5
15	-3.00	-2.90	-3.00	-0.5	-2.90	-1.60	-2.90	-0.5
20	-3.00	-2.90	-3.00	-0.5	-2.90	-1.60	-2.90	-0.5
25	-2.80	-2.50	-2.80	-0.5	-2.50	-1.50	-2.50	-0.5
30	-2.70	-2.20	-2.70	-0.5	-2.20	-1.50	-2.20	-0.5
	C	A	C		B	A	B	

BS EN 1991-1-4 Table 7.6 Zones

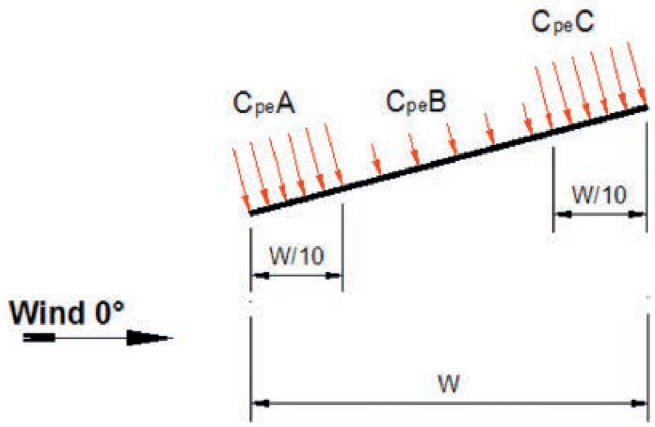
Table E.8b: C_{pe} for Mono-Pitched Canopies – Edge Sections – with Side Wall



Pitch Angle, α°	(Minimum ϕ = 1)							
	Wind Direction, θ = 0° (& reversed, θ=180°)				Wind Direction, θ = 90°			
	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}L	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}D
5	-2.20	-2.20	-2.20	-0.5	-2.20	-2.50	-1.60	-0.5
10	-2.60	-2.60	-2.60	-0.5	-2.60	-2.70	-2.10	-0.5
15	-2.90	-2.90	-2.90	-0.5	-2.90	-3.00	-1.60	-0.5
20	-2.90	-2.90	-2.90	-0.5	-2.90	-3.00	-1.60	-0.5
25	-2.50	-2.50	-2.50	-0.5	-2.50	-2.80	-1.50	-0.5
30	-2.20	-2.20	-2.20	-0.5	-2.20	-2.70	-1.50	-0.5
	B	B	B		B	C	A	

BS EN 1991-1-4 Table 7.6 Zones

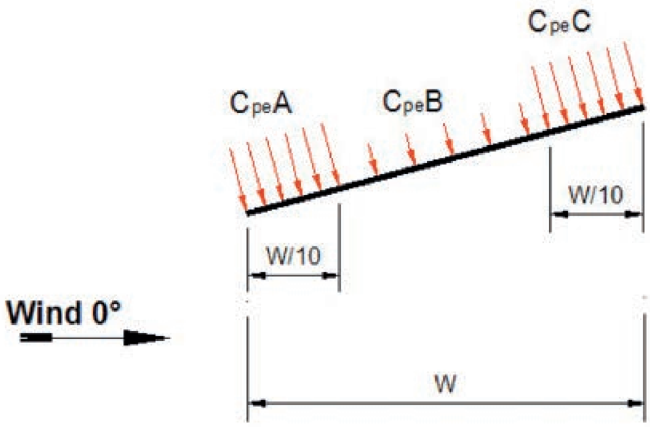
Table E.9a: C_{pe} for Mono-Pitched Canopies – Central Sections – without Side Wall



Pitch Angle, α°	(Minimum ϕ = 0)					
	Wind Direction, θ = 0° (& reversed, θ=180°)			Wind Direction, θ = 90°		
	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}A	C_{pe}B	C_{pe}C
5	-1.80	-1.10	-1.80	-1.70	-1.10	-1.70
10	-2.10	-1.50	-2.10	-2.00	-1.50	-2.00
15	-2.50	-1.80	-2.50	-2.40	-1.80	-2.40
20	-2.90	-2.20	-2.90	-2.80	-2.20	-2.80
25	-3.20	-2.60	-3.20	-3.20	-2.60	-3.20
30	-3.60	-3.00	-3.60	-3.80	-3.00	-3.80
	C	A	C	B	A	B

BS EN 1991-1-4 Table 7.6 Zones

Table E.9b: C_{pe} for Mono-Pitched Canopies – Edge Sections – without Side Wall



Pitch Angle, α°	(Minimum ϕ = 0)					
	Wind Direction, θ = 0° (& reversed, θ=180°)			Wind Direction, θ = 90°		
	C_{pe}A	C_{pe}B	C_{pe}C	C_{pe}A	C_{pe}B	C_{pe}C
5	-1.70	-1.70	-1.70	-1.70	-1.80	-1.10
10	-2.00	-2.00	-2.00	-2.00	-2.10	-1.50
15	-2.40	-2.40	-2.40	-2.40	-2.50	-1.80
20	-2.80	-2.80	-2.80	-2.80	-2.90	-2.20
25	-3.20	-3.20	-3.20	-3.20	-3.20	-2.60
30	-3.80	-3.80	-3.80	-3.80	-3.60	-3.00
	B	B	B	B	C	A

BS EN 1991-1-4 Table 7.6 Zones

INTERNAL PRESSURE COEFFICIENTS

Without dominant openings	With dominant openings	
C_{pi} = +0.2 or -0.3	Ratio of open area to remainder of area	
Whichever is the more onerous	2	$C_{pi} = 0.75 \times C_{pe}$
	3	$C_{pi} = 0.90 \times C_{pe}$

APPENDIX F: DESIGN CHECKING

F.1 Prior to the commencement of the construction work, the proposed temporary structure design should be checked for concept, adequacy, correctness, safe buildability by operatives and compliance with the design brief.

This check should be carried out by a competent person or persons independent from those responsible for the design. The ability of the checker and his remoteness or independence from the designer should be greater where new ideas are incorporated or the temporary works are complex.

F.2 **Temporary roof and temporary buildings are complex structures. Therefore, a design check should be carried out by an individual not involved in the design, and not consulted by the designer. Typically, this will be a Category 2 check (BS. 5975)**

F.3 **If a BS. 5975 Category 3 check is required, it should be specified within the design brief.**

For a Category 3 check, the check should be carried out by another without reference to the designer's calculations, using only the design brief, design statement, drawings and specification and associated information not produced by the designer.

F.4 On completion of the design and design check, a certificate should be issued, stating the category of check and confirming that the design complies with the requirements of the design brief, the standards/technical literature used and the constraints or loading conditions imposed. The certificate should identify the drawings/sketches, specification and any methodology that are part of the design and it should be signed by the designer and design checker. The package of information, including this certificate, should be issued to the person responsible for temporary works who should ensure that loads imposed by the temporary structure can be safely withstood.

Then the design may be designated as ‘for Construction

APPENDIX G: USEFUL REFERENCES

BS EN 16508	"Temporary Roofing – Performance and general design"	
BS EN 39	Steel scaffold tube	
BS EN 74	Steel couplers	
BS EN 12811	"Scaffolding: Performance requirements and general design"	
BS EN 1991		**Actions on structures**
	Part 1-4:	General actions – Wind actions.
	Part 1-3:	General actions – Snow loads.
BS 5975	Code of practice for temporary works procedures and the permissible stress design of falsework	
NASC TG20	Guide to good practice for scaffolding with tube and fittings.	
NASC TG4	Anchorage systems for scaffolding.	
NASC TG14	Supplementary couplers and check couplers	
NASC TG16	Anchoring to the ground	

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