User's manual for Protan WindLoadCalc 1.3

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Contents

What's new in version 1.3

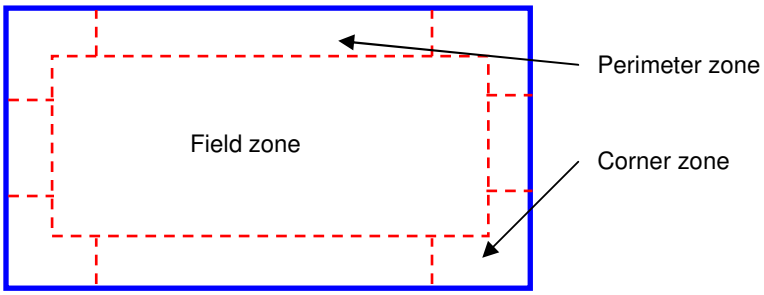
Protan WindLoadCalc 1.3 is similar to version 1.2 except for the following changes:

- The definition for low and high buildings has been changed for slim buildings.
- The limit for wind exposed areas has been increased 25% from 3000 Pa to 3750 Pa.
- The database for fasteners has been upgraded to the latest approvals for wind load capacity based on both ETAG 006 and NT BUILD 307.
- Rules for 2 meter systems have been upgraded.

1. About Protan WindLoadCalc 1.3

Protan WindLoadCalc 1.3 is an excel workbook program (Excel 2003 version). It is used to provide a specification for mechanically fastened exposed Protan roofing. The program calculates the total number of fasteners that shall be used on a roof. The different roof zones are treated individually:

- Field zone
- Perimeter zone
- Corner zone
- Ridge zone (only for duopitched roofs).



The program calculates the total number of fasteners for each zone as well as the extent of each zone.

The workbook consists of 7 worksheets:

- Building
- Terrain
- Wind load
- Roofing
- Construction
- Result
- Sketch of flat roof.

Input fields are blue, and results are yellow in all worksheets throughout the program..

The program is based on EN 1991-1-4 [ref. 1], ENV 1991-1 [ref. 2] and TPF No. 5 [ref. 3]. Protan is not responsible for any errors or deviations, or consequences to this, due to incorrect keystroke or errors in the program. The result shall always be looked over by an expert.

If you need a program that is solely based on EN 1991-1-4 and ENV 1991-1 for a particular project, please contact Protan.

2. Building

2.1 Site information

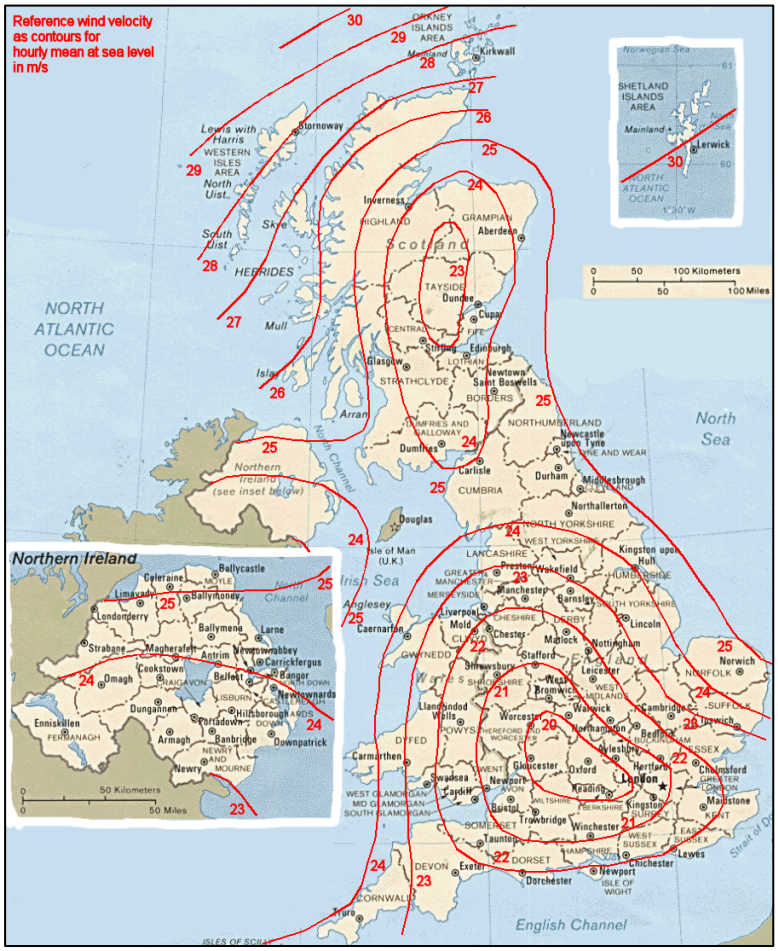
Input of:

- Project
- Building
- Address
- Postal code
- Place

2.2 Reference wind speed

This is average wind speed measured for 10 minutes, 10 m above flat terrain at sea level with terrain category II in wide circumference. The return period is 50 years (the probability of exceeding this value is 0,02). That means that you will experience this kind of wind once every 50 years. Typical values range from 20 to 32 m/s.

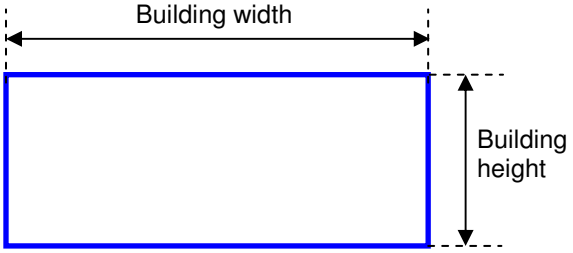
This value forms the basis of the whole wind load calculation. It is necessary to obtain this value for the current building location. The reference wind speed can be obtained in all European countries at their national building research institutes, national approval bodies or national building authorities. A map of reference wind speed for Great Britain is shown below.

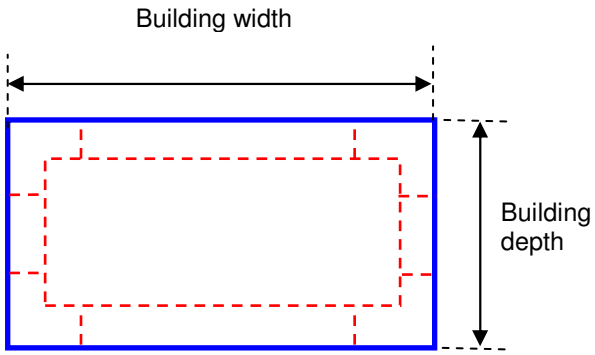


2.3 Roof types

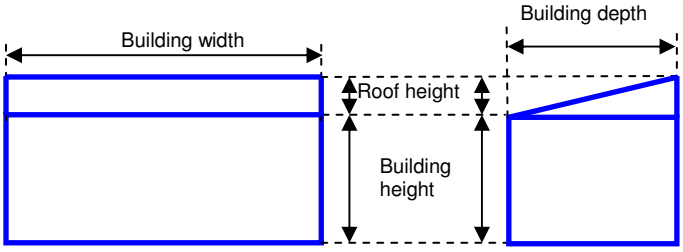
The different roof types are shown below. Please note the definition of roof height. For barrelled vault roof (arched roof) and cupola “Roof area” is part of the input data.

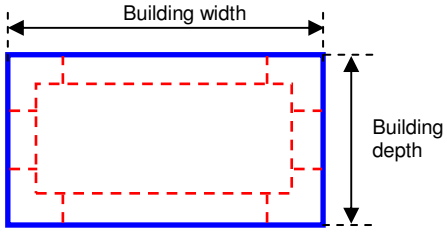
Flat roof



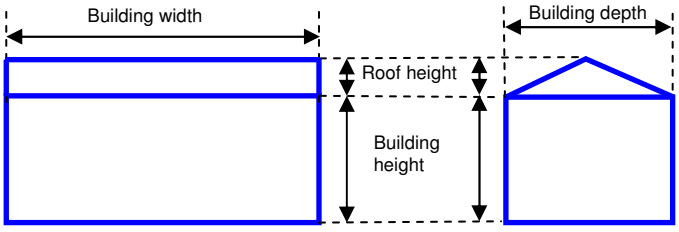


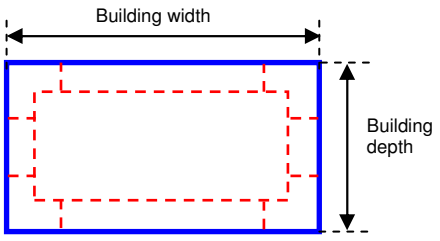
Monopitched roof



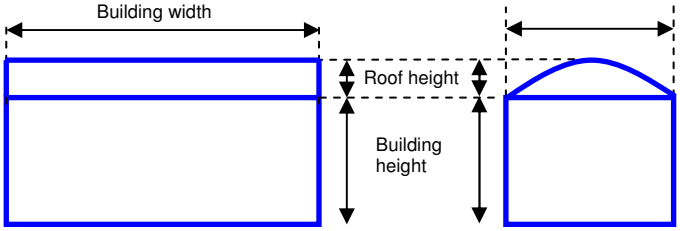


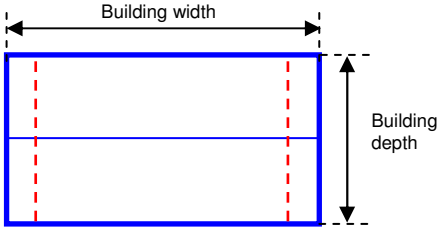
Duopitched roof



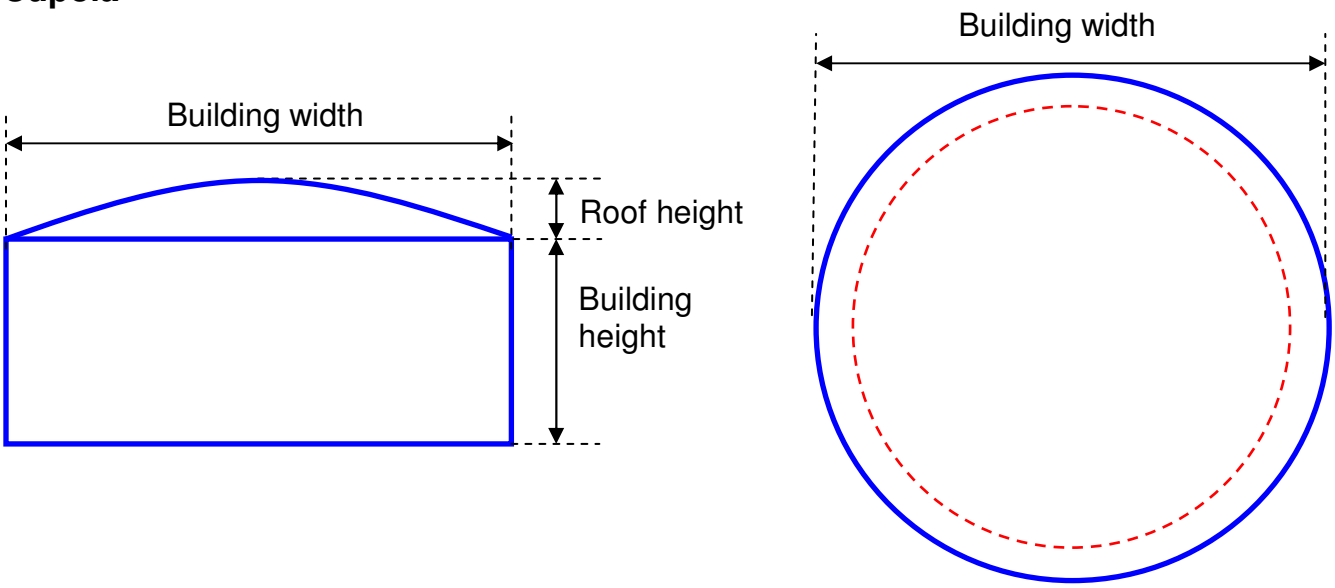


Barreled vault roof (arched roof)





Cupola



2.4 Procedure for non-rectangular roofs

Flat roofs, monopitched roofs and duopitched roofs are all considered to be rectangular in this program. This is a simplification, but most roofs are rectangular with four corner zones, four perimeter zones and one field zone. For these kinds of roofs it is both sufficient and easy to provide the dimensions of the roof as a width and a depth for the building, as shown in the figures above.

For these kinds of roofs that are non-rectangular, the following procedure should be followed:

1. Find the area of the roof.
2. Find the building width. This is the length of the widest façade of the building.
3. Calculate a virtual "building depth" by dividing the area of the roof from point 1 with the building width from point 2.
4. Use the building width from point 2 and the building depth from point 3 in the program (worksheet "Building").
5. The program provides a result that assumes four corner zones and four perimeter zones. This is not valid for a non-rectangular roof, which have more zones. This means that the program will not calculate completely correctly, but the result will still be useful as an estimate.
6. If a completely correct calculation is necessary, you have to use the calculated "Width perimeter zone" and "Length corner zone" from worksheet "Building" to manually calculate the total areas for corner zones, perimeter zones and field zones for your particular roof. Then you can calculate the total number of fasteners by .using "No. of fasteners pr. m^2" from worksheet "Result" for each zone by multiplication with each zone area, respectively.

3. Terrain

3.1 Terrain categories

Terrain category 0

Open ocean.

Terrain category I

Seacoast, lakes or flat and horizontal area with negligible vegetation and without obstacles.

Terrain category II

Area with low vegetation such as gras and isolated obstacles (trees, buildings), with separation of at least 50 obstacle heights.

Terrain category III

Area with regular cover of vegetation or buildings or with isolated obstacles (such as villages, suburban terrain, permanent forest).

Terrain category IV

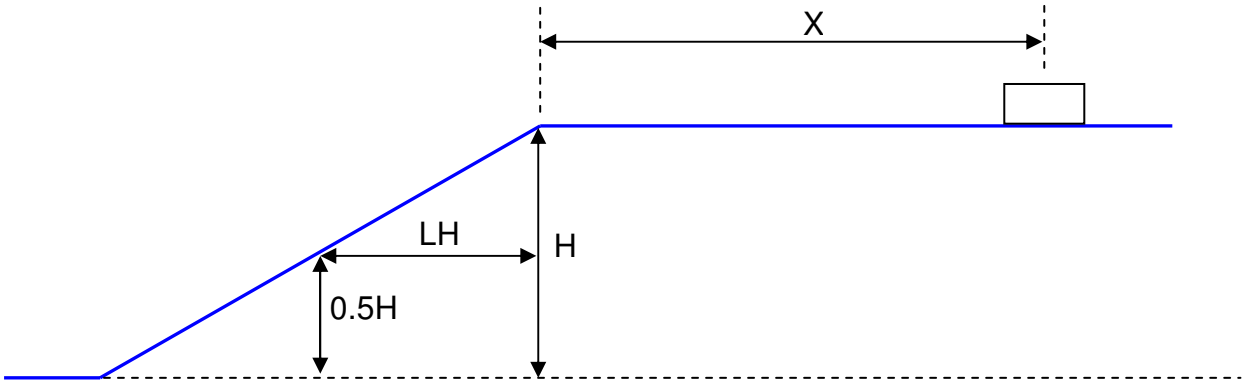
Areas in which at least 15% of the surface is covered with buildings and their average height exceeds 15 m.

3.2 Topography

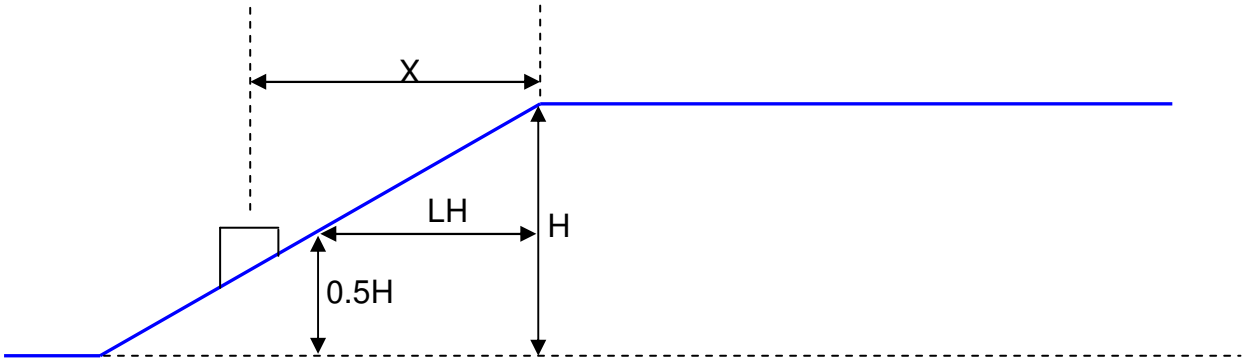
Flat terrain

This option is selected when the terrain is flat.

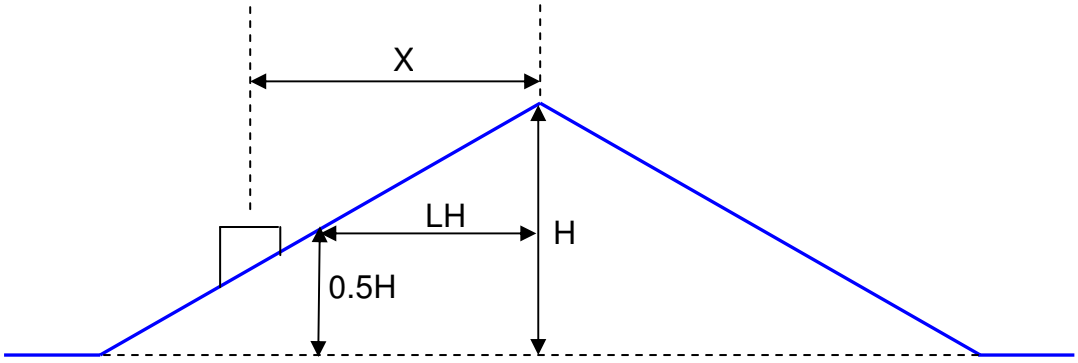
Elevation



Sloping hill

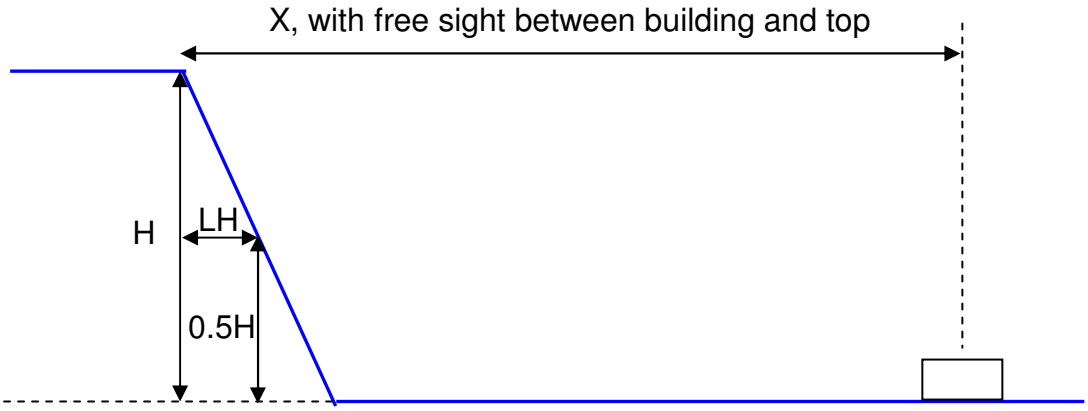


Ridging hill



Shelter side of steep sloping terrain

Slope must be at least 30°. There must be free sight between building and top. This option is normally only valid for terrain category I and II, but also for III and IV for special cases where local knowhow about terrain and weather requires it. For these cases, terrain category II shall be selected in stead of III or IV.



4. Wind load

In this worksheet there are two options:

- Use automatic calculation of the wind load
- Give manual input for the gust wind pressure.

Selection of the former (automatic) is the default option in the program. Here the gust wind pressure is calculated automatically based on input in the worksheets “Building” and “Terrain”.

Selection of the latter (manual input) is done when the gust wind pressure already has been calculated for the building. That means that the gust wind pressure is provided in the technical specification for the building, and this value can then be used directly as input in the program. That makes worksheet “Terrain” redundant for this case.

5. Roofing

Roofing materials, fasteners are selected for:

- Field zone
- Corner- and perimeter zone (as well as ridge zone for duopitched roofs).

Loadbearing construction and fixing type (screw type) are selected for the whole roof.

Based on the selections, a dimensioning capacity is calculated for the system for both the field zone and the corner & perimeter zone (also including the ridge zone for duopitched roof).

You can select between the following roofing materials:

- Protan SE
- Protan EXG
- Protan EX

- Protan SE with secret strip
- Protan FP.

And the following widths:

- 0,5 m
- 0,67 m
- 1,0 m
- 2,0 m
- Special widths.

For Protan SE with secret strip you can select between:

- Secret fix (you must specify the secret strip distance)
- Secret strip (you must specify the secret strip distance).

You can select between the following load bearing constructions:

- Steel 0,65 mm
- Steel 0,7 mm
- Steel 0,8 mm
- Steel 0,9 mm or greater
- Concrete
- Lightweight concrete C55
- Lightweight tiles 700 kg/m³
- Lightweight concrete 450 kg/m³
- Lightweight concrete 500 kg/m³
- Wood.

Based on these selections, lists for suitable fasteners and fixings (screws) are generated in the Combobox-lists in the spreadsheet. Please note that for both fasteners and fixings it is possible to select “User specified” in the Combobox-lists. Then you have to specify the designation and capacity for the fastener or fixing (screw).

6. Construction

6.1 Efficiency of external load

If the roof substructure, the walls and the parapets all are considered as airtight, the roof shall be considered as airtight, then the external load efficiency coefficient is set to 0,8. This means that a small vacuum suction works against the external wind loads on the roofing. The factor of 0,8 is based on Norwegian experience, and is documented in TPF No. 5.

For other cases, the external load efficiency coefficient is set to 1.

6.2 Load coefficients for external load

The load coefficient for external loads vary with the roof types and with the roof zones (field, corner, perimeter and ridge). These coefficients are given in the standard. However, for field zones we use slightly different load coefficients for all roof types: -1,0 in stead of -1,2. This is based on Norwegian experience, and is documented in TPF No. 5. The load coefficients for external load are shown in the table in worksheet “Construction”.

6.3 Efficiency of internal load

If the roof substructure, the walls and the parapets all are considered as airtight, the roof shall be considered as airtight, and the internal load efficiency coefficient is set to 0.

For other cases, the roof is considered having air leakages, and the internal load efficiency coefficient is set to 1.

If the roof deck consists of corrugated steel plates, the internal load efficiency coefficient should be set to 1, because there will always be some air leaks through the steel deck and the vapour control layer. However, if the vapour control layer is installed with sealed overlaps (welded or with butyl tape) and with no perforations, the coefficient can be set to 0.

6.4 Load coefficients for internal load

It must be checked whether there is an internal wind load in the building. Airleaks at e.g. parapets may cause an internal wind load acting on the roofing from below. As a simplification, we consider only two cases:

1) For a closed building with no dominating wind facades: The load coefficient for internal load is set to 0,2. This applies to the majority of buildings. The factor of 0,2 is based on Norwegian experience, and is documented in TPF No. 5.
2) For a building with permanent openings, with at least one dominating wind facade: The load coefficient for internal load is set to 0,7. This applies to special buildings, such as open warehouses. The factor of 0,7 is based on Norwegian experience, and is documented in TPF No. 5.

If the area of openings on two facades (walls or roof) both are larger than 30% of the facade area, the building shall be treated as "free-standing roof". This program shall not be used for such cases.

Please note that for special cases a closed building should still have a load coefficient of 0,7. This applies to roof decks of corrugated steel plates with cornices that extend far outside the walls. Even if the building is closed, the roofing can experience an internal wind load that stems from air leakages at the cornices.

A facade is a "dominating wind facade" if it has an aera of openings at least twice the sum of the area of openings in the other facades of the building.

6.5 Safety factor

In the wind load calculation we use a safety factor of 1,5 as specified in TPF No. 5. This is according to table E1.1: "Unfavourable, dominating variable load" in ENV 1991-1.

However, we also use a reduction factor of 0,9 as specified in TPF No. 5. This is according to table 9.2: "Reliability class 2" in ENV 1991-1.

6.6 Dimensioning wind load

The following equation is used to calculate the dimensioning wind load (q_d):

$$q_d = 1{,}5 \cdot 0{,}9 \cdot \left(- f_1 \cdot c_{pe} + f_2 \cdot c_{pi}\right) \cdot q_{gust}$$

f_1 is the external load efficiency coefficient, f_2 is the internal load efficiency coefficient, c_{pe} is the load coefficient for external loads, and c_{pi} is the load coefficient for internal loads. Please note that c_{pe} is a negative number. q_{qust} is the gust wind pressure. 1,5 is the safety factor, and 0,9 is the reduction factor.

6.7 Rules

For a dimensioning load <= 3750 Pa, the minimum number of fasteners pr. m² is 1. For a dimensioning load > 3750 Pa, the minimum number of fasteners pr. m² is 2.

For all cases the minimum allowable row distance and fixing distance is 0,2 m.

For a dimensioning load <= 3750 Pa, the maximum allowable row distance and fixing distance are:

- 1,0 m for corner, perimeter and ridge zones.
- No requirements for the field zone.

For a dimensioning load > 3750 Pa, the maximum allowable row distance and fixing distance are:

- 0,6 m for corner, perimeter and ridge zones.
- 1,0 m for the field zone.

These rules are based on Norwegian experience. 3750 Pa is called the limit for wind exposed areas.

If the cells for row distance or fixing distance turn red in the table in worksheet “Construction”, it means that the calculated values are outside the allowable range (above or below also shown in the table). It is up to the user to decide whether this is acceptable or not. This provides a possibility to use some engineering judgement, which can be useful if the input values are just outside the allowable range.

6.8 Manual adjustment of fixing distance

In worksheet “Construction” there is two options:

- Use automatic calculation of the number of fasteners
- Use manual adjustment for the fixing distance.

Selection of the former (automatic) is the default option in the program. Here the fixing distance is calculated automatically.

Sometimes the automatically calculated fixing distance might be very unpractical, particularly on corrugated steel decks. Then you should select the latter (manual) in order to specify the fixing distance yourself.

If the allowable upper limits for the fixing distances are exceeded, then the cells for fixing distances turn red. However, it is up to the user to decide whether this is acceptable or not. This provides a possibility to use some engineering judgement, which can be useful if the input values are just outside the allowable range.

7. Result

On this page all input and output is summarized in tables. This page is supposed to be printed as the wind load documentation for the roofing. There is a separate field for signature at the bottom of the page. Please note the Protan logo in the upper right corner.

If you have trouble printing the result page on one single A4 sheet, then you must change the margin settings at “Print Format” or “Page Format” in the Excel File Menu.

8. Sketch of flat roof

This is a very simple roof plan, showing the specifications for the different roof zones (corner, perimeter and field). This sketch only applies to a flat (rectangular) roof.

9. References

1) EN 1991-1-4. Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions.

2) ENV 1991-1. Eurocode 1: Basis of design and actions on structures – Part 1: Basis of design.

3) TPF No. 5 (Mechanically fastening of exposed flexible roofing sheets), www.tpf-info.org, available in Norwegian and English. This is the Norwegian industry norm for fastening of mechanically fastened exposed flexible roofing sheets.