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SunMan x ARUP

Structural Design Guide

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SunMan eArc - Ultra-light, Glass-free Technology

This document provides a structural guidance for adhering solar panels directly to roofs without the need for screw penetrations.

The solar panels utilize an organic polymer composite, devoid of glass, known for its exceptional durability in withstanding diverse climatic conditions and extreme temperatures.

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Structural Design Guide

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Initial Evaluation / Due Dilligance

To determine if panels can be installed on existing buildings, check whether these initial criteria are met.

Does your roof fit within the parameters: less than 25 meters and a slope of less than 5 degrees? Roofs beyond these limits are still feasible, but they are not directly covered in this document and require a bespoke wind calculation.

Checking the roof structure: Is the minimal additional weight likely to cause any issues? Refer to a structural engineer if uncertain.

Checking the roof surface membrane:

- Is the material/substructure suitable?
- What is the age and condition – any corrosion or peeling?
- Is cleaning or repair of the surface necessary?

Checking if chosen adhesive is generally suitable for bonding with roof surface.

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Load Calculation

To determine if panels can be installed on existing buildings, consider these key loads and parameters.

The lightweight panels, with a self-weight of just 3.5 kg/m^2, typically don't pose structural issues since their load is minimal compared to the roof's weight and other loads such as snow.

Wind suction is usually the key factor in deciding suitable buildings for panel installation and the amount of adhesive needed to secure the panels.

To ensure structural safety in accordance with Eurocode the design action E_d must not exceed the design resistance R_d.

$$E_d \leq R_d$$

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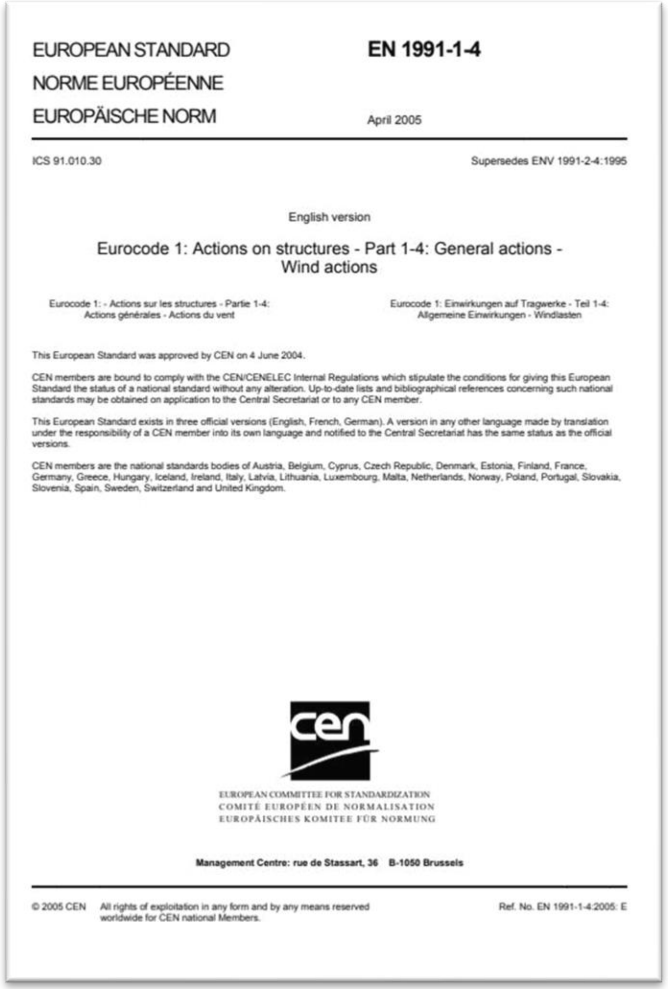
Load Calculation

Wind Load – EN 1991-4 – Eurocode

The Eurocode EN 1991-4 provides guidelines for calculating wind loads on structures, offering a comprehensive framework to ensure structural safety against wind forces.

The design wind loads for panels and adhesives depend on the project location, building dimensions, roof edge details, and panel positions. Suction forces are higher at corners and edges of flat roofs, so varying adhesive width based on position is possible.



EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1991-1-4

April 2005

ICS 91.010.30

Supersedes ENV 1991-2-4:1995

English version

Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions

Eurocode 1: - Actions sur les structures - Partie 1-4: Actions générales - Actions du vent

Eurocode 1: Einwirkungen auf Tragwerke - Teil 1-4: Allgemeine Einwirkungen - Windlasten

This European Standard was approved by CEN on 4 June 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 1991-1-4:2005: E

Load Calculation

Wind Load – EN 1991-4 – Germany

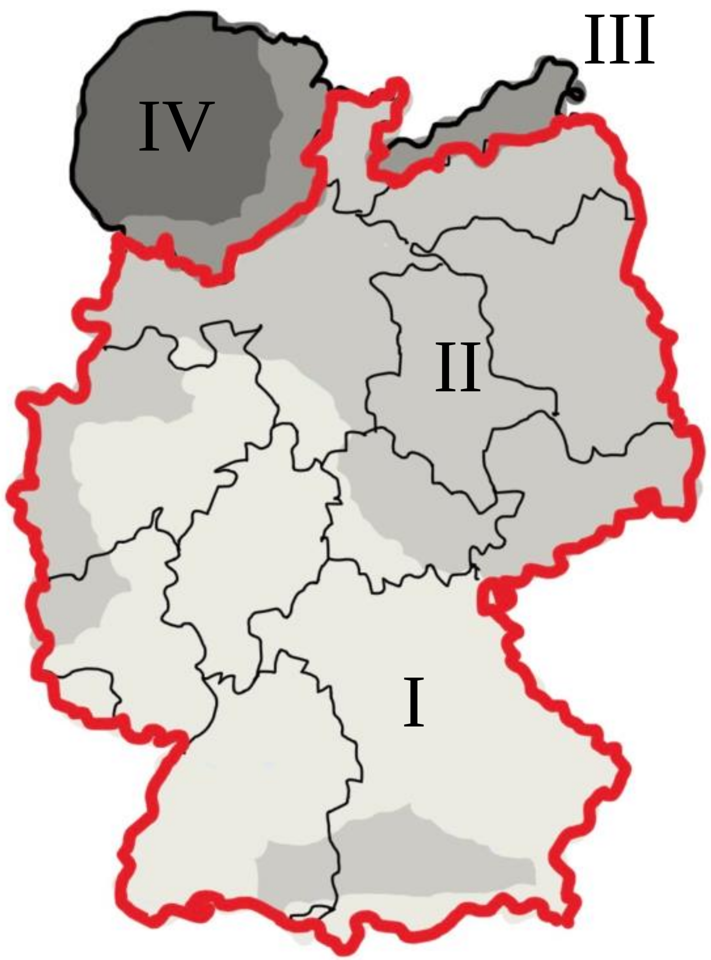
Fundamental Basic Wind Velocity v_b : Represents the speed of wind at a standard height above ground level, unaffected by local topography or obstacles.

Basic Velocity Pressure q_p : The dynamic pressure exerted by the wind at a given fundamental basic wind velocity.

To cover about 90% of Germany the wind zones I and II will be considered in this design guide (other zones are possible but require bespoke wind calculations)

$$v_b = 25\ m/s$$

$$q_p = 0.39\ kN/m^2$$



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Load Calculation

Wind Load – EN 1991-4 – Belgium

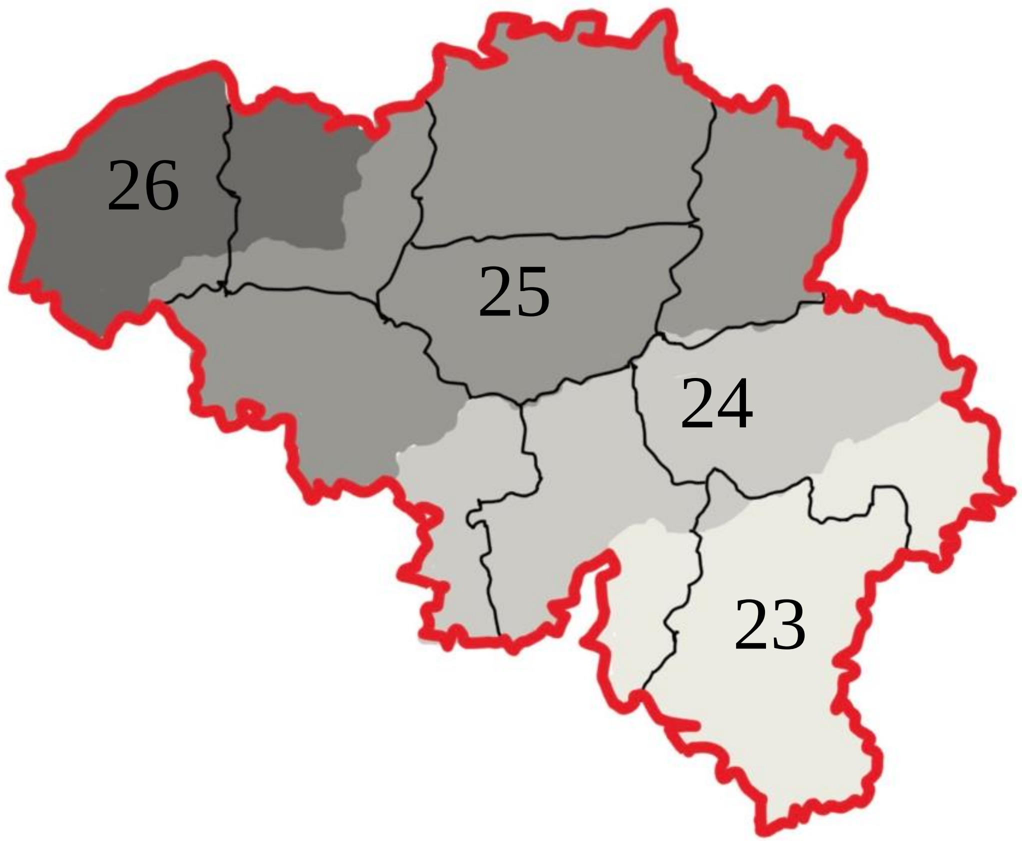
Fundamental Basic Wind Velocity v_b : Represents the speed of wind at a standard height above ground level, unaffected by local topography or obstacles.

Basic Velocity Pressure q_p : The dynamic pressure exerted by the wind at a given fundamental basic wind velocity.

All four wind zones are covered as shown in the map.

$$v_b = 26\ m/s$$

$$q_p = 0.42\ kN/m^2$$



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Load Calculation

Wind Load – EN 1991-4 – Netherlands

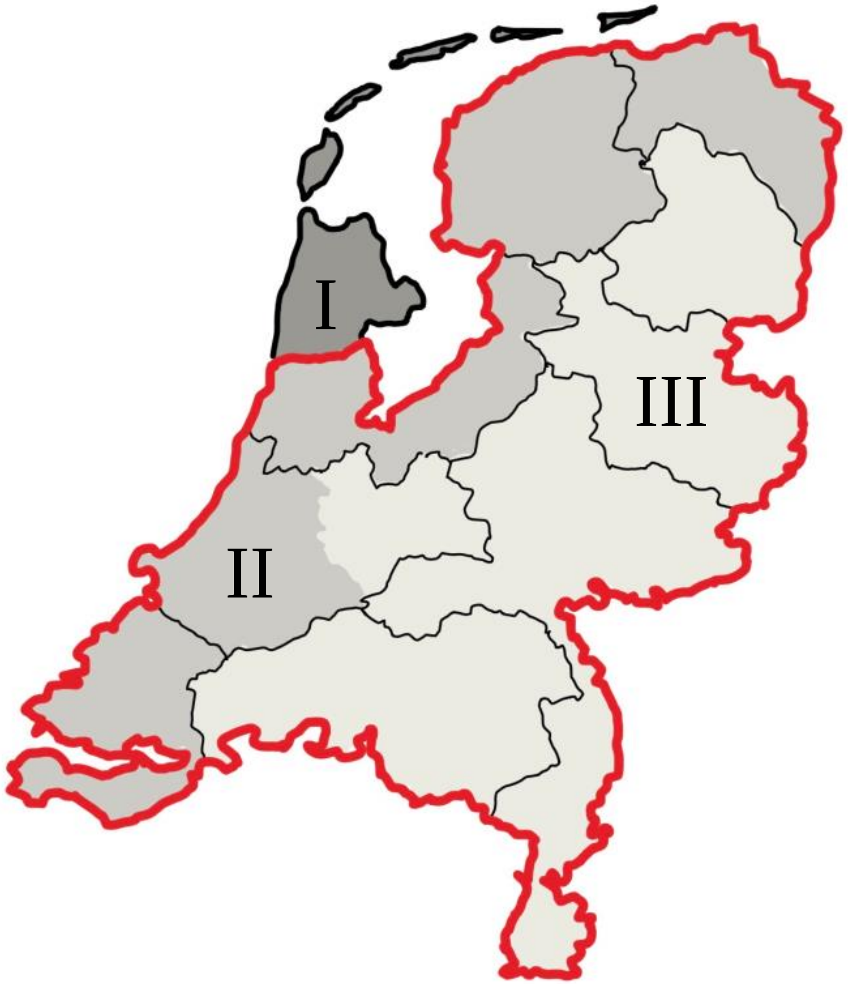
Fundamental Basic Wind Velocity v_b : Represents the speed of wind at a standard height above ground level, unaffected by local topography or obstacles.

Basic Velocity Pressure q_p : The dynamic pressure exerted by the wind at a given fundamental basic wind velocity.

This design guide focuses on wind zones II and III, which cover approximately 90% of the Netherlands. Designs for other zones are feasible but require bespoke wind calculations.

$$v_b = 27\ m/s$$

$$q_p = 0.46\ kN/m^2$$



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Load Calculation

Wind Load – EN 1991-4 – Poland

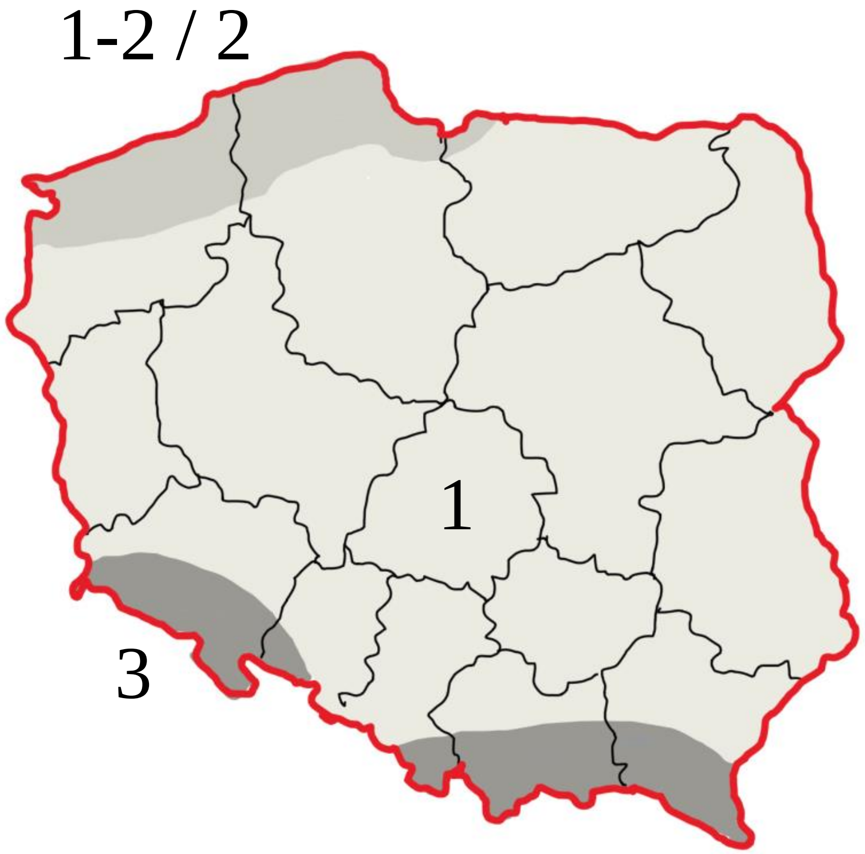
Fundamental Basic Wind Velocity v_b : Represents the speed of wind at a standard height above ground level, unaffected by local topography or obstacles.

Basic Velocity Pressure q_p : The dynamic pressure exerted by the wind at a given fundamental basic wind velocity.

This design guide focuses on all wind zones and covers entire Poland. Designs for other zones are feasible but require bespoke wind calculations.

$$v_b = 27\ m/s$$

$$q_p = 0.46\ kN/m^2$$



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Load Calculation

Wind Load – EN 1991-4 – Czech Republic

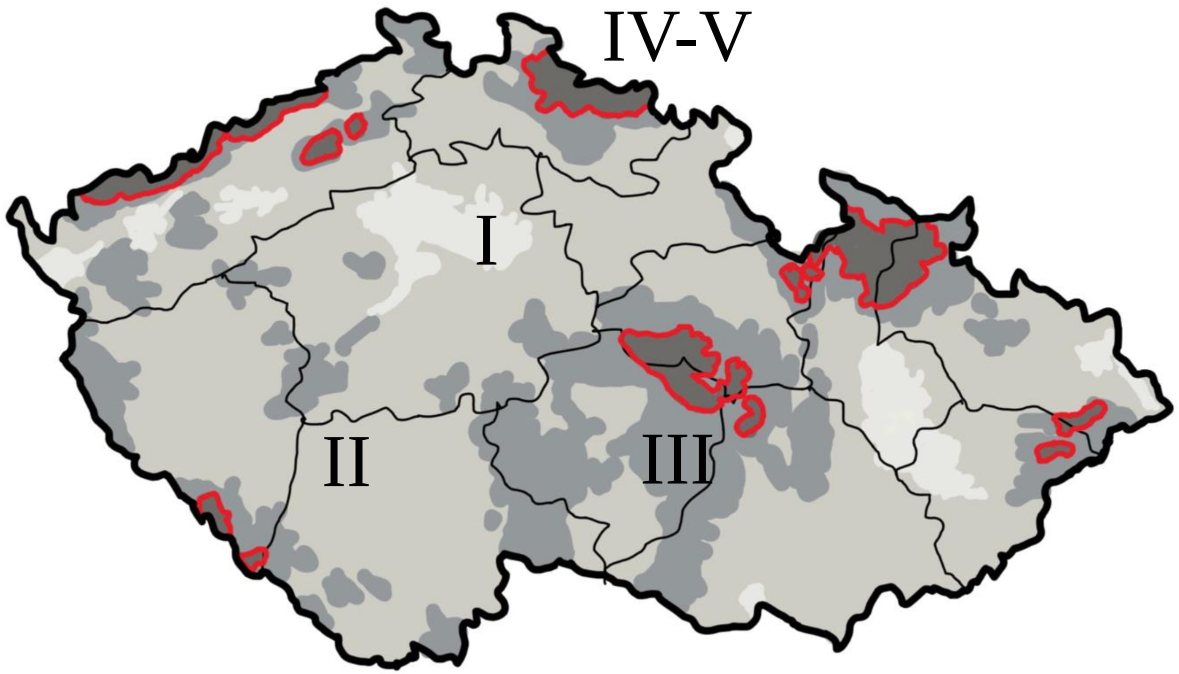
Fundamental Basic Wind Velocity v_b : Represents the speed of wind at a standard height above ground level, unaffected by local topography or obstacles.

Basic Velocity Pressure q_p : The dynamic pressure exerted by the wind at a given fundamental basic wind velocity.

This design guide focuses on wind zones I to III and **not wind zones IV-V** (red marked). Designs for other zones are feasible but require bespoke wind calculations.

$$v_b = 27.5\ m/s$$

$$q_p = 0.47\ kN/m^2$$



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Load Calculation

Wind Load – EN 1991-4 – Spain

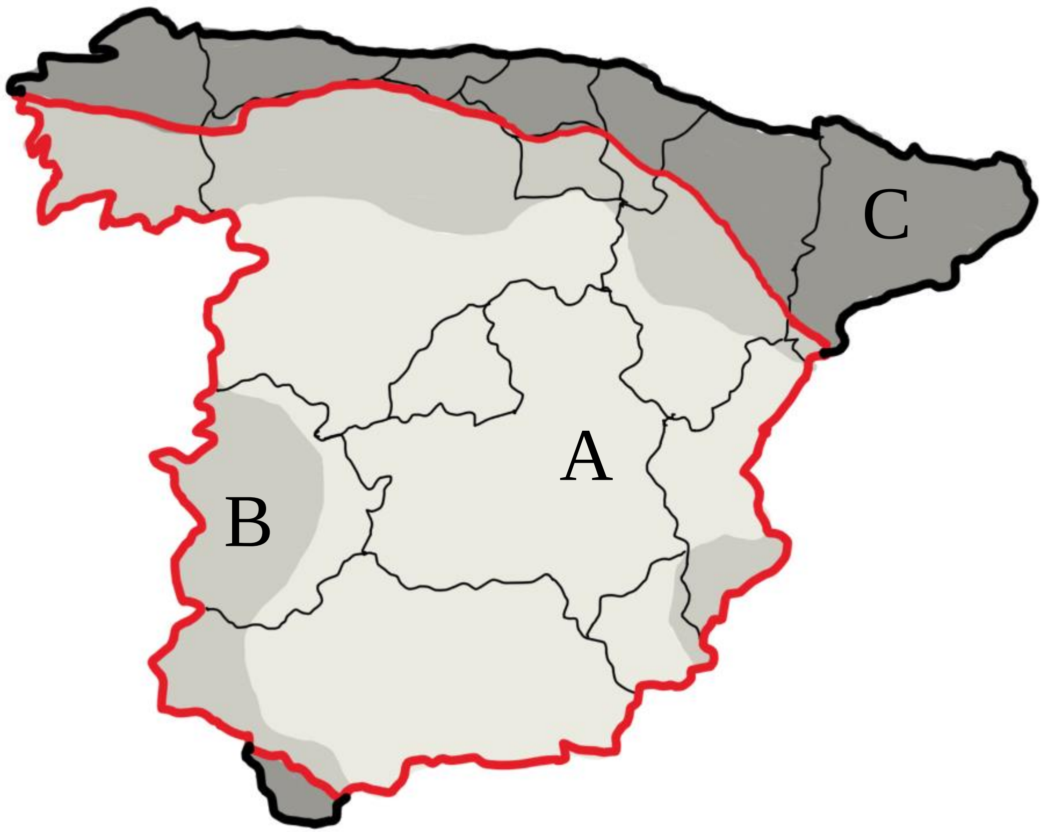
Fundamental Basic Wind Velocity v_b : Represents the speed of wind at a standard height above ground level, unaffected by local topography or obstacles.

Basic Velocity Pressure q_p : The dynamic pressure exerted by the wind at a given fundamental basic wind velocity.

This design guide focuses on wind zones A and B and covers most of Spain. Designs for other zones are feasible but require bespoke wind calculations.

$$v_b = 27\ m/s$$

$$q_p = 0.46\ kN/m^2$$



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Load Calculation

Wind Load – EN 1991-4 – Italy

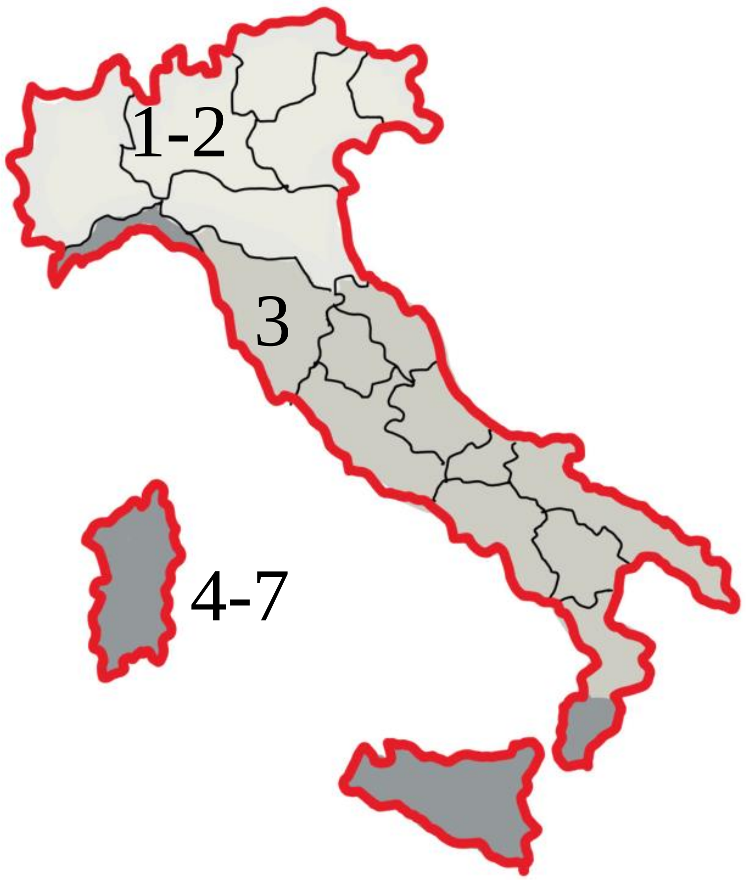
Fundamental Basic Wind Velocity v_b : Represents the speed of wind at a standard height above ground level, unaffected by local topography or obstacles.

Basic Velocity Pressure q_p : The dynamic pressure exerted by the wind at a given fundamental basic wind velocity.

This design guide focuses on wind zones 1 to 7 and covers most of Italy. Designs for other zones are feasible but require bespoke wind calculations.

$$v_b = 28\,m/s$$

$$q_p = 0.49\,kN/m^2$$



Load Calculation

Wind Load – EN 1991-4 Ch. 4.3.2

The terrain category describes the surface roughness of the surrounding area 500m from the housing site. In this guide, only categories II to IV will be considered, with Category II being the governing category.

0. Lake, coastal areas exposed to the open sea.

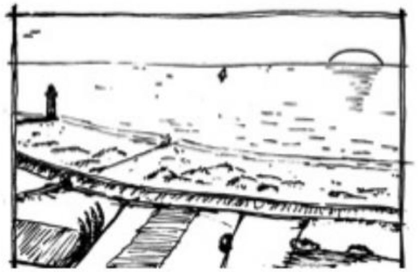
1. Lakes or areas with low vegetation and no obstacles.

2. Areas with low vegetation such as grass and isolated obstacles (trees, buildings) with distances of at least 20 times the obstacle height.

3. Areas with uniform vegetation or buildings, or with individual objects spaced less than 20 times the obstacle height (e.g., villages, suburban areas, forested regions).

4. Areas where at least 15% of the surface is covered with buildings with an average height greater than 15 meters.

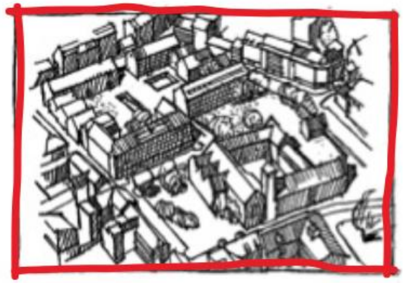
It will also focus exclusively on buildings up to a height of 25 meters.



Category 0 - I

Category II

Category III



Category IV

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Load Calculation

Wind Load – EN 1991-4 – Overview

Roof Area	Wind Zone	Terrain Category	Fundamental Basic Wind Velocity	Base Velocity Pressure	Gust Speed Pressure
-	-	-	v_b	q_p	$q_p(z)$
Germany	I - II	II - IV	25 m/s	0,39 kN/m²	1,15 kN/m²
Belgium	23 - 26	II - IV	26 m/s	0,42 kN/m²	1,25 kN/m²
Netherlands	II - III	II - IV	27 m/s	0,46 kN/m²	1,34 kN/m²
Poland	I - III	II - IV	27 m/s	0,46 kN/m²	1,34 kN/m²
Czech	I - III	II - IV	27,5 m/s	0,47 kN/m²	1,39 kN/m²
Spain	A-B	II - IV	27 m/s	0,46 kN/m²	1,34 kN/m²
Italy	1 - 7	II - IV	28 m/s	0,49 kN/m²	1,45 kN/m²
		MAX	28 m/s	0,49 kN/m²	1,45 kN/m²

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Load Calculation

Characteristic Wind Load – EN 1991-4

3 factors define the applicable wind loads

EN 1991-1-4

Gust Speed Pressure ($q_p(z)$) – *Geschwindigkeitsdruck* – in kN/m² represents the base wind force, determined by the project's location and local exposure category.

$$w_k = q_p(z) \times c_{pe,1} \times \chi$$

External Pressure Coefficient ($c_{pe,1}$) – *Aerodynamischer Beiwert für den Außendruck* – accounts for the PV panel size and the smallest construction elements, such as glue lines with a 0.5m²/m load area. Here, $c_{pe,1}$ is applied.

An **additional factor χ** (1.2) is added for surface roughness due to wind flow around panels, undercurrents on rooftops and continuous behavior.

Load Calculation

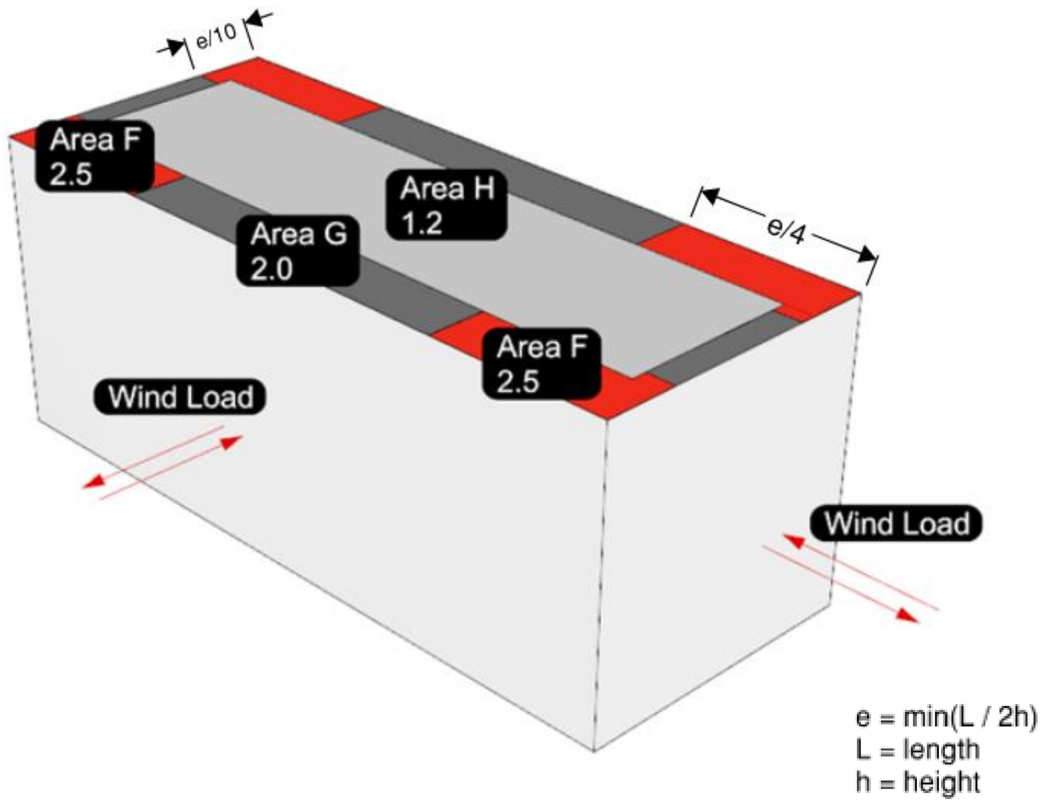
Design Wind Load – EN 1991-4

For designing the adhesives, a **partial safety factor γ** (1.5) for wind is applied according to the code.

$$w_d = w_k \times \gamma$$

Load Calculation

Wind Load – EN 1991-4 Ch. 7.2.3 – External Pressure Coefficients



Flat roofs with a slope of less than 5%

Due to the varying wind suction forces acting on the sealing surfaces, a flat roof is divided into three areas:

- Corner area (F)
- Edge area (G)
- Inner edge area (H)

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Load Calculation

Wind Load – EN 1991-4 – Germany

Roof Area	Gust Speed Pressure	External Pressure Coefficient	Additional Factor	Partial Safety Factor	Char. Wind Load	Design Wind Load
-	$q_p(z)$	$c_{pe,1}$	χ	ψ	w_k	w_d
F	1,15 kN/m²	2,5	1,2	1,5	3,5 kN/m²	5,2 kN/m²
G	1,15 kN/m²	2,0	1,2	1,5	2,8 kN/m²	4,1 kN/m²
H	1,15 kN/m²	1,2	1,2	1,5	1,7 kN/m²	2,5 kN/m²

$$w_d = q_p(z) \times c_{pe,1} \times \chi \times \psi$$

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Load Calculation

Wind Load – EN 1991-4 – Belgium

Roof Area	Gust Speed Pressure	External Pressure Coefficient	Additional Factor	Partial Safety Factor	Char. Wind Load	Design Wind Load
-	$q_p(z)$	$c_{pe,1}$	χ	ψ	w_k	w_d
F	1,25 kN/m²	2,5	1,2	1,5	3,7 kN/m²	5,6 kN/m²
G	1,25 kN/m²	2,0	1,2	1,5	3,0 kN/m²	4,5 kN/m²
H	1,25 kN/m²	1,2	1,2	1,5	1,8 kN/m²	2,7 kN/m²

$$w_d = q_p(z) \times c_{pe,1} \times \chi \times \psi$$

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Load Calculation

Wind Load – EN 1991-4 – Netherlands

Roof Area	Gust Speed Pressure	External Pressure Coefficient	Additional Factor	Partial Safety Factor	Char. Wind Load	Design Wind Load
-	$q_p(z)$	$c_{pe,1}$	χ	ψ	w_k	w_d
F	1,34 kN/m²	2,5	1,2	1,5	4,0 kN/m²	6,0 kN/m²
G	1,34 kN/m²	2,0	1,2	1,5	3,2 kN/m²	4,8 kN/m²
H	1,34 kN/m²	1,2	1,2	1,5	1,9 kN/m²	2,9 kN/m²

$$w_d = q_p(z) \times c_{pe,1} \times \chi \times \psi$$

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Load Calculation

Wind Load – EN 1991-4 – Poland

Roof Area	Gust Speed Pressure	External Pressure Coefficient	Additional Factor	Partial Safety Factor	Char. Wind Load	Design Wind Load
-	$q_p(z)$	$c_{pe,1}$	χ	ψ	w_k	w_d
F	1,34 kN/m²	2,5	1,2	1,5	4,0 kN/m²	6,0 kN/m²
G	1,34 kN/m²	2,0	1,2	1,5	3,2 kN/m²	4,8 kN/m²
H	1,34 kN/m²	1,2	1,2	1,5	1,9 kN/m²	2,9 kN/m²

$$w_d = q_p(z) \times c_{pe,1} \times \chi \times \psi$$

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Load Calculation

Wind Load – EN 1991-4 – Czech Republic

Roof Area	Gust Speed Pressure	External Pressure Coefficient	Additional Factor	Partial Safety Factor	Char. Wind Load	Design Wind Load
-	$q_p(z)$	$c_{pe,1}$	χ	ψ	w_k	w_d
F	1,39 kN/m²	2,5	1,2	1,5	4,2 kN/m²	6,3 kN/m²
G	1,39 kN/m²	2,0	1,2	1,5	3,3 kN/m²	5,0 kN/m²
H	1,39 kN/m²	1,2	1,2	1,5	2,0 kN/m²	3,0 kN/m²

$$w_d = q_p(z) \times c_{pe,1} \times \chi \times \psi$$

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Load Calculation

Wind Load – EN 1991-4 – Italy

Roof Area	Gust Speed Pressure	External Pressure Coefficient	Additional Factor	Partial Safety Factor	Char. Wind Load	Design Wind Load
-	$q_p(z)$	$c_{pe,1}$	χ	ψ	w_k	w_d
F	1,45 kN/m²	2,5	1,2	1,5	4,3 kN/m²	6,5 kN/m²
G	1,45 kN/m²	2,0	1,2	1,5	3,5 kN/m²	5,2 kN/m²
H	1,45 kN/m²	1,2	1,2	1,5	2,1 kN/m²	3,1 kN/m²

$$w_d = q_p(z) \times c_{pe,1} \times \chi \times \psi$$

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Load Calculation

Wind Load – EN 1991-4 – Spain

Roof Area	Gust Speed Pressure	External Pressure Coefficient	Additional Factor	Partial Safety Factor	Char. Wind Load	Design Wind Load
-	$q_p(z)$	$c_{pe,1}$	χ	ψ	w_k	w_d
F	1,34 kN/m²	2,5	1,2	1,5	4,0 kN/m²	6,0 kN/m²
G	1,34 kN/m²	2,0	1,2	1,5	3,2 kN/m²	4,8 kN/m²
H	1,34 kN/m²	1,2	1,2	1,5	1,9 kN/m²	2,9 kN/m²

$$w_d = q_p(z) \times c_{pe,1} \times \chi \times \psi$$

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Suitable Construction

Structural adhesives can be used to attach the panels directly or using sub-frames without mechanical connectors.

Direct fixing to roof membrane or with sub structure

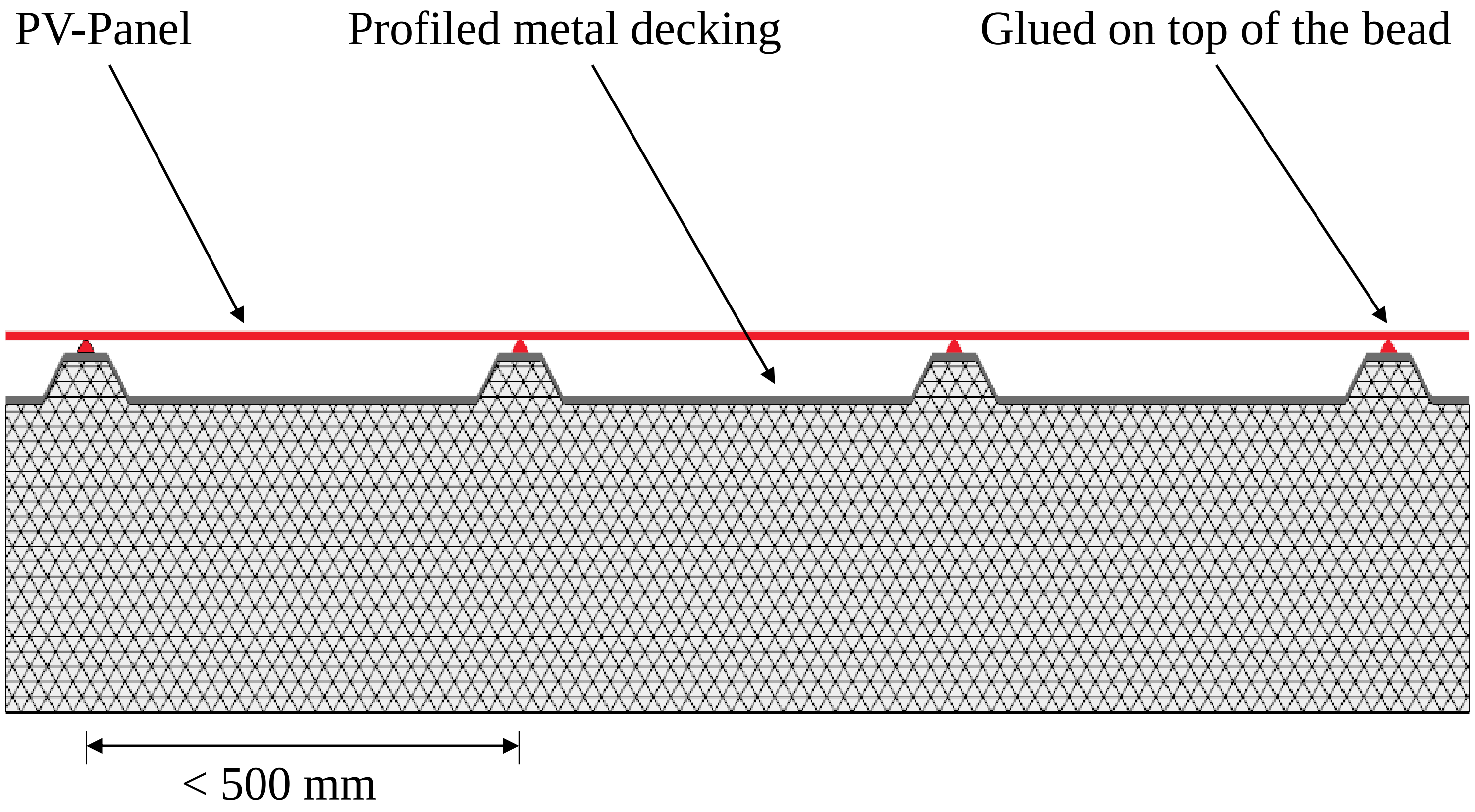
All glued joints must be strong enough to withstand design loads without permanent deformation

Safety Factor Key:

- ETAG based total factor
- Eurocode based partial safety factors (Load & Material)

Construction Method

Profiled metal decking with direct gluing



Profiled metal decking with direct gluing

- various coating

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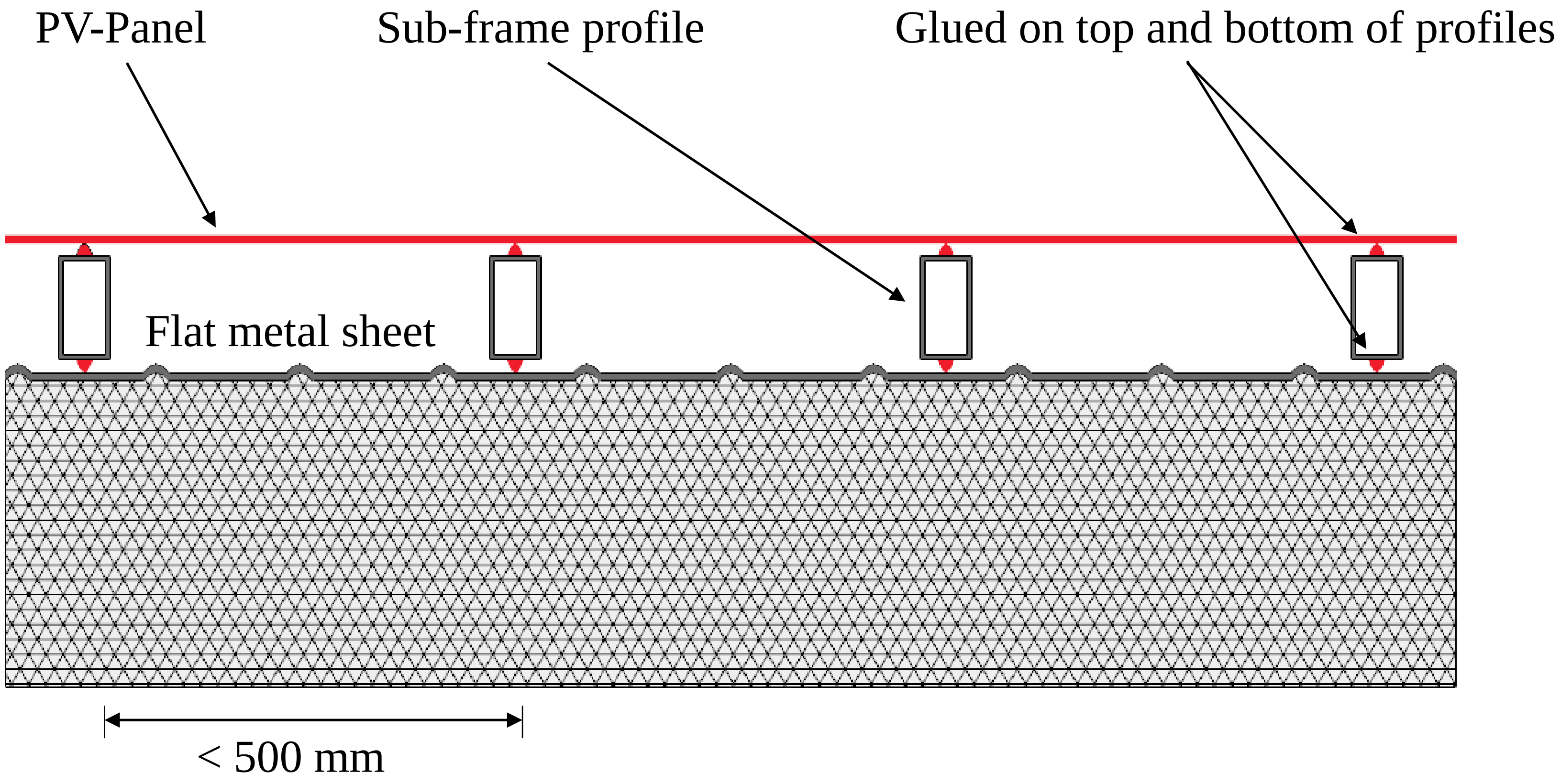
Construction Method

Flat metal sheets with sub-frame

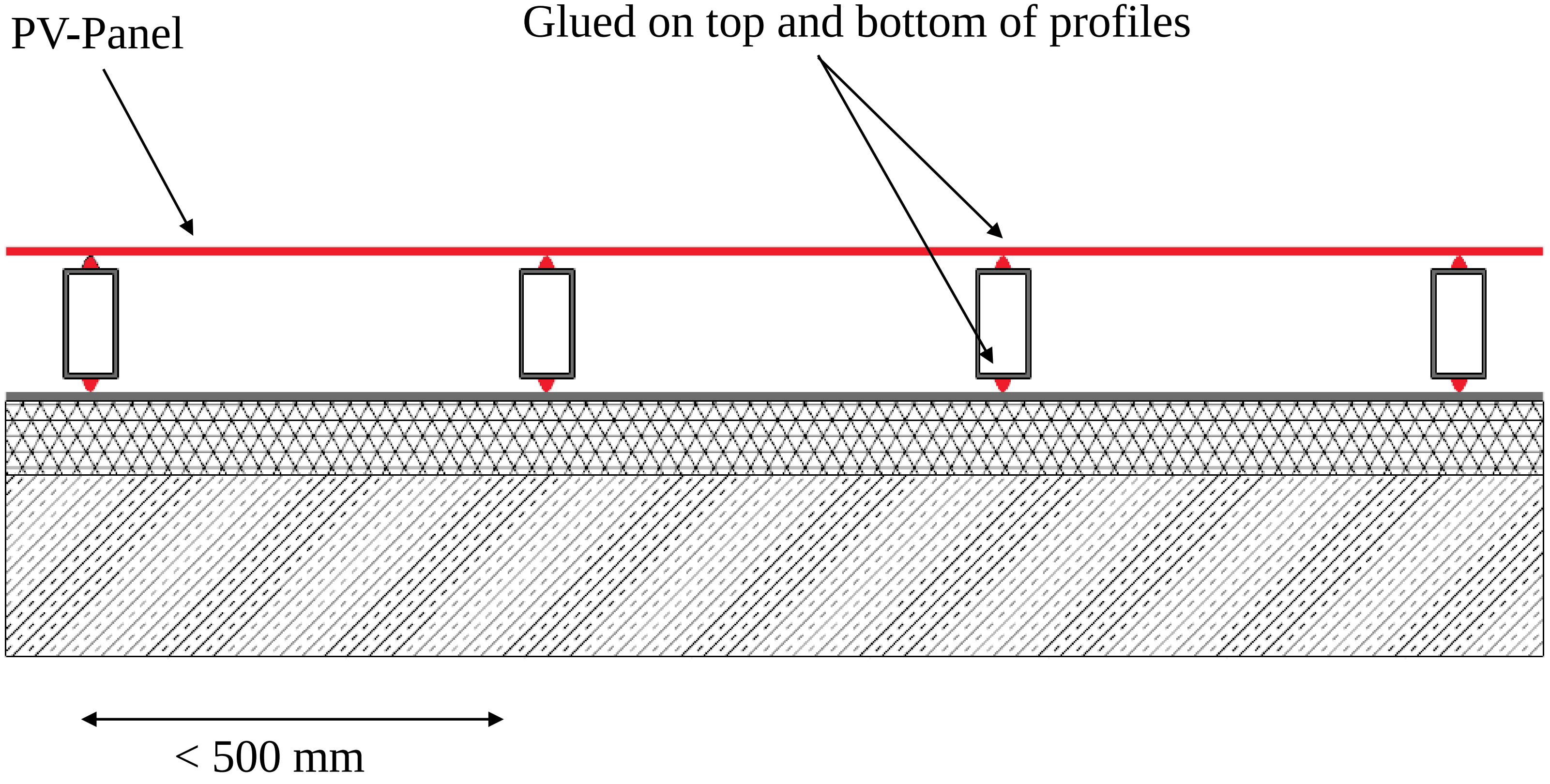


Flat metal sheets with sub-frame

- Flat metal sheets e.g. Kalzip or Klip-Lok Roof Sheeting
- On flat roofs an application is possible with using sub-frames only

Construction Method

Membranes with sub-frame



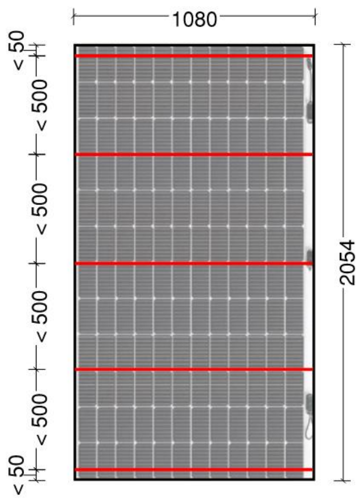
Membranes

with sub-frame

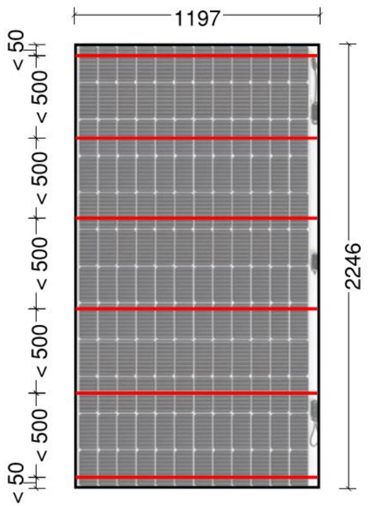
Membranes, PVC or EPDM or other material that are compatible with chosen adhesive product.

Construction Method

Panel Sizes and Maximum Gluing Distance



SMF 430



SMF 520

Panel Sizes

SMF 430
B = 1080mm
L = 2054mm

SMF 520
B = 1197mm
L = 2246mm

Maximum Gluing Distance

A maximum gluing distance of 50cm must be guaranteed.

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Glue Joint Resistance

The characteristic glue joint resistance needs to be obtained and verified from a glue manufacturer according to European standards.

The design glue joint resistance is either

approved by **ETAG (recommended)**, with independent testing and safety factors included in the "design strength" eliminating the need for reduction factors or

not approved by ETAG and needs reduction according to **Eurocode** based partial safety factors. The characteristic glue joint resistance should be verified by the adhesive manufacturer - non-approved products typical rely on testing and data from the manufacturer)

Note: Testing is generally required by all manufacturers to verify there is sufficient bond between the adhesive and the roof surface.

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Design

Characteristic Glue Joint Resistance

- The **characteristic glue joint resistance** R_k refers to the minimum resistance provided by the adhesive and cohesive strengths of the glue.
- **Adhesive strength** R_a
- **Cohesive strength** R_c

$$R_k = min(R_a | R_c)$$

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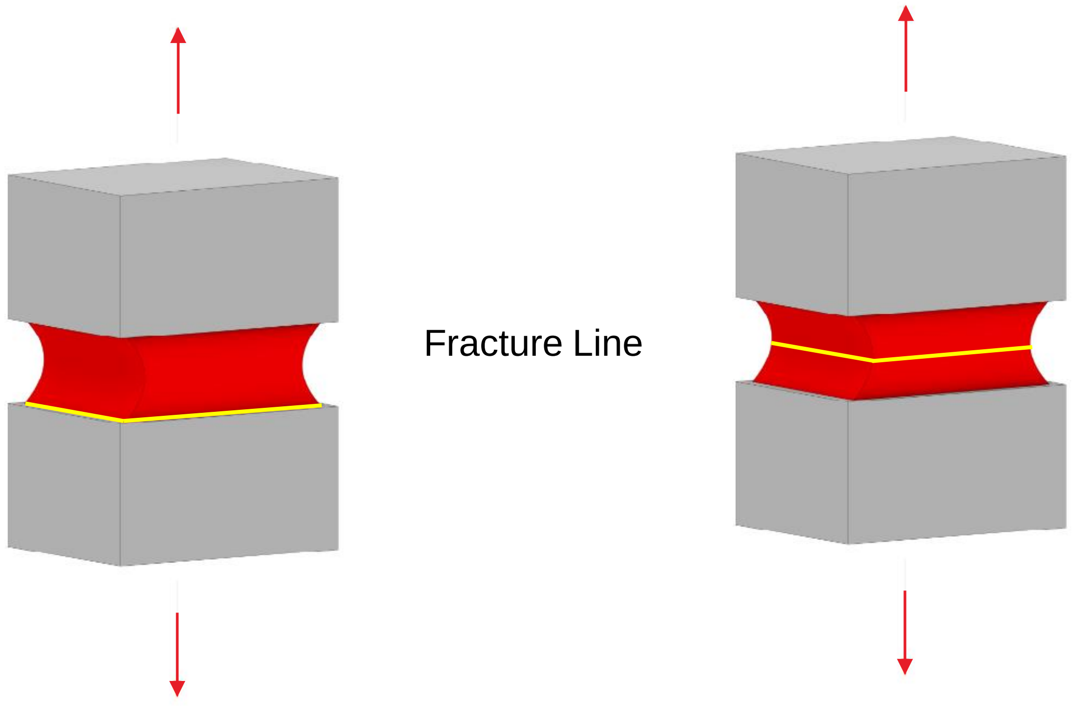
Design

Failure Modes



Adhesive Strength **Cohesive Strength**

Adhesive strength

The adhesive strength is measured by pulling back two bonded substrates in a direct tension and peeling motion. It depends on the type of adhesive, the materials being bonded, the surface preparation, and the environmental conditions. An adhesive failure is where there is no adhesive on one surface after testing.

Cohesive strength

The cohesive strength is the peak force an adhesive can withstand when stretched apart, divided by its cross-sectional area, indicating the adhesive's ability to resist loads under stress without failure. A cohesive failure is where there is adhesive on both services indicating the tensile capacity of the adhesive is governing.

Design

Compatibility Testing & Failure Modes

Adhesive Failure
(to be avoided)

Cohesive Failure
(desired)

Failure Modes & Consequences

A peel test following a recognized testing procedure (e.g., EN/ISO) is typically required to verify the bond between the adhesive and substrate.

If a 100% cohesive failure is observed, then the design tensile strength of the glue is the governing factor and can be used for determining the glue width required.

If adhesive or mixed failure is observed, it indicates that the bond between the glue and the surface is weaker than the glue itself, and thus becomes the governing factor. This requires individual testing (e.g. pull test) to determine the adhesive strength of the bond. The product design tensile strength can no longer be used as a basis for calculating glue thickness This should be avoided if possible.

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Design

Design Glue Joint Resistance

Eurocode

- Characteristic glue joint resistance R_k
- Material safety factor $\gamma_M = 1.3$
- Factor influencing ageing and freeze-thaw cycles $K_A = 1.6$
- Influencing factor for ambient temperature $K_T = 1.0$
- These factors are based on precedence for similar applications.
- The characteristic glue joint resistance R_k is divided by approx. 2.1

$$R_d = \frac{R_k}{\gamma_M \, K_A \, K_T}$$

ETAG

If the glue is ETAG approved, the design strength R_d is typically specified in the datasheet, eliminating the need for further reduction factors.

Design

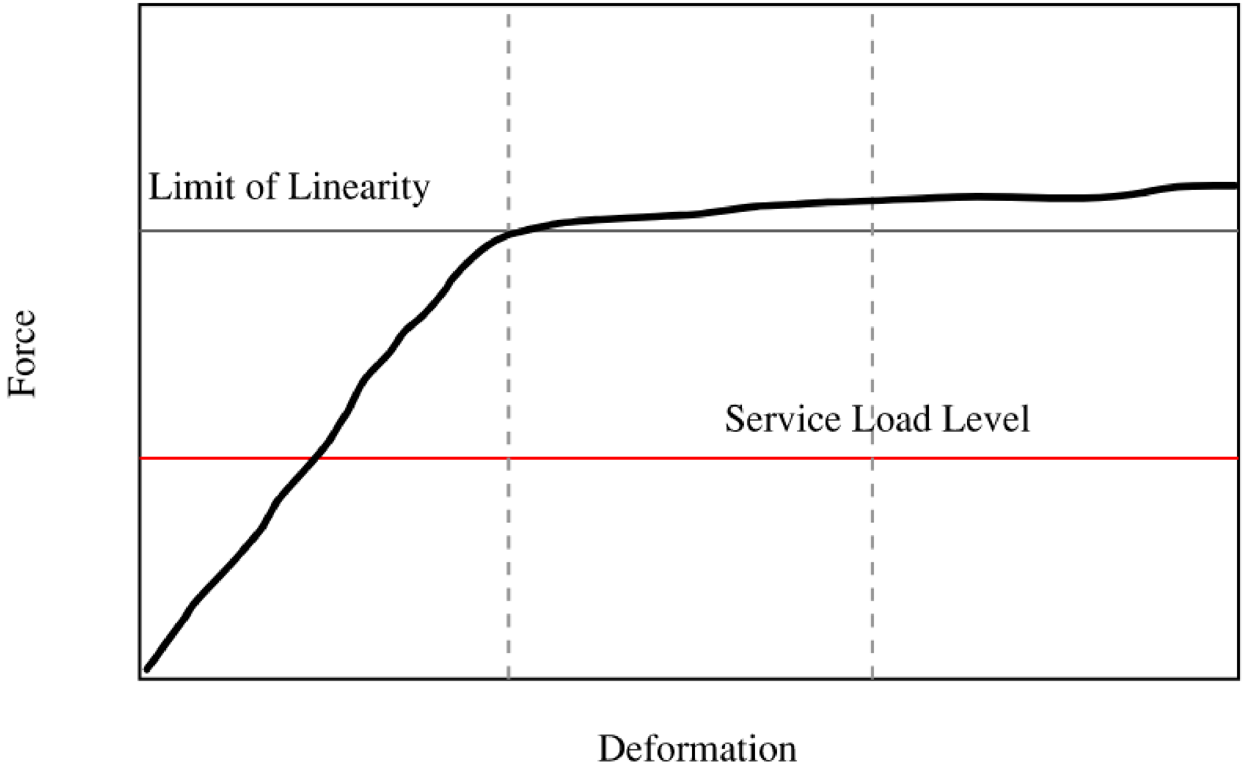
Design Action and Design Resistance

- The structural safety must be verified according to Eurocode standards for the **Ultimate Limit State** of bearing capacity.
- The design action w_d is the design wind suction.
- The design resistance R_d of the adhesive results from the **adhesive design strength** and the **cohesive design strength**.

$$w_d \leq R_d$$

Design

Linear Material Behavior



Linear Material Behavior

The intention of safety factors in relation to linearity is to ensure that linear material behavior is maintained under characteristic (unfactored) conditions, providing a reliable and predictable response under all expected load conditions.

Under characteristic conditions (Service Load Level), there should be no permanent deformations.

Design Tables

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Design Tables

The design tables are used for the preliminary design of solar panels. The **highest design wind loads** for various roof areas in the specified countries are considered, and the required adhesive width is determined for a gluing distance of 0.5m, based on the following adhesive products:

- Sika Sikasil® SG-20
- Dowsil ® 895

Note:
The glue joint resistance is provided by the adhesive manufacturer and is only valid if sufficient bond between the surfaces has been verified (e.g. cohesive failure from peel test).

Otherwise, R_d should be calculated using the procedure outlined in this report, based on the characteristic strength R_k provided by the manufacturer.

Glue height and width to be installed according to manufacturer’s guidelines.

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Design Table

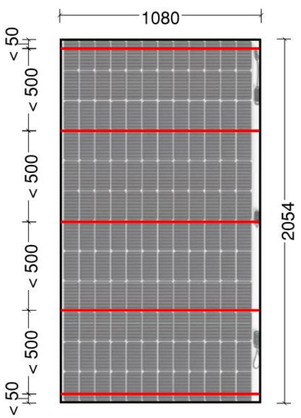
Sika – Sikasil SG-20 – Cohesive Strength

The **highest** design wind loads from all specified countries are considered in this table.

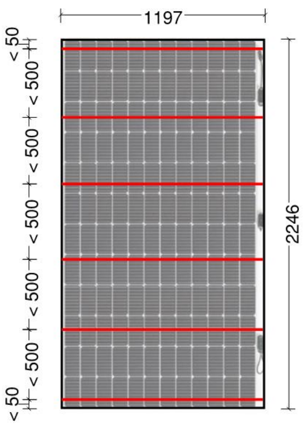
		F	G	H	
Roof Coefficient	c_{pe}	2,5	2,0	1,2	-
Additional Factor	X	1,2	1,2	1,2	-
Partial Safety Factor	ψ	1,5	1,5	1,5	-
Char. Wind Load	w_k	4,3	3,5	2,1	kN/m²
Design Wind Load	w_d	6,5	5,2	3,1	kN/m²
Wind Load	w_d	3,3	2,6	1,6	kN/m
Gluing Width	w	19	15	9	mm - required
Gluing Width	w	20	20	10	mm - rounded to next 10mm
Check	eta	96%	77%	92%	utilization

Assumptions

Gluing distance	0,5 m
Glue Manufacturer	Sika Sikasil SG-20
Glue joint resistance R_d - design	0,17 N/mm²



SMF 430



SMF 520

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Design Table

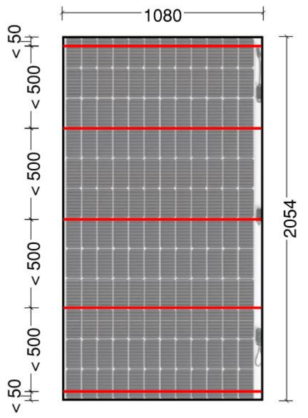
Dowsil 895 Structural Glazing - Cohesive Strength

The **highest** design wind loads from all specified countries are considered in this table.

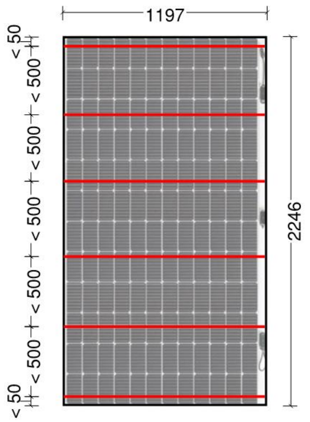
		F	G	H	
Roof Coefficient	c_{pe}	2,5	2,0	1,2	-
Additional Factor	X	1,2	1,2	1,2	-
Partial Safety Factor	ψ	1,5	1,5	1,5	-
Char. Wind Load	w_k	4,3	3,5	2,1	kN/m²
Design Wind Load	w_d	6,5	5,2	3,1	kN/m²
Wind Load	w_d	3,3	2,6	1,6	kN/m
Gluing Width	w	23	19	11	mm - required
Gluing Width	w	30	20	20	mm - rounded to next 10mm
Check	eta	77%	93%	56%	utilization

Assumptions

Gluing distance	0,5 m
Glue Manufacturer	Dowsil 895
Glue joint resistance R_d - design	0,14 N/mm²



SMF 430



SMF 520

Note: Instead of 5 lines of 30 mm, 8 lines of 20 mm are also possible.

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Design Table

Required gluing width

Required gluing width (mm)

mm		w_d					
R_k	R_d	2,0 kN/m²	3,0 kN/m²	4,0 kN/m²	5,0 kN/m²	6,0 kN/m²	7,0 kN/m²
0,10 N/mm²	0,05 N/mm²	21	31	42	52	62	73
0,15 N/mm²	0,07 N/mm²	14	21	28	35	42	49
0,20 N/mm²	0,10 N/mm²	10	16	21	26	31	36
0,25 N/mm²	0,12 N/mm²	8	12	17	21	25	29
0,30 N/mm²	0,14 N/mm² *	7	10	14	17	21	24
0,35 N/mm²	0,17 N/mm² **	6	9	12	15	18	21
0,42 N/mm²	0,20 N/mm²	5	7	10	12	15	17

* R_d *matches the provided cohesive design strength for Dowsil 895*

** R_d *matches the provided cohesive design strength for Sikasil SG-20*

Design Table

This design table specifies the required gluing width (mm) for various design wind loads w_d and cohesive design resistance values R_d.

Intermediate values can be linearly interpolated to achieve precise requirements.

$$R_d = \frac{R_k}{\gamma_M \, K_A \, K_T} \approx \frac{R_k}{2.1}$$

Required Gluing Width

$$w_{req} = \frac{w_d * B}{R_d}$$

B= $500mm\ (max.\, gluing\ distance)$

Checks on Roof Substructure

Adhesive Application and Structural Assessment Requirements

- An adhesion test to verify compatibility is required up to this point.
- Detailed calculations should be performed based on this design guide if applicable or separate load calculation if outside the parameters.
- Verification of the roof substrate or substructure is necessary to assess tying down forces.
- Determine the exact layout and width of the glue lines for the chosen product.
- Identify the surface preparation required, including cleaning, priming, etc.

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Approval/ Permission

Local building regulations

- It is the responsibility of the building owner or project developer to ensure compliance with the necessary planning requirements and to determine if planning permission is required.
- Additional certified testing of adhesives or the system may be necessary as part of project-based construction approval or by local building authorities. The following information is typically required
    - Structural Calculations – PV, Subframe and Adhesives
    - Structural Verification – existing roof structure
    - Certified testing data

Construction

Installation and Compliance Protocols

- Installation must be performed exclusively by qualified companies.
- Assembly instructions should be followed as provided by the manufacturer.
- Documentation of the building process, including photos of the preparation, cleaning and quality control measures is highly recommended.

Completion and Maintainance

Establishing Maintenance and Inspection Guidelines

- The operator must create detailed operating instructions.
- Regular tasks should include cleaning and inspecting contact surfaces for any unwanted deformations, as well as checking the adhesive surfaces.
- The inspection intervals should be determined. Typically, annual visual inspections are recommended.
- An independent inspection by a specialized company should occur at extended intervals, potentially every five years and possibly including an adhesion test.

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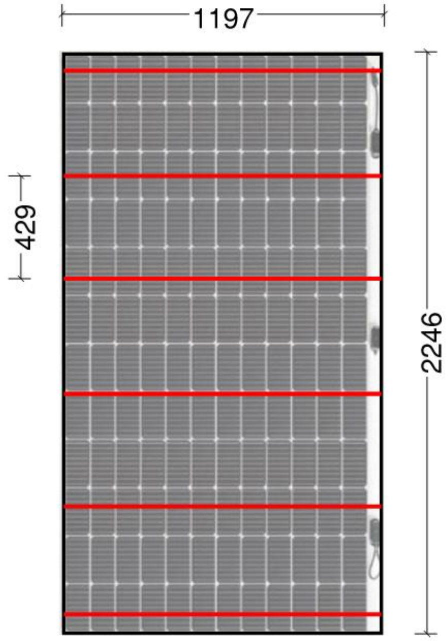
Example Calculation

Example of Detailed Calculation

Input Parameters

- Germany
- Wind Zone II
- Terrain Category II
- Building Height: 20m
- Building Size: 200m x 50m
- Panel Size: SMF 520
- Glue Lines: 6
- Adhesive: Dowsil 895



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Design Guidance

Design Example

Base Velocity Pressure

Country	Germany	
Wind Zone	II	
Fund. Basic Wind Velocity v_{b0}	25 m/s	*page 7*
Base Velocity Pressure q_p	0,39 kN/m²	*page 7*

Gust Speed Pressure

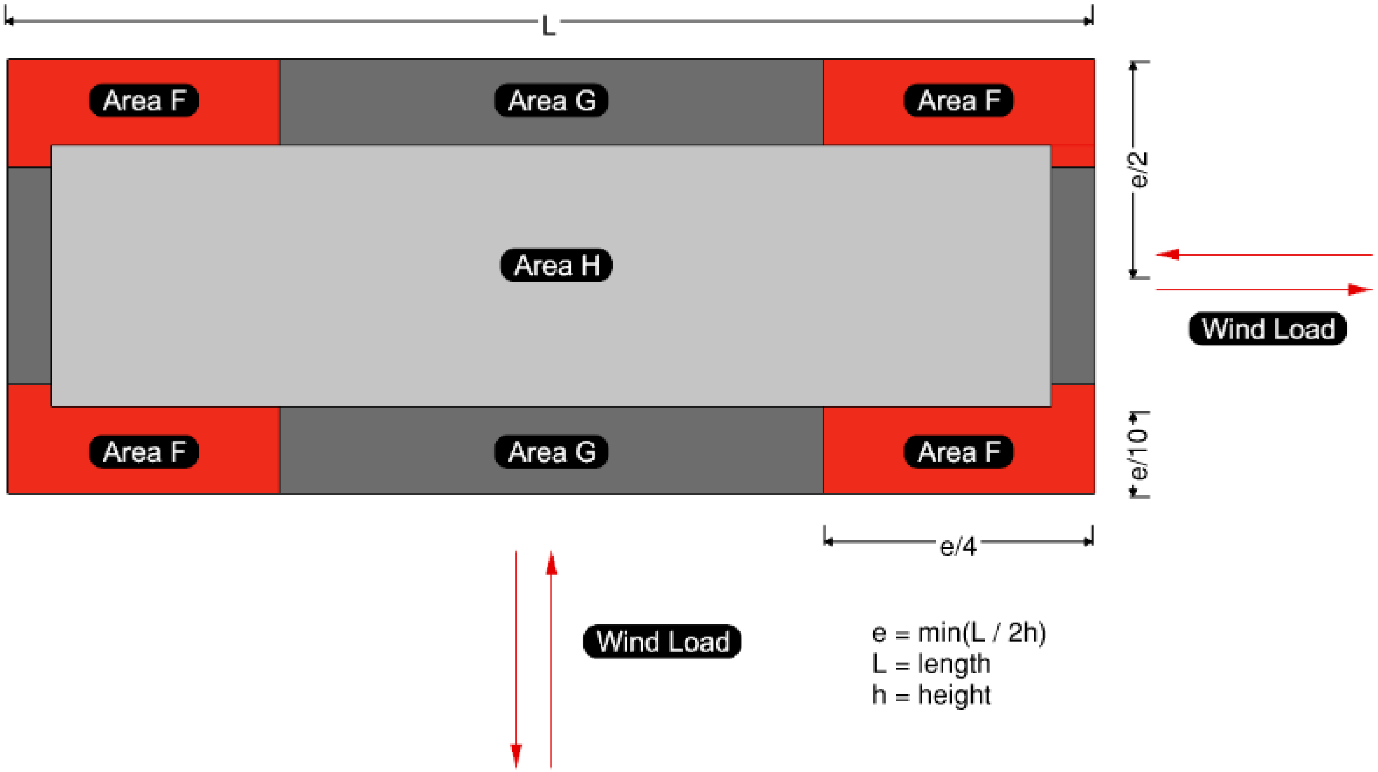
Terrain Category	II	*page 14*
Building height	20,0 m	$h \leq 25m$ - page 4
Gust Speed Pressure $q_p(z)$	1,15 kN/m²	*page 15*

Determine design wind loads

- Base Velocity Pressure
- Gust Speed Pressure

Design Guidance

Design Example



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Determine design wind loads

- Base Velocity Pressure
- Gust Speed Pressure
- Roof areas

Flat Roof

Flat roofs with a slope of less than 5%

	Length	Width
Dimension	200 m	50 m
Parameter e	40 m	40 m
e/10	4 m	4 m
e/4	10 m	10 m

Design Guidance

Design Example

Loading Factors

Additional factor χ	1,20	*page 16*
Partial safety factor ψ	1,50	*page 17*

Design Wind Load

External pressure coefficients for flat roofs with a slope of less than 5%

	F	G	H	
Coefficients	2,50	2,00	1,20	*page 19*
w_k	3,5 kN/m²	2,8 kN/m²	1,7 kN/m²	$w_k = q_p(z) \times c_{pe,1} \times \chi$
w_d	5,2 kN/m²	4,1 kN/m²	2,5 kN/m²	$w_d = w_k \times \psi$

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Determine design wind loads

- Base velocity pressure
- Gust speed pressure
- Roof areas
- Coefficients for roof areas
- Design wind loads for each roof area

Design Guidance

Design Example

Design of Gluing

Gluing distance	0,43 m	SMF 520
Adhesive resistance R_d	0,14 N/mm²	Dowsil 895
Utilization aim	80%	

	F	G	H	
w_d	5,2	4,1	2,5	kN/m^2
Gluing width	16	13	8	mm
Gluing width	20	20	10	mm - 80% and rounded
Gluing width	20	20	20	mm - max width
Check	79%	63%	38%	utilization

$$Gluing\ width = \frac{w_d \times distance_{glue}}{R_d}$$

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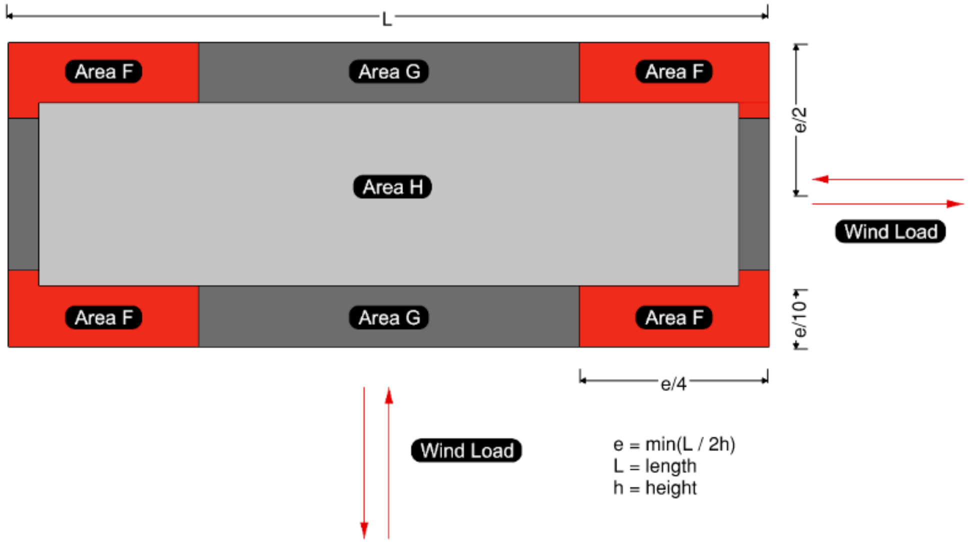
Determine the required gluing width

Note:
It is recommended to aim for a utilization of less then 80%.

Design Guidance

Design Example

	F	G	H	
w_d	5,2	4,1	2,5	kN/m^2
Gluing width	16	13	8	mm
Gluing width	20	20	10	mm - 80% and rounded
Gluing width	20	20	20	mm - max width
Check	79%	63%	38%	utilization



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Final gluing width for each roof area.

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