

Wind and Snow Loads LWS+

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Basic Documentation – Overview

In addition to the individual program manuals, you will find basic explanations on the operation of the programs on our homepage www.frilo.com in the Campus-download-section.

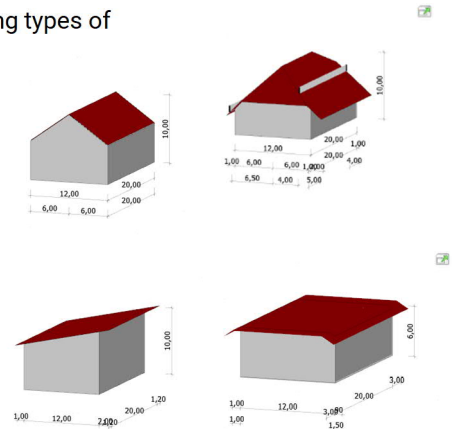
Application options

The software is suitable for the calculation of wind and snow actions on the following types of structures:

- Double-pitch roof
- Hip roof
- Single-pitch roof
- Flat roof with sharp-edged, bevelled or rounded eaves, or with a parapet.
Optional with Photovoltaic.

In addition:

- Snow drifts on superstructures
- Loads by down-sliding snow from abutting taller structures
- Canopies
- Wind-induced internal pressure in closed buildings
- Wind action on free-standing wall, pitched roof, pent roof
- Photovoltaic
- Trough roof



Pitched roof
Hipped roof
Pent roof
Flat roof
Drifted snow
Height difference
Porch
Wind-inside pressure
Free-standing wall
Wind at dupitched canopy roof
Wind at monopitched canopy roof
Photovoltaic
Trough roof

Standards

You can calculate the loads in line with the following standards:

- EN 1991-1-3:2010, EN 1991-1-4:2010
- DIN EN 1991-1-3/NA:2010/2019, DIN EN 1991-1-4/NA:2010/2019
- ÖNORM EN 1991-1-3:2013/2018/2022, ÖNORM EN 1991-1-4:2013/2018
- BS EN 1991-1-3:2015, BS EN-1-4:2011
- NTC EN 1991-1-3:2018, NTC EN 1991-1-4:2018
- PN EN 1991-1-3:2010, PN EN 1991-1-4:2010

The software calculates the site-specific basic wind velocity pressure q_b and the gust velocity pressure $q(z)$ on walls and roof surfaces with consideration of the defined geographic border conditions.

The aerodynamic coefficients and the resulting wind loads are calculated for areas = 10 m², for areas < 1 m² (uplift) and, optionally, for areas between 1 and 10 m² for upwind angles of 0°, 90°, 180° and 270°. For areas with alternating pressure and suction loads, always both values are put out.

The aerodynamic coefficients and the wind loads can be put out graphically and, optionally, in the form of tables.

The wind loads are calculated exclusively in accordance with the wind pressure coefficient method.

For structures with special geometric border conditions, such as chimneys, billboards, free-standing roofs, the code stipulates that wind loads be determined in accordance with the wind force coefficient method! Therefore, the present application CANNOT be used in these cases.

The software allows you to determine the ground snow loads and the resulting roof snow loads as well as the snow loads on the eaves at roof overhangs.

You can put out roof snow loads in a graphical representation and, optionally, also in the form of tables.

Basis of calculation

General

The software first calculates the basic wind velocity pressures for the different directions of approach as well as the ground snow load based on the specified geographic border conditions.

After the definition of the system parameters, the aerodynamic coefficients with the associated wind loads and/or roof snow loads are calculated.

For the special types 'wind-induced internal pressure' and 'wind on free-standing walls', only the wind loads and for 'snow drifts' and 'roofs abutting taller structures', only the snow loads are calculated.

You can find a calculation example for the LWS+ program here: [Calculation example \(in German\)](#)

Wind loads

The software first determines the basic wind velocity pressure q_b . Depending on the selected standard, the value must either be specified manually by the user or is proposed automatically based on the geographic border conditions.

By taking various coefficients and factors into account, the height-specific gust velocity pressure $q_p(z)$ can be calculated.

As shown in illustration 7.5, the gust velocity pressure $q_p(z)$ on all roof surfaces and walls is always calculated for the reference height z = ridge height.

The software allows a height-specific distribution of the gust velocity pressure over vertical walls in accordance with illustration 7.4 .

The external and internal pressures are calculated with the help of the aerodynamic coefficients for the different types of buildings.

Wind action on free-standing walls is calculated with the help of aerodynamic coefficients in accordance with paragraph 7.4.

For flat roofs with a parapet, the wind load on the parapet is calculated as for free-standing walls in accordance with paragraph 7.4.

EN 1991-1-4

Eurocode proposes the following equation for the calculation of the basic wind velocity pressure q_b :

$$q_b = \frac{1}{2} \cdot \rho \cdot v_b^2 \quad (4.10)$$

$$\text{with } v_b = c_{dir} \cdot c_{season} \cdot v_{b,0} \quad (4.1)$$

The directional and the seasonal factor can be set to 1 for reasons of simplification whereas the basic value of the basic wind velocity $v_{b,0}$ is imposed by the competent authority or the relevant National Annex.

The gust velocity pressure for the height z can be calculated from q_b with the help of the terrain factor as per (4.8) and (4.9):

$$q_p(z) = c_e(z) \cdot q_b$$

As shown in illustration 7.5, the gust velocity pressure $q_p(z)$ on all roof surfaces and walls is always calculated for the reference height z = ridge height.

The terrain factor c_e is determined with the help of various coefficients in the expression:

$$c_e(z) = [1 + 7 \cdot I_v(z)] \cdot c_r^2(z) \cdot c_o^2(z)$$

$$\text{with turbulence intensity } I_v(z) = \frac{k_I}{c_o(z) \cdot \ln \frac{z}{z_0}} \quad (4.7)$$

The turbulence factor k_I and the topographic factor c_o may be assumed 1.0 for simplification. Methods for the accurate calculation are proposed in the annex to EN.

The friction coefficient can be determined as follows:

$$c_r(z) = k_r \cdot \ln \frac{z}{z_0} \quad (4.4) \quad \text{with} \quad k_r = 0,19 \cdot \left(\frac{z_0}{z_{0,II}} \right)^{0,07}$$

The aerodynamic coefficients are specified for the different building shapes in paragraph 7.2. The wind loads are calculated using these factors:

$$\text{Exterior: } w_e = q_p(z) \cdot c_{pe}$$

$$\text{Interior: } w_i = q_p(z) \cdot c_{pi}$$

Wind action on canopies is not treated in the Eurocode (without NA).

The National Annexes may specify other methods and values!

In the text below, only the differences between the National Annexes are described:

DIN EN 1991

Equation 4.8 cannot be used for Germany because of the wind profile for this region. The gust velocity pressure is calculated as specified in annex NA.B instead.

In Germany, wind zones are distinguished in addition to terrain categories.

The tables NA.B.2 and NA.B.4 propose formulae for the determination of q_p and v_p for different terrain categories and wind zones.

In Germany, the aerodynamic coefficients stipulated by the Eurocode (without NA) are used in most cases. There are some tables for vertical walls and a supplement for flat roofs, however.

Wind action on canopies is calculated using the aerodynamic coefficients specified in annex NA.V.

ÖNORM EN 1991

Equation 4.8 cannot be used for Austria due to the applicable wind profile for this region. The stipulations for the calculation of the gust velocity pressure specified in annex NA.6.3.2.1 is used instead.

In paragraph 6.3.2.1, table 1 gives different expressions for the determination of q_p depending on the terrain category. In Austria, the categories 0 and I need not be taken into consideration.

Paragraph 9.2 contains standard-specific tables for wind pressure coefficients for wind action on the different types of buildings.

Wind action on canopies is calculated using the aerodynamic coefficients specified in paragraph 9.2.9.

Snow loads

The software first determines the ground snow load s_k based on the specified border conditions.

Subsequently, the roof snow load s_i can be calculated by taking various factors and the shape coefficients μ for the different types of buildings into account.

Depending on the selected type, the snow drift load and the snow load on the eaves are determined in addition with the help of shape coefficients.

You can optionally put out accidental snow loads for a given factor C_{esl} .

Another option allows you to put out the snow drift load cases for saddle-type roofs (case II and III).

If projections have been defined, the loads caused by overhanging snow at the eaves are determined. Because high roof snow loads in exposed locations may produce unrealistically high snow loads on the eaves, State Building Codes often provide factors to reduce the loads by overhanging snow.

Optionally, you can define snow guards and calculate the snow loads on these guards.

EN 1991-1-3

The Eurocode without NAs distinguishes in Annex C different climatic zones.

For each of these zones, table C.1 specifies a different expression for the determination of the ground snow load s_k :

Alpine Region	$s_k = (0,642 \cdot Z + 0,009) \cdot \left[1 + \left(\frac{A}{728} \right)^2 \right]$
Central East	$s_k = (0,264 \cdot Z + 0,002) \cdot \left[1 + \left(\frac{A}{256} \right)^2 \right]$
Central West	$s_k = 0,164 \cdot Z - 0,082 + \frac{A}{966}$
Greece	$s_k = (0,420 \cdot Z + 0,030) \cdot \left[1 + \left(\frac{A}{917} \right)^2 \right]$
Iberian Peninsula	$s_k = (0,190 \cdot Z + 0,095) \cdot \left[1 + \left(\frac{A}{524} \right)^2 \right]$
Mediterranean Region	$s_k = (0,498 \cdot Z + 0,209) \cdot \left[1 + \left(\frac{A}{452} \right)^2 \right]$
Norway	
Sweden, Finland	$s_k = 0,790 \cdot Z + 0,375 + \frac{A}{336}$
UK, Republic of Ireland	$s_k = 0,140 \cdot Z - 0,100 + \frac{A}{501}$

The snow load on the roof is calculated accordingly in the following equations:

$$s = \mu \cdot C_e \cdot C_t \cdot s_k \quad (5.1)$$

or $s = \mu \cdot C_e \cdot C_t \cdot s_k \cdot C_{esl}$ (5.2, 4.1) for accidental situations with a recommended $C_{esl} = 2,0$.

The environmental coefficient C_e and the thermal coefficient C_t can be defined by the user whereas the shape coefficients μ are determined in accordance with paragraph 5.3.

If there are projections at the eaves, you can optionally determine the loads by overhanging snow:

$$s_e = k \cdot \frac{s^2}{\gamma} \quad (6.4) \text{ whereby Eurocode recommends } \gamma = 3 \text{ kN/m}^3 \text{ as a specific weight and for } k = \frac{3}{d} \text{ with } k \leq d \cdot \gamma.$$

If snow guards have been defined, the snow loads on the guards can be calculated as follows:

$$F_s = s \cdot b \cdot \sin \alpha \quad (6.5)$$

Loads from snow drifts at walls, superstructures and canopies can be determined in accordance with paragraph 6.2:

$$\text{Regular snow load } s_1 = \mu_1 \cdot s_k \text{ with } \mu_1 = 0.8 \quad (6.1)$$

$$\text{and } s_2 = \mu_2 \cdot s_k \text{ with } \mu_2 = \gamma \cdot \frac{h}{s_k} \text{ and } \gamma = 2.0 \quad (6.1), \text{ whereby } 0.8 \leq \mu_2 \leq 2.0 \quad (6.2)$$

$$\text{and } l_s = 2 \cdot h \text{ with } 5\text{m} \leq l_s \leq 15\text{m} \quad (6.3)$$

The snow sliding off from taller structures is calculated in accordance with paragraph 5.3.4 as follows:

$$s_1 = \mu_1 \cdot s_k \text{ with } \mu_1 = 0.8 \quad (5.6) \text{ under the assumption that the lower roof surface is flat.}$$

$$s_2 = \mu_2 \cdot s_k \text{ with } \mu_2 = \mu_s + \mu_w \quad (5.7)$$

$$\text{The shape coefficient for snow drift is } \mu_w = \frac{b_1 + b_2}{2 \cdot h} \leq \gamma \cdot \frac{h}{s_k} \quad (5.8) \text{ with } 0.8 \leq \mu_w \leq 4.$$

It is permissible to set the shape coefficient for sliding-off snow μ_s to 0 if $\alpha \leq 15^\circ$. Otherwise, the value is assumed 50 % of the roof snow load of the abutting roof surface.

$$\mu_s = \begin{cases} 0 (\alpha \leq 15^\circ) \\ 0,5 \cdot \mu_{\text{Roofarea}} (\alpha > 15^\circ) \end{cases}$$

The length of the snow drift is $l_s = 2 \cdot h$ with $5\text{m} \leq l_s \leq 15\text{m}$ (6.3)

The National Annexes may specify other methods and values!

In the text below, only the differences among the National Annexes are described:

DIN EN 1991

The snow and climatic zones specified in Annex C are not relevant for Germany. The German NA specifies its own snow zones as shown on the map NA.1 and associated formulae for the calculation of the ground snow load s_k such as the equations specified by NA.1 to NA.3 including specific basic amounts.

The shape coefficients μ are taken over for the most part, except for the coefficients for adjacent roofs and roofs abutting taller structures, which are stipulated in the NCI to 5.3.4(4) and 5.3.6.

It is permissible to determine μ_w in accordance with (NA.4). The expressions (NA.5) to (NA.8) stipulate deviating limits for $\mu_w + \mu_s$.

For snow loads on the eaves, the German NA recommends setting the k coefficient to 0.4.

For the accidental situation, a factor $C_{esl} = 2.3$ should be assumed.

ÖNORM EN 1991

The snow zones and climatic zones specified in Annex C are not relevant for Austria. The Austrian NA specifies its own snow zones in NA Annex A and associated formulae for the calculation of the ground snow load s_k in NA Annex B.

The shape coefficients μ are taken over for the most part. Specific values are defined in 4.5.2 for μ_2 and barrel roofs.

4.5.2.3 specifies deviating limits for μ_w .

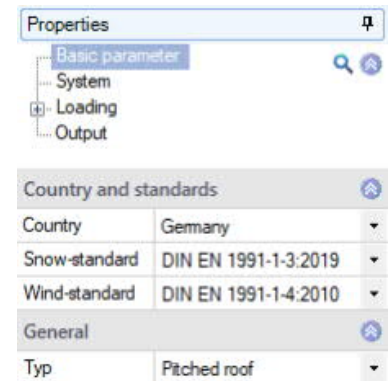
For snow loads on the eaves, the NA gives a separate formula in 4.6.2.

Data entry

Assistant

The [assistant](#) is launched as a standard/automatically when the program starts.

With the help of the assistant, you can quickly define a basic structural system and gain a first impression of the results. Subsequently, you can adjust secondary parameters in a second step.



Basic parameters

Under the basic parameters the country and thus the standard setting as well as the roof type can be selected/changed.

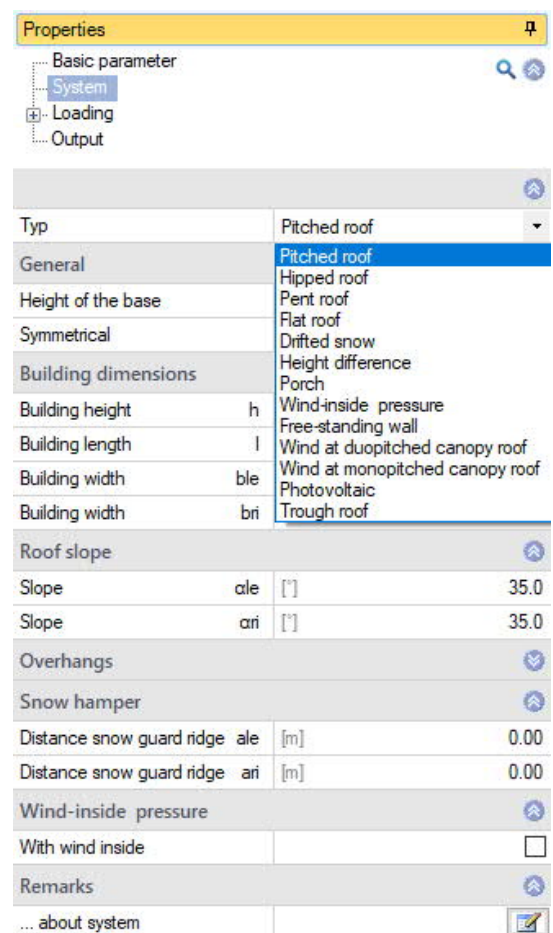
Note: The version of the load standard can also be set/changed under "[Loading](#)".
The [available standards](#) depend on your licences.

Structural system

Type select the [type of roof](#).

Height of the base optional additional height of the base point above the terrain if the base point is not on the site, but on another building, for example.

Symmetrical if this option is enabled, the symmetrical values are set automatically and are greyed out in the user interface.



Building dimensions

First, the values for a double-pitch roof are described. Values for other roof types are described subsequently.

Pitched / Pent roof

- h building height up to the ridge
- l building length (in ridge direction, from gable to gable)
- ble building width on the left side of the ridge (projection length)
- bri building width on the right side of the ridge (projection length)
- α_{le} roof pitch on the left
- α_{ri} roof pitch on the right
- ole roof overhang on the left
- ori roof overhang on the right
- o1 roof overhang at the front gable
- o2 roof overhang at the rear gable
- ble distance of the left snow guard to the ridge (if applicable)
- bri distance of the right snow guard to the ridge (if applicable)

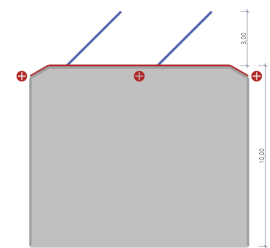
With wind-inside see the type [wind-induced internal pressure](#)

Hipped roof

- $\alpha 1$** hip pitch at the front gable
 $\alpha 2$ hip pitch at the rear gable
l1 pitch length (in the projection) at the front gable (bottom of the graph)
l2 pitch length (in the projection) at the front gable (bottom of the graph)

Flat roof

- b** building width (projection length)
Eaves design of the eaves:
 - sharp-edged
 - with parapet
 - bevelled
 - rounded
 - with circumferential parapet
hp,le parapet height on the left side
hp,ri parapet height on the right side
 α_{le} bevel pitch on the left side
 α_{ri} bevel pitch on the right side
ls,le bevel length on the left side
ls,ri bevel length on the right side
rle radius of left rounding
rri radius of right rounding



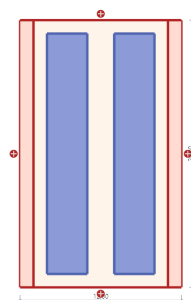
Snow due to attica Select whether the snow loads on the parapet should be determined as for superstructures (snow drift), or after recommendation of the design questions as for a vertical jump (height difference).

Photovoltaic system on flat roof

Optionally, you can define a photovoltaic system (PV system) for the flat roof.

The program only processes panel heights \leq length of the PV system.

The input parameters are explained in the info line when you click in an input field. Check the input via the various graphic views.



Snow drift

h / l / lx height, length and width of the superstructure

Height difference

- b** width of the main building
b3 effective building width (ridge to eaves) of the abutting side
 α_D pitch of the roof surface abutting the main building

With snow guard optionally, the snow can be prevented from slipping. Therefore, this snow load portion can be dispensed with on the annex

Accessible for snow clearance optionally, the roof can be accessible for snow clearance.

ht eaves height (of the main building)

b2 width of the annex

h2 height of the annex

h difference in height between the smaller building and the taller building (eaves).

Porch

h_f	ridge height of the building
b_G	width of the building
α_{ob}	roof pitch of the building
b_3	building width (ridge to eaves) of the abutting side
h_1	height of the canopy above ground level
b_1	width of the canopy
d_1	length (depth) of the canopy

Wind-inside pressure

Openings you can select whether the building is closed or, otherwise, the sides that are open: closed, open on one side, open on two sides across the corner, open on two opposite sides, open on three sides

h	building height
l	length of the building
b	width of the building
ΔA_{le}	total of openings on the left side
ΔA_{ri}	total of openings on the right side
ΔA_1	total of openings on the front side
ΔA_2	total of openings on the rear side

Free-standing wall

l	wall length
h	wall height
b	wall width
l_1	angle side length (with angular walls)
φ	Solidity ratio: 1 = solid wall ... 0.8 = wall with 20 % openings
ψ_s	shadowing factor for walls one behind the other, normally 0.3 to 1

Free-standing pitched roof

l_y	Roof length
l_x, l bzw. r	Roof width left or right
α_{li} bzw. r	Roof slope left or right
φ	Degree of obstruction for wind in the transverse/longitudinal direction of the building (lateral flow)

Free-standing pent roof

h, l	Roof height left
l_y, l_x	Length and width
α, φ	Roof slope and degree of obstruction

Photovoltaic

See [Photovoltaic system on flat roof](#).

Trough roof

As described under pitched roof, the valley height h_k is also queried.

Loading

See also the document "[Wind and Snow Loads-PLUS](#)"

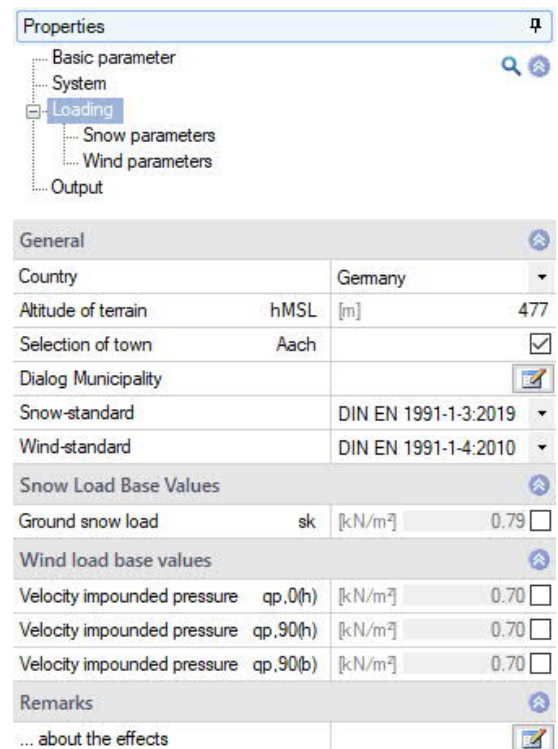
Depending on the selected standard, it is possible to select a municipality from a list. Certain values, such as the snow or wind zone, are pre-assigned based on the selected municipality. If the values are changed manually, the selected municipality is discarded.

The terrain height above sea level is also set.

An interface to HORA (www.hora.gv.at) has been integrated for ÖNORM EN 1991. To do this, select "Location" and open the map using the edit button. You can enter an address on the map or click directly on the map to display the values (height, snow load, basic wind speed) and accept them if necessary.

Ground snow load The ground snow load s_k can be adjusted manually here. In the case of a previously defined municipality, the data of the set municipality is discarded (municipality selection is deactivated).

Velocity impounded pressure The velocity impounded pressure per direction (0° , 90°) is preset by the program according to the standard and can be modified for further calculation (tick the option).



Snow loads

The available options depend on the selected standard.

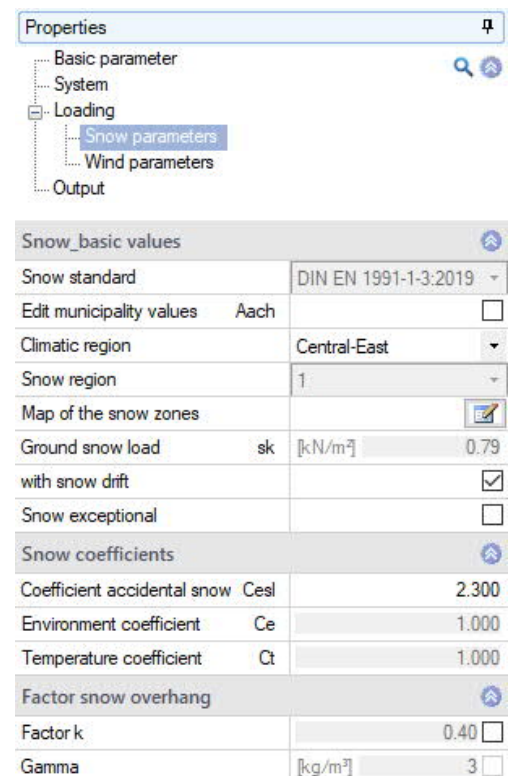
Climate region selection of the climate region for the snow load. The region is independent of the selected municipality. The displayed regions depend on the country and the selected standard.

Snow region if the snow zone was not set through the selection of the municipality, you can select it in this menu.

Snow drift option to take the alternative snow load cases automatically into account

Snow exceptional option to consider accidental snow loads
Cesl coefficient for accidental snow loads (e.g. 2.3 in the Northern Germany, in some regions, the coefficient is determined by the building authorities) see also EN 1991-1-3, 4.3 (1).

Environment coefficient to consider the reduction or increase of the snow load on a roof of an unheated building as a portion of the characteristic snow load on the ground.
 Windy = 0.8
Rather flat, unobstructed areas or areas that are poorly shielded by the terrain as well as high buildings or trees.



Typical = 1.0

Areas, in which the terrain prevents considerable snow clearance through wind as well as other buildings or spaces.

Shielded = 1.2

Areas, where the structures are considerably lower than the surrounding terrain, or structures that are surrounded by high trees or other high buildings. See also EN 1991-1-3, 5.2 (7)

Temperature coefficient considers the reduction of the snow load on a roof of a heated building that is caused by melting due to the heat flow through the roof.

Factor snow overhang Factor taking into account the irregular shape of the snow overhang.

Wind parameters

See also the multi-program document "[Wind and Snow Loads-PLUS](#)".

The available options depend on the selected standard

Wind region if the wind zone is not defined via the selection of the municipality, you can select it in this menu.

Category of terrain selection of the terrain category (depends on the selected standard), see also EN 1991-1-4, tab. 4.1. Some national Annexes possibly specify additional mixed categories.

- Category I:
Lakes or areas with low vegetation and without obstructions.
- Mixed category coast:
Lakes, coastal areas bordering the open sea.
- Category II:
Areas with low vegetation, such as grassland and individual obstructions (trees, buildings) that have a distance of at least 20 times their height to each other.
- Category III:
Areas with uniform vegetation or development or with individual objects that are closer to each other than 20 times the obstacle height (e.g. villages, suburban development, forest areas).
- Category IV:
Areas of which 15 % of the surface is covered with buildings of medium height taller than 15 m.

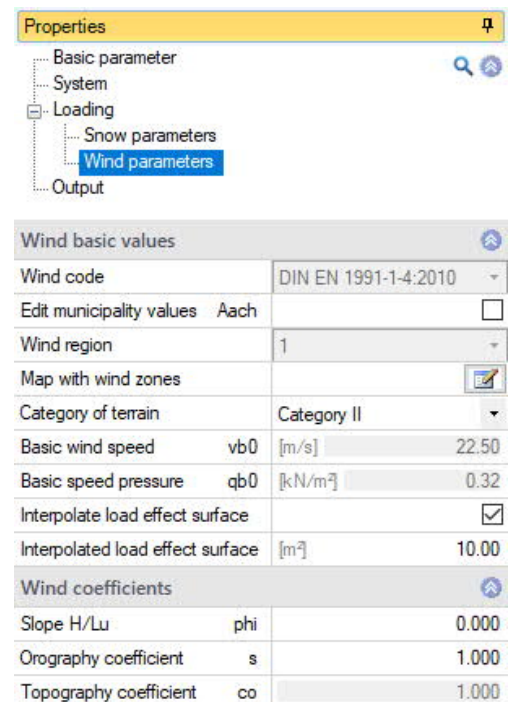
Basic wind speed to specify a value, disable the selection of the municipality (see above).

Basic speed pressure the indicated value qb0 is determined by the basic wind velocity.

Interpolate load-effect surface you can optionally consider a user-defined load-application area between 1 m² and 10 m². Interpolation of the cpe values (1 to 10).

Slope H/Lu specifies the value H/Lu in the flow direction. On isolated mountains, mountain chains or rocks, different wind speeds result from the slope of the ground surface. H refers to the height of the slope and Lu to the length of the slope, see also EN 1991-1-4, A.3 (1).

Orography coefficient factor as per EN 1991-1-4, figure A.2 for cliffs or offsets in the ground surface or A.3 for hilltops and hill crests, related to the effective length Le of the windward gradient.



Wind basic values			
Wind code	DIN EN 1991-1-4:2010		
Edit municipality values	Aach	<input type="checkbox"/>	
Wind region	1		
Map with wind zones			
Category of terrain	Category II		
Basic wind speed	vb0	[m/s]	22.50
Basic speed pressure	qb0	[kN/m ²]	0.32
Interpolate load effect surface	<input checked="" type="checkbox"/>		
Interpolated load effect surface	[m ²]		
10.00			
Wind coefficients			
Slope H/Lu	phi	0.000	
Orography coefficient	s	1.000	
Topography coefficient	co	1.000	

Topography coefficient	coefficient c_o as per EN 1991-1-4, 4.3.3. At places where the topography (e.g. mountains, cliffs etc.) increases wind speed by more than five percent, the speed increase is to be considered via the topography factor c_o .
CDir	coefficient for the wind direction (only in combination with EN 1991).
CSeason	seasonal factor (only in combination with EN 1991).

Output and results

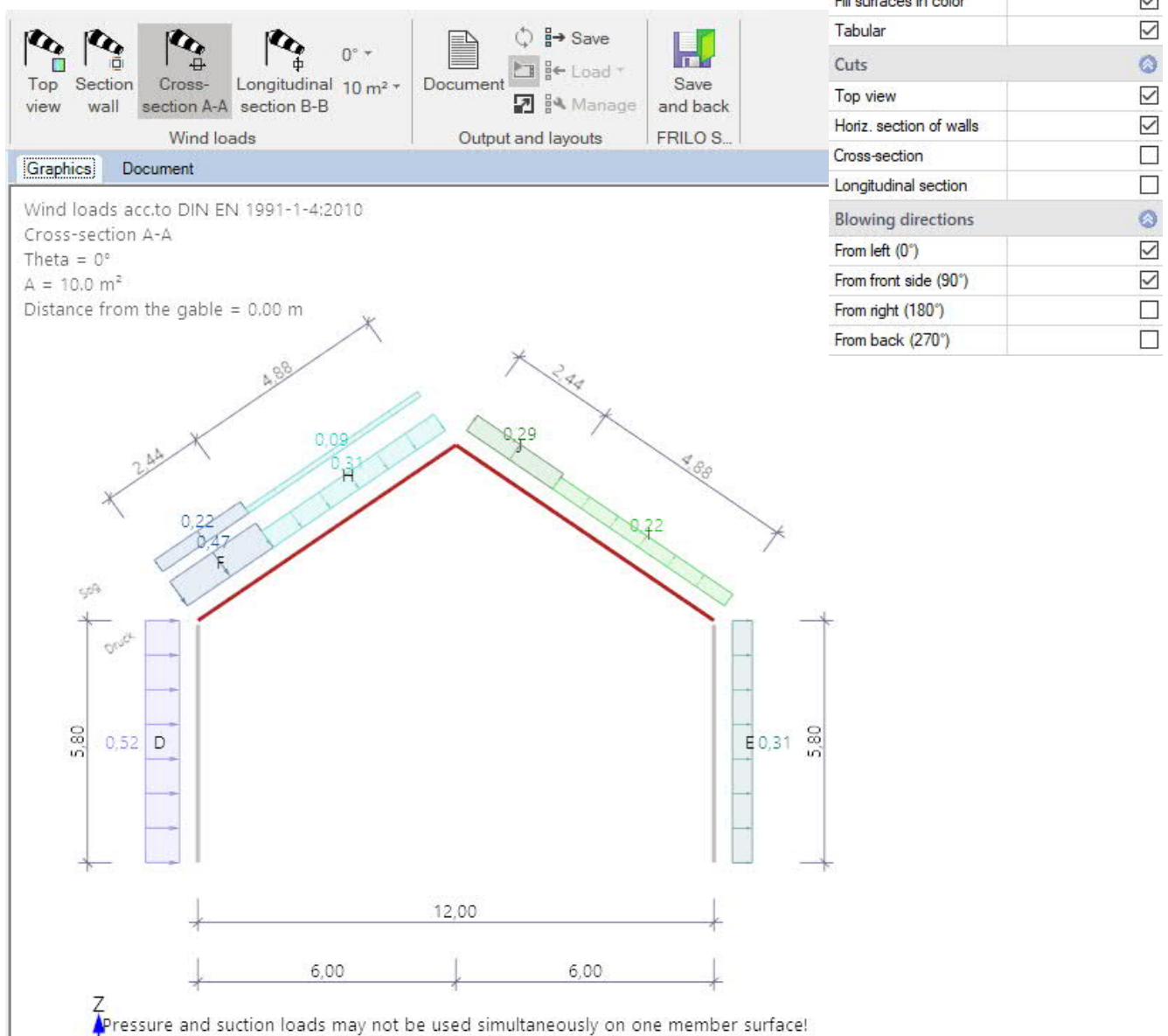
The 'Output' menu item allows you to define the scope of data to be put out by checking the desired options. To include additional contents, select 'comprehensive output'.

The output document can be accessed by clicking on the 'Document' tab (above the graphic screen).

See also [Output and printing](#).

Graphical representation

You can display the wind and snow loads via the corresponding buttons.



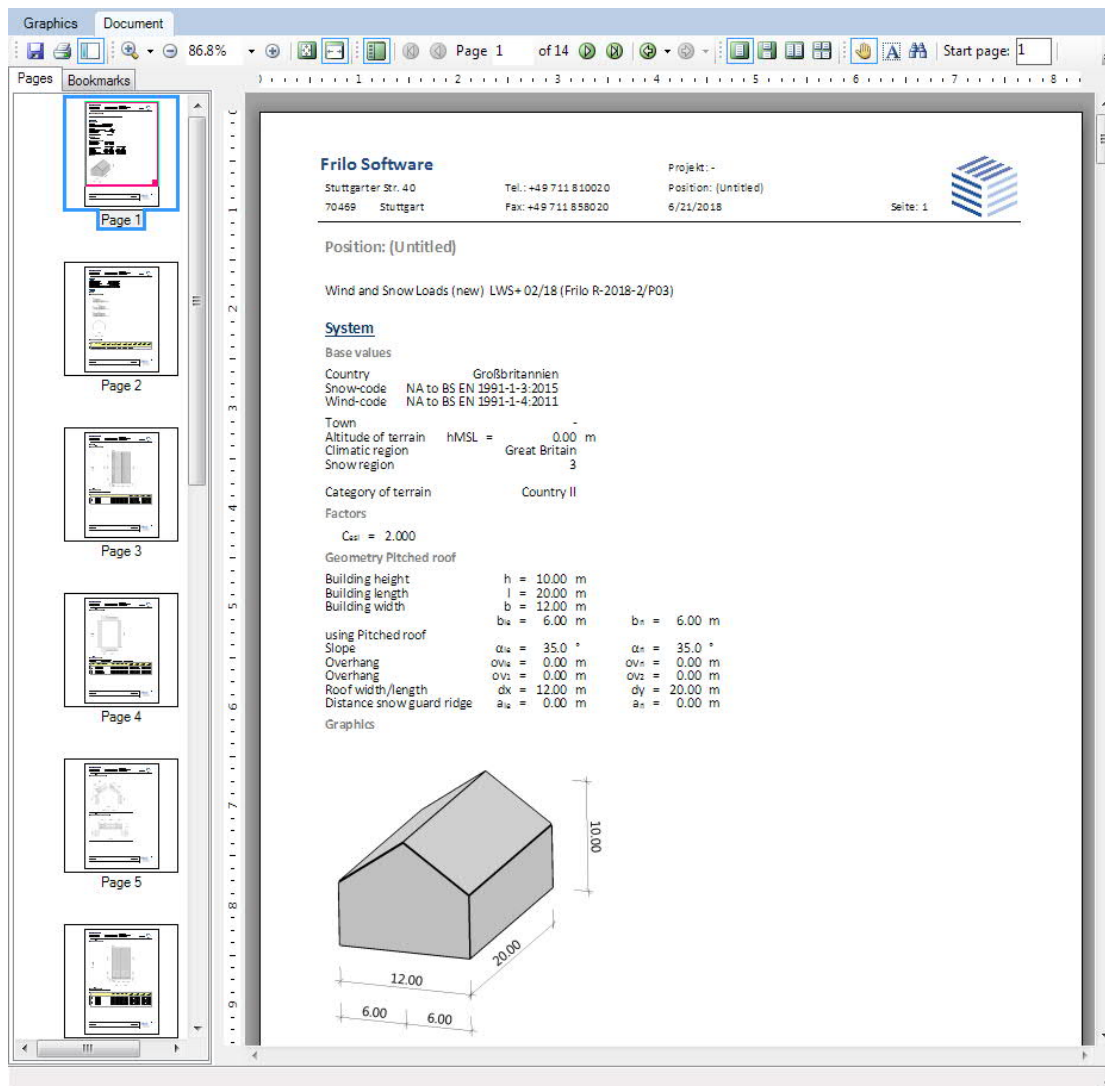


Fig.: The output document can be displayed via the 'Document' tab.