Steel Buildings
M.Sc. - 2010 II

DESIGN LOADS FOR SIMPLE BUILDINGS

Notes for Design Project
Practice 4 (4^{th} week)

1. GENERAL

The appropriate European Design Code: **EN 1991** Actions on Structures

The types of loads for simple duo pitch roofs:

- self weight
- weight of covering
- installation
- snow
- wind

1.1 The self weight of the structure

The weight of the steel: **77-78,5 kN/m^3**
The programs can take this load automatically into consideration.

1.2 The weight of covering system

It should be determined by analysis of the layers. The load may be taken into consideration as **0,4-0,6 kN/m^2**.

1.3 Installation load

This load is a distributed dead load on the roof given by the architectural or/and mechanical engineer. In the project it may be taken as **0,2 kN/m^2**.

1.4 Snow load

The snow load is specified by the **EN 1991-1-3**. The snow load for regular design situation is

$$s = \mu_i C_e C_t s_k$$

where

s snow load on the horizontal surface [kN/m^2];
μ_i shape factor;
C_e wind factor;

C_t heat factor;
s_k characteristic value of the surface snow load [kN/m^2].

The snow load in Hungary:

$$s_k = 0{,}25\left(1+\frac{A}{100}\right)\cdot\left[\frac{kN}{m^2}\right]$$
$$s_k \geq 1{,}25\frac{kN}{m^2}$$

where *A* [*m*] is the height of the ground to the Adria level. The wind factor:

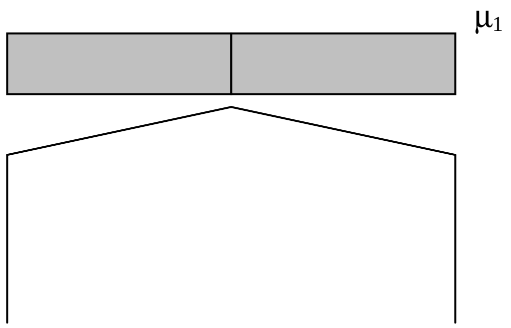
- high windy country: $C_e = 1{,}2$
- **low windy country:** $\boldsymbol{C_e = 1{,}0}$
- protected area: $C_e = 0{,}8$

The shape factor when the snow can slip from the roof:

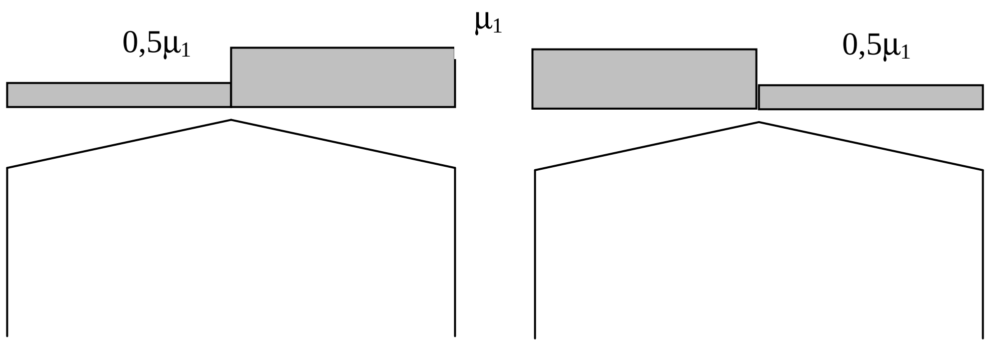
Slope of roof (α)	0° ≤ α ≤ 30°	30° < α < 60°	60° ≤ α
μ_1	0,8	0,8(60-α)/30	0,0

The types of snow distribution on the roof:

- **symmetric total distribution**



- **unsymmetrical distribution (now we can neglect this cases!)**



The heat factor is usually: $C_t = 1,0$.

NORNATIVE INFORMATION - The unusual snow weight is the following (do not use it):

type of snow	[kN/m³]
fresh snow	1,0
old snow	2,0
very old snow	2,5 - 3,5
humid snow	4,0

1.5 Wind load

1.5.1 General

The wind load acts on the surface perpendicularly. The wind load may be **compression** or **sucking**. The wind effect may be **external** or/and **internal**. The friction effect of the wind may be possible. The wind load is live load. The wind load is specified by the **EN 1991-1-3**. The wind effect is determined by the following parameters of the building:

- dimension
- shape
- dynamic properties

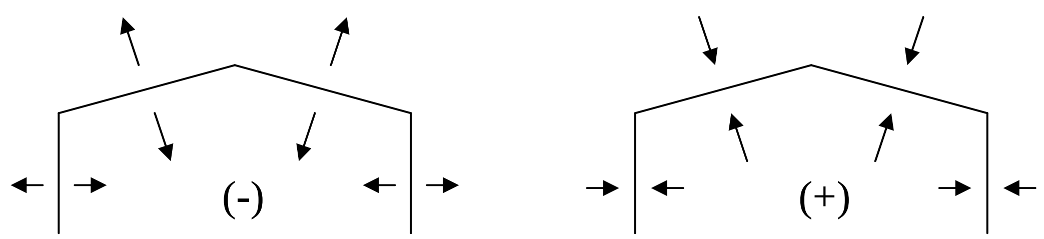
The external and the internal wind load may be calculated by the following expressions:

$$w_e = q_p(z_e) \cdot c_{pe}$$
$$w_i = q_p(z_i) \cdot c_{pi}$$

where

$q_p(z)$	- pressure for peak wind ;
z_e	- external reference height;
z_i	- internal reference height;
c_{pe}	- external wind pressure factor;
c_{pi}	- internal wind pressure factor.

The sign law for ***sucking*** and ***pressure***:



Both the external and internal reference heights for symmetric pitch roof which is not higher than the span of the building is equal to the height of the top point of the roof.

1.5.2 Wind pressure for the peak velocity wind

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

where

$c_e(z)$ - **exposure factor**;
q_b - **basic velocity pressure**

1.5.2.1 The basic velocity pressure

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

where the air density is

$$\rho = 1{,}25 \frac{kg}{m^3}$$

and the mean wind velocity is

$$v_m(z) = c_r(z) \cdot c_0(z) \cdot v_b$$

where
v_b basic wind velocity;
$c_r(z)$ roughness coefficient;
$c_0(z)$ orography coefficient.

The basic wind velocity in Hungary: $v_b = C_{DIR} \cdot v_{b0} = 0{,}85 \cdot 23{,}6 = 20 \frac{m}{s}$
The orography coefficient in on the flat country (slope is not greater than 5%): $c_0(z) = 1{,}0$
The roughness coefficient depends on the reference height:

- if $z < z_{min}$ than $c_r(z) = k_r \cdot ln\left(\frac{z_{min}}{z_0}\right)$
- if $z \geq z_{min}$ than $c_r(z) = k_r \cdot ln\left(\frac{z}{z_0}\right)$

where the terrain factor:

$$k_r = 0{,}19\left(\frac{z_0}{z_{0,II}}\right)^{0{,}07}$$

where $z_{0,II} = 0{,}05[m]$ (see the table below).

The roughness length z_0 and the z_{min} depends on the terrain category given in the below table:

terrain category		z_0 (m)	z_{min} (m)
I	lakes and flat and horizontal area	0,01	1
II	area with low cover	0,05	2
III	area with regular cover	0,3	5
IV	area which covered by buildings at least 15% and their average height exceeds 15 m	1,0	10

1.5.2.2 Exposure factor

The exposure factor shows that the peak velocity wind pressure is how much times grater than the basic wind velocity pressure:

$$c_e(z) = (1 + 7 \cdot I_v(z)) \cdot c_0^2 \cdot c_r^2$$

where the intensity of turbulence:

- if $z < z_{min}$ than $I_v(z) = \dfrac{k_I}{c_0(z) \cdot ln\left(\dfrac{z_{min}}{z_0}\right)}$
- if $z \geq z_{min}$ than $I_v(z) = \dfrac{k_I}{c_0(z) \cdot ln\left(\dfrac{z}{z_0}\right)}$

The turbulence coefficient usually $k_I = 1{,}0$.

1.5.3 The external pressure coefficient

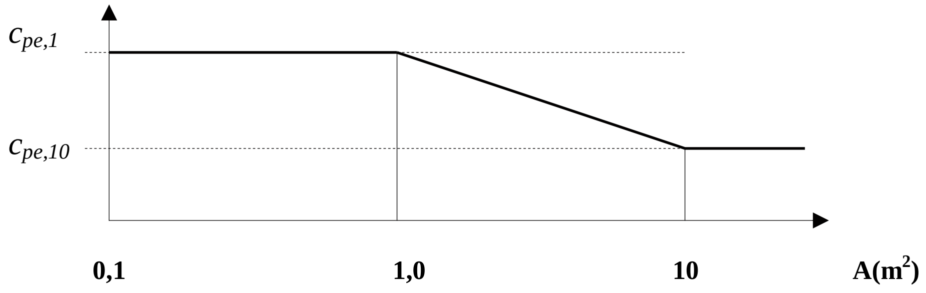
The external pressure coefficient depends on the **reference height** and the **loaded area**. The standard gives two values depending on the loaded area:

$c_{pe,1}$ - value for **1m^2** loaded area (for sheeting and purlin);

$c_{pe,10}$ - value for **10 m^2** loaded area (for main frame).

For $\boldsymbol{A}$ $\boldsymbol{m^2}$ area between the two values interpolation should be applied:

$$c_{pe,A} = c_{pe,1} - (c_{pe,1} - c_{pe,10}) \cdot lg_{10} A$$



The external pressure coefficients are given in tables:

- wind pressure on vertical walls (Annex 1)
- wind pressure on roof by cross wind ($\theta=0^0$; Annex 2)
- wind pressure on roof by longitudinal wind ($\theta=90^0$; Annex 3)

Very important law: on one roof surface the rows of the table can not be changed! This means that for example in case of 5 degree roof slope there are four variations of the wind pressure:

α	zones									
	F		G		H		I		J	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
5/1	-1,7	-2,5	-1,2	-2,0	-0,6	-1,2	-0,6	-0,6	+0,2	+0,2
5/2	-1,7	-2,5	-1,2	-2,0	-0,6	-1,2	-0,6	-0,6	-0,6	-0,6
5/3	0	0	0	0	0	0	-0,6	-0,6	+0,2	+0,2
5/4	0	0	0	0	0	0	-0,6	-0,6	-0,6	-0,6

1.5.4 The internal pressure coefficient

The external and the internal pressures may act in the same time, but the internal pressure may acts only with the external pressure. The c_{pi} internal pressure coefficient depends on the distribution of the openings.

In the case when there is a dominant surface on the building (a surface is dominant if the openings of the surface are more than the double of the openings of the other surfaces of the building). In this case:

$$c_{pi} = 0{,}75 \cdot c_{pe}$$

If the openings of the dominant surface are more than the triple of the openings of the other surfaces of the building:

$$c_{pi} = 0{,}90 \cdot c_{pe}$$

If there is no dominant surface and the distribution of the openings uniform, the internal pressure coefficient:

- $h / d \leq 0{,}25$

  - if $\mu \leq 0{,}33$ than $c_{pi} = 0{,}35$
  - if $\mu > 0{,}9$ than $c_{pi} = -0{,}3$
  - if $0{,}33 < \mu \leq 0{,}9$ than $c_{pi} = 0{,}726 - 1{,}14\mu$

- $h / d \geq 1{,}0$

  - if $\mu \leq 0{,}33$ than $c_{pi} = 0{,}35$
  - if $\mu > 0{,}95$ than $c_{pi} = -0{,}5$
  - if $0{,}33 < \mu \leq 0{,}95$ than $c_{pi} = 0{,}802 - 1{,}37\mu$

The μ opening coefficient:

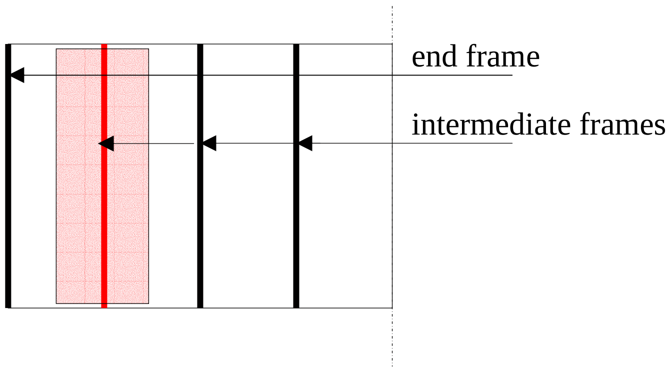
$$\mu = \frac{\sum A_{negatív}}{\sum A}$$

where $\sum A_{negatív}$ is the sum of the openings where c_{pe} is negative, $\sum A$ is the sum of the whole openings.

1.5.5 The design wind load

1.5.5.1 The wind load cases

The wind load is changing on the roof. Select the second frame for design:



The main wind load cases for the intermediate frame (example for *h/d<0,25*, $\alpha=5^0$ *and* $A>10m^2$):

- cross wind ($\theta=0^0$) and external pressure (Annex 4)
- cross wind ($\theta=0^0$) and external + internal pressure (Annex 5)
- longitudinal wind ($\theta=90^0$) and external pressure (Annex 6)
- longitudinal wind ($\theta=90^0$) and external + internal pressure (Annex 7)

2 LOAD MODEL FOR COMPUTER APPLICATION

2.1 Design load combinations

For regular design the load combination specified by EN 1990 6.4.3.2. (6.10 equation):

$$\sum \gamma_{G,j} \cdot G_{k,j} + \gamma_{Q,1} \cdot Q_{k,1} + \sum \psi_{0,i} \cdot Q_{k,i}$$

where

γ_G partial factor for dead load (**1,35**)
$\gamma_{Q,i}$ partial factor for load *i* (for snow and wind: **1,5**)
$\Psi_{0,i}$ combination factor (for snow and wind: **0,5**)

The suggested design combination for simple and symmetric pitched roof buildings:

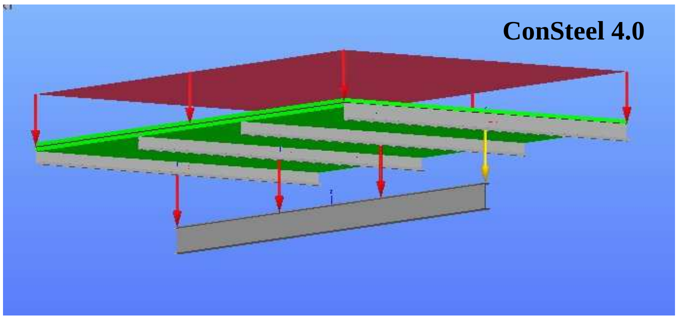
1. dead + snow
2. dead + snow (1) + wind_1
3. dead + snow (1) + wind_2
4. dead + snow (1) + wind_3
5. dead + snow (1) + wind_4
6. dead + wind_5
7. dead + wind_6

where

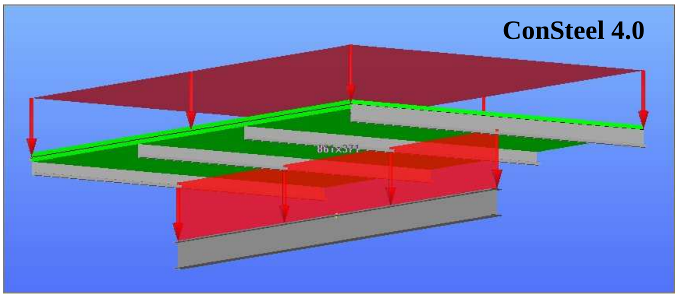
- **wind_1**: cross wind and external pressure (which case gives the lower sucking);
- **wind_2**: cross wind and external + internal pressure (which case gives the lower sucking);
- **wind_3**: longitudinal wind and external pressure (which case gives the lower sucking);
- **wind_4**: longitudinal wind and external + intrenal pressure (which case gives the lower sucking);
- **wind_5**: cross wind and external + internal pressure (which case gives the greatest sucking);
- **wind_6**: longitudinal wind and external + internal pressure (which case gives the greatest sucking);

2.2 Computer application

The load may be modeled as concentrated or distributed load on or along the structural members:



The concentrated loads may be replaced by distributed loads:



The needed load cases:

1. dead (+self weight automatically)
2. snow
3. wind_1
4. wind_2
5. wind_3
6. wind_4
7. wind_5
8. wind_6

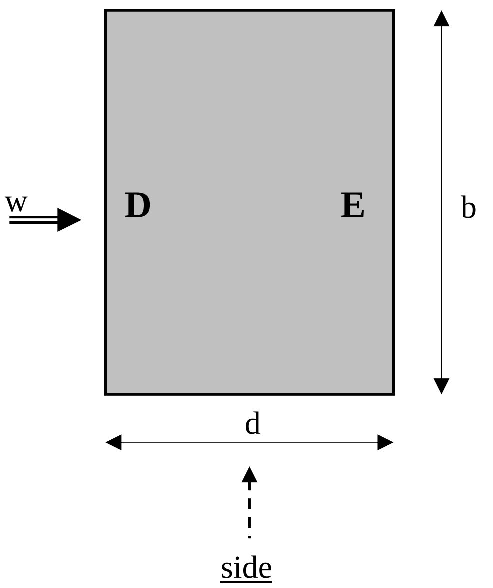
The needed load combinations:

1. 1,35×dead + 1,5×snow
2. 1,35× dead + 1,5×snow + 0,5×1,5×wind_1
3. 1,35× dead + 1,5×snow + 0,5×1,5×wind_2
4. 1,35× dead + 1,5×snow + 0,5×1,5×wind_3
5. 1,35× dead + 1,5×snoww + 0,5×1,5×wind_4
6. 1,0× dead + 1,5×wind_5
7. 1,0× dead + 1,5×wind_6

Annex 1: wind pressure on vertical walls

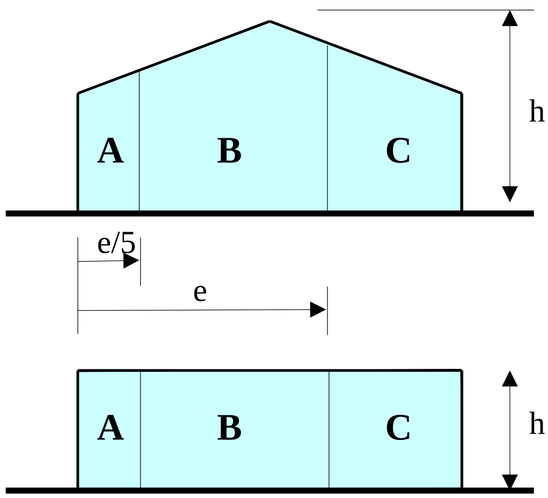
h/d	zone									
	A		B		C		D		E	
	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$	$C_{pe,10}$	$C_{pe,1}$
1	-1,2	-1,4	-0,8	-1,1	-0,5		0,8	1,0	-0,5	
≤0,25	-1,2	-1,4	-0,8	-1,1	-0,5		0,7	1,0	-0,3	

Top view

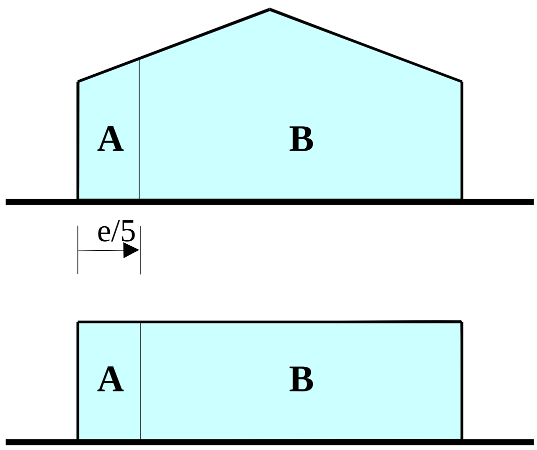


$e = min(b;2h)$

side zones e<d then:



Side zones e>d then:

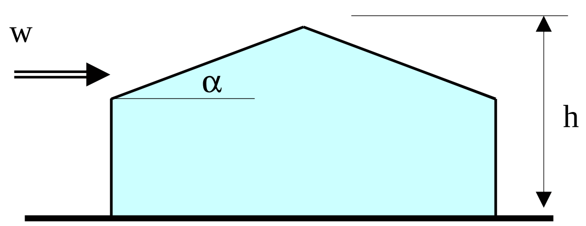


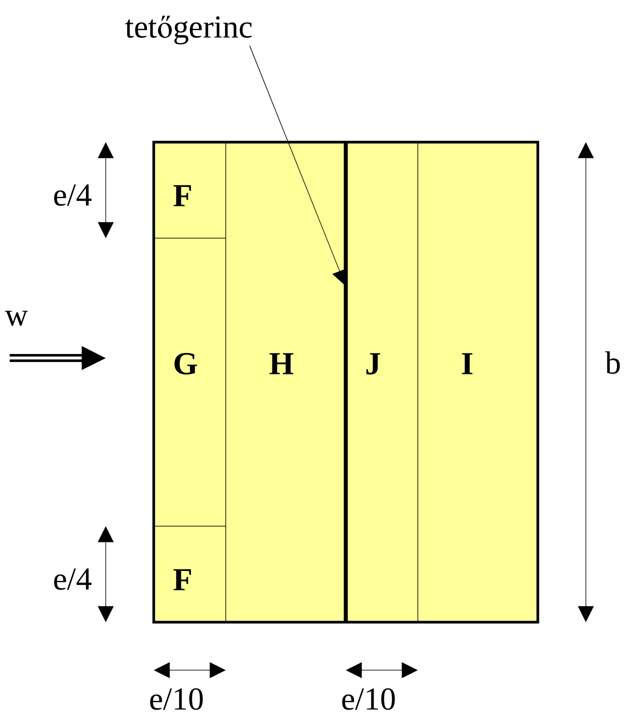
Notes!
The b is always the width of the wall which is loaded.
Cross wind ($\theta=0^0$) – *the longer side is loaded*
Longitudinal wind ($\theta=90^0$) – *the shorter side is loaded*

Annex 2: wind pressure on roof by cross wind ($\theta=0^0$)

α	zone									
	F		G		H		I		J	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
0	-1,8	-2,5	-1,2	-2,0	-0,7	-1,2	+0,2	+0,2	+0,2	+0,2
							-0,2	-0,2	-0,2	-0,2
5	-1,7	-2,5	-1,2	-2,0	-0,6	-1,2	-0,6	-0,6	+0,2	+0,2
	+0,0	+0,0	+0,0	+0,0	+0,0	+0,0			-0,6	-0,6
10	-1,3	-2,25	-1,0	-1,75	-0,45	-0,75	-0,5	-0,5	-0,4	-0,65
	+0,1	+0,1	+0,1	+0,1	+0,1	+0,1			+0,1	+0,1
15	-0,9	-2,0	-0,8	-1,5	-0,3	-0,3	-0,4	-0,4	-1,0	-1,5
	+0,2	+0,2	+0,2	+0,2	+0,2	+0,2	+0,0	+0,0	+0,0	+0,0

$\theta=0^0$



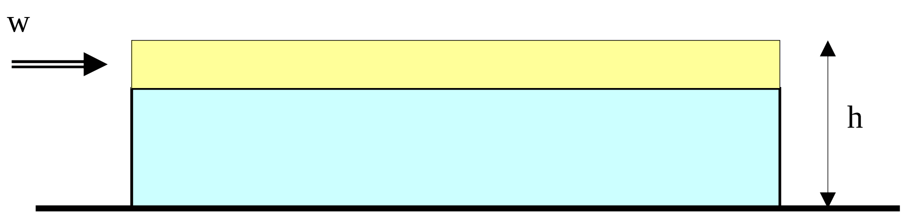


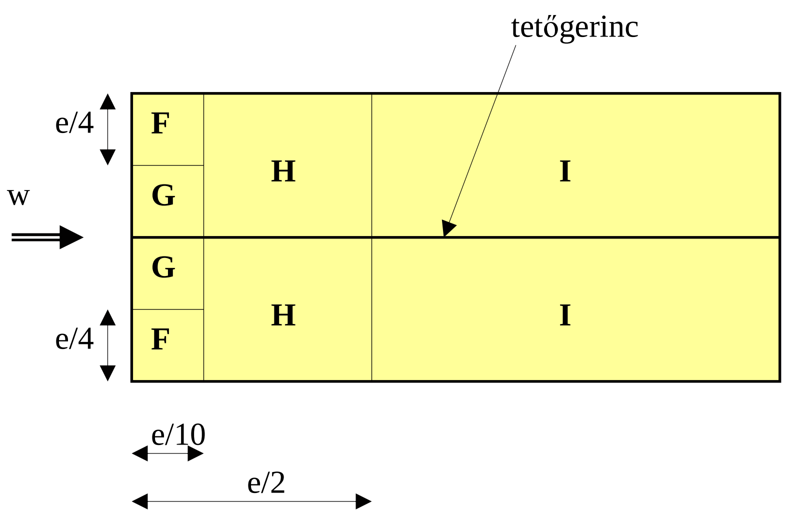
$e = min(b;2h)$

Annex 3: wind pressure on roof by longitudinal wind ($\theta=90^0$)

α	**F**		**G**		**H**		**I**	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
0	-1,8	-2,5	-1,2	-2,0	-0,7	-1,2	+0,2	+0,2
							-0,2	-0,2
5	-1,6	-2,2	-1,3	-2,0	-0,7	-1,2	-0,6	-0,6
10	-1,45	-2,1	-1,3	-2,0	-0,65	-1,2	-0,55	-0,55
15	-1,3	-2,0	-1,3	-2,0	-0,6	-1,2	-0,5	-0,5

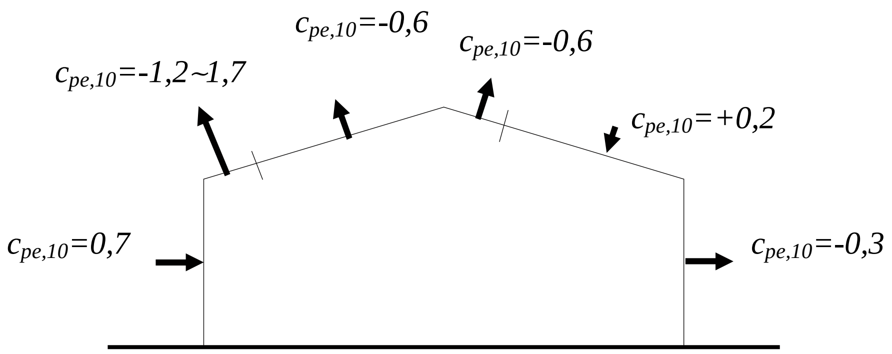
$\theta=90^0$



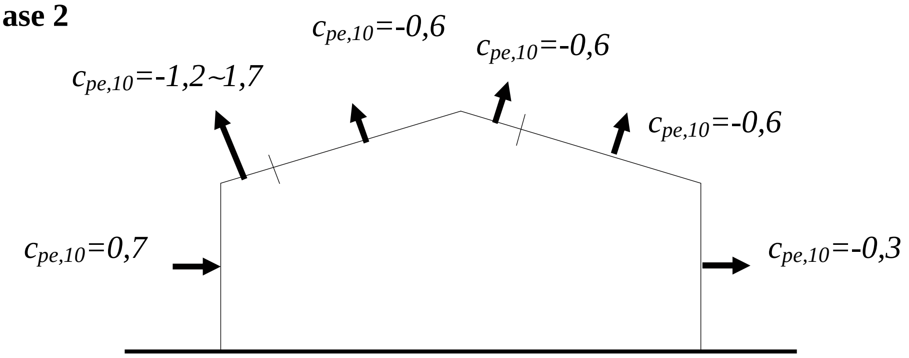


Annex 4: cross wind ($\theta=0^0$) and external pressure

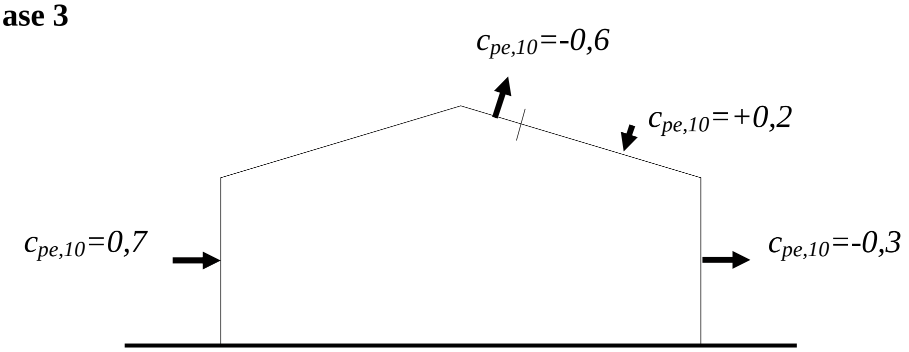
Case 1



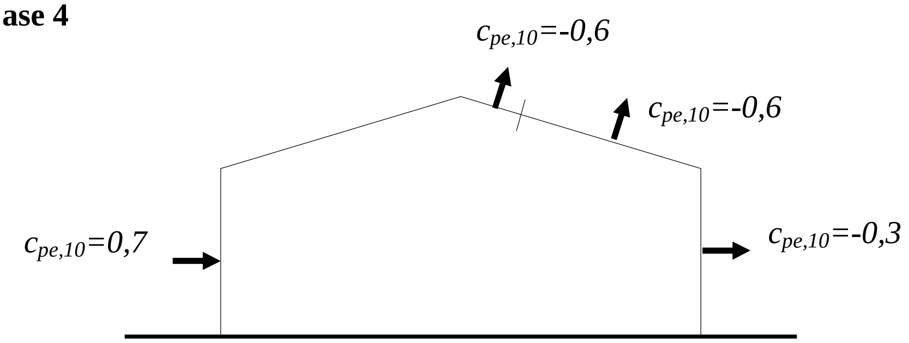
Case 2



Case 3

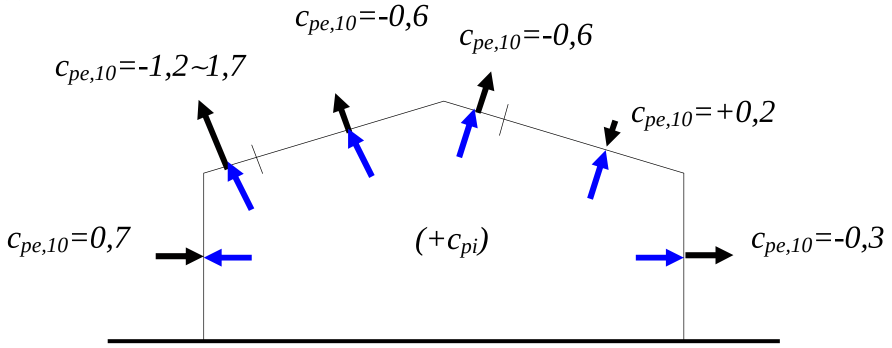


Case 4

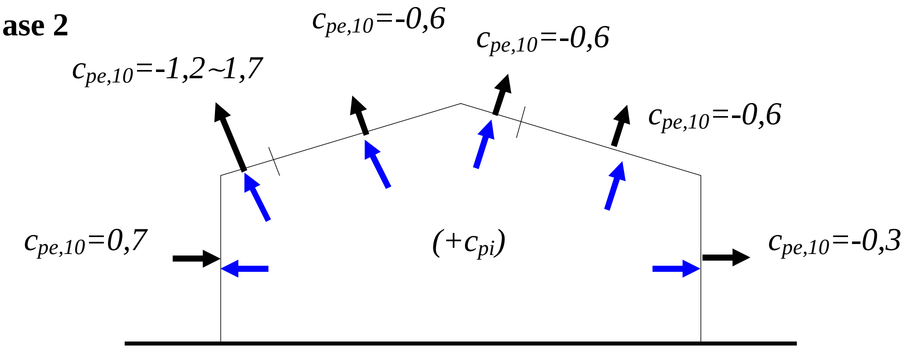


Annex 5: cross wind ($\theta=0^0$) and external + internal pressure

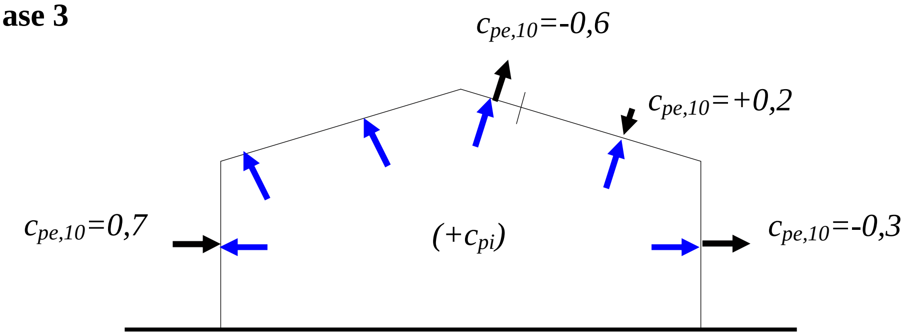
Cass 1



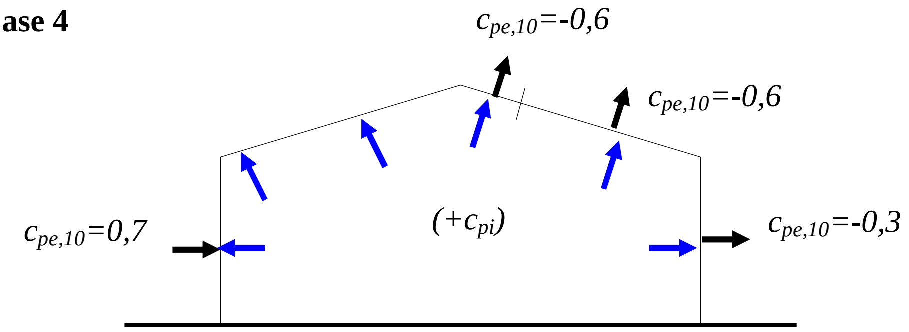
Case 2



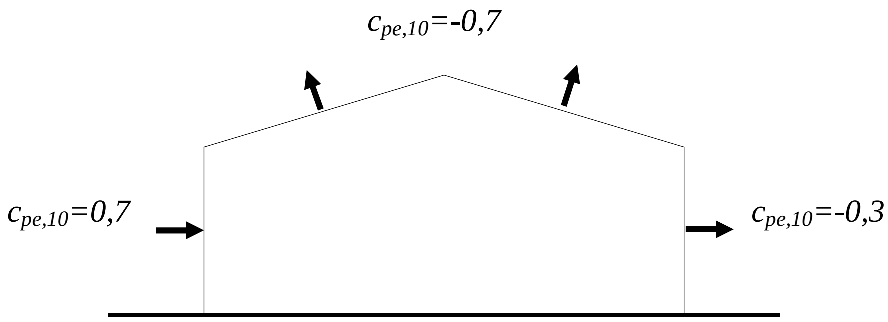
Case 3



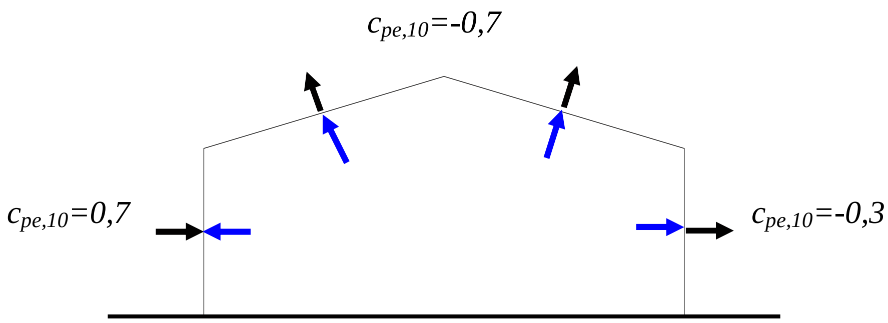
Case 4



Annex 6: longitudinal wind ($\theta=90^0$) and external pressure



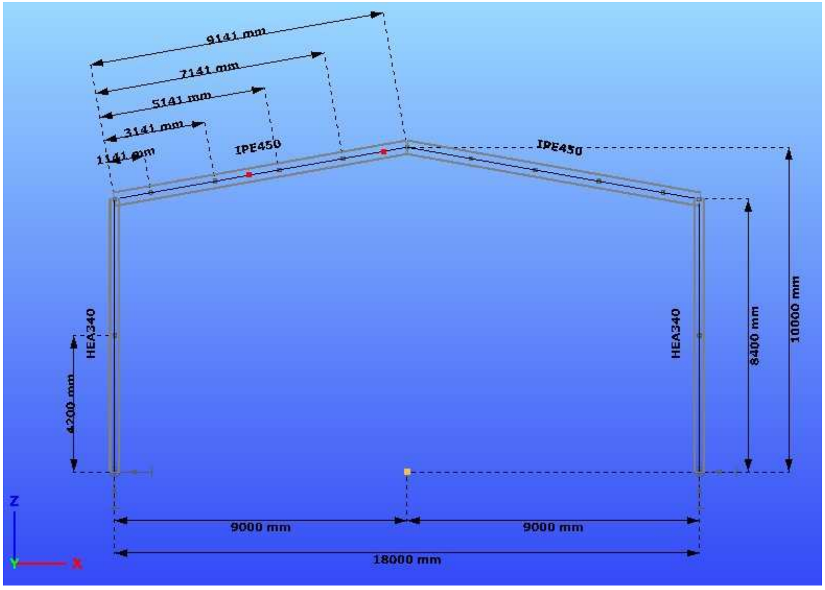
Annex 7: longitudinal wind ($\theta=90^0$) and external + internal pressure



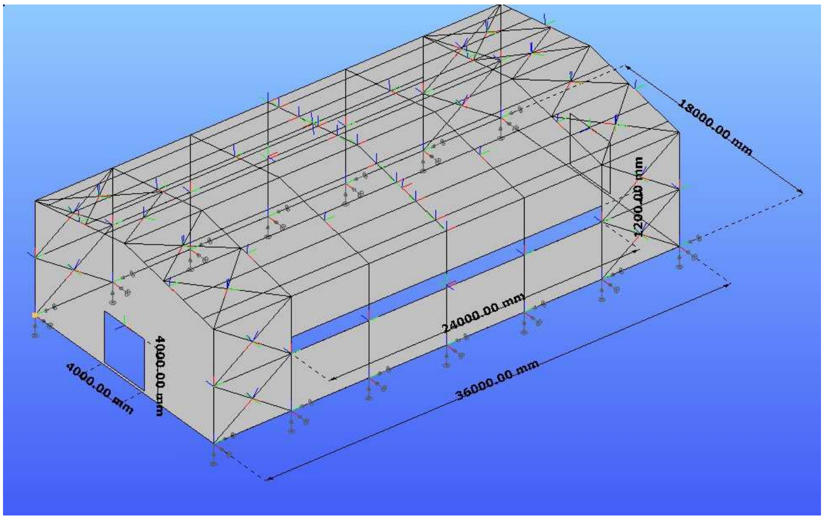
3 EXAMPLE

3.1 Initial data

- column: *HEA 340*
- beam: *IPE 450*
- span of frame: $L = 18{,}0m$
- height of the column: $h = 8{,}4m$
- height of the building: $H = 10{,}0m$
- frame corner: *short haunch*
- column base: *fix*
- fix point on the column from column base: $4200mm$
- fix points on the beams from the corner: $1141mm; 3141mm; 5141mm; 7141mm$



- distance between frames: $6000mm$
- length of the building: $36000mm$
- openings on the side walls: $28{,}8m^2$
- openings on the end walls: $16{,}0m^2$
- height of the building area: $A = 200m$



- by analysis of the covering system : $g = 0{,}60 kN / m^2$

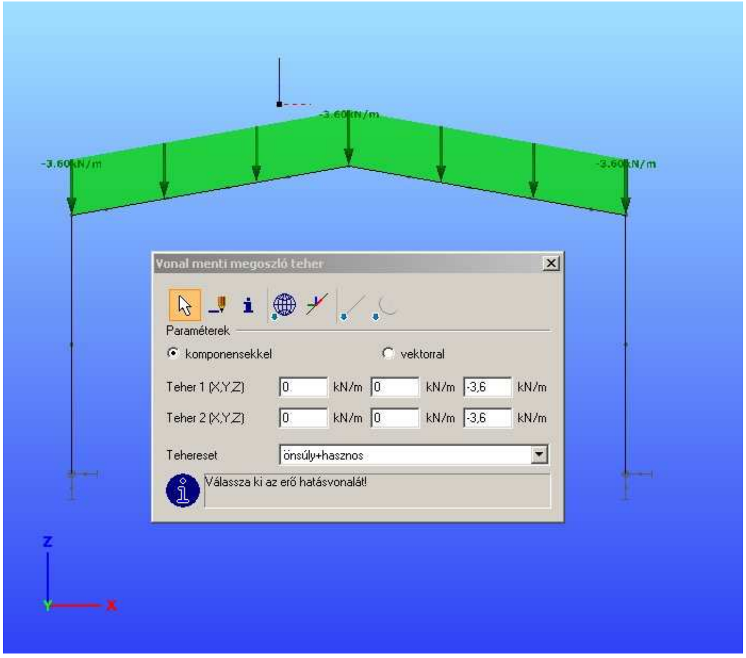
3.2 Calculation of loads

Loads on the simple symmetric pitch roofed building

3.2.1 Dead load

The self weight of the frame is considered by the program automatically. The given dead load contains the weight of the purlin, covering layers and the installation loads. The weight of the wall covering may be neglected. The dead load on the beams of the frame:

$$p_g = g \cdot l = 0{,}6 \cdot 6 = 3{,}6 \frac{kN}{m}$$



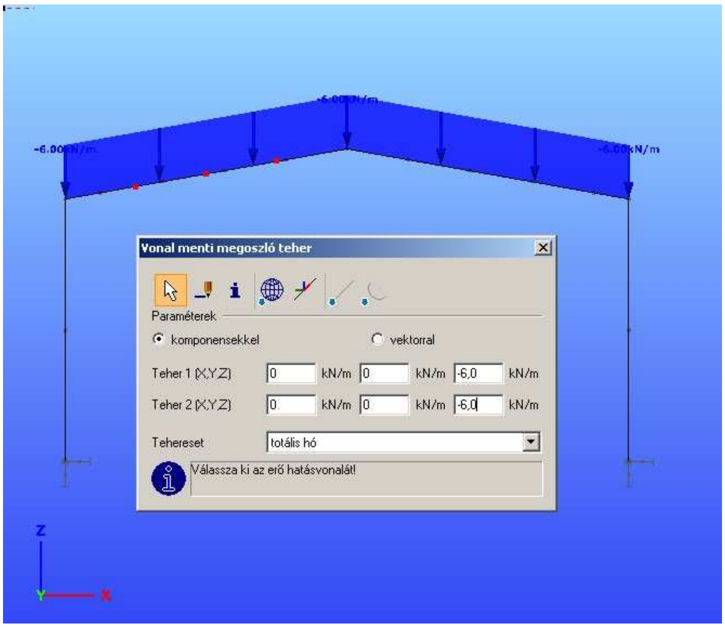
3.2.2 Snow load

The snow load is considered as regular load. The accidental snow load is neglected. The regular snow load:

$$C_e = 1{,}0$$
$$C_t = 1{,}0$$
$$s_k = 0{,}25\left(1 + \frac{A}{100}\right) = 0{,}25\left(1 + \frac{200}{100}\right) = 0{,}75 \le 1{,}25\frac{kN}{m^2}$$
$$s_k = 1{,}25\frac{kN}{m^2}$$
$$\alpha = 10^0 \Rightarrow \mu_i = 0{,}8$$
$$s = \mu_i C_e C_t s_k = 0{,}8 \cdot 1{,}0 \cdot 1{,}0 \cdot 1{,}25 = 1{,}0\frac{kN}{m^2}$$

The snow load on the beam of the frame (the reduction by slope of the roof is neglected):

$$p_s = s \cdot l = 1{,}0 \cdot 6{,}0 = 6{,}0\frac{kN}{m}$$



3.2.3 Wind load

(a) Wind pressure for basic velocity

Assume that the terrain category is III:

$z_0 = 0{,}3m$

$z_{0,II} = 0{,}05m$

$z_{min} = 5{,}0m$

The terrain factor:

$$k_r = 0{,}19\left(\frac{z_0}{z_{0,II}}\right)^{0{,}07} = 0{,}19\left(\frac{0{,}3}{0{,}05}\right)^{0{,}07} = 0{,}215$$

The reference height is equal to the height of the building:

$z = 10{,}0m > z_{min} = 5{,}0m$

from which the roughness coefficient:

$$c_r(z) = k_r \cdot ln\left(\frac{z}{z_0}\right) = 0{,}215 \cdot ln\left(\frac{10{,}0}{0{,}3}\right) = 0{,}754$$

The basic wind velocity:

$$v_b = 20\frac{m}{s}$$

The orography factor for flat and horizontal country:

$c_0(z) = 1{,}0$

The wind pressure for basic wind velocity:

$$q_b = \frac{1}{2}\rho \cdot v_b^2(z) = 0{,}5 \cdot 1{,}25 \cdot 20{,}00^2 = 0{,}25\frac{kN}{m^2}$$

(b) The exposure factor

The turbulence factor:

$k_I = 1{,}0$

The turbulence intensity:

$$I_v(z) = \frac{k_I}{c_0(z) \cdot ln\left(\frac{z}{z_0}\right)} = \frac{1}{1{,}0 \cdot ln\left(\frac{10}{0{,}3}\right)} = 0{,}285$$

The exposure factor:

$$c_e(z) = (1 + 7 \cdot I_v(z)) \cdot c_0^2 \cdot c_r^2 = (1 + 7 \cdot 0{,}285) \cdot 1^2 \cdot 0{,}754^2 = 1{,}71 \frac{kN}{m^2}$$

(c) The wind pressure for peak velocity

$$q_p(z) = c_e(z) \cdot q_b = 1{,}71 \cdot 0{,}25 = 0{,}426 \frac{kN}{m^2}$$

(d) The external pressure coefficient

Cross wind ($\theta = 0^0$)

$$b = 36{,}0m$$
$$d = 18{,}0m$$
$$h = 10{,}0m$$
$$h/d = 0{,}56$$
$$e = min(b;2h) = 20{,}0m$$
$$e/5 = 4{,}0m$$

- external pressure coefficient on the walls:

$$c_{pe,D} = 0{,}7 + \left(\frac{h/d - 0{,}25}{0{,}75} \right) \cdot 0{,}1 = (+)0{,}741$$
$$c_{pe,E} = 0{,}3 + \left(\frac{h/d - 0{,}25}{0{,}75} \right) \cdot 0{,}2 = (-)0{,}383$$

- external pressure coefficient on the roof:

$$c_{pe,F} = -1{,}3$$
$$c_{pe,G} = -1{,}0$$
$$c_{pe,H} = -0{,}45$$
$$c_{pe,J} = -0{,}4$$
$$c_{pe,I} = -0{,}8$$

Longitudinal wind ($\theta=90^0$)

$b = 18{,}0m$

$d = 36{,}0m$

$h = 10{,}0m$

$h/d = 0{,}28$

$e = min(b;2h) = 18{,}0m$

$e/5 = 3{,}6m$

$e/2 = 9{,}0m$

$e/10 = 1{,}8m$

$e/4 = 4{,}5m$

- external pressure coefficient on the walls:

$c_{pe,A} = -1{,}2$

$$c_{pe,B} = 0{,}3 + \left(\frac{h/d - 0{,}25}{0{,}75}\right) \cdot 0{,}2 = -0{,}8$$

- external pressure coefficient on the roof:

$c_{pe,F} = -1{,}45$

$c_{pe,G} = -1{,}3$

$c_{pe,H} = -0{,}65$

$c_{pe,I} = -0{,}55$

(e) The internal pressure coefficient

Cross wind

- openings on the surfaces of the building:

$\sum A = 2 \cdot (28{,}8 + 16) = 89{,}6m^2$

- openings on the surfaces of the building where the external pressure coefficient is negative:

$\sum A_{negatív} = 28{,}8 + 2 \cdot 16 = 60{,}8m^2$

- the openings factor:

$$\mu = \frac{\sum A_{negatív}}{\sum A} = \frac{60{,}8}{89{,}6} = 0{,}678$$

- geometrical ratio:

$$h/d = \frac{10}{18} = 0{,}56$$

- internal pressure coefficient for h/d=0,25:

$c_{pi,0.25} = 0{,}726 - 1{,}14\mu = 0{,}726 - 0{,}773 = -0{,}047$

- internal pressure coefficient for h/d=1,0:

$c_{pi,1.0} = 0{,}802 - 1{,}37\mu = 0{,}802 - 0{,}929 = -0{,}127$

- internal pressure coefficient by interpolation:

$$c_{pi} = -0{,}047 + \left(\frac{h/d - 0{,}25}{0{,}75}\right) \cdot (-0{,}127 + 0{,}047)$$

$$c_{pi} = -0{,}08$$

Longitudinal wind

- openings on the surfaces of the building:

$$\sum A = 2 \cdot (28{,}8 + 16) = 89{,}6\,m^2$$

- openings on the surfaces of the building where the external pressure coefficient is negative:

$$\sum A_{negatív} = 2 \cdot 28{,}8 + 16 = 73{,}6\,m^2$$

- the openings factor:

$$\mu = \frac{\sum A_{negatív}}{\sum A} = \frac{73{,}6}{89{,}6} = 0{,}821$$

- geometrical ratio:

$$h/d = \frac{10}{36} \approx 0{,}25$$

- internal pressure coefficient

$$c_{pi} = 0{,}726 - 1{,}14\mu = 0{,}726 - 0{,}936 = -0{,}21$$

(f) The wind load

Cross wind

- external wind load on walls:

$$w_{e,D} = c_{pe,D} \cdot q_p(z) = 0{,}741 \cdot 0{,}426 = 0{,}316 \frac{kN}{m^2}$$

$$w_{e,E} = c_{pe,E} \cdot q_p(z) = -0{,}383 \cdot 0{,}426 = -0{,}163 \frac{kN}{m^2}$$

- external wind load on roof:

$$w_{e,F} = c_{pe,F} \cdot q_p(z) = -1{,}3 \cdot 0{,}426 = -0{,}554 \frac{kN}{m^2}$$

$$w_{e,G} = c_{pe,G} \cdot q_p(z) = -1{,}0 \cdot 0{,}426 = -0{,}426 \frac{kN}{m^2}$$

$$w_{e,H} = c_{pe,H} \cdot q_p(z) = -0{,}45 \cdot 0{,}426 = -0{,}192 \frac{kN}{m^2}$$

$$w_{e,I} = c_{pe,I} \cdot q_p(z) = -0{,}5 \cdot 0{,}426 = -0{,}213 \frac{kN}{m^2}$$

$$w_{e,J} = c_{pe,J} \cdot q_p(z) = -0{,}8 \cdot 0{,}426 = -0{,}340 \frac{kN}{m^2}$$

Longitudinal wind

- external wind load on walls:

$$w_{e,A} = c_{pe,A} \cdot q_p(z) = -1{,}2 \cdot 0{,}426 = -0{,}511 \frac{kN}{m^2}$$

$$w_{e,B} = c_{pe,B} \cdot q_p(z) = -0{,}8 \cdot 0{,}426 = -0{,}341 \frac{kN}{m^2}$$

- external wind load on roof:

$$w_{e,F} = c_{pe,F} \cdot q_p(z) = -1{,}45 \cdot 0{,}426 = -0{,}618 \frac{kN}{m^2}$$

$$w_{e,G} = c_{pe,G} \cdot q_p(z) = -1{,}3 \cdot 0{,}426 = -0{,}128 \frac{kN}{m^2}$$

$$w_{e,H} = c_{pe,H} \cdot q_p(z) = -0{,}65 \cdot 0{,}426 = -0{,}277 \frac{kN}{m}$$

$$w_{e,I} = c_{pe,I} \cdot q_p(z) = -0{,}55 \cdot 0{,}426 = -0{,}234 \frac{kN}{m^2}$$

Cross wind

- internal wind load on all surfaces

$$w_i = c_{pi} \cdot q_p(z) = -0{,}08 \cdot 0{,}426 = -0{,}034 \frac{kN}{m^2}$$

Longitudinal wind

- internal wind load on all surfaces

$$w_i = c_{pi} \cdot q_p(z) = -0{,}21 \cdot 0{,}426 = -0{,}089 \frac{kN}{m^2}$$

3.2.4 Wind load cases for design of the frame

Since $h < 15m$ $c_s c_d = 1{,}0$.

(1) External wind load from Cross Wind:

$$p_{e,D} = w_{e,D} \cdot l = 0{,}316 \cdot 6{,}0 = 1{,}90 \frac{kN}{m}$$

$$p_{e,E} = w_{e,E} \cdot l = -0{,}163 \cdot 6{,}0 = -0{,}78 \frac{kN}{m}$$

$$p_{e,F} = w_{e,F} \cdot 2{,}0 = -0{,}554 \cdot 2{,}0 = -1{,}18 \frac{kN}{m}$$

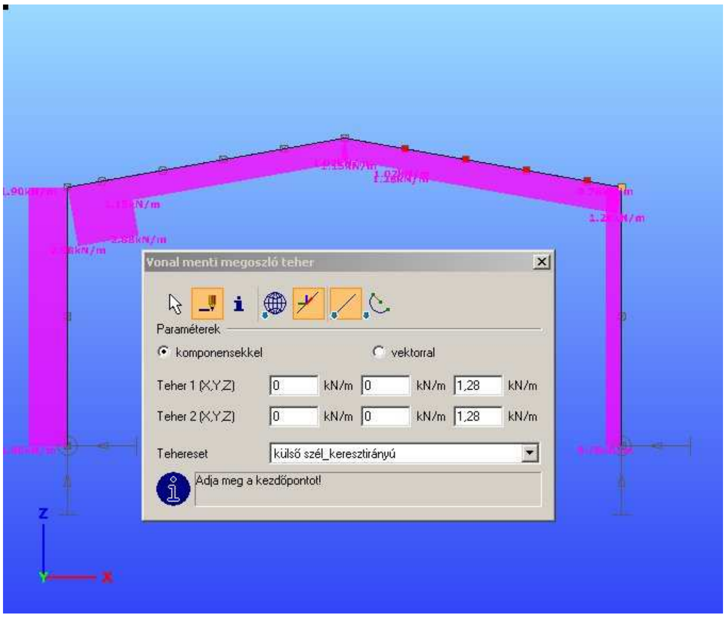
$$p_{e,G} = w_{e,G} \cdot 4{,}0 = -0{,}426 \cdot 4{,}0 = -1{,}70 \frac{kN}{m}$$

$$p_{e,FG} = p_{e,F} + p_{e,G} = -(1{,}18 + 1{,}70) = -2{,}88 \frac{kN}{m}$$

$$p_{e,H} = w_{e,H} \cdot l = -0{,}192 \cdot 6{,}0 = -1{,}15 \frac{kN}{m}$$

$$p_{e,j} = w_{e,j} \cdot l = -0{,}340 \cdot 6{,}0 = -2{,}04 \frac{kN}{m}$$

$$p_{e,I} = w_{e,I} \cdot l = -0{,}213 \cdot 6{,}0 = -1{,}28 \frac{kN}{m}$$



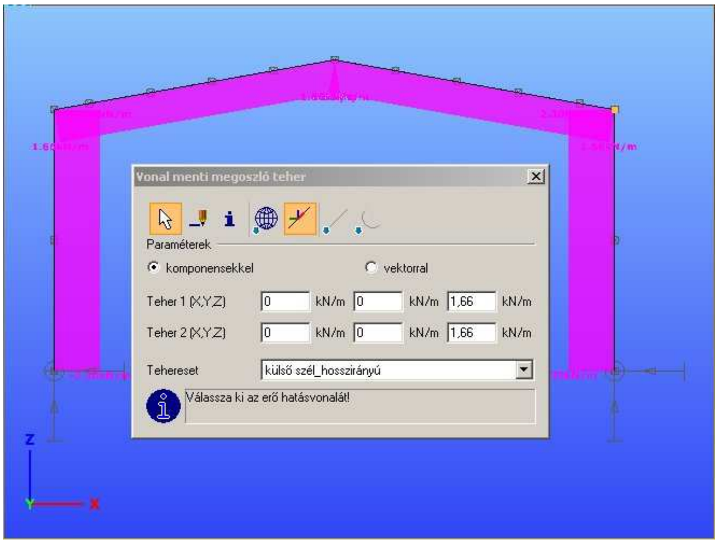
(2) External wind load from Longitudinal Wind:

$$p_{e,A} = w_{e,A} \cdot 1,5 = -0,511 \cdot 1,5 = -0,767 \frac{kN}{m}$$

$$p_{e,A} = w_{e,A} \cdot 4,5 = -0,341 \cdot 4,5 = -1,535 \frac{kN}{m}$$

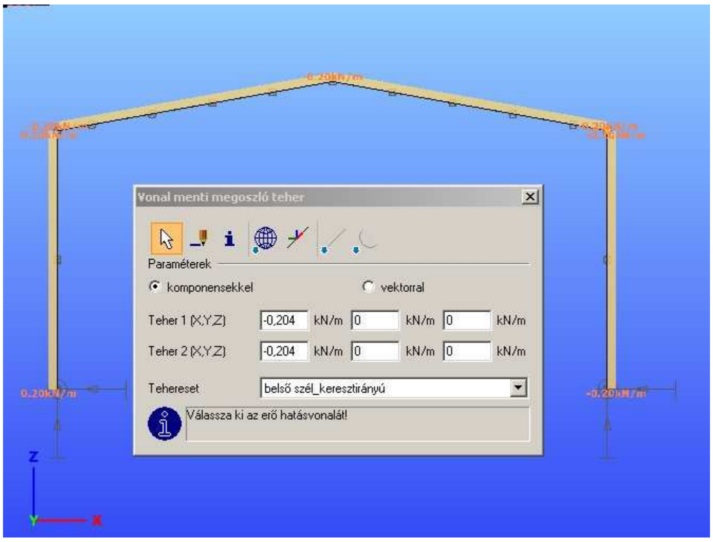
$$p_{e,AB} = p_{e,A} + p_{e,B} = -(0,767 + 1,535) = -2,30 \frac{kN}{m}$$

$$p_{e,H} = w_{e,H} \cdot 6,0 = -0,277 \cdot 6,0 = -1,66 \frac{kN}{m}$$



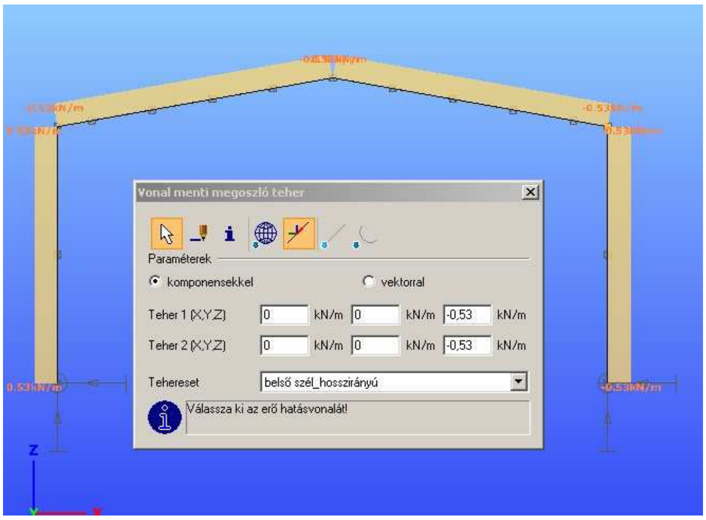
(3) Internal wind load from Cross Wind:

$$p_i = w_i \cdot l = -0,034 \cdot 6,0 = -0,204 \frac{kN}{m}$$

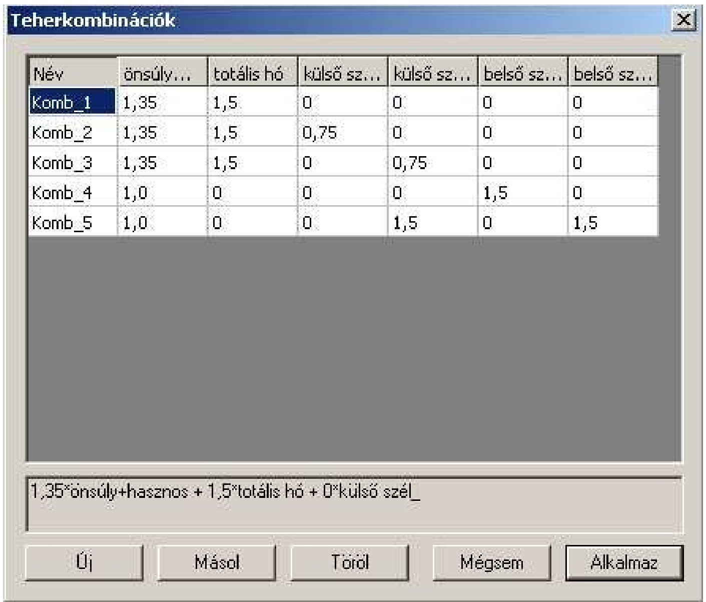


(4) Internal wind load from Longitudinal Wind:

$$p_i = w_i \cdot l = -0{,}089 \cdot 6{,}0 = -0{,}53\frac{kN}{m}$$



The applied design load combinations:



Név	önsúly...	totális hó	külső sz...	külső sz...	belső sz...	belső sz...
Komb_1	1,35	1,5	0	0	0	0
Komb_2	1,35	1,5	0,75	0	0	0
Komb_3	1,35	1,5	0	0,75	0	0
Komb_4	1,0	0	0	0	1,5	0
Komb_5	1,0	0	0	1,5	0	1,5