Section 13 Eurocode 1 EN 1991-1-4 Section 7 (Page 40 to 42)

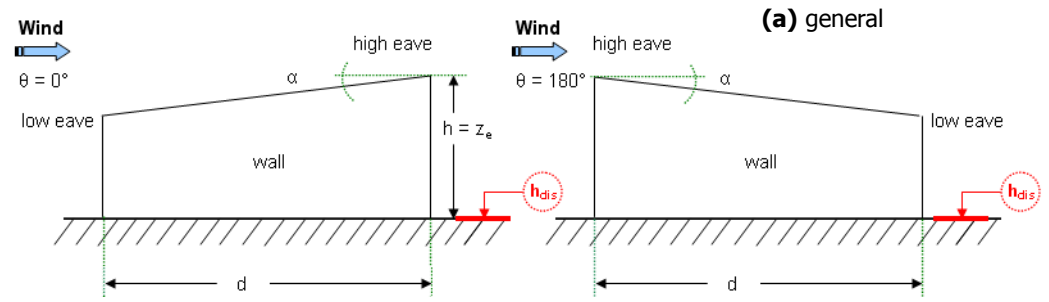
13.1 Pressure and force coefficients - Monopitch roofs

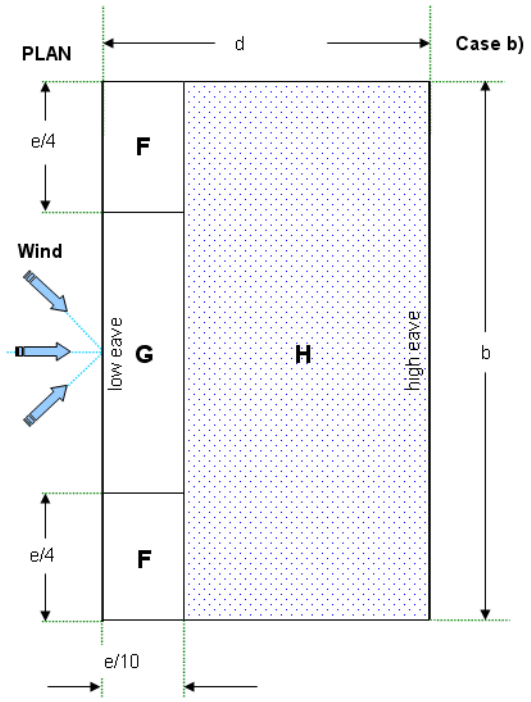
The roof, including protruding parts, should be divided into zones as shown in Figure 7.7. The reference height z_e should be taken equal to h. The pressure coefficients for each zone that should be used are given in Table 7.3a and 7.3.b.

	Zone for wind direction θ = 0°						Zone for wind direction θ = 180°					
Pitch angle α [°]	F		G		H		F		G		H	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
5°	- 1,7 0,00	- 2,5 0,00	- 1,2 0,00	- 2,0 0,00	- 0,6 0,00	- 1,2 0,00	- 2,3	- 2,5	- 1,3	- 2,0	- 0,8	- 1,2
15°	- 0,9 0,2	- 2,0 0,2	- 0,8 0,2	- 1,5 0,2	- 0,3 0,2	- 0,3 0,2	- 2,5	- 2,8	- 1,3	- 2,0	- 0,9	- 1,2
30°	- 0,5 0,7	- 1,5 0,7	- 0,5 0,7	- 1,5 0,7	- 0,2 0,4	- 0,2 0,4	- 1,1	- 1,3	- 0,8	- 1,5	- 0,8	- 0,8
45°	0,00 0,7	0,00 0,7	0,00 0,7	0,00 0,7	0,00 0,6	0,00 0,6	- 0,6	- 1,3	- 0,5	- 0,5	- 0,7	- 0,7
60°	0,7	0,7	0,7	0,7	0,7	0,7	- 0,5	- 1,0	- 0,5	- 0,5	- 0,5	- 0,5
75°	0,8	0,8	0,8	0,8	0,8	0,8	- 0,5	- 1,0	- 0,5	- 0,5	- 0,5	- 0,5

Table 13.29 From Table 7.3a - External pressure coefficients for monopitch roofs.[(a)]

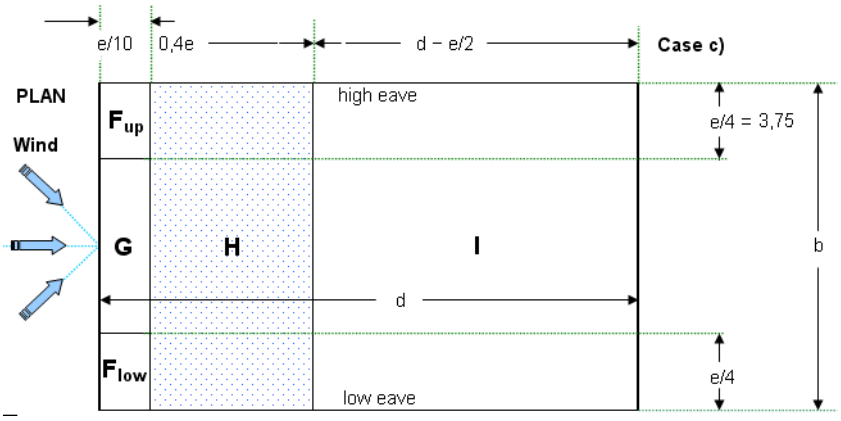
(a). At θ = 0° the pressure changes rapidly between positive and negative values around a pitch angle of α = +5° to +45°, so both positive and negative values are given. For those roofs, two cases should be considered: one with all positive values, and one with all negative values. No mixing of positive and negative values is allowed on the same face.





$$e = \min[b; 2h] = \min[b; 2z_e]$$

(b) wind direction θ = 0° and θ = 180°



(c) wind direction θ = 90°

Figure 13.68 From Figure 7.7 - Key for monopitch roofs.

Linear interpolation for intermediate pitch angles may be used between values of the same sign. The values equal to 0,00 are given for interpolation purposes.

Pitch angle α [°]	Zone for wind direction θ = 90°									
	F_{up}		F_{low}		G		H		I	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
5°	- 2,1	- 2,6	- 2,1	- 2,4	- 1,8	- 2,0	- 0,6	- 1,2	- 0,5	- 0,5
15°	- 2,4	- 2,9	- 1,6	- 2,4	- 1,9	- 2,5	- 0,8	- 1,2	- 0,7	- 1,2
30°	- 2,1	- 2,9	- 1,3	- 2,0	- 1,5	- 2,0	- 1,0	- 1,3	- 0,8	- 1,2
45°	- 1,5	- 2,4	- 1,3	- 2,0	- 1,4	- 2,0	- 1,0	- 1,3	- 0,9	- 1,2
60°	- 1,2	- 2,0	- 1,2	- 2,0	- 1,2	- 2,0	- 1,0	- 1,3	- 0,7	- 1,2
75°	- 1,2	- 2,0	- 1,2	- 2,0	- 1,2	- 2,0	- 1,0	- 1,3	- 0,5	- 0,5

Table 13.30 From Table 7.3b - External pressure coefficients for monopitch roofs.

13.2 Verification tests

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- Splash
- CodeSec7(40to42).

EXAMPLE 13-BH- External pressure coefficients for monopitch roofs- **test1**

Given: Let us consider the wind pressure on an industrial hall. The main structure consists of a simple rectangular building with monopitch roof. The dimensions of the building are: High eave height 4,5 m, low eave height 3 m, width 15 m and depth 30 m (from low to high eave).

It is assumed in this example, that in case of a storm there is no opening in the surface of the hall, so that the internal pressure can be neglected, i.e. $c_{pi} = 0$. Find the external pressure coefficients for the roof.

[*Reference sheet:* CodeSec7(40to42)]-[*Cell-Range: A1:O1-A129:O129*].

Solution: The pitch angle is equal to $\alpha = 5,7°$ (slope: 10,0%): $(4,5-3)/15 = 0,1 \rightarrow 10\%$. The reference height above the ground (or above h_{dis}) is $z_e = h = 4,5$ m. For wind directions $\theta = 0°$ and $\theta = 180°$ the crosswind dimension is then $b = 15$ m. Linear interpolation from Table 7.3a (*"External pressure coefficients for monopitch roofs"*):

Zone for wind direction θ = 0° (with all negative values):

$$\frac{(-1,7)-(-0,9)}{15-5} = \frac{c_{pe,10}-(-0,9)}{15-5,7} \quad \rightarrow \quad c_{pe,10} \approx -1,64 \text{ (zone } \mathbf{F})$$

$$\frac{(-2,5)-(-2,0)}{15-5} = \frac{c_{pe,1}-(-2,0)}{15-5,7} \rightarrow c_{pe,1} \approx -2,47 \text{ (zone F)}$$

$$\frac{(-1,2)-(-0,8)}{15-5} = \frac{c_{pe,10}-(-0,8)}{15-5,7} \rightarrow c_{pe,10} \approx -1,17 \text{ (zone G)}$$

$$\frac{(-2,0)-(-1,5)}{15-5} = \frac{c_{pe,1}-(-1,5)}{15-5,7} \rightarrow c_{pe,1} \approx -1,97 \text{ (zone G)}$$

$$\frac{(-0,6)-(-0,3)}{15-5} = \frac{c_{pe,10}-(-0,3)}{15-5,7} \rightarrow c_{pe,10} \approx -0,58 \text{ (zone H)}$$

$$\frac{(-1,2)-(-0,3)}{15-5} = \frac{c_{pe,1}-(-0,3)}{15-5,7} \rightarrow c_{pe,1} \approx -1,14 \text{ (zone H).}$$

	Zone for wind direction θ = 0°						Zone for wind direction θ = 180°					
Pitch angle α [°]	F		G		H		F		G		H	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
5°	- 1,7 0,00	- 2,5 0,00	- 1,2 0,00	- 2,0 0,00	- 0,6 0,00	- 1,2 0,00	- 2,3	- 2,5	- 1,3	- 2,0	- 0,8	- 1,2
15°	- 0,9 0,2	- 2,0 0,2	- 0,8 0,2	- 1,5 0,2	- 0,3 0,2	- 0,3 0,2	- 2,5	- 2,8	- 1,3	- 2,0	- 0,9	- 1,2

Table 13.31 From Table 7.3a - External pressure coefficients for monopitch roofs.(a)

(a). At θ = 0° the pressure changes rapidly between positive and negative values around a pitch angle of α = +5° to +45°, so both positive and negative values are given. For those roofs, two cases should be considered: one with all positive values, and one with all negative values. No mixing of positive and negative values is allowed on the same face.

Zone for wind direction θ = 0° (with all positive values):

$$\frac{(0)-(0,2)}{15-5} = \frac{c_{pe,10}-(0,2)}{15-5,7} \rightarrow c_{pe,10} = c_{pe,1} \approx 0,01 \text{ (zone F, G, H).}$$

Linear interpolation from Table 7.3a (*"External pressure coefficients for monopitch roofs"*):

Zone for wind direction θ = 180°

$$\frac{(-2,3)-(-2,5)}{15-5} = \frac{c_{pe,10}-(-2,5)}{15-5,7} \rightarrow c_{pe,10} \approx -2,31 \text{ (zone F)}$$

$$\frac{(-2,5)-(-2,8)}{15-5} = \frac{c_{pe,1}-(-2,8)}{15-5,7} \rightarrow c_{pe,1} \approx -2,52 \text{ (zone F)}$$

(*from Table*) $c_{pe,10} = c_{pe,1} = -1,3$ (zone G)

(*from Table*) $c_{pe,10} = c_{pe,1} = -2,0$ (zone G)

$$\frac{(-0,8)-(-0,9)}{15-5} = \frac{c_{pe,10}-(-0,9)}{15-5,7} \rightarrow c_{pe,10} \approx -0,81 \text{ (zone } \mathbf{H})$$

(*from Table*) $c_{pe,10} = c_{pe,1} = -1,2$ (zone **H**)

Linear interpolation from Table 7.3b ("*External pressure coefficients for monopitch roofs*"):

Zone for wind direction θ = 90°:

$$\frac{(-2,1)-(-2,4)}{15-5} = \frac{c_{pe,10}-(-2,4)}{15-5,7} \rightarrow c_{pe,10} \approx -2,12 \text{ (zone } \mathbf{F_{sup}})$$

$$\frac{(-2,6)-(-2,9)}{15-5} = \frac{c_{pe,1}-(-2,9)}{15-5,7} \rightarrow c_{pe,1} \approx -2,62 \text{ (zone } \mathbf{F_{sup}})$$

$$\frac{(-2,1)-(-1,6)}{15-5} = \frac{c_{pe,10}-(-1,6)}{15-5,7} \rightarrow c_{pe,10} \approx -2,07 \text{ (zone } \mathbf{F_{low}})$$

(*from Table*) $c_{pe,1} = -2,4$ (zone $\mathbf{F_{low}}$)

$$\frac{(-1,8)-(-1,9)}{15-5} = \frac{c_{pe,10}-(-1,9)}{15-5,7} \rightarrow c_{pe,10} \approx -1,81 \text{ (zone } \mathbf{G})$$

$$\frac{(-2,0)-(-2,5)}{15-5} = \frac{c_{pe,1}-(-2,5)}{15-5,7} \rightarrow c_{pe,1} \approx -2,04 \text{ (zone } \mathbf{G})$$

$$\frac{(-0,6)-(-0,8)}{15-5} = \frac{c_{pe,10}-(-0,8)}{15-5,7} \rightarrow c_{pe,10} \approx -0,61 \text{ (zone } \mathbf{H})$$

(*from Table*) $c_{pe,1} = -1,2$ (zone **H**)

$$\frac{(-0,5)-(-0,7)}{15-5} = \frac{c_{pe,10}-(-0,7)}{15-5,7} \rightarrow c_{pe,10} \approx -0,51 \text{ (zone } \mathbf{I})$$

$$\frac{(-0,5)-(-1,2)}{15-5} = \frac{c_{pe,1}-(-1,2)}{15-5,7} \rightarrow c_{pe,1} \approx -0,55 \text{ (zone } \mathbf{I}).$$

Pitch angle α [°]	Zone for wind direction θ = 90°									
	F_{up}		F_{low}		G		H		I	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
5°	- 2,1	- 2,6	- 2,1	- 2,4	- 1,8	- 2,0	- 0,6	- 1,2	- 0,5	- 0,5
15°	- 2,4	- 2,9	- 1,6	- 2,4	- 1,9	- 2,5	- 0,8	- 1,2	- 0,7	- 1,2

Table 13.32 From Table 7.3b - External pressure coefficients for monopitch roofs.

From Figure 7.7 "*Key for monopitch roofs*":

(b) wind directions θ = 0° and θ = 180° (with crosswind dimension b = 15,00 m):

$e = \min[b; 2h] = \min[15; 2 \times 4,5] = 9,0$ m. Therefore, assuming $\cos\alpha \approx 1$, we get e/4 = 2,25 m and e/10 = 0,90 m with: A(F) = 2,25 x 0,90 = 2,025 m^2; A(H) = (30 – 0,90) x 15 = 436,50 m^2; A(G) = (15 – 2 x 2,25) x 0,90 = 9,45 m^2. We have: 1 < A(F) < 10; A(H) > 10 and 1 < A(G) < 10. Therefore: **F** and **G** with $c_{pe} = c_{pe,1} - (c_{pe,1} - c_{pe,10}) \cdot \log A$, H with $c_{pe,10}$.

(c) wind directions θ = 90° (with crosswind dimension b = 30,00 m):

$e = \min[b; 2h] = \min[30; 2 \times 4,5] = 9,0$ m. Therefore, assuming $\cos\alpha \approx 1$, we get e/10 = 0,90 m, 0,4e = 3,60 m and d – e/2 = 15 – 0,5 x 9 = 10,50 m with: $A(F_{up}) = A(F_{low})$ = 0,90 x 2,25 = 2,025 m^2; A(G) = (30 – 2,25 x 2) x 0,90 = 25,50 x 0,90 = 22,95 m^2, A(H) = (0,4 x 9,00) x 30,00 = 108 m^2 and A(I) = (10,50 x 30,00) = 315,00 m^2. We have: $1 < A(F_{up/low}) < 10$; A(H) > 10 and A(G) > 10. Therefore: $\mathbf{F_{up/low}}$ with $c_{pe} = c_{pe,1} - (c_{pe,1} - c_{pe,10}) \cdot \log A$, **G**, **H** and **I** with $c_{pe,10}$. Finally, we find:

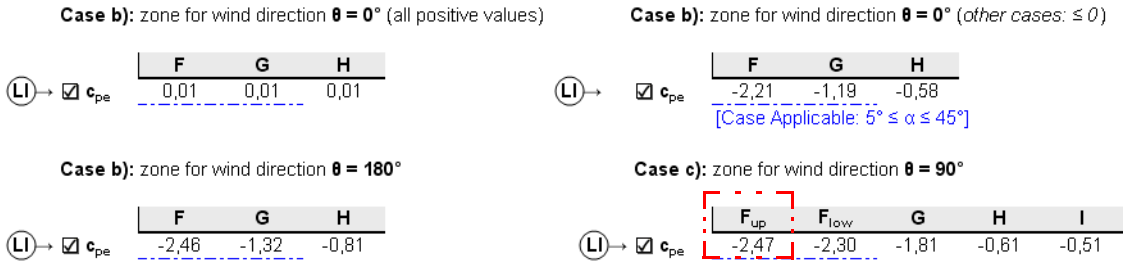

Figure 13.69 Final report.

In particularly for $\mathbf{F_{up}}$ (A = 2,025 m^2), we have:

$$c_{pe} = c_{pe,1} - (c_{pe,1} - c_{pe,10}) \cdot \log A = (-2,62) - [(-2,62) - (-2,12)] \cdot \log(2,025) = -2,47.$$

example-end

13.3 References [Section 13]

EN 1991-1-4:2005/A1:2010. Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions. Brussels: CEN/TC 250 - Structural Eurocodes, April 2010.

EN 1991-1-4:2005. Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions. Brussels: CEN/TC 250 - Structural Eurocodes, March 2005 (DAV).

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