September 2015

Appendices A-E
Actions on Structures and Combination of Loads

Available aids, if relevant, at the exams in the Masters Programme “Structural Engineering and Building performance Design”. The aim is to prepare students for their future careers and help them understand and apply the principles of Eurocode 1.

Appendix A: Combination of loads

Table 2.8 Design values of actions for equilibrium (EQU) and strength (STR) limit states*

Ultimate limit state (under persistent and transient design situations – fundamental combinations)		Relevant equation in EC0	Permanent actions		Leading variable action	Accompanying variable actions	
			Unfavourable‖	Favourable‖		Main	Others
EQU	(a)†	*(6.10)*	$1.10G_{k,j,sup}$	$0.90G_{k,j,inf}$	$1.5Q_{k,1}$ (0 when favourable)	–	$1.5\psi_{0,i}Q_{k,i}$ (0 when favourable)
	(b)‡ The highest design value from combination (i) or (ii)	(i) *(6.10)*	$1.35G_{k,j,sup}$	$1.15G_{k,j,inf}$	$1.5Q_{k,1}$ (0 when favourable)	–	$1.5\psi_{0,i}Q_{k,i}$ (0 when favourable)
		(ii) *(6.10)*	$1.0G_{k,j,sup}$	$1.0G_{k,j,inf}$	$1.5Q_{k,1}$ (0 when favourable)	–	$1.5\psi_{0,i}Q_{k,i}$ (0 when favourable)
STR§ (not involving geotechnical actions)	(c)	(i) *(6.10)*	$1.35G_{k,j,sup}$	$1.0G_{k,j,inf}$	$1.5Q_{k,1}$ (0 when favourable)	–	$1.5\psi_{0,i}Q_{k,i}$ (0 when favourable)
	(d)	(ii) *(6.10a)*	$1.35G_{k,j,sup}$	$1.0G_{k,j,inf}$	–	$1.5\psi_{0,1}Q_{k,1}$	$1.5\psi_{0,i}Q_{k,i}$
		(iii) *(6.10b)*	$0.925 \times 1.35G_{k,j,sup}$	$1.0G_{k,j,inf}$	$1.5Q_{k,1}$	–	$1.5\psi_{0,i}Q_{k,i}$

Appendix A: Combination of loads

Fundamental combination, ULS STR, cf. Table 2.8, Eq. 6.10.

$$\sum_{j\geq 1} \gamma_{G,j} G_{k,j} \text{"+"} \gamma_P P \text{"+"} \gamma_{Q,1} Q_{k,1} \text{"+"} \sum_{i>1} \gamma_{Q,i} \psi_{0,i} Q_{k,i}$$

Characteristic combination, SLS

$$\sum_{i} G_{k,i} + Q_{k,1} + \sum_{j>1} \psi_{0,j} Q_{k,j}$$

Quasi-permanent combination, SLS

$$\sum_{i} G_{k,i} + \sum_{j\geq 1} \psi_{2,j} Q_{k,j}$$

Partial safety factors γ_f for permanent and variable loads (ULS and SLS)

Design situation	ULS		SLS	
	Permanent action γ_g	Variable action γ_q	Permanent action γ_g	Variable action γ_q
Fundamental				
favourable	1.0	0	1.0	0
unfavourable	1.35	1.5	1.0	1.0
Accidental	1.0	1.0	-	-

ACTION	ψ_0	ψ_1	ψ_2
Imposed load			
Categ. A, B	0.7	0.5	0.3
Categ. C, D	0.7	0.7	0.6
Categ. E	1.0	0.9	0.8
Wind load	0.6	0.2	0
*Snow load			
$s_k \geq 3$ kN/m^2	0.8	0.6	0.2
$2.0 \leq s_k < 3.0$ kN/m^2	0.7	0.4	0.2
$1.0 \leq s_k < 2.0$ kN/m^2	0.6	0.3	0.1

* These coefficients are applicable to Scandinavian countries

Appendix B: Imposed loads

	category	imposed loads		ψ-coefficients			→ horizontal loads
		q_k [kN/m²]	Q_k [kN]	ψ_0	ψ_1	ψ_2	q_k [kN/m]
A	areas for domestic and residential activities						
	general	2.0	2.0	0.7	0.5	0.3	0.5
	stairs	3.0					
	balconies	4.0					
B	office areas	3.0	2.0	0.7	0.5	0.3	1.0
C	areas where people may congregate						
C1	Areas with tables (e.g., in schools, cafés, restaurants, dining halls, reading rooms, receptions)	3.0	4.0	0.7	0.7	0.6	1.0
C2	Areas with fixed seats (e.g., areas in churches, theatres, cinemas, conference rooms, lecture halls, assembly halls, waiting rooms)	4.0	4.0				1.5 [a])
C3	Areas without obstacles for moving people (e.g., areas in museums, exhibition rooms, and access areas – e.g. in public and administration buildings, hotels)	5.0	4.0				1.5 [a])
C4	Areas with possible physical activities (e.g., dance halls, gymnastic rooms, stages)	5.0	7.0				1.5 [a])
C5	Areas susceptible to overcrowding (e.g., in buildings for public events like concert halls, sport halls including stands, terraces and access areas)	5.0	4.0				3.0
D	Shopping areas						
D1	areas in general retails shops	5.0	4.0	0.7	0.7	0.6	1.5
D2	Areas in department stores (e.g., areas in warehouses, stationery, and office stores)	5.0	7.0	0.7	0.7	0.6	1.5
E	Areas for storage including libraries						
	Only minimum loads given, further guidance see 4.6	6.0	7.0	1.0	0.9	0.8	

[a]) for areas susceptible to overcrowding associated with public events the line load should be taken according to category C5

The self-weight of movable partitions may be taken into account as a uniformly-distributed load q_k which should be added to the imposed loads (Cat. A to D) of floors obtained from this table.

Appendix B: Imposed loads

Imposed loads (ULS)

$$\alpha_A = \frac{5}{7}\psi_0 + \frac{A_0}{A} \leq 1.0$$ EN 1991-1-1 (6.1)

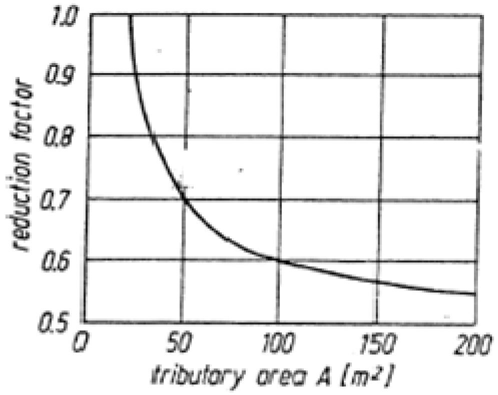
where:

ψ_0 is the factor according to EN 1990 Annex A1

$A_0 = 10{,}0\text{m}^2$

A is the loaded area

Imposed loads q_k may be reduced (for categories A-E) by applying a reduction factor α_A



Factor α_A as a function of A

$\alpha_A = 0.5 + 10/A[\text{m}^2] \leq 1$ for categories A – D ($\psi_0 = 0.7$)

$$\alpha_n = \frac{2 + (n-2)\,\psi_0}{n}$$ EN 1991-1-1 (6.2)

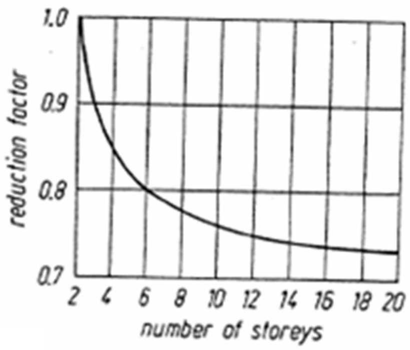
where

n number of stories *above* the loaded element

ψ_0

α_n accounts for the fact that it is unlikely that loads on several floors attain high values at the same time.

Imposed loads q_k from more than two storeys may be reduced (for categories A-D) by applying a reduction factor α_n



Reduction factor α_n for $\psi_0 = 0.7$

The reduction factors α_A and α_n must NOT be combined. For the design of floors and roofs α_A can be used. For structural members that carry imposed loads from several stories α_n can be taken and the imposed loads can be assumed as uniformly distributed. When the imposed load is considered as an accompanying action, only one of the two factors ψ_0 and α_n shall be applied.

Appendix C: Snow loads EN 1991-1-3:2003 (BFS 2008:19)

Characteristic snow values s_k for some Swedish town (urban) districts	
Alingsås	2.0
Arvika	2.5
Borås	2.0-2.5
Borlänge	3.0
Falun	2.5-3.0
Gällivare	3.0-4.5
Göteborg	1.5
Halmstad	1.5-2.5
Haparanda	3.0
Hofors	2.5
Härnösand	3.5
Jokkmokk	3.0-4.5
Jönköping	2.5-3.0
Karlstad	2.5
Kiruna	2.5-4.5
Kungälv/ Kungsbaka	1.5
Landskrona	1.0
Luleå	3.0
Lund	1.5
Malmö	1.0
Stockholm	2.0
Örebro	2.5
Östersund	2.0-3.5

The upper values of the intervals apply to terrain in high places.

Appendix C: Characteristic value of snow load:

$S = \mu_i \, C_e \, C_t \, s_k \qquad s = \mu_i \, s_k$

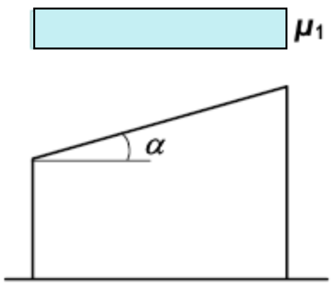
s_k characteristic value of snow on the ground,

C_e exposure coefficient, should be taken as 1.0 unless otherwise specified for different topographies

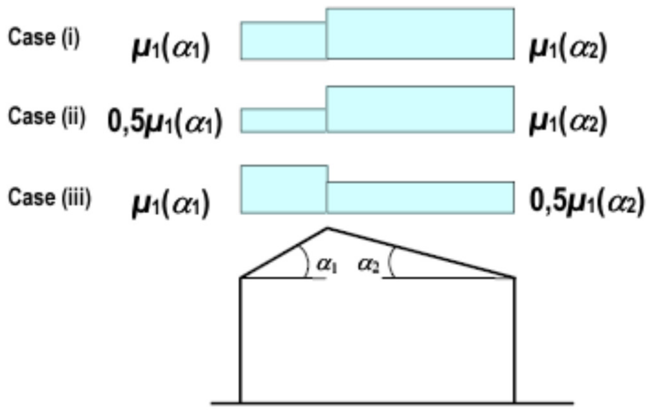
C_t thermal coefficient, high thermal transmittance (> 1 W/m2K), in particular for some glass covered roofs, because of melting caused by heat loss. For all other cases: C_t = 1.0

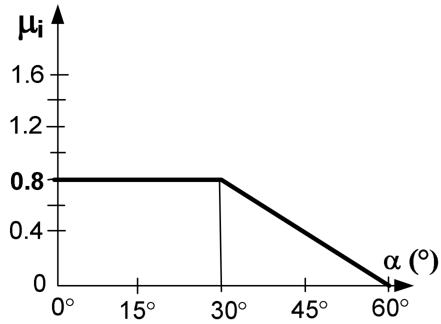
μ_i shape coefficients

Monopitch roofs

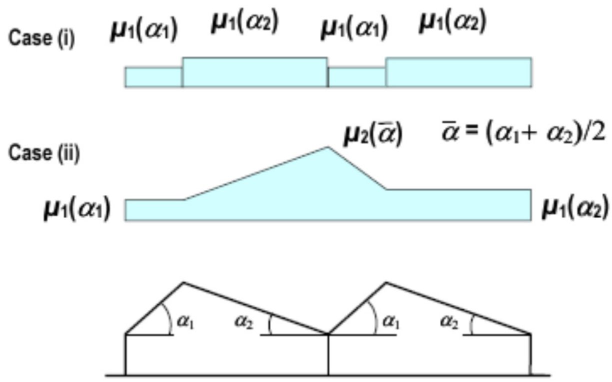


Pitched roofs





Multi-span roofs



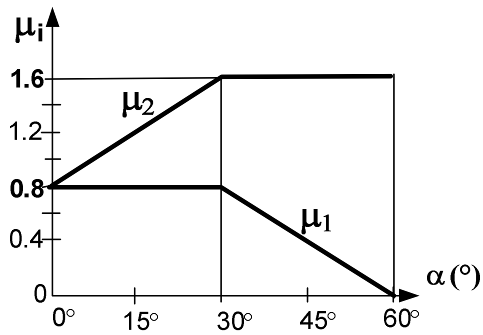
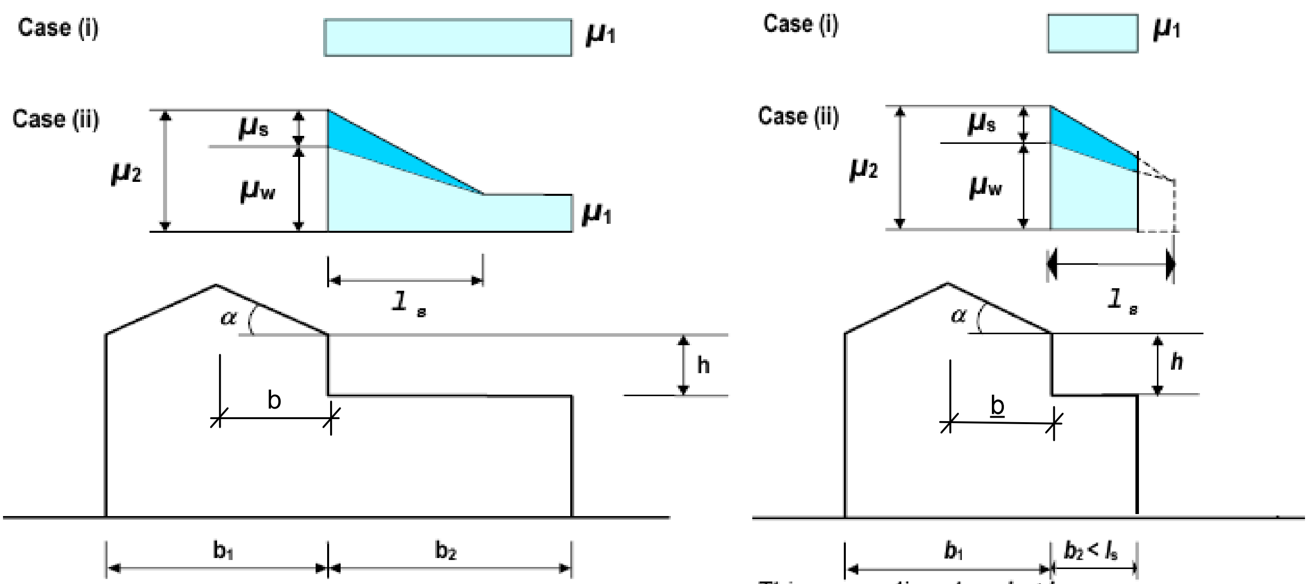


Table 5.2: Snow load shape coefficients

Angle of pitch of roof α	$0° \le \alpha \le 30°$	$30° < \alpha < 60°$	$\alpha \ge 60°$
μ_1	0,8	0,8(60 - α)/30	0,0
μ_2	0,8 + 0,8 α/30	1,6	--

Appendix C

Roofs abutting to taller construction works



This case applies where $b_2 < l_s$

μ_1 = 0,8 (assuming the lower roof is flat)

$\mu_2 = \mu_S + \mu_W$

Shape coefficients

$\mu_2 = \mu_S + \mu_W$

μ_S due to sliding of snow from the upper roof

μ_W due to wind

For $\alpha \leq 15°$ $\mu_S = 0$

$\alpha > 15°$ μ_S is determined from an additional load amounting to 50% of the maximum total snow load, on the on the adjacent slope of the upper roof

$\mu_w = (b_1 + b_2)/2h \leq \gamma\, h/s_k$

where: γ is the weight density of snow, which may be taken as 2 kN/m^3. $0.8 \leq \mu_w \leq 4$

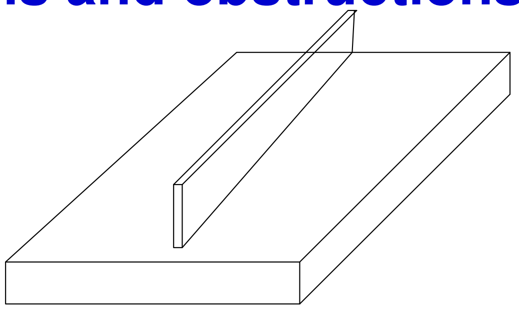
The drift length: $l_S = 2h$. The recommended restriction is $5 \leq l_S \leq 15$ m.

(In Sweden $5 \leq l_S \leq 10$ m)

Appendix C

Drifting at projections and obstructions

Drift against a wall



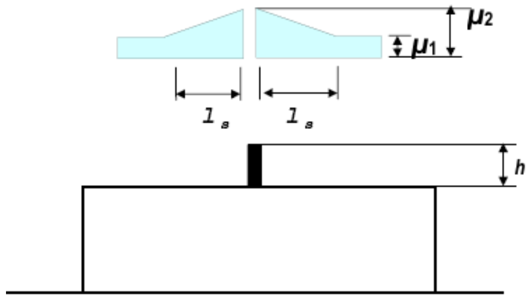
Shape coefficients μ

$\mu_1 = 0{,}8 \quad \mu_2 = \gamma\, h/s_k$

With the restriction: $0{,}8 \leq \mu_2 \leq 2{,}0$

The drift length: $l_S = 2h$

With the restriction is $5 \leq l_S \leq 10$ m



Appendix D1: Wind loads

EN 1991-1-4, April 2005

Wind pressure on surfaces

Wind pressure on external surfaces (w_e) and internal surfaces (w_i) should be calculated to

External pressure:

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

Internal pressure:

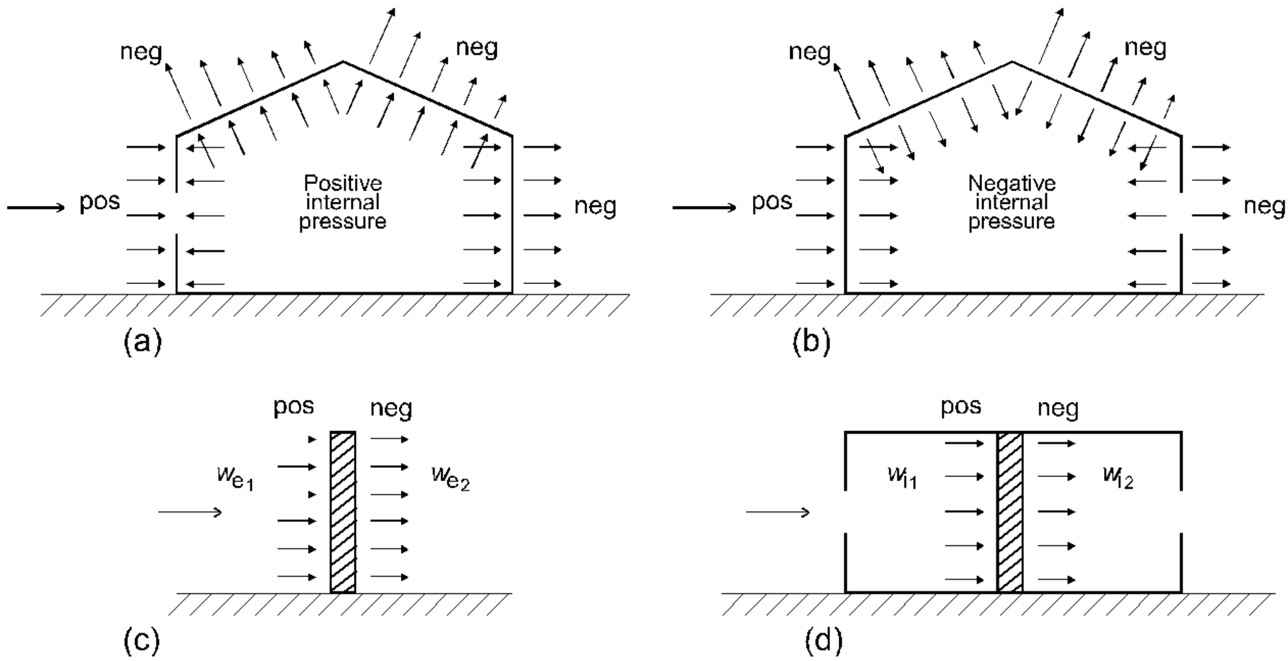
$w_i = q_p(z_e) \cdot c_{pi}$

where: $q_p(z_e)$ is the peak velocity pressure, see D2, which dependents on the reference height, z_e,

c_{pe} and c_{pi} are the pressure coefficients for the external and internal pressure respectively, see D4-D15

Pressure on surfaces

The net pressure on a wall, roof or element is the difference between the pressures on the opposite surfaces taking due account of their signs. Pressure, directed towards the surface is taken as positive, and suction, directed away from the surface as negative.



Wind forces

The wind forces for the whole structure or a structural component should be determined:
– by calculating forces using force coefficients or
– by calculating forces from surface pressures
The wind force F_W acting on a structure or a structural component may be determined directly by using:

$$F_W = c_S c_d c_f q_p(z_e) A_{ref}$$

where c_S, c_d· can for most structures assumed to be 1
c_f is the force coefficient for the structure or structural element.

Appendix D2

Peak velocity pressure

$q_p(z_e) = c_e(z)q_b$

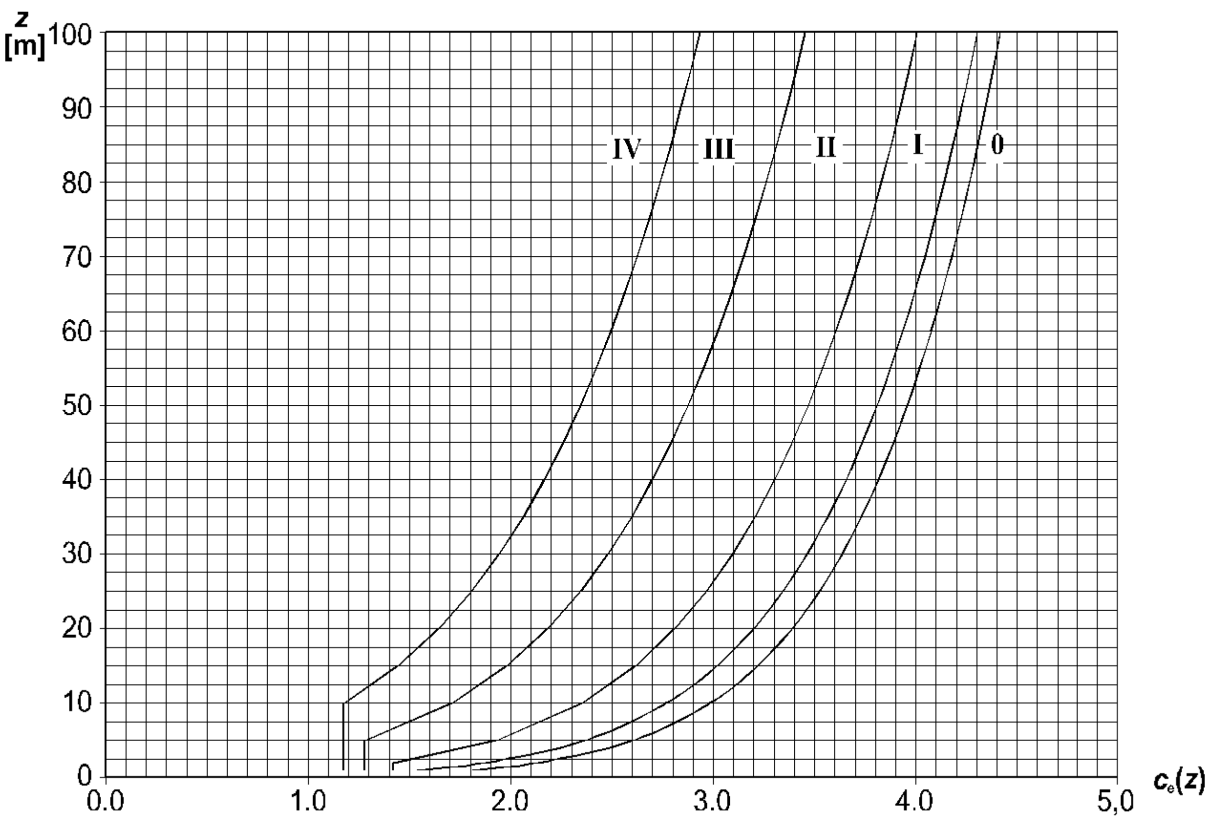
where $c_e(z)$ is the exposure factor, using Table D2 and Figure D2

$q_b = \frac{1}{2}\rho v_b^2 = \frac{v_b^2}{1600}$ is the reference mean (basic) velocity pressure in kN/m², with the recommended value for the air density $\rho = 1.25\ kg/m^3$ and the basic wind velocity, v_b in m/s, according to Appendix D3

Table D2 Terrain categories and terrain parameter

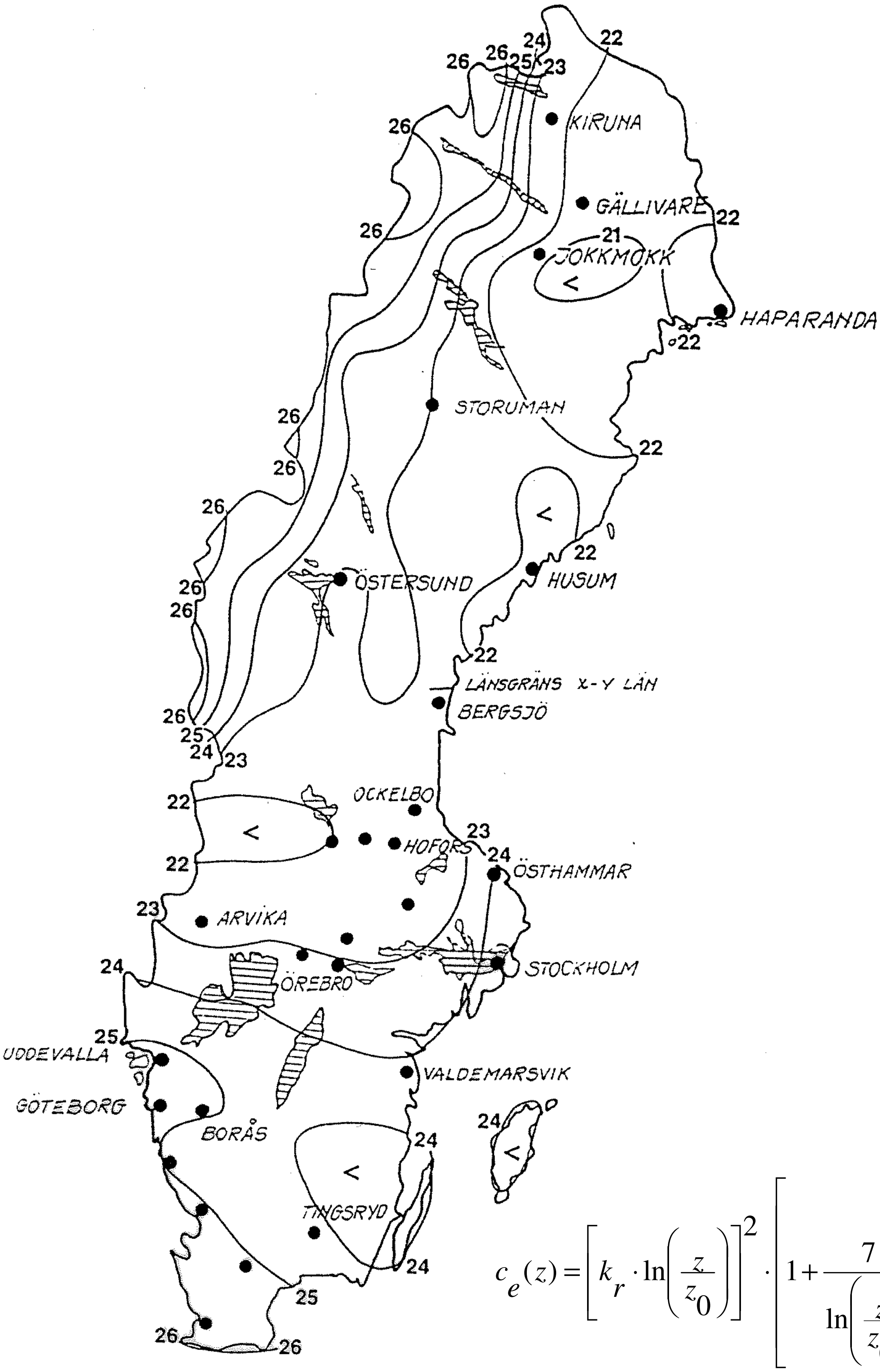
Terrain category		z_0 m	z_{min} m	k_r -
0	Sea or coastal area exposed to the open sea	0,003	1	0,16
I	Lakes or flat and horizontal area with negligible vegetation and without obstacles	0,01	1	0,17
II	Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights	0,05	2	0,19
III	Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	0,3	5	0,22
IV	Area in which at least 15 % of the surface is covered with buildings and their average height exceeds 15 m	1,0	10	0,24
NOTE: The terrain categories are illustrated in A.1.				

Figure D2 Illustration of the exposure factor $c_e(z)$ for c_0=1.0



Appendix D3.

Reference wind speed v_b in [m/s] for Sweden



$$c_e(z) = \left[k_r \cdot \ln\left(\frac{z}{z_0}\right)\right]^2 \cdot \left[1 + \frac{7}{\ln\left(\frac{z}{z_0}\right)}\right]$$

Expression above for the exposure factor $c_e(z)$ shown in Fig D2
(Coefficients shown in Table D2)

Appendix D4

Internal pressure coefficients

For a building with a **dominant face the internal pressure** should be taken as a fraction of the external pressure at the openings of the dominant face. The values given by Eq (7.2) and (7.3) should be used.
When the area of the openings at the dominant face is twice the area of the openings in the remaining faces,

$c_{pi} = 0{,}75 \cdot c_{pe}$ (7.2)

When the area of the openings at the dominant face is at least 3 times the area of the openings in the remaining faces,

$c_{pi} = 0{,}9 \cdot c_{pe}$ (7.3)

where c_{pe} is the value for the external pressure coefficient at the openings in the dominant face.

For buildings **without a dominant face**, the internal pressure coefficient c_{pi} should be determined from Figure 7.13, and is a function of the ratio of the height and the depth of the building, h/d, and the opening ratio μ for each wind direction θ, which should be determined from Eq (7.4).

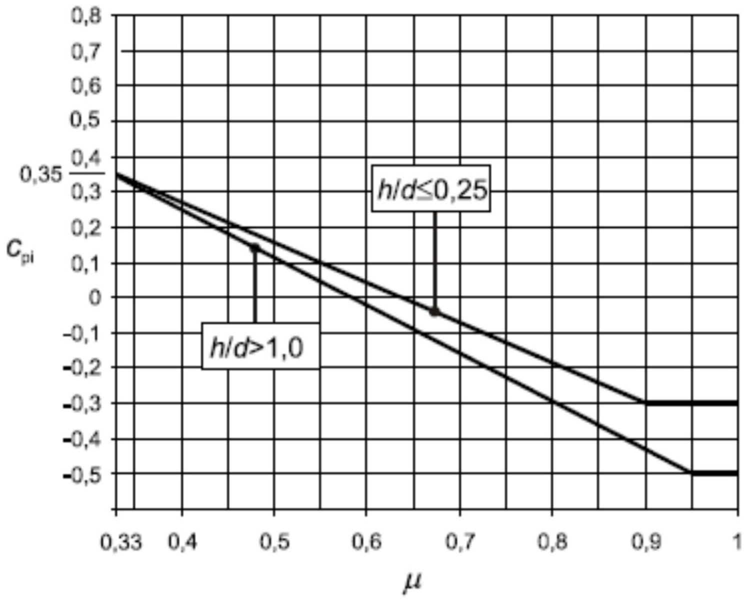


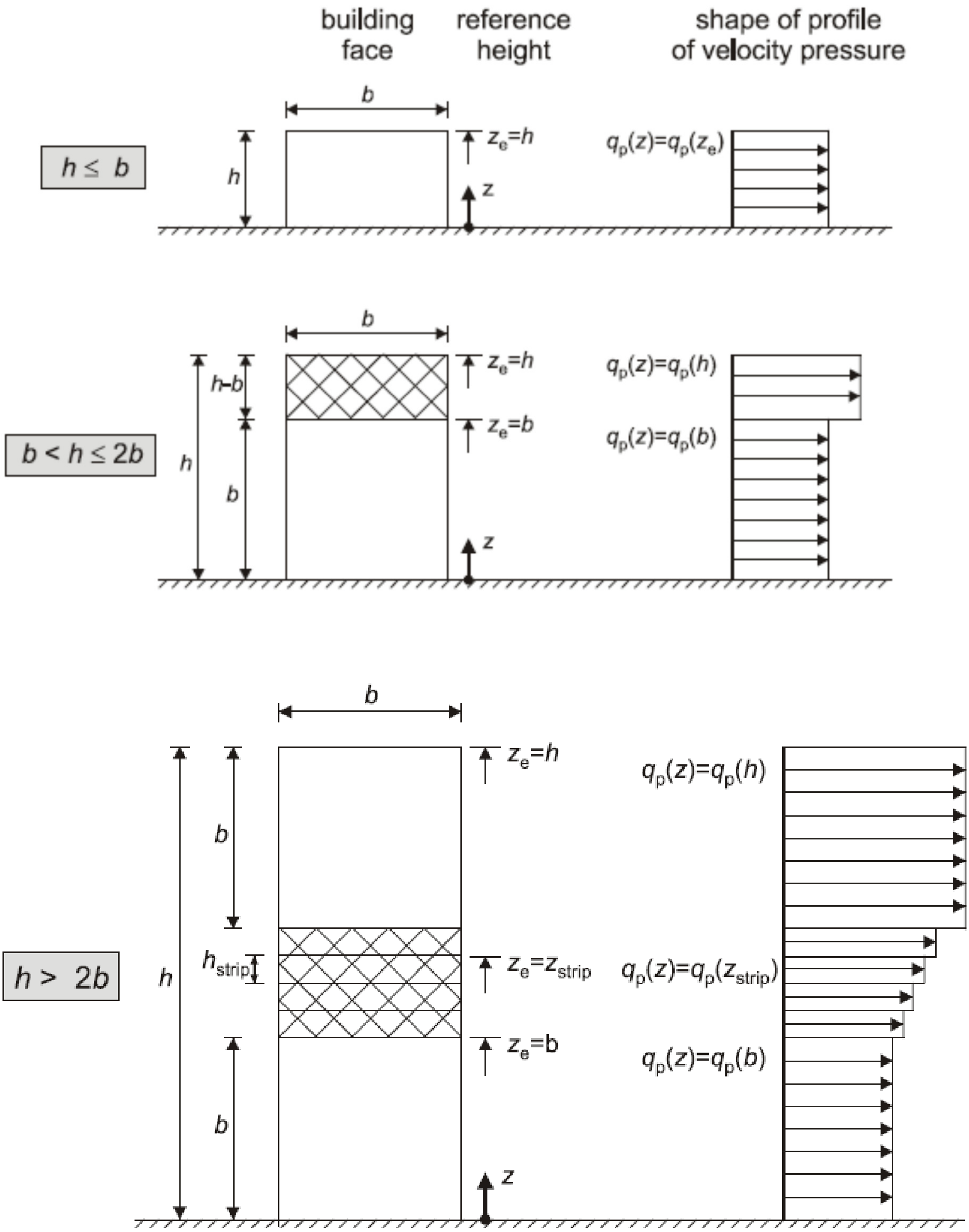
Figure 7.13 — Internal pressure coefficients for uniformly distributed openings

$$\mu = \frac{\sum \text{area of openings where } c_{pe} \text{ is negative or } -0{,}0}{\sum \text{area of all openings}}$$

If the area of openings is unknown use c_{pi} = + 0.2 or -0.3

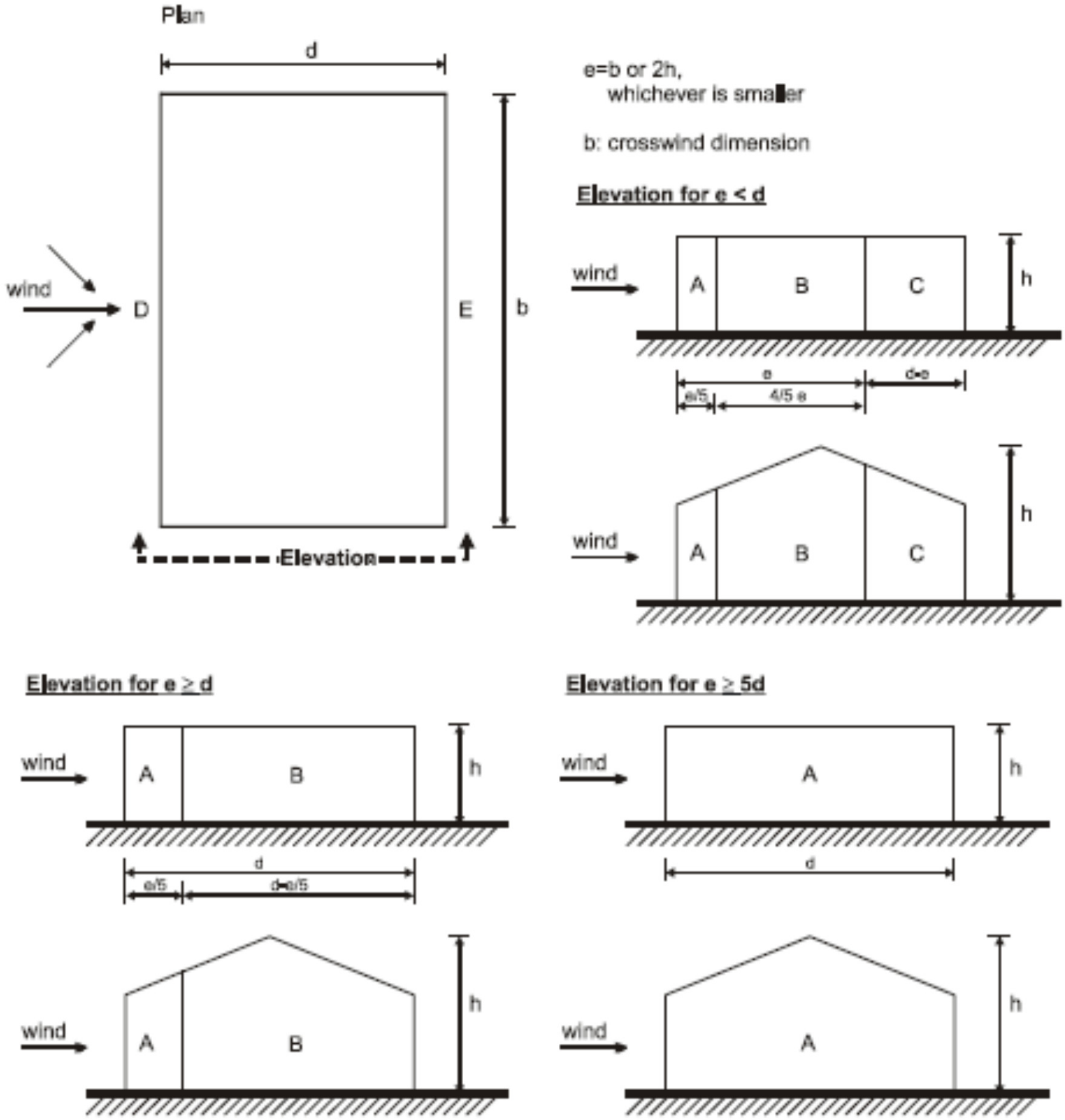
Appendix D5

Reference height, z_e, depending on h and b, and corresponding velocity pressure profile



NOTE The velocity pressure should be assumed to be uniform over each horizontal strip considered.

Appendix D6 Pressure coefficients on the external walls



The values of $c_{pe,10}$ and $c_{pe,1}$ may be given in the NA. The recommended values are given in Table below, depending on the ratio *h*/*d*. For intermediate values of *h*/*d*, linear interpolation may be applied. The values of Table also apply to walls of buildings with inclined roofs, such as duopitch and monopitch roofs.

Zone	A		B		C		D		E	
h/d	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
5	-1,2	-1,4	-0,8	-1,1	-0,5		+0,8	+1,0	-0,7	
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	

For intermediate values of *h*/*d*, linear interpolation may be applied.

Appendix D7 Flat roofs

Flat roofs are defined as having a slope (α) of $-5° < \alpha < 5°$

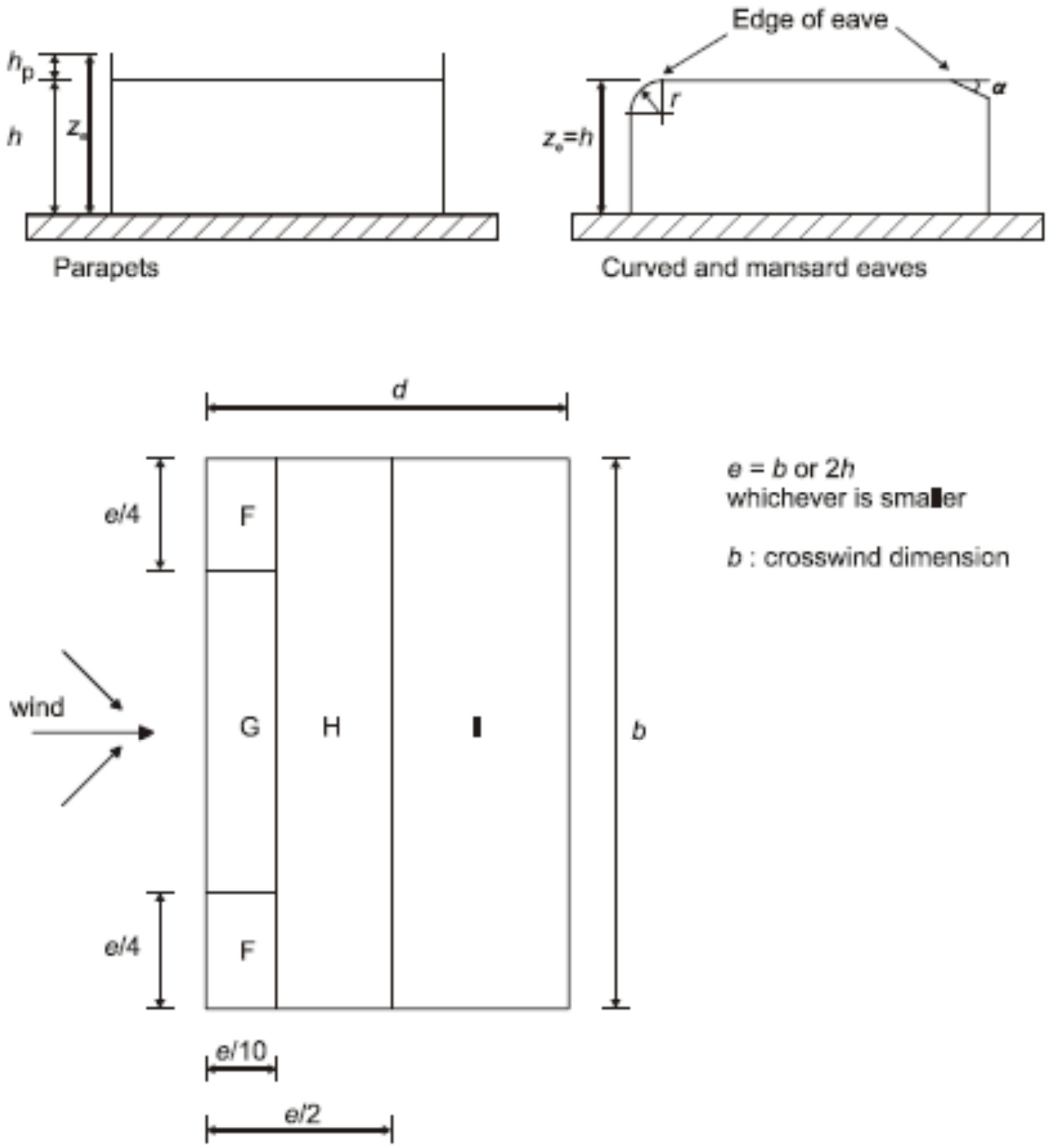


Figure 7.6 — Key for flat roofs

Appendix D8 Flat roofs

Table 7.2 — External pressure coefficients for flat roofs

Roof type		Zone F $c_{pe,10}$	F $c_{pe,1}$	G $c_{pe,10}$	G $c_{pe,1}$	H $c_{pe,10}$	H $c_{pe,1}$	I $c_{pe,10}$	I $c_{pe,1}$
Sharp eaves		-1,8	-2,5	-1,2	-2,0	-0,7	-1,2	+0,2	
								-0,2	
With Parapets	h_p/h=0,025	-1,6	-2,2	-1,1	-1,8	-0,7	-1,2	+0,2	
								-0,2	
	h_p/h=0,05	-1,4	-2,0	-0,9	-1,6	-0,7	-1,2	+0,2	
								-0,2	
	h_p/h=0,10	-1,2	-1,8	-0,8	-1,4	-0,7	-1,2	+0,2	
								-0,2	
Curved Eaves	r/h = 0,05	-1,0	-1,5	-1,2	-1,8	-0,4		+0,2	
								-0,2	
	r/h = 0,10	-0,7	-1,2	-0,8	-1,4	-0,3		+0,2	
								-0,2	
	r/h = 0,20	-0,5	-0,8	-0,5	-0,8	-0,3		+0,2	
								-0,2	
Mansard Eaves	α = 30°	-1,0	-1,5	-1,0	-1,5	-0,3		+0,2	
								-0,2	
	α = 45°	-1,2	-1,8	-1,3	-1,9	-0,4		+0,2	
								-0,2	
	α = 60°	-1,3	-1,9	-1,3	-1,9	-0,5		+0,2	
								-0,2	

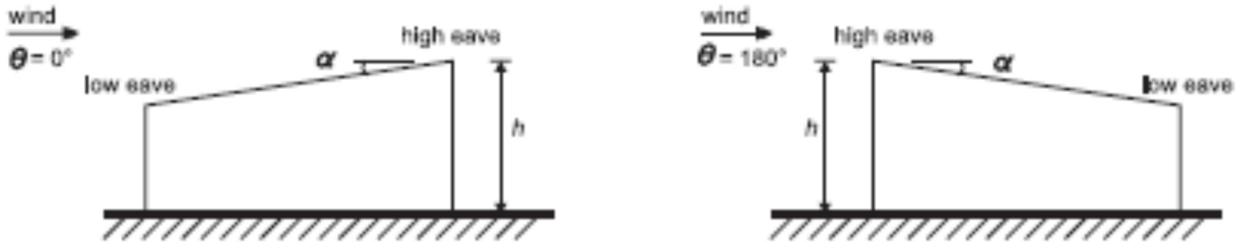
NOTE 1 For roofs with parapets or curved eaves, linear interpolation may be used for intermediate values of h_p/h and r/h.

NOTE 2 For roofs with mansard eaves, linear interpolation between α = 30°, 45° and α = 60° may be used. For α > 60° linear interpolation between the values for α = 60° and the values for flat roofs with sharp eaves may be used.

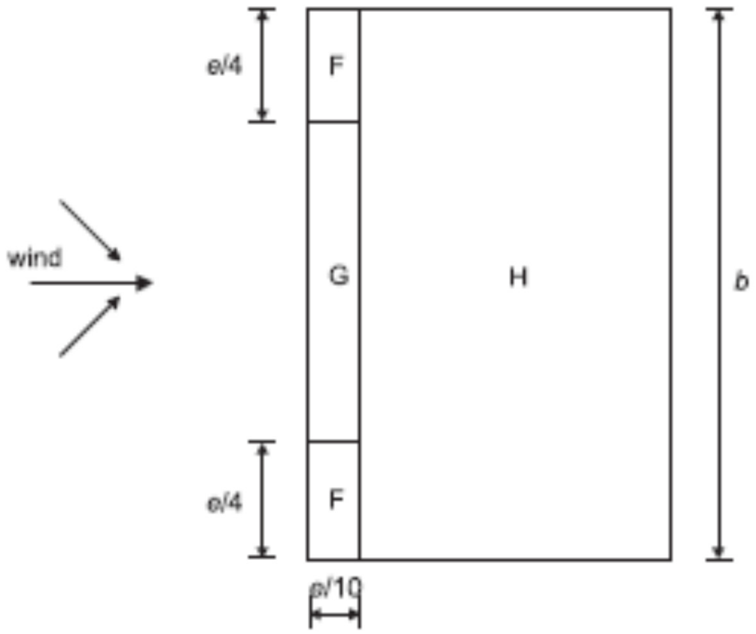
NOTE 3 In Zone I, where positive and negative values are given, both values shall be considered.

Appendix D9 Monopitch roofs

The roof, including protruding parts, should be divided into zones as shown in Figure below. The reference height z_e should be taken equal to h.



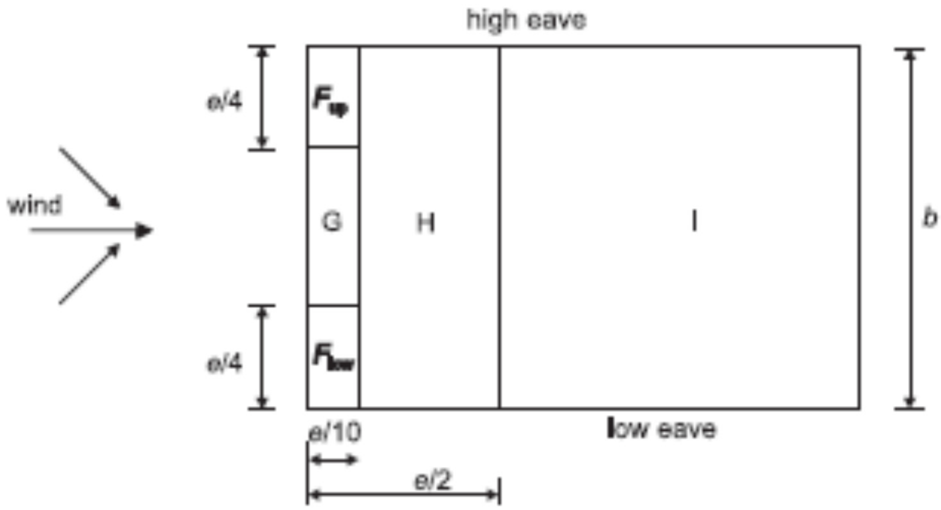
(a) general



(b) wind directions $\theta = 0°$ and $\theta = 180°$

$e = b$ or $2h$ whichever is smaller

b : crosswind dimension



(c) wind direction $\theta = 90°$

Appendix D10

Monopitch roofs

Table 7.3a — External pressure coefficients for monopitch roofs

Pitch Angle α	Zone for wind direction $\theta = 0°$						Zone for wind direction $\theta = 180°$					
	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	-2,5	-1,2	-2,0	-0,6	-1,2	-2,3	-2,5	-1,3	-2,0	-0,6	-1,2
	+0,0		+0,0		+0,0							
15°	-0,9	-2,0	-0,8	-1,5	-0,3		-2,5	-2,8	-1,3	-2,0	-0,9	-1,2
	+0,2		+0,2		+ 0,2							
30°	-0,5	-1,5	-0,5	-1,5	-0,2		-1,1	-2,3	-0,8	-1,5	-0,8	
	+0,7		+0,7		+0,4							
45°	-0,0		-0,0		-0,0		-0,6	-1,3	-0,5		-0,7	
	+0,7		+0,7		+0,6							
60°	+0,7		+0,7		+0,7		-0,5	-1,0	-0,5		-0,5	
75°	+0,8		+0,8		+0,8		-0,5	-1,0	-0,5		-0,5	

Table 7.3b — External pressure coefficients for monopitch roofs

Pitch Angle α	Zone for wind direction $\theta = 90°$									
	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	
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	

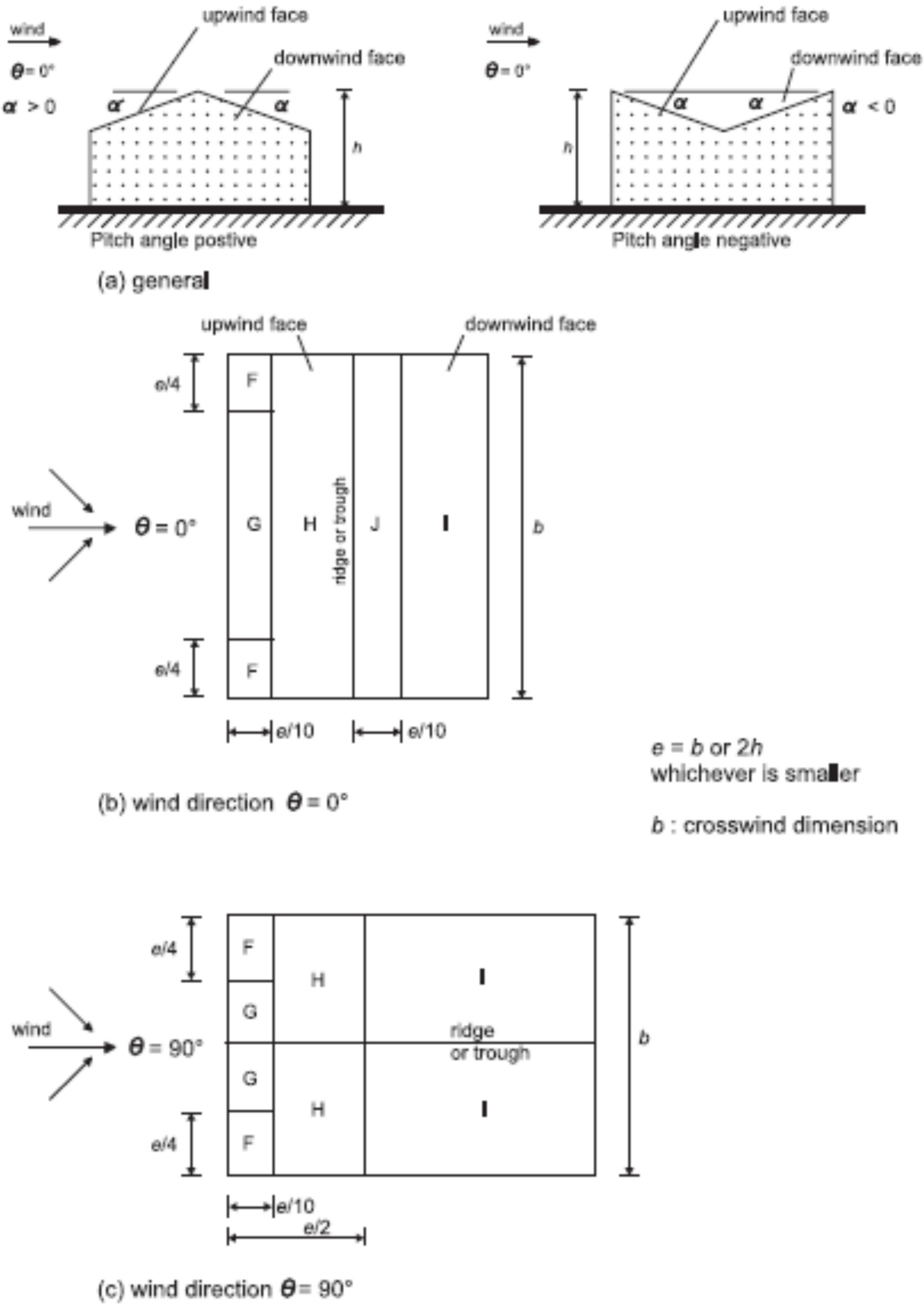
NOTE 1 At $\theta = 0°$ (see table a)) the pressure changes rapidly between positive and negative values around a pitch angle of $\alpha = +5°$ to $+45°$, so both positive and negative values are given. For those roofs, two cases should be considered: one with all positive values, and one with all negative values. No mixing of positive and negative values is allowed on the same face.

NOTE 2 Linear interpolation for intermediate pitch angles may be used between values of the same sign. The values equal to 0.0 are given for interpolation purposes

Appendix D11

Duopitch roofs

The roof, including protruding parts, should be divided into zones as shown in Figure below. The reference height z_e should be taken equal to h.



Appendix D12

Duopitch roofs

Table 7.4a — External pressure coefficients for duopitch roofs

Pitch Angle α	Zone for wind direction $\theta = 0°$									
	F		G		H		I		J	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
-45°	-0,6		-0,6		-0,8		-0,7		-1,0	-1,5
-30°	-1,1	-2,0	-0,8	-1,5	-0,8		-0,6		-0,8	-1,4
-15°	-2,5	-2,8	-1,3	-2,0	-0,9	-1,2	-0,5		-0,7	-1,2
-5°	-2,3	-2,5	-1,2	-2,0	-0,8	-1,2	+0,2		+0,2	
							-0,6		-0,6	
5°	-1,7	-2,5	-1,2	-2,0	-0,6	-1,2	-0,6		+0,2	
	+0,0		+0,0		+0,0				-0,6	
15°	-0,9	-2,0	-0,8	-1,5	-0,3		-0,4		-1,0	-1,5
	+0,2		+0,2		+0,2		+0,0		+0,0	+0,0
30°	-0,5	-1,5	-0,5	-1,5	-0,2		-0,4		-0,5	
	+0,7		+0,7		+0,4		+0,0		+0,0	
45°	-0,0		-0,0		-0,0		-0,2		-0,3	
	+0,7		+0,7		+0,6		+0,0		+0,0	
60°	+0,7		+0,7		+0,7		-0,2		-0,3	
75°	+0,8		+0,8		+0,8		-0,2		-0,3	

NOTE 1 At $\theta = 0°$ the pressure changes rapidly between positive and negative values on the windward face around a pitch angle of $\alpha = -5°$ to $+45°$, so both positive and negative values are given. For those roofs, four cases should be considered where the largest or smallest values of all areas F, G and H are combined with the largest or smallest values in areas I and J. No mixing of positive and negative values is allowed on the same face.

Table 7.4b — External pressure coefficients for duopitch roofs

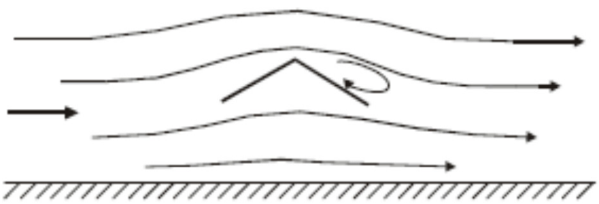
Pitch angle α	Zone for wind direction $\theta = 90°$							
	F		G		H		I	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
-45°	-1,4	-2,0	-1,2	-2,0	-1,0	-1,3	-0,9	-1,2
-30°	-1,5	-2,1	-1,2	-2,0	-1,0	-1,3	-0,9	-1,2
-15°	-1,9	-2,5	-1,2	-2,0	-0,8	-1,2	-0,8	-1,2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

Appendix D13 Canopy roof

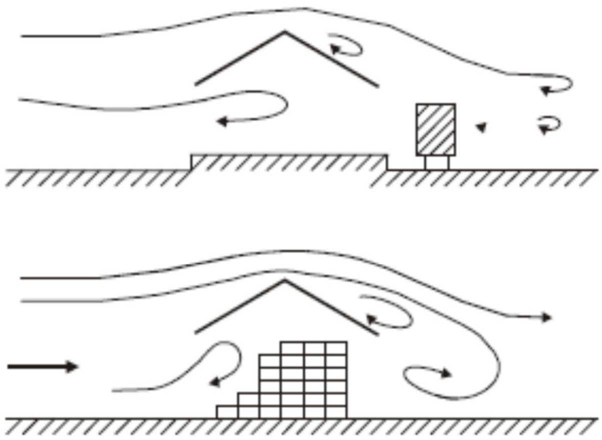
A canopy roof is defined as the roof of a structure that does not have permanent walls, such as petrol stations, dutch barns, etc.

The degree of blockage under a canopy roof is shown in Figure 7.15. It depends on the blockage φ, which is the ratio of the area of feasible, actual obstructions under the canopy divided by the cross sectional area under the canopy, both areas being normal to the wind direction. φ = 0 represents an empty canopy, and φ = 1 represents the canopy fully blocked with contents to the down wind eaves only (this is not a closed building).

The overall force coefficients, c_f, and net pressure coefficients $c_{p,net}$, given in Tables 7.6 to 7.8 for φ = 0 and φ = 1 take account of the combined effect of wind acting on both the upper and lower surfaces of the canopies for all wind directions. Intermediate values may be found by linear interpolation.



Empty, free-standing canopy (φ = 0)



Canopy blocked to the downwind eaves by stored goods (φ = 1)

Appendix D14 Duopitch canopy

Duopitch canopy (Table 7.7) the centre of pressure should be taken at the centre of each slope (Figure 7.17). In addition, a duopitch canopy should be able to support one pitch with the maximum or minimum load, the other pitch being unloaded.

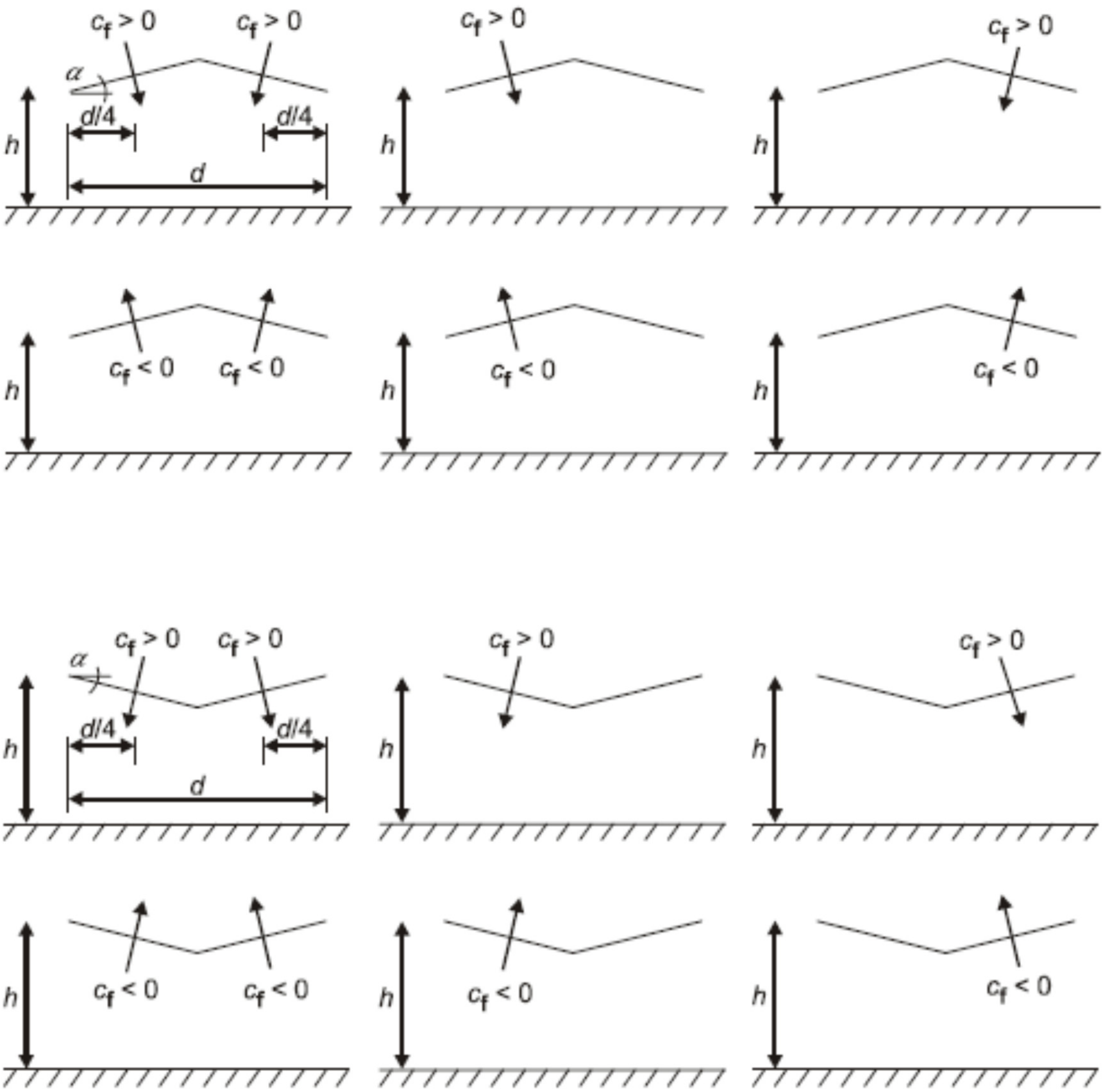


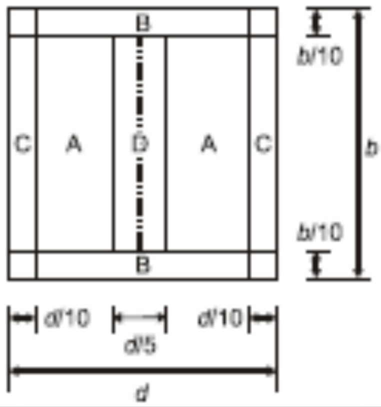
Figure 7.17 — Arrangements of loads obtained from force coefficients for duopitch canopies

Appendix D15

Table 7.7 — $c_{p,net}$ and c_f values for duopitch canopies

Net pressure coefficients $c_{p,net}$

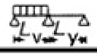
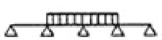
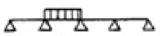
Key plan



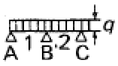
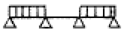
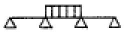
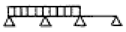
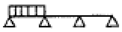
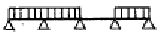
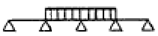
Roof angle α [°]	Blockage φ	Overall Force Coefficient c_f	Zone A	Zone B	Zone C	Zone D
- 20	Maximum all φ	+ 0,7	+ 0,8	+ 1,6	+ 0,6	+ 1,7
	Minimum φ = 0	- 0,7	- 0,9	- 1,3	- 1,6	- 0,6
	Minimum φ = 1	- 1,3	- 1,5	- 2,4	- 2,4	- 0,6
- 15	Maximum all φ	+ 0,5	+ 0,6	+ 1,5	+ 0,7	+ 1,4
	Minimum φ = 0	- 0,6	- 0,8	- 1,3	- 1,6	- 0,6
	Minimum φ = 1	- 1,4	- 1,6	- 2,7	- 2,6	- 0,6
- 10	Maximum all φ	+ 0,4	+ 0,6	+ 1,4	+ 0,8	+ 1,1
	Minimum φ = 0	- 0,6	- 0,8	- 1,3	- 1,5	- 0,6
	Minimum φ = 1	- 1,4	- 1,6	- 2,7	- 2,6	- 0,6
- 5	Maximum all φ	+ 0,3	+ 0,5	+ 1,5	+ 0,8	+ 0,8
	Minimum φ = 0	- 0,5	- 0,7	- 1,3	- 1,6	- 0,6
	Minimum φ = 1	- 1,3	- 1,5	- 2,4	- 2,4	- 0,6
+ 5	Maximum all φ	+ 0,3	+ 0,6	+ 1,8	+ 1,3	+ 0,4
	Minimum φ = 0	- 0,6	- 0,6	- 1,4	- 1,4	- 1,1
	Minimum φ = 1	- 1,3	- 1,3	- 2,0	- 1,8	- 1,5
+ 10	Maximum all φ	+ 0,4	+ 0,7	+ 1,8	+ 1,4	+ 0,4
	Minimum φ = 0	- 0,7	- 0,7	- 1,5	- 1,4	- 1,4
	Minimum φ = 1	- 1,3	- 1,3	- 2,0	- 1,8	- 1,8
+ 15	Maximum all φ	+ 0,4	+ 0,9	+ 1,9	+ 1,4	+ 0,4
	Minimum φ = 0	- 0,8	- 0,9	- 1,7	- 1,4	- 1,8
	Minimum φ = 1	- 1,3	- 1,3	- 2,2	- 1,6	- 2,1
+ 20	Maximum all φ	+ 0,6	+ 1,1	+ 1,9	+ 1,5	+ 0,4
	Minimum φ = 0	- 0,9	- 1,2	- 1,8	- 1,4	- 2,0
	Minimum φ = 1	- 1,3	- 1,4	- 2,2	- 1,6	- 2,1

+ values indicate a net downward acting wind action;
- values represent a net upward acting wind action

Appendix E1: Continuous beams with uniformly-distributed loads Sectional forces

load case	max. field moment (factor: qL^2)					support moment (factor: qL^2)				reaction forces (factor: qL)				
	M_1	M_2	M_3	M_4	M_5	M_B	M_C	M_D	M_E	A	B_v B_h	C_v C_h	D_v D_h	E_v E_h
2 spans 	0,0703	0,0703				−0,1250				0,3750	0,6250 0,6250	0,3750		
	0,0957					−0,0625				0,4375	0,5625 0,0625	−0,0625		
3 spans 	0,0800	0,0250	0,0800			−0,1000	−0,1000			0,4000	0,6000 0,5000	0,5000 0,6000	0,4000	
	0,1013		0,1013			−0,0500	−0,0500			0,4500	0,5500 0	0 0,5500	0,4500	
		0,0750				−0,0500	−0,0500			−0,0500	0,0500 0,5000	0,5000 0,0500	−0,0500	
	0,0735	0,0535				−0,1167	−0,0333			0,3833	0,6167 0,5834	0,4166 0,0333	−0,0333	
	0,0939					−0,0667	+0,0167			0,4333	0,5667 0,0834	−0,0834 −0,0167	0,0167	
4 spans 	0,0772	0,0364	0,0364	0,0772		−0,1071	−0,0714	−0,1071		0,3929	0,6071 0,5357	0,4643 0,4643	0,5357 0,6071	0,3929
	0,0996		0,0805			−0,0536	−0,0357	−0,0536		0,4464	0,5536 0,0179	−0,0179 0,4821	0,5179 0,0536	−0,0536
	0,0720	0,0610		0,0977		−0,1205	−0,0179	−0,0580		0,3795	0,6205 0,6026	0,3974 −0,0401	0,0401 0,5580	0,4420
		0,0561	0,0561			−0,0357	−0,1072	−0,0357		−0,0357	0,0357 0,4285	0,5715 0,5715	0,4285 0,0357	−0,0357
	0,0940					−0,0665	+0,0179	−0,0045		0,4335	0,5665 0,0844	−0,0844 −0,0224	0,0224 0,0045	−0,0045
		0,0737				−0,0491	−0,0536	+0,0134		−0,0491	0,0491 0,4955	0,5045 0,0670	−0,0670 −0,0134	0,0134

Appendix E2: Continuous beams with uniformly-distributed loads Deflection

load case	deflection in mid span $w = k \frac{qL^4}{100EI}$			
	k_1	k_2	k_3	k_4
2 spans 	0,521	0,521		
	0,912	−0,391		
3 spans 	0,677	0,052	0,677	
	0,990	−0,625	0,990	
	−0,313	0,677	−0,313	
	0,573	0,365	−0,208	
	0,885	−0,313	0,104	
4 spans 	0,632	0,186	0,186	0,632
	0,967	−0,558	0,744	−0,355
	0,549	0,437	−0,474	0,939
	−0,223	0,409	0,409	−0,223
	0,884	−0,307	0,084	−0,028
	−0,307	0,660	−0,251	0,084