UNIVERSITI SAINS MALAYSIA

2nd. Semester Examination
2001/2002 Academic Session

FEBRUARY / MARCH 2002

EAS 553/4 – Advanced Structural Design

Time : 3 hours

Direction to student:-

1. Ensure that this paper contains **TWENTY FOUR (24)** printed pages include appendices.

2. This paper contains **SEVEN (7)** question. Answer **FIVE (5)** question only. Marks will be given to the **FIRST FIVE (5)** question put in order on the answer script and **NOT** the **BEST FIVE (5).**

3. All questions carry the same mark.

4. All questions **MUST BE** answered in Bahasa Malaysia.

5. Write answered question number on the cover sheet of answer script.

1. (a) Define what is the meaning of formwork and falsework. (4 marks)

(b) Figure 1 shows a reinfoced concrete retaining wall with 4.5 m height and 400 mm thick, supported by a timber element AB which is spacing of 5m centre to centre. Given the type of concrete is OPC with 30% PFA, temperature during concreting is 20°C, width of the wall is 5.0 m and the pouring rate for the concrete is $3m^3$/hr.

i. Calculate the pressure exerted on the wall. (3 marks)

ii. Calculate the force exerted on bending member AC in kN/m and the axial force in member AB in kN.

(3 marks)

iii. If a solid timber, group A - wet, standard, is going to be used for the design of the bending member AC to carry out the short term loading find the minimum and norminal size of member AC to withstand the force in section 1b)ii.

(8 marks)

iv. Explain whether member AB and CD experience a sharing load factor?

(2 marks)

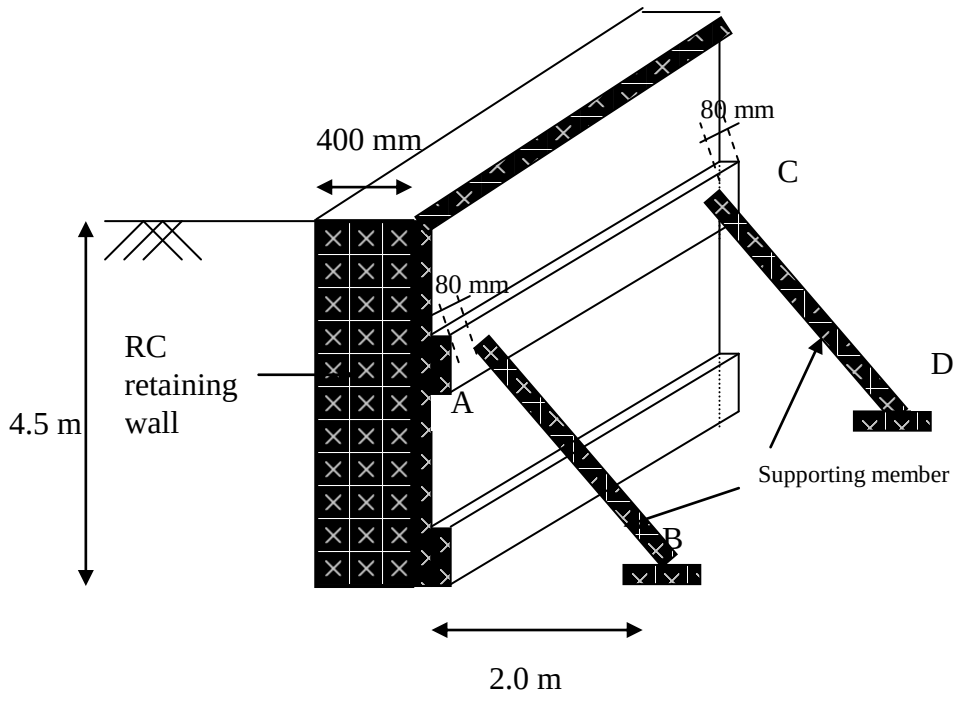

Figure 1

2 (a) An industrial building shown in Figure 2, situated at Ipoh in the terain category 3 with the basic wind speed of 33.5 m/s^2 is built for the furniture's factory. Assumed that it is made of steel structure, find the maximum wind pressure on W (windward), L (leeward), S (sidewall), U (upwind) and D (downwind) surfaces. Hence sketch the net wind pressures for each surface.

(15 marks)

(b) The industrial building is also equipped with a signboard of 50m x 1m on windward surface as shown in Figure 2. Assumed that it is a cladding element, find the maximum pressure experienced by the signboard.

Design data is given in Appendix B

(5 marks)

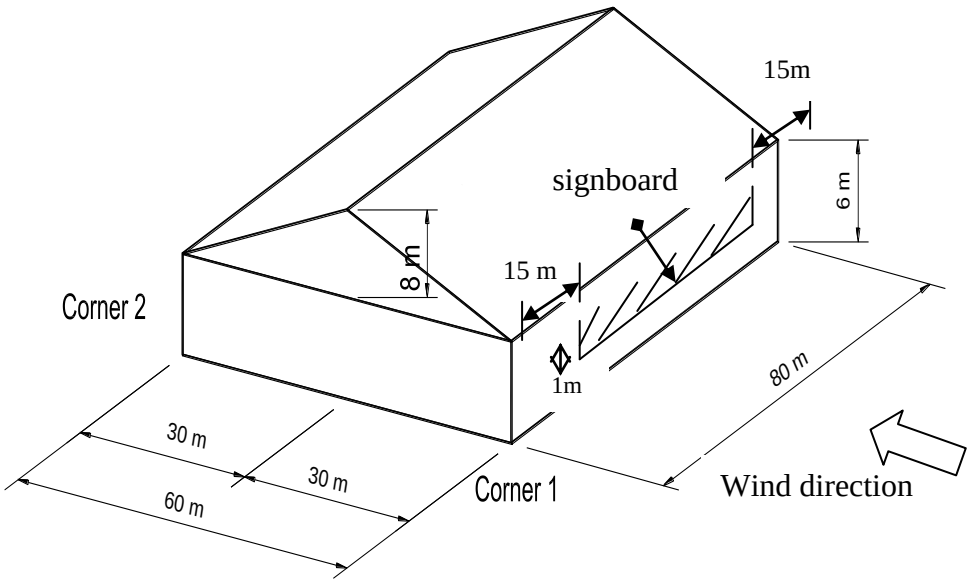

Figure 2

3. An open cylindrical tank as shown in Fig. 3 to store treated sewerage is to be constructed with an internal diameter of 33.5 m and a maximum liquid depth of 9.5 m. The wall of the tank is to be of uniform thickness. The sewerage is to be regarded as water for loading considerations. The walls are to be considered as being continuous with the base and with a free top.

Materials:
f_{cu}=35 N/mm^2 , f_{ct}=1.5 N/mm^2 , E_c=30 kN/mm^2
f_y= 460 N/mm^2 , f_s=130 N/mm^2, E_s=200 kN/mm^2

Self-weight:
$\gamma_{concrete}$ =24 kN/m^3 ; γ_{water} = 9.81 kN/m^3

Formula for membrane stress resultants:
$N_x = -\int p_x + C$; $N_\theta = p_r .a$

(a) Estimate the required wall thickness. (8 marks)

(b) Design the vertical and hoop reinforcements. (12 marks)

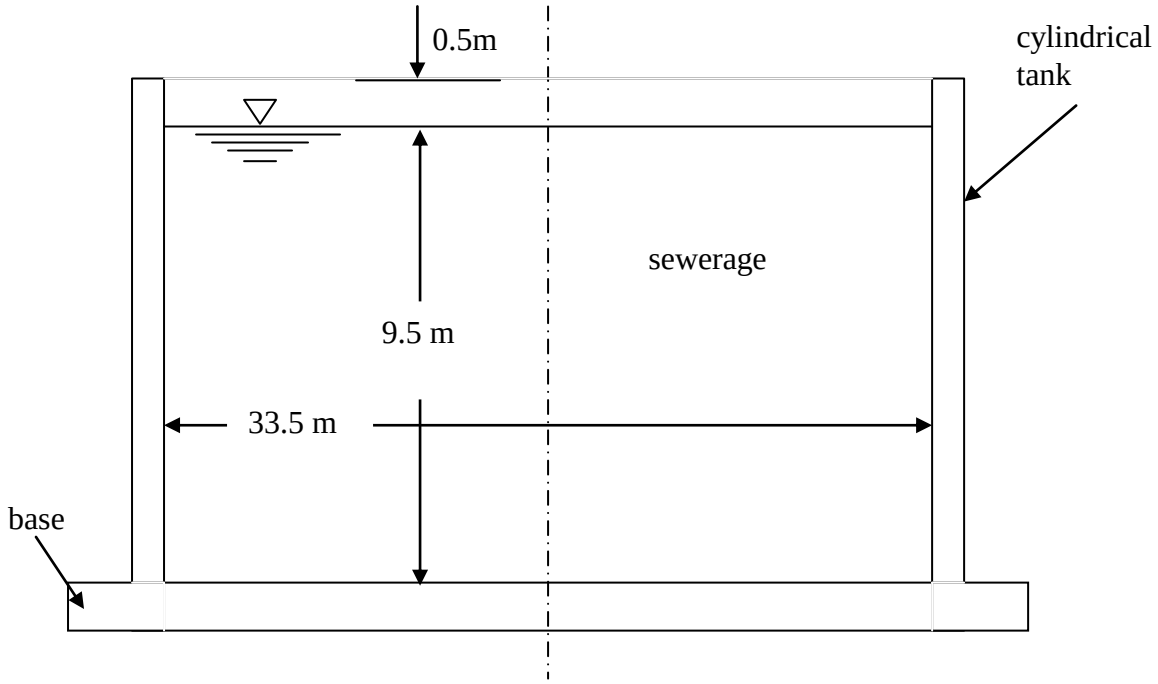

Figure 3

4. (a) Draw and show the behaviour of simply supported and continuous steel beam under load in the position of elastic, elastic-plastic and fully plastic. Explain briefly the relationship between the applied load against the deflection at the mid-span of the beam.

(5 marks)

(b) State **FOUR (4)** required assumptions in the plastic design when the plastic hinged develop in the steel member.

(5 marks)

(c) Figure 4 shows a continous beam having three unequal span subjected to several point loads. Design the cross-section of steel beam (Appendix D) based upon:

i. Uniform section
ii. Non-uniform section

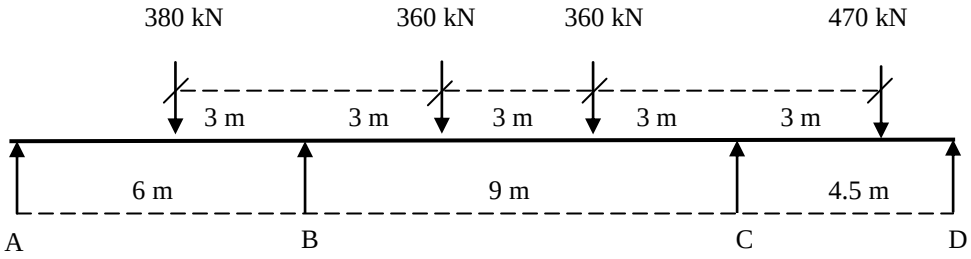

Figure 4

(10 marks)

5. Figure in Appendix E shows the table for standard PCA inverted-T sections. A simply supported prestressed beam with a span of 10 m will be designed for resisting a live load of 25 kN/m.

(a) Select a suitable section from the table. Determine the amount of strands required. Obtain the range of eccentricity e.

(10 marks)

(b) Plot the allowable cable zone if variable cable profile is used with the same amount of strands. Sketch the appropriate strand arrangement for the profile.

(10 marks)

6. Figure 5 shows a floor for resisting a design load of 20 kN/m^2. Compute the bending moment at the section where you think is critical by using Hillerborg Strip Method. Next, compute the reaction forces along the floor supports.

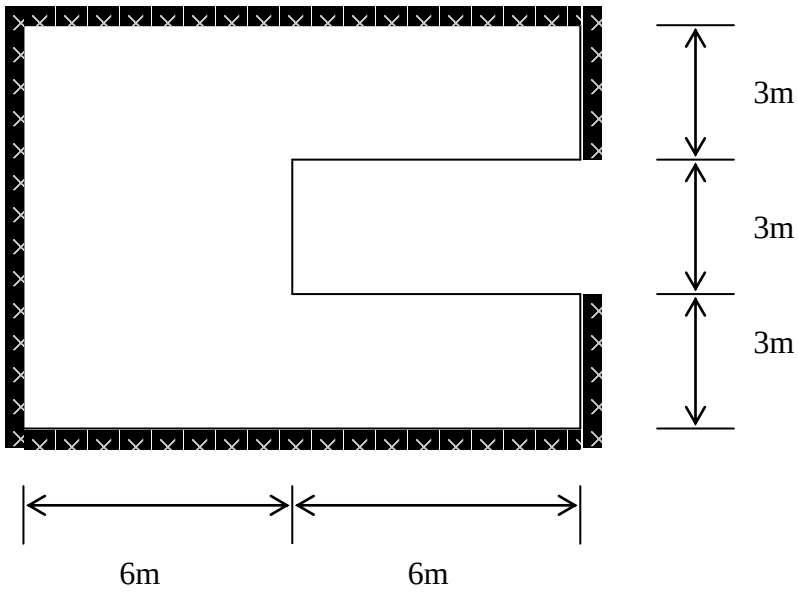

Figure 5

(20 marks)

7. A 65-storey international standard hotel with a total height of 250 m and a typical floor height of 3.5 m has been proposed for construction in Parit Buntar, Perak. Area of building perimeter is 75m x 15m. Center-to-center distances between columns in the length and tranverse directions are 10.5m and 5m, respectively.

You have been requested by the architect to propose a suitable structural system by taking into account the following points :

(i). Optimal usage of space
(ii). Hotel rooms along both faces of building
(iii). Provision of window in all rooms
(iv). Provision of lift in the center of building as well as at both ends of building

Discuss about the advantages of the structural system that you select.

(20 marks)

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APPENDIX A

Jadual 1.6 : Tegasan dan modulus keanjalan lembap* untuk kumpulan kekuatan (N/mm^2) (*MS 544 – Table 3.4*)

Kumpulan	Gred	Lentur	Tegangan selari dengan ira	Mampatan selari dengan ira	Mampatan serenjang dengan ira	Ricih selari dengan ira	Modulus keanjalan	
							Purata	Minimum
A	Asas	20.70	-	17.20	1.72	2.75		
	Select	16.50	9.90	13.80	1.45	1.93	13 790	8 620
	Standard	12.75	7.65	10.70	1.38	1.52		
	Common	10.30	6.18	8.60	1.24	1.24		
B	Asas	17.20	-	13.80	1.03	2.07		
	Select	13.80	8.28	11.00	0.87	1.45	11 030	6 205
	Standard	10.34	6.20	8.60	0.83	1.10		
	Common	8.60	5.16	6.90	0.76	0.90		
C	Asas	12.40	-	9.65	0.69	1.38		
	Select	9.93	5.96	7.58	0.59	0.96	8 960	5 170
	Standard	7.58	4.55	5.86	0.55	0.76		
	Common	6.20	3.72	4.83	0.52	0.62		
D	Asas	7.58	-	6.55	0.41	1.38		
	Select	5.86	3.52	5.17	0.34	0.97	5 720	2 965
	Standard	4.48	2.69	3.79	0.31	0.76		
	Common	3.79	2.27	3.24	0.28	0.62		

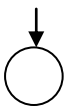
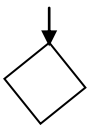
Nota : * Kayu yang mempunyai kandungan lembapan lebih daripada 19%
Tegangan selari dengan ira = 0.6 x nilai tegasan lentur. Ini merupakan pindaan daripada MS 544 yang dibuat oleh penulis (bukan oleh SIRIM) berasaskan BS 5268: Part 2: 1984

Data rekabentuk anggota lenturan :

Sistem yang mempunyai dua atau tiga anggota yang menaggung beban bersama-sama, nilai modulus keanjalan ialah $E_N = E_p - \frac{E_p - E_m}{\sqrt{N}}$

Panjang Galas(mm)	**10**	**15**	**25**	**40**	**50**	**75**	**100**	**≥150**
Nilai K_2	**1.74**	**1.67**	**1.53**	**1.33**	**1.20**	**1.14**	**1.10**	**1.00**

Rasuk ditakik dibahagian bawah	$K_{3.1} = \frac{D_e}{D}$
Rasuk ditakik dibahagian atas	$K_{3.2} = \frac{D}{D_e} - \left(\frac{D - D_e}{D_e^2}\right) e$ *untuk* $e < D$ $K_{3.2} = 1.0$ *untuk* $e \geq D$ $\frac{D_e}{D}$ *tidak kurang daripada* 0.6

K_4 = 1.18 	***K_4 = 1.41*** 

Ukur dalam rasuk, $K_5 = 0.81\dfrac{D^2 + \ 92300}{D^2 + \ 56800} \quad untuk \quad D > 300mm$

APPENDIX A

Kestabilan sisi, **Jadual 2.4: Nisbah ukur dalam kepada lebar (anggota pejal)**

Darjah sokongan sisi	Nisbah maksimum ukur dalam-lebar
Tiada sokongan sisi.	**2**
Hujung-hujung dipegang pada kedudukannya.	**3**
Hujung-hujung dipegang pada kedudukannya dan anggota dipegang dalam barisan, seperti oleh gulung-gulung atau batang pengikat.	**4**
Hujung-hujung dipegang pada kedudukannnya dan bahagian mampatan dipegang dalam barisan, seperti secara sambungan langsung dengan papan lantai, geladak atau gelegar.	**5**
Hujung-hujung dipegang pada kedudukannya dan bahagian mampatan dipegang dalam barisan, seperti secara sambungan langsung dengan papan lantai, geladak atau gelegar, beserta dengan rembatan yang cukup pada jarak luang tidak melebihi 6 kali ul dalamnya.	**6**
Hujung-hujung dipegang pada kedudukannya dan kedua-dua bahagian atas dan bawah anggota dipegang teguh dalam barisan.	**7**

Tegasan lentur, $fs \leq fp$ iaitu $fs=M/Z$ dan $fp = fg \ X \ K_1 \ X \ K_{kb} \ X \ K_4 \ X \ K_5$

Tegasan ricih, $qs \leq q_p$ iaitu $qs = 1.5 \ V/A$ dan $q_p = q_g \ X \ K_1 \ X \ K_{kb} \ X \ K_3$

Pesongan, $\Delta s < \Delta p$ iaitu $\Delta s = 5wL^4/384EI + FM_o/GA$ dan $\Delta p = 0.003L$

Tegasan galas, $C_{ts} \leq C_{tp}$ iaitu $C_{ts} = R/A_a$ dan $C_{tp} = C_{tg} \ X \ K_1 \ X \ K_{kb} \ X \ K_2$

<u>Data rekabentuk anggota mampatan :</u>

E minimum perlu digunkan untuk anggota mampatan.

C_{sg} ialah mampatan selari dengan ira

Nisbah kelangsingan = $\dfrac{Le}{r}$ iaitu r = $\sqrt{\dfrac{I}{A}}$

Anggapan Lex = Ley = 1.0 L_{AB}

Tegasan izin = C_{sg} x K_6 x K_{kb}

Beban izin = Tegasan izin x luas keratan

APPENDIX B

A P P E N D I X A
(normative)

S I M P L I F I E D P R O C E D U R E

A1. Limitations

The simplified procedure of analysis shall be applied to the design of cladding and main structural system of building structures, which meet all of the following criteria:

a) the buildings are rectangular in plan, or a combination of rectangular units;
b) the average roof height of a structure, h, is not greater than 15.0m.
c) the ratio of the average roof height to the least horizontal dimension does not exceed 3.
d) the location of structure is not at unusually exposed locations such as hill-crest or at headland; and
e) the following types of building is considered in this section:

i) buildings and structures where the primary occupancy is one in which more than 300 people congregate in one area.
ii) essential buildings and structures
iii) hospital and medical facilities
iv) fire and police stations
v) structures and equipment in civil defense
vi) communication centres and facilities for emergency response
vii) power stations and other emergency utilities
viii) defense shelter.

A2. Procedures

A2.1 The design wind pressures, p in Pa, shall be taken as

a) $p = 0.613 (V_S)^2(M_{z,cat})^2(C_{pe}K_l - C_{pi})$ for cladding,

b) $p = 0.613(V_S)^2(M_{z,cat})^2(C_{pe} - C_{pi})$ for structural system,

where :

V_S 33.5 m/s and 32.5 m/s for Zone I and Zone II respectively (see Figure A1)

$(M_{z,cat})$ terrain/height multiplier as given in Table A2

C_{pe} external pressure coefficients for surfaces of enclosed building as

given in Section A2.3 and A2.4

C_{pi} internal pressure coefficients for surfaces of enclosed buildings which shall be taken as +0.6 or –0.3. The two cases shall be considered to determine the critical load requirements for the appropriate condition.

K_l Local pressure factor as given in Table A8 and Figure A2

APPENDIX B

A2.2 The design wind pressure used in the design of cladding and main structural system shall not be less than 0.65 kN/m^2.

Table A2. Terrain height multiplier, $M_{z,cat}$

Height, z (m)	$M_{z,cat}$			
	Terrain Category 1	Terrain Category 2	Terrain Category 3	Terrain Category 4
≤3	0.99	0.85	0.75	0.75
5	1.05	0.91	0.75	0.75
10	1.12	1.00	0.83	0.75
15	1.16	1.05	0.89	0.75

NOTE. Terrain Category Definition

a) Category 1 : Exposed open terrain with few or no obstructions.

b) Category 2 : Water surfaces, open terrain, grassland with few well scattered obstructions having height generally from 1.5m to 10.0m.

c) Category 3 : Terrain with numerous closely spaced obstructions 3.0m to 5.0m high such as areas of suburban housing.

d) Category 4 : Terrain with numerous large, high (10.0m to 30.0m high) and closely spaced obstructions such as large city centres and well-developed industrial complexes.

A2.3 The external pressure coefficients, $C_{p,e}$, for windward wall shall be taken as 0.8. $C_{p,e}$ for leeward and side wall shall be as per Table A3 and A4 respectively.

Table A3. External pressure coefficients $C_{p,e}$, for leeward wall

α*	d/b*	$C_{p,e}$
≤10°	≤1 2 ≥4	-0.5 -0.3 -0.2
15° 20° ≥25°	All values	-0.3 -0.4 -0.5

* For intermediate values of d/b and α, use linear interpolation.

Table A4. External pressure coefficients $C_{p,e}$, for side walls

Horizontal distance from windward edge	$C_{p,e}$
0 to 2h >2h	-0.65 -0.30

APPENDIX B

A2.4 The external pressure coefficients, C_{pe}, for roofs shall be as per Table A5, A6 and A7.

Table A5. For up-wind slope, u and down-wind slope, d for α<10° and R for gable roofs

Roof type and slope		Horizontal distance from windward edge	External pressure coefficient, $C_{p,e}$	
Cross wind slopes for gable roofs, R	Up- wind slopes, U, Down-wind slope, D		*h*/*d* ≤ 0.5**	*h*/*d* ≥ 1.0**
All α	α < 10°	0 to 1h 1h to 2h > 2h	-0.9, -0.4 -0.5, 0 -0.3, 0.2	-1.3, -0.6 (-0.7)*, (-0.3)*

Table A6. Up-wind slope, U, α ≥ 10°

Roof type And slope	Ratio *h*/*d*	External pressure coefficients, $C_{p,e}$						
Up-wind Slope, U		Roof pitch, α degrees *						
		10	15	20	25	30	35	≥ 45
α ≥ 10°	≤ 0.25	-0.7, -0.3	-0.5, -0.0	-0.3, -0.2	-0.2, -0.3	-0.2, -0.4	-0.0, 0.5	0, 0.8sinα
	0.5	-0.9, -0.4	-0.7, -0.3	-0.4, -0.0	-0.3, -0.2	-0.2, -0.3	-0.2, 0.4	
	≥ 1.0	-1.3, -0.6	-1.0, -0.5	-0.7, -0.3	-0.5, -0.0	-0.3, -0.2	-0.2, 0.3	

Table A7. Down-wind slope, D, α ≥ 10° and R for hip roofs

Roof type and slope		Ratio *h*/*d**	External pressure coefficient, $C_{p,e}$		
Cross-wind slopes for hip roof, R	Down-wind slopes, D		Roof pitch, α degrees*		
			10	15	≥ 20
All α	α ≥ 10°	≤ 0.25	-0.3	-0.5	- 0.6
		0.5	-0.5	-0.5	-0.6
		≥ 1.0	-0.7	-0.6	-0.6

* Interpolation shall only be carried out on values of the same sign.
* For intermediate values of roof slopes and *h*/*d* ratios, use linear interpolation

APPENDIX B

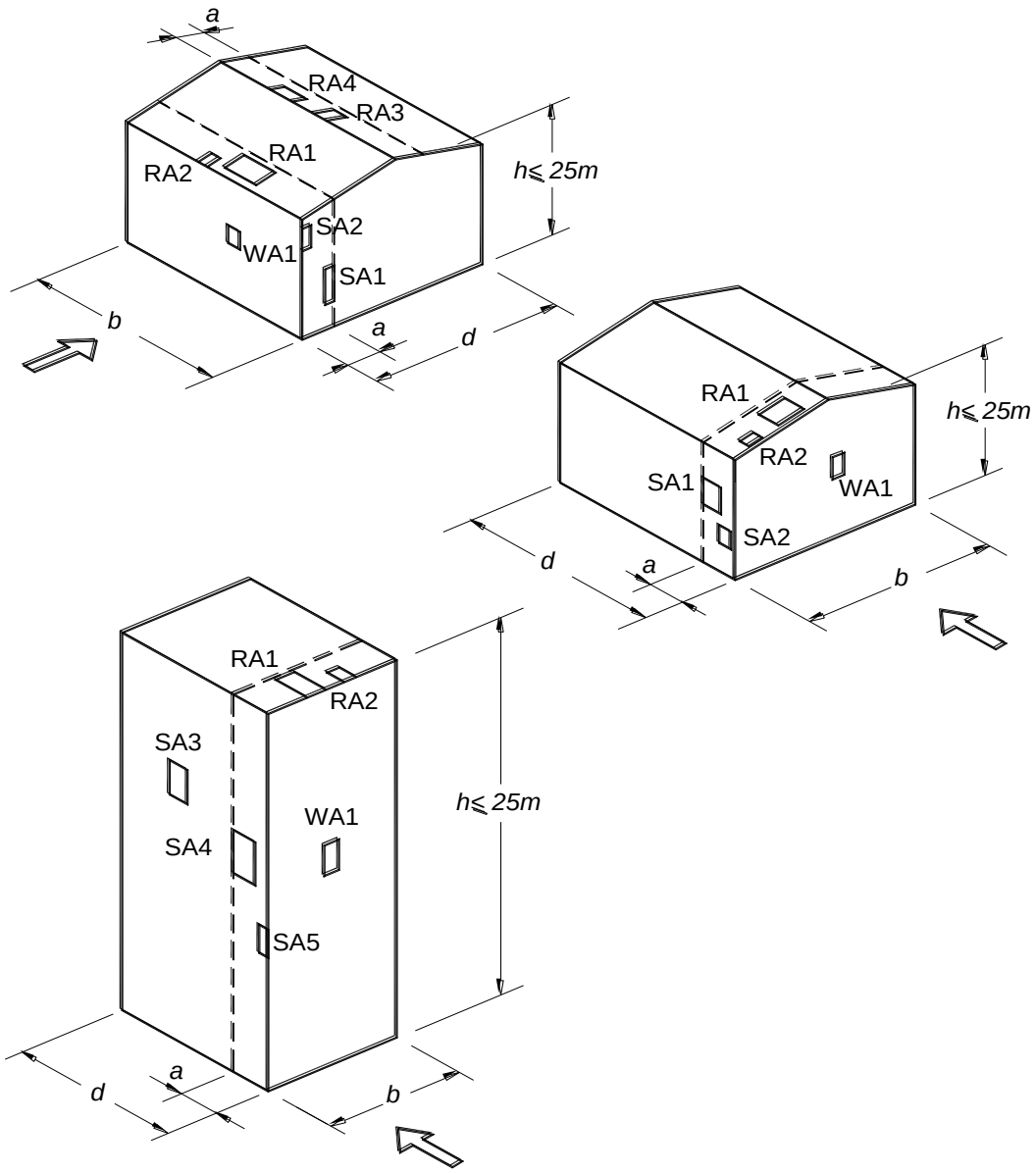
Table A8. Local pressure factor, K_l for claddings

Design case	Figure A2 reference number	*h* (m)	Area, *A*	Proximity to edge	K_l
Positive pressures					
Windward wall	WA1	All	$A \leq 0.25a^2$	Anywhere	1.25
All other areas	-	All	-	-	1.0
Negative pressures					
Roof edges	RA1	All	$0.25a^2 < A \leq a^2$	< a	1.5
	RA2	All	$A \leq 0.25a^2$	< 0.5a	2.0
Hips and ridges of roofs With pitch $\geq 10°$	RA3	All	$0.25a^2 < A \leq a^2$	< a	1.5
	RA4	All	$A \leq 0.25a^2$	< 0.5a	2.0
Side walls near Windward wall edges	SA1	≤ 25	$0.25a^2 < A \leq a^2$	< a	1.5
	SA2		$A \leq 0.25a^2$	< 0.5a	2.0
	SA3	> 25	$A \leq 0.25a^2$	> a	1.5
	SA4		$0.25a^2 < A \leq a^2$	< a	2.0
	SA5		$A \leq 0.25a^2$	< 0.5a	3.0
All other areas	-	All	-	-	1.0

NOTES:

1. The dimension, a, and the Figure reference numbers are defined in Figure A2
2. Design cases attracting $K_l = 1.5$ or 3.0 are alternative cases and need not be applied simultaneously.
3. The areas for local pressure factor are not necessarily square.

APPENDIX B



Note: The value of the dimension *a*, is the minimum of 0.2*b*, 0.2*d* and *h*

Figure A2. Local pressure factors (K_l)

APPENDIX C

Steel Area Section

Table 1

Sectional areas of groups of bars (mm^2)										
Bar size	Number of bars									
(mm)	1	2	3	4	5	6	7	8	9	10
6	28.3	56.6	84.9	113	142	170	198	226	255	283
8	50.3	101	151	201	252	302	352	402	453	503
10	78.5	157	236	314	393	471	550	628	707	785
12	113	226	339	452	566	679	792	905	1020	1130
16	201	402	603	804	1010	1210	1410	1610	1810	2010
20	314	628	943	1260	1570	1890	2200	2510	2830	3140
25	491	982	1470	1960	2450	2950	3440	3930	4420	4910
32	804	1610	2410	3220	4020	4830	5630	6430	7240	8040
40	1260	2510	3770	5030	6280	7540	8800	10100	11300	12600

Table 2

Sectional areas per metre width for various bar spacing (mm^2)									
Bar size (mm)	Spacing of bars								
	50	75	100	125	150	175	200	250	300
6	566	377	283	226	189	162	142	113	94.3
8	1010	671	503	402	335	287	252	201	168
10	1570	1050	785	628	523	449	393	314	262
12	2260	1510	1130	905	754	646	566	452	377
16	4020	2680	2010	1610	1340	1150	1010	804	670
20	6280	4190	3140	2510	2090	1800	1570	1260	1050
25	9820	6550	4910	3930	3270	2810	2450	1960	1640
32	16100	10700	8040	6430	5360	4600	4020	3220	2680
40	25100	16800	12600	10100	8380	7180	6280	5030	4190