UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2017/2018

COURSE NAME	:	STRUCTURAL ANALYSIS & DESIGN
COURSE CODE	:	BNP 20803
PROGRAMME CODE	:	BNA/BNB/BNC
EXAMINATION DATE	:	JUNE/JULY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS **ONLY**

DESIGN SHOULD BE BASED ON:
BS EN 1990:2002+A1 2005
NA BS EN 1990:2002+A1:2005
BS EN 1991-1-1:2002
NA BS EN 1991-1-1:2002
BS EN 1992-1-1:2004
BS 8110:PART 1:1997
BS EN 1993 :2005

THIS QUESTION PAPER CONSISTS OF **EIGHTEEN (18)** PAGES

Q1. One continuous beam is loaded with a uniformly and concentrated load as shown in **Figure Q1.** The cross section and Young Modulus of the beam is constant.

(a) Define the meaning of indeterminate beam.

(2 marks)

(b) Calculate the end moment at the joints by using modified moment distribution method.

(12 marks)

(c) Determine the support reactions.

(5 marks)

(d) Sketch the shear force diagram

(3 marks)

(e) Sketch the bending moment diagram.

(3 marks)

Q2. (a) High yield bars (H) is denoted as a classification of different class of bars. Name the classes of bars that may be used in the concrete design.

(3 marks)

(b) Explain briefly the important of serviceability limit state in the design stage for the structures.

(2 marks)

(c) **Figure Q2** shows part of the ground floor plan of a reinforced concrete office building. Slab thickness is 125 mm. Dimensions of the beams is given in the diagram. The finishes, ceiling and services form a characteristics permanent action of 1.5 kN/m^2. The characteristic variable action is 3.0 kN/m^2 and 3.0 m high brickwall weighing 2.6 kN/m^2 is placed over the entire span of all beams. Given the additional following data:

Concrete Grade, f_{ck}	= 25 N/mm^2
Steel reinforcement Grade 500, f_{yk}	= 500 N/mm^2
Weight of concrete	= 25 kN/m^3

(i) Analyze the design action carried by beam B/1-2 and sketch the action distribution on the beam from each slab.

(15 marks)

(ii) Calculate and sketch the bending moment and shear force for beam B/1-2.

(5 marks)

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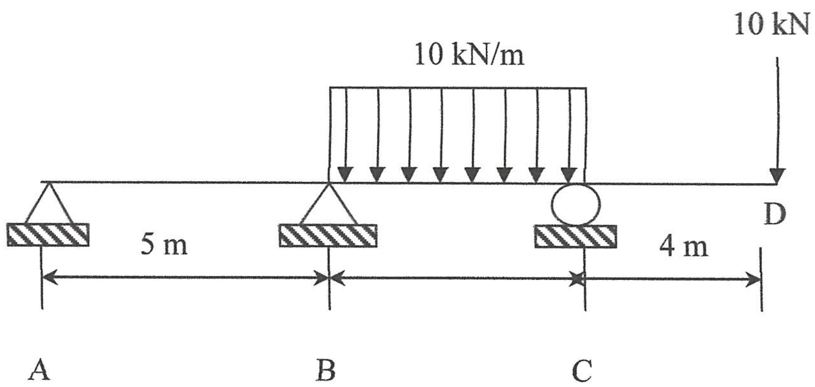

FIGURE Q1

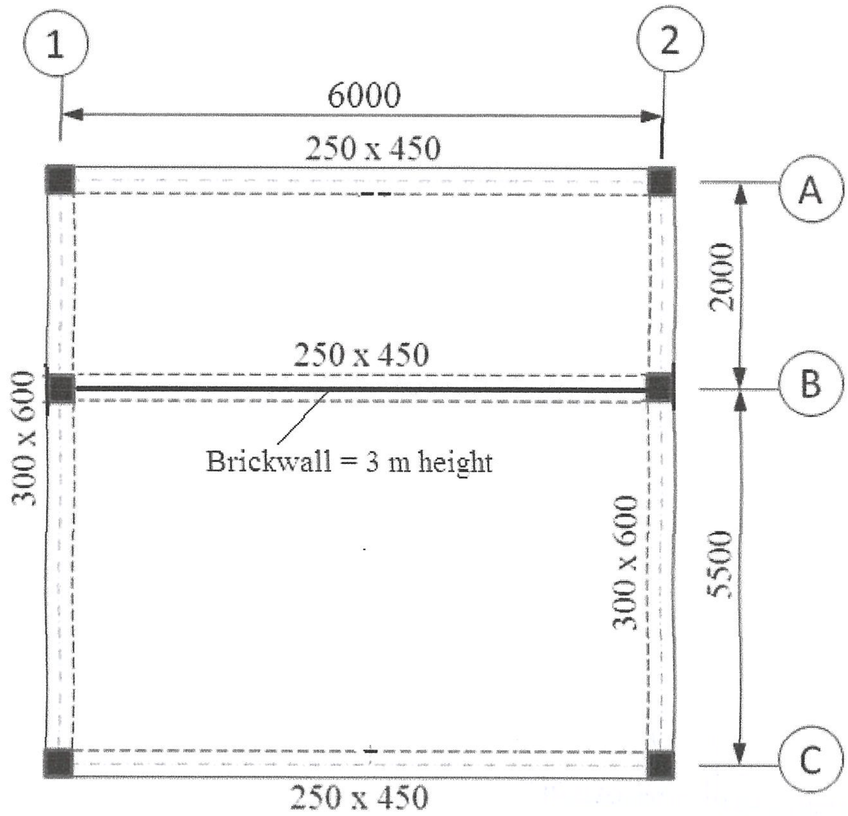

FIGURE Q2

Q3 Layout in **Figure Q3** is a plan for the part of the ground floor of reinforced concrete buildings. By assuming ground beam gb2 2/A-D as rectangular beam and ignore the beam flange answer all subquestion below. Given dimensions, characteristic action and material as below:

Dimension:

Span	= 6.00 m
Width	= 3.00 m
Slab thickness	= 110 mm
Beam Size	= 200 x 500 mm

Characteristic Action:

Finishes etc.	= 1.5 kN/m² (excluding selfweight)
Variable, qk	= 3 kN/m²

Material

Unit weight of Concrete	= 25 kN/m³
Characteristic strength of concrete, fck	= 25 N/mm²
Characteristic Strength of steel, fyk	= 500 N/mm²
Characteristic Strength of link, fyk	= 500 N/mm²
Use nominal cover	= 30 mm

Use assumed size of bar as bellow:

Øbar1 = 20 mm
Øbar2 = 16 mm
Ølink = 6 mm

(a) Calculate design load transfer from slab to beam 2/A-D.

(3 marks)

(b) By using simplified method determine the shear force and bending moment for beam 2/A-D.

(3marks)

(c) Design the main reinforcement of beam at span A-B, B-C and C-D.

(7marks)

(d) Design the main reinforcement of beam at support B and C.

(6marks)

(e) Design shear reinforcement at support, mid span and ignore additional longitudinal reinforcement for tensile force

(6marks)

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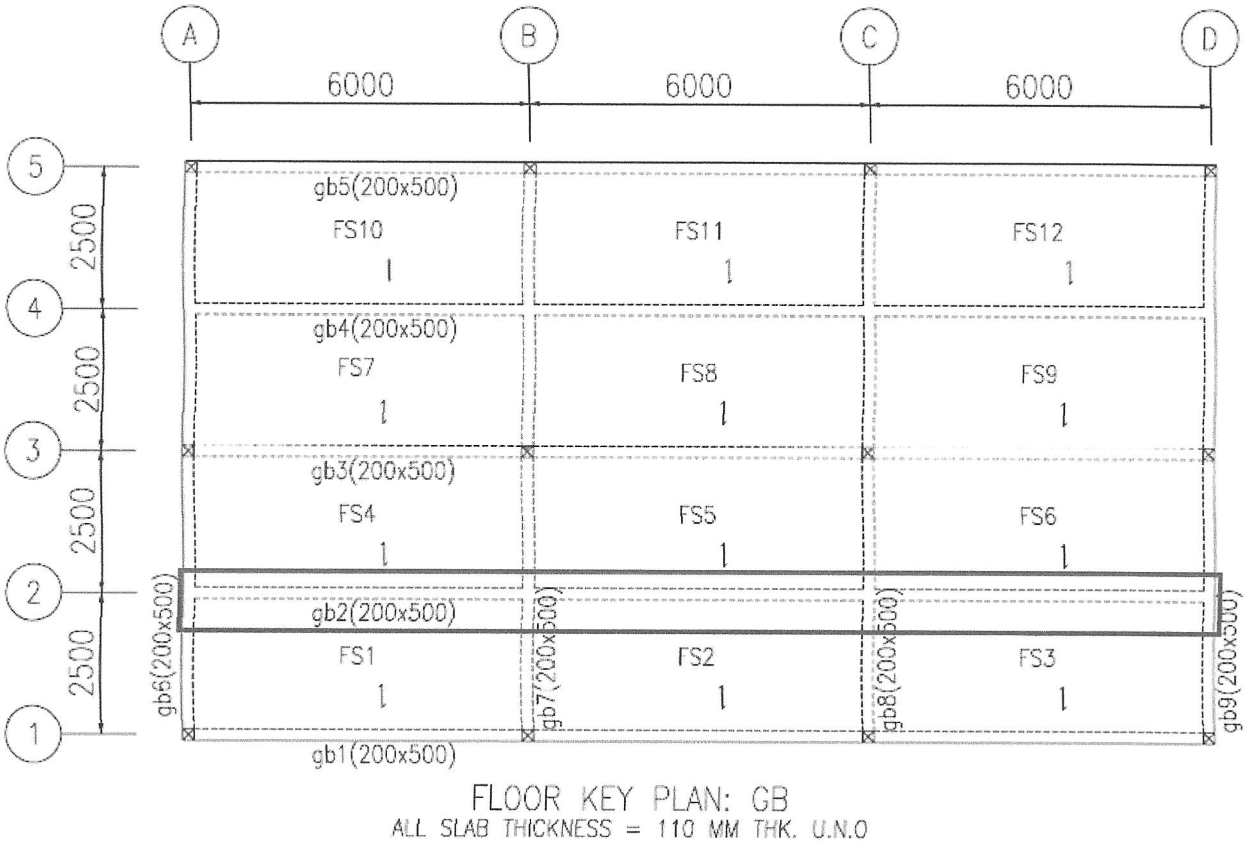

FIGURE Q3

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Q4 **Figure Q4** shows the layout plan for the part of the first floor of reinforced concrete buildings. Reinforced concrete slabs is assigned as continuous slab. The concrete for slabs and beams are poured together and the thickness of the slab is 150 mm. Detail specification is given as follows:

Characteristic Action:

Finishes etc.	= 1.0 kN/m² (excluding selfweight)
Variable, qk	= 3.5 kN/m²
Design life	= 50 Years
Fire resistance	=R90
Exposure Classes	= XC1

Material

Unit weight of Concrete	= 25 kN/m³
Characteristic strength of concrete, fck	= 25 N/mm²
Characteristic Strength of steel, fyk	= 500 N/mm²

Use assumed size of bar as bellow:

Øbar = 10 mm

(a) Determine the nominal concrete cover.

(3 marks)

(b) Determine the shear force and bending moment

(3 marks)

(c) Determine the minimum, maximum reinforcement area and proposed secondary bar on slab.

(3 marks)

(d) Design the reinforcement for all slab panel in **Figure Q4**.

(10 marks)

(e) Check the deflection for the slab panel.

(6 marks)

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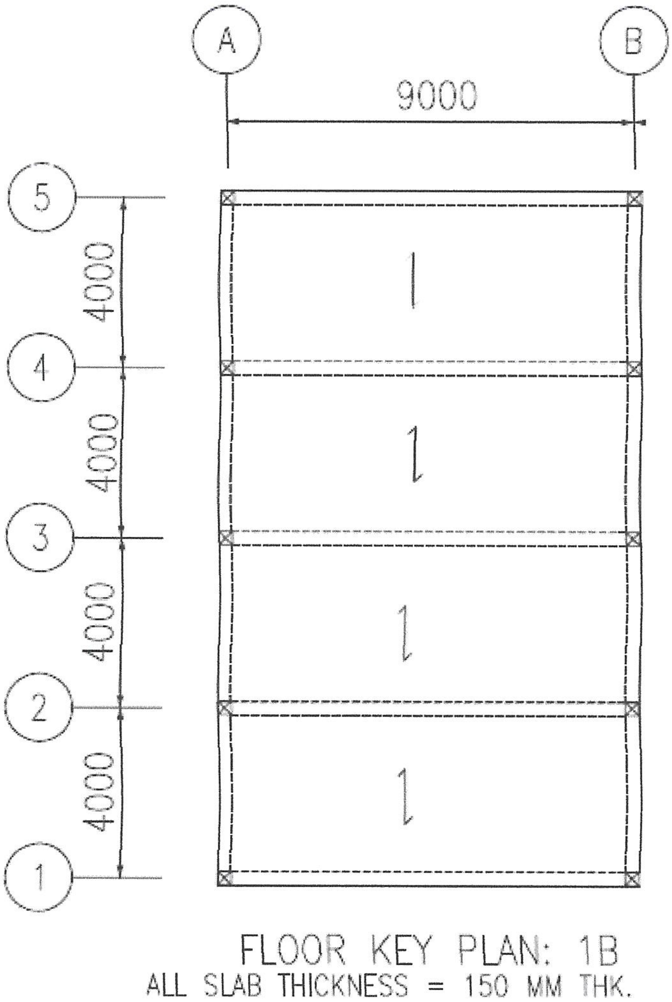

FIGURE Q4

Q5 a) Structure of Steel sections are rolled or formed into a variety of cross-sections. The classification of steel is based on Table 5.2 EC3. The steel cross sections are classified into 4 classes. Describe the all section characteristic in all classes.

(8 Marks)

b) A typical floor plan for a multi-storey steel frame building is shown in **Figure Q5**. The floor load consists of permanent load from in-situ concrete slab with concrete slab depth of 150 mm and 3.5 kN/m2 variable loads. All joints are of simple connections. Consider all beam sizes of 610 x 229 x 125 UB grade S275 and calculate the subquestion below:

i. Calculate design load transfer from slab to HJ and GH beam.

(5 Marks)

ii. Determine the shear force and bending moment of HJ and GH beam

(4 Marks)

iii. Classify the cross-section of a 610 x 229 x 125 UB for HJ beam and 406 x 178 x 74 UB and GH beam. All steel grade are S275.

(8 Marks)

- END OF QUESTIONS -

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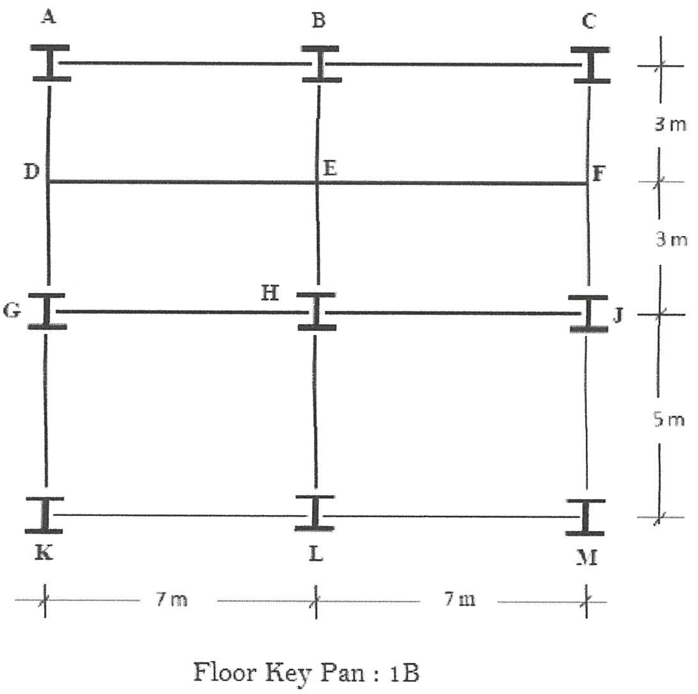

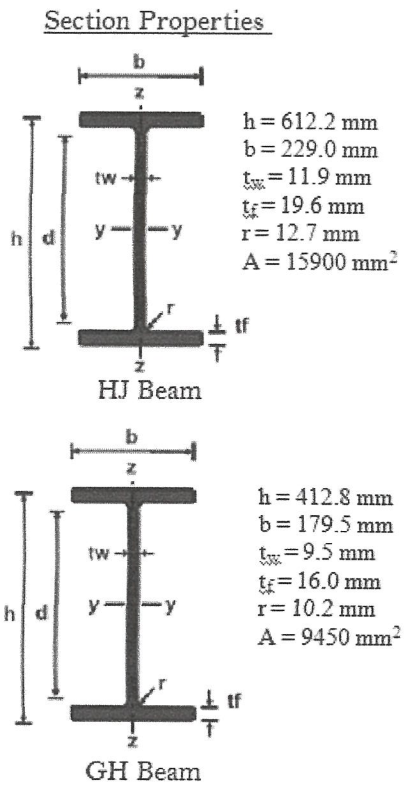

FIGURE Q5

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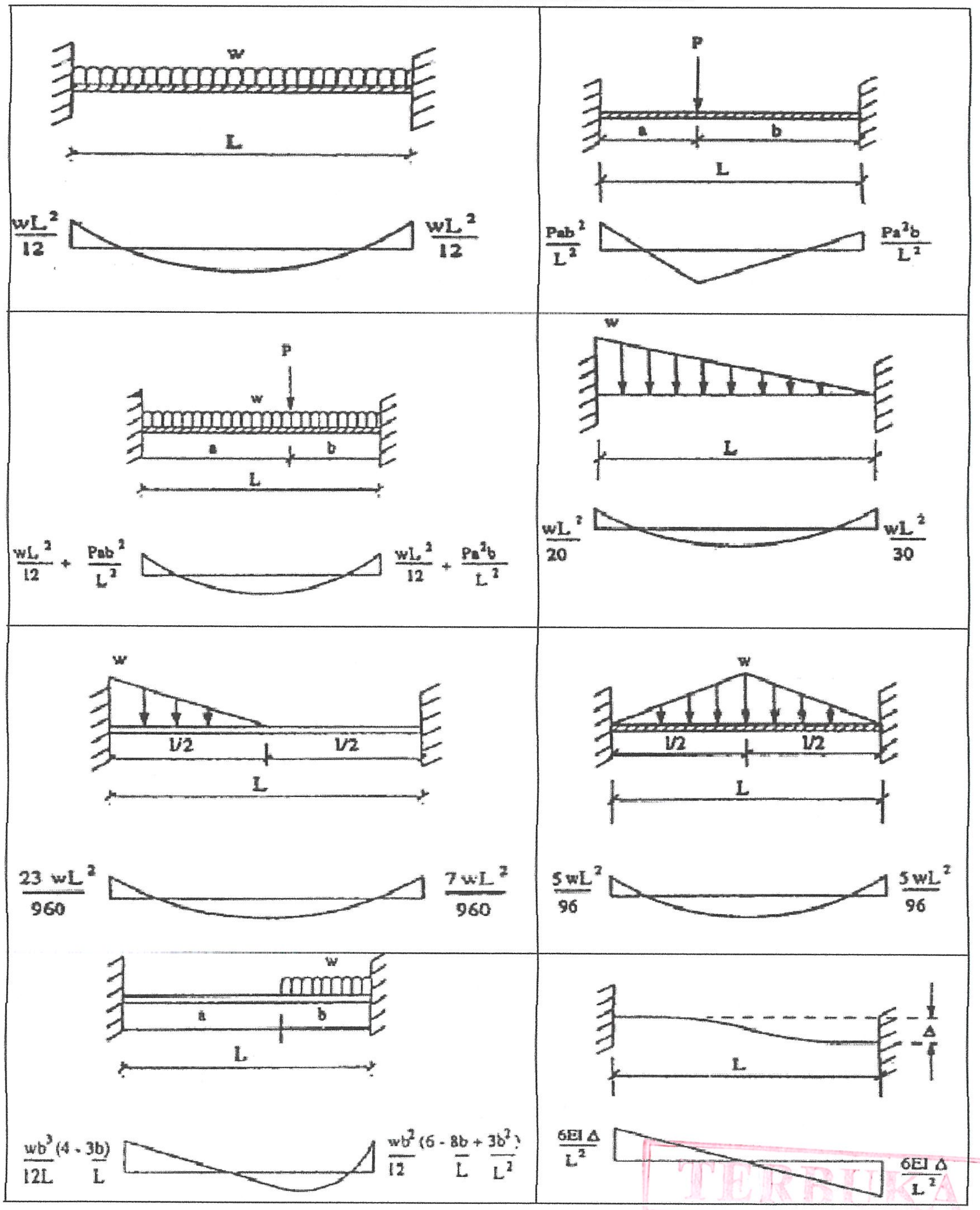
APPENDIX

Table 1: Fix End Moment Formula



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APPENDIX

Table 3.14 — Bending moment coefficients for rectangular panels supported on four sides with provision for torsion at corners

Type of panel and moments considered	Short span coefficients, β_{sx}								Long span coefficients, β_{sy} for all values of l_y/l_x
	Values of l_y/l_x								
	1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.0	
Interior panels									
Negative moment at continuous edge	0.031	0.037	0.042	0.046	0.050	0.053	0.059	0.063	0.032
Positive moment at mid-span	0.024	0.028	0.032	0.035	0.037	0.040	0.044	0.048	0.024
One short edge discontinuous									
Negative moment at continuous edge	0.039	0.044	0.048	0.052	0.055	0.058	0.063	0.067	0.037
Positive moment at mid-span	0.029	0.033	0.036	0.039	0.041	0.043	0.047	0.050	0.028
One long edge discontinuous									
Negative moment at continuous edge	0.039	0.049	0.056	0.062	0.068	0.073	0.082	0.089	0.037
Positive moment at mid-span	0.030	0.036	0.042	0.047	0.051	0.055	0.062	0.067	0.028
Two adjacent edges discontinuous									
Negative moment at continuous edge	0.047	0.056	0.063	0.069	0.074	0.078	0.087	0.093	0.045
Positive moment at mid-span	0.036	0.042	0.047	0.051	0.055	0.059	0.065	0.070	0.034
Two short edges discontinuous									
Negative moment at continuous edge	0.046	0.050	0.054	0.057	0.060	0.062	0.067	0.070	—
Positive moment at mid-span	0.034	0.038	0.040	0.043	0.045	0.047	0.050	0.053	0.034
Two long edges discontinuous									
Negative moment at continuous edge	—	—	—	—	—	—	—	—	0.045
Positive moment at mid-span	0.034	0.046	0.056	0.065	0.072	0.078	0.091	0.100	0.034
Three edges discontinuous (one long edge continuous)									
Negative moment at continuous edge	0.057	0.065	0.071	0.076	0.081	0.084	0.092	0.098	—
Positive moment at mid-span	0.043	0.048	0.053	0.057	0.060	0.063	0.069	0.074	0.044
Three edges discontinuous (one short edge continuous)									
Negative moment at continuous edge	—	—	—	—	—	—	—	—	0.058
Positive moment at mid-span	0.042	0.054	0.063	0.071	0.078	0.084	0.096	0.105	0.044
Four edges discontinuous									
Positive moment at mid-span	0.055	0.065	0.074	0.081	0.087	0.092	0.103	0.111	0.056

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Table 5.5: Minimum dimensions and axis distances for simply supported beams made with reinforced and prestressed concrete

Standard fire resistance	Minimum dimensions (mm)						
	Possible combinations of a and b_{min} where a is the average axis distance and b_{min} is the width of beam				Web thickness b_w		
					Class WA	Class WB	Class WC
1	2	3	4	5	6	7	8
R 30	b_{min} = 80 a = 25	120 20	160 15*	200 15*	80	80	80
R 60	b_{min} = 120 a = 40	160 35	200 30	300 25	100	80	100
R 90	b_{min} = 150 a = 55	200 45	300 40	400 35	110	100	100
R 120	b_{min} = 200 a = 65	240 60	300 55	500 50	130	120	120
R 180	b_{min} = 240 a = 80	300 70	400 65	600 60	150	150	140
R 240	b_{min} = 280 a = 90	350 80	500 75	700 70	170	170	160
$a_{sd} = a + 10$mm (see note below)							

For prestressed beams the increase of axis distance according to 5.2(5) should be noted.

a_{sd} is the axis distance to the side of beam for the corner bars (or tendon or wire) of beams with only one layer of reinforcement. For values of b_{min} greater than that given in Column 4 no increase of a_{sd} is required.

* Normally the cover required by EN 1992-1-1 will control.

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Table 3.1 (continued): Nominal values of yield strength f_y and ultimate tensile strength f_u for structural hollow sections

Standard and steel grade	Nominal thickness of the element t [mm]			
	$t \leq 40$ mm		$40 \text{ mm} < t \leq 80$ mm	
	f_y [N/mm^2]	f_u [N/mm^2]	f_y [N/mm^2]	f_u [N/mm^2]
EN 10210-1				
S 235 H	235	360	215	340
S 275 H	275	430	255	410
S 355 H	355	510	335	490
S 275 NH/NLH	275	390	255	370
S 355 NH/NLH	355	490	335	470
S 420 NH/NHL	420	540	390	520
S 460 NH/NLH	460	560	430	550
EN 10219-1				
S 235 H	235	360		
S 275 H	275	430		
S 355 H	355	510		
S 275 NH/NLH	275	370		
S 355 NH/NLH	355	470		
S 460 NH/NLH	460	550		
S 275 MH/MLH	275	360		
S 355 MH/MLH	355	470		
S 420 MH/MLH	420	500		
S 460 MH/MLH	460	530		

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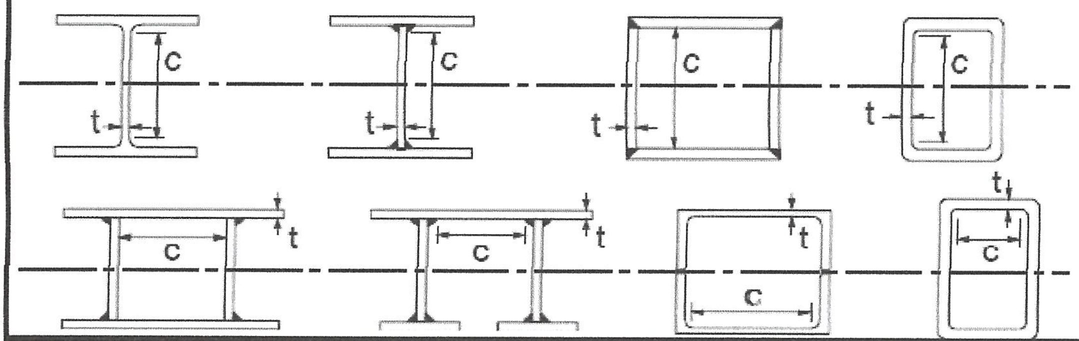
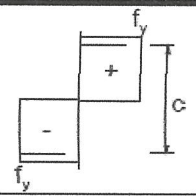
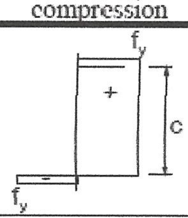
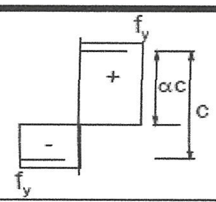
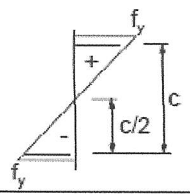
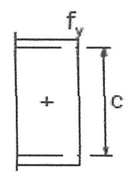
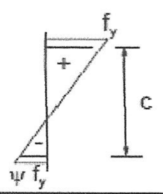
APPENDIX

Table 5.2 (sheet 1 of 3): Maximum width-to-thickness ratios for compression parts

Internal compression parts



Class	Part subject to bending	Part subject to compression	Part subject to bending and compression
Stress distribution in parts (compression positive)			
1	$c/t \le 72\varepsilon$	$c/t \le 33\varepsilon$	when $\alpha > 0.5: c/t \le \frac{396\varepsilon}{13\alpha - 1}$ when $\alpha \le 0.5: c/t \le \frac{36\varepsilon}{\alpha}$
2	$c/t \le 83\varepsilon$	$c/t \le 38\varepsilon$	when $\alpha > 0.5: c/t \le \frac{456\varepsilon}{13\alpha - 1}$ when $\alpha \le 0.5: c/t \le \frac{41.5\varepsilon}{\alpha}$
Stress distribution in parts (compression positive)			
3	$c/t \le 124\varepsilon$	$c/t \le 42\varepsilon$	when $\psi > -1: c/t \le \frac{42\varepsilon}{0.67 + 0.33\psi}$ when $\psi \le -1$*) $: c/t \le 62\varepsilon(1-\psi)\sqrt{(-\psi)}$

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71

*) $\psi \le -1$ applies where either the compression stress $\sigma \le f_y$ or the tensile strain $\varepsilon_y > f_y/E$

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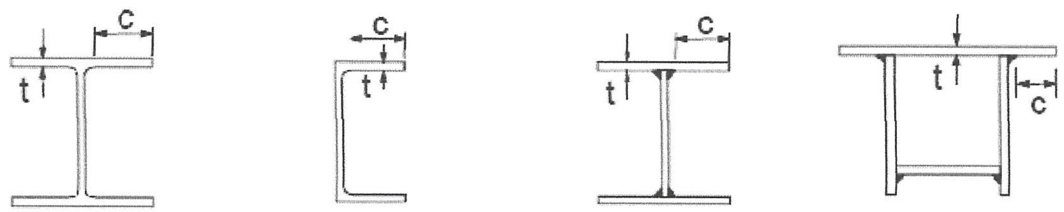
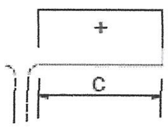
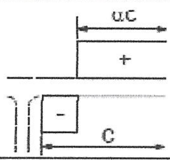
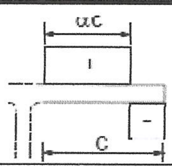
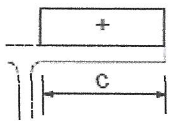
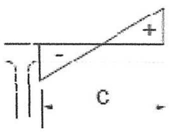
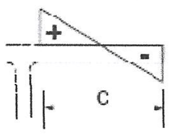
APPENDIX

Table 5.2 (sheet 2 of 3): Maximum width-to-thickness ratios for compression parts

Outstand flanges



Rolled sections — Welded sections

Class	Part subject to compression	Part subject to bending and compression: Tip in compression	Part subject to bending and compression: Tip in tension
Stress distribution in parts (compression positive)			
1	$c/t \leq 9\varepsilon$	$c/t \leq \frac{9\varepsilon}{\alpha}$	$c/t \leq \frac{9\varepsilon}{\alpha\sqrt{\alpha}}$
2	$c/t \leq 10\varepsilon$	$c/t \leq \frac{10\varepsilon}{\alpha}$	$c/t \leq \frac{10\varepsilon}{\alpha\sqrt{\alpha}}$
Stress distribution in parts (compression positive)			
3	$c/t \leq 14\varepsilon$	$c/t \leq 21\varepsilon\sqrt{k_\sigma}$ For k_σ see EN 1993-1-5	

$\varepsilon = \sqrt{235/f_y}$					
f_y	235	275	355	420	460
ε	1,00	0,92	0,81	0,75	0,71

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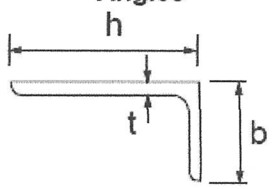
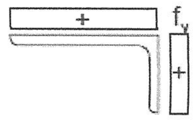
Table 5.2 (sheet 3 of 3): Maximum width-to-thickness ratios for compression parts

Angles

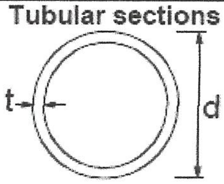


Refer also to "Outstand flanges" (see sheet 2 of 3)

Does not apply to angles in continuous contact with other components

Class	Section in compression
Stress distribution across section (compression positive)	
3	[AC2] $h/t \le 15\varepsilon$ and $\frac{b+h}{2t} \le 11.5\varepsilon$ [AC2]

Tubular sections



Class	Section in bending and/or compression
1	$d/t \le 50\varepsilon^2$
2	$d/t \le 70\varepsilon^2$
3	$d/t \le 90\varepsilon^2$ NOTE For $d/t > 90\varepsilon^2$ see EN 1993-1-6.

$\varepsilon = \sqrt{235/f_y}$						
	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71
	ε^2	1,00	0,85	0,66	0,56	0,51

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FORMULA

$$z = d[0.5 + \sqrt{0.25 - \frac{K_{bal}}{1.134}}$$

$$As' = \frac{(K - K_{bal}) f_{ck} b d^2}{0.87 f_{yk} (d - d')}$$

$$As = \frac{K_{bal} f_{ck} b d^2}{0.87 f_{yk} z_{bal}} + As'$$

$$K = \frac{M}{b d^2 f_{ck}}$$

$$K_{bal} = 0.454(\delta - k_1)k_2 - 0.182[(\delta - k_1)/k_2]^2$$

$$V_{Rd,\max} = \frac{0.36 b_w d f_{ck} (1 - fck/250)}{\cot\theta + \tan\theta}$$

$$\theta = 0.5 \sin^{-1}\left(\frac{V_{Ed}}{0.18 b_w d f_{ck} (1 - f_{ck}/250)}\right)$$

$$\frac{A_{sw}}{s} = \frac{V_{Ed}}{0.78 f_{yk} d \cot\theta}$$

$$\frac{A_{sw\max}}{s} = \frac{0.08 f_{ck}^{1/2} b_w}{f_{yk}}$$

$$f_s = \frac{f_{yk}}{1.15}\left[\frac{G_k + 0.3Q_k}{1.35G_k + 1.5Q_k}\right]\frac{1}{\delta}$$

$$\frac{1}{d} = K\left[11 + 1.5\sqrt{f_{ck}}\frac{\rho_o}{\rho - \rho'} + \frac{1}{12}\sqrt{f_{ck}}\sqrt{\frac{\rho'}{\rho_o}}\right]$$

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Table 1: Cross Sectional Area (mm^2) according to Size and Numbers of Bar

Bar Size (mm)	Number of bar								Perimeter (mm)
	1	2	3	4	5	6	7	8	
6	28.3	56.6	84.9	113	141	170	198	226	18.9
8	50.3	101	151	201	251	302	352	402	25.1
10	78.6	157	236	314	393	471	550	629	31.4
12	113	226	339	453	566	679	792	905	37.7
16	201	402	603	805	1006	1207	1408	1609	50.3
20	314	629	943	1257	1571	1886	2200	2514	62.9
25	491	982	1473	1964	2455	2946	3438	3929	78.6
32	805	1609	2414	3218	4023	4827	5632	6437	100.6
40	1257	2514	3771	5029	6286	7543	8800	10057	125.7

Table 2: Cross Sectional Area (mm^2) for every meter width at distance between bar

Bar Size (mm)	Distance between Bar (mm)								
	50	75	100	125	150	175	200	250	300
6	566	377	283	226	189	162	141	113	94
8	1006	670	503	402	335	287	251	201	168
10	1571	1048	786	629	524	449	393	314	262
12	2263	1509	1131	905	754	647	566	453	377
16	4023	2682	2011	1609	1341	1149	1006	805	670
20	6286	4190	3143	2514	2095	1796	1571	1257	1048
25	9821	6548	4911	3929	3274	2806	2455	1964	1637
32	16091	10728	8046	6437	5364	4598	4023	3218	2682
40	25143	16762	12571	10057	8381	7184	6286	5029	4190