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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	STRUCTURAL ANALYSIS AND DESIGN
COURSE CODE	:	BNP 20803
PROGRAMME CODE	:	BNA/BNB/BNC
EXAMINATION DATE	:	JUNE/JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **SEVENTEEN (17)** PAGES

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Q1. One continuous beam which is supported by roller at B and D and fixed end support at C has uniformly distributed load 1500 kN/m along the beam as shown in **Figure Q1.** Given EI is constant.

(a) Define the meaning of indeterminate beam.

(2 marks)

(b) Calculate the moment at the joints by using moment distribution method. Conduct four (4) rotations for moment distribution.

(10 marks)

(c) Determine the support reaction.

(5 marks)

(d) Draw the shear force diagram

(4 marks)

(e) Draw the bending moment diagram.

(4 marks)

Q2 (a) Composite action is produced due to combination of concrete and steel reinforcement. Describe the properties of concrete and steel reinforcement which lead into an economical structure.

(4 marks)

(b) **Figure Q2** shows the plan view of slab-beam system in one building. Beam and slab has to act as a pre-cast concrete slab due to construction works. Given;

Slab thickness	=	150 mm
Beam size	=	250 mm x 500 mm
Finishes	=	1.0 kN/m^2
Ceiling	=	1.0 kN/m^2
Brickwall (3.0 m height)	=	2.6 kN/m^2
Chac. variable action, q_k	=	3.0 kN/m^2
Chac. strength of concrete, f_{ck}	=	30 N/mm^2
Chac. strength of steel, f_{yk}	=	500 N/mm^2

(i) Sketch the action distribution on the beam from each slab.

(3 marks)

(ii) Calculate the design action act on beam by referring to the simply supported beam B/1-2;

(12 marks)

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

(6 marks)

Q3 The **Figure Q3** shows a simply supported rectangular reinforced concrete beam with 6 m length. The beam is inside building subject to a 1 hour fire resistance and design for 50 years design life. Design the beam with deflection and crack check. Illustrate the beam detailing. Use concrete characteristic strength, fck = 30 N/mm^2 and steel characteristic strength, fyk = 500 N/mm^2.

Dimension:

Span	= 6.00 m
Beam Size	= 200 x 500 mm

Characteristic Action:

Finishes etc.	= 10 kN/m (excluding selfweight)
Variable, qk	= 8 kN/m^2
Design life	= 50 Years
Fire resistance	=R60
Exposure Classes	= XC1

Material

Unit weight of Concrete	= 25 kN/m^3
Characteristic strength of concrete, fck	= 30 N/mm^2
Characteristic Strength of steel, fyk	= 500 N/mm^2
Characteristic Strength of link, fyk	= 500 N/mm^2

Use assumed size of bar as bellow:

Øbar1 = 20 mm
Øbar2 = 12 mm
Ølink = 8 mm

(a) Determine the nominal concrete cover.

(3 marks)

(b) Calculate the shear force and bending moment

(3 marks)

(c) Calculate all the area of steel required for beam in **Figure Q3.**

(12 marks)

(d) Determine the minimum and maximum reinforcement area on beam.

(2 marks)

(e) Check the deflection for the beam in **Figure Q3.**

(5 marks)

Q4 The **Figure Q4** shows part of the second floor plan of a reinforced concrete office building. 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,ceiling and services.	= 1.5 kN/m^2 (excluding selfweight)
Variable, qk	= 4.5 kN/m^2

Material

Unit weight of Concrete	= 25 kN/m^3
Characteristic strength of concrete, fck	= 25 N/mm^2
Characteristic Strength of steel, fyk	= 500 N/mm^2
Use assumed size of bar	= 10 mm

Nominal Cover = 25 mm

(a) Calculate the design action on Slab **C-D/1-2.**

(3 marks)

(b) Calculate the shear force and bending moment of slab **C-D/1-2**

(3 marks)

(c) Determine the minimum and maximum reinforcement **C-D/1-2.**

(3 marks)

(d) Calculate the area of steel required for the slab slab **C-D/1-2**

(10 marks)

(e) Check the deflection for the slab **C-D/1-2.**

(6 marks)

Q5 a) List the **FIVE (5)** advantages and **FIVE (5)** disadvantages of steel as a structural material

(5 marks)

b) Local buckling of typical steel beam cross-sections occurred due to pure compression.

(i) Describe what is Local Buckling of steel beam.

(4 marks)

(ii) Sketch to show the answer **Q5(b)(i)** above.

(4 marks)

c) A welded I section beam in **Figure Q5 (a)** is under pure bending. The chosen section is of grade S275 steel, and has two 200 mm × 20 mm flanges and a 560 mm× 6 mm web. The weld size (leg length) s is 6.0 mm. Assuming full lateral restraint, classify the cross-section.

(6 marks)

d) A steel member in **Figure Q5 (b)** is to be designed to carry combined bending and axial load. In the presence of a major axis (y-y) bending moment and an axial force of 300kN, determine the cross-section classification of a 406×178UB54 in grade S275 steel.

(6 marks)

- END OF QUESTIONS –

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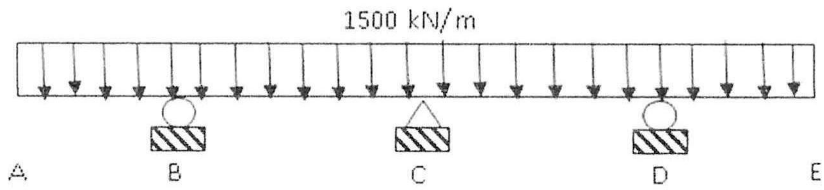

Figure Q1: Continuous Beam

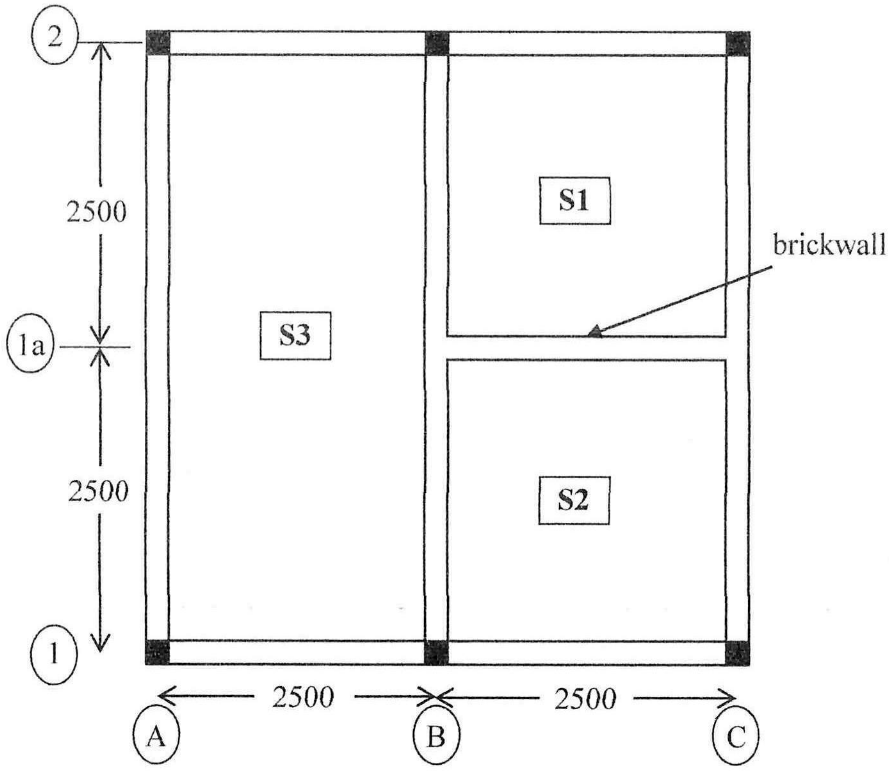

Figure Q2: Beam and Slab Layout

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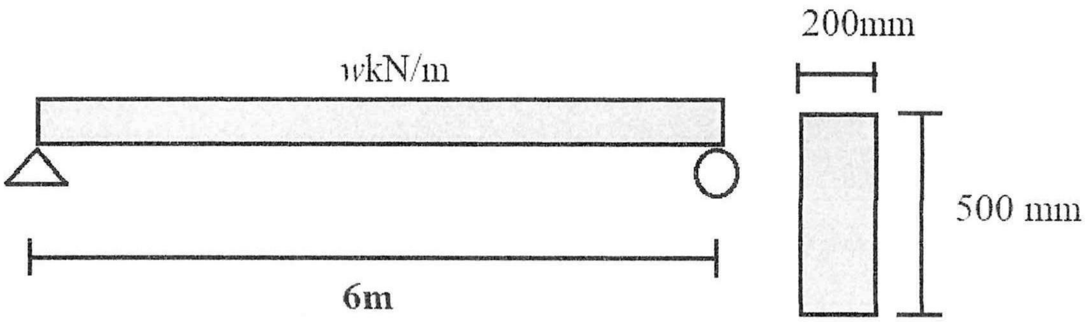

Figure Q3: Simply Supported Beam

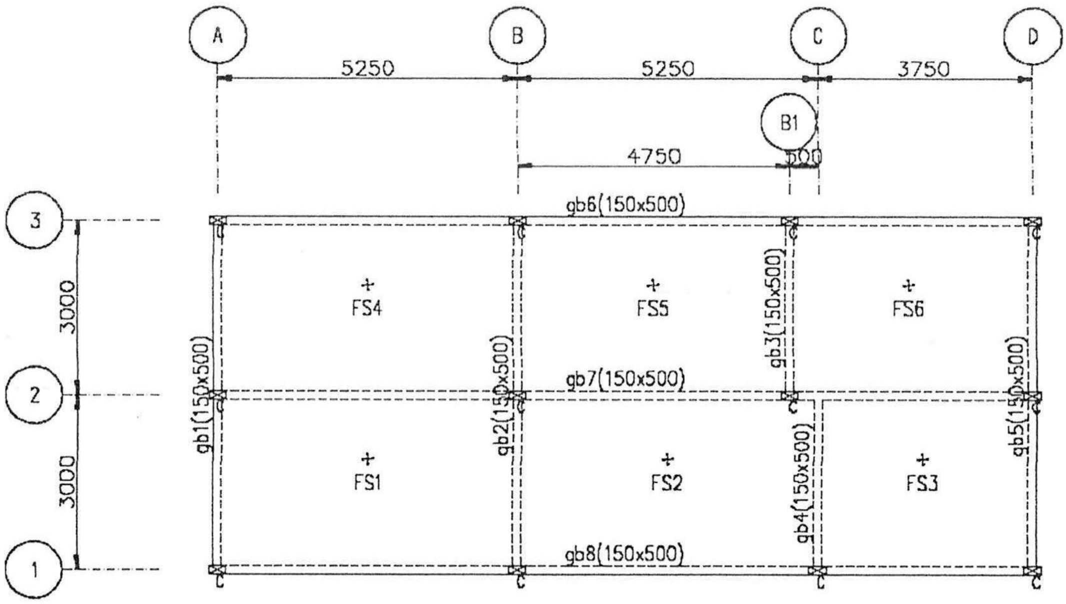

Figure Q4: Ground Beam Layout

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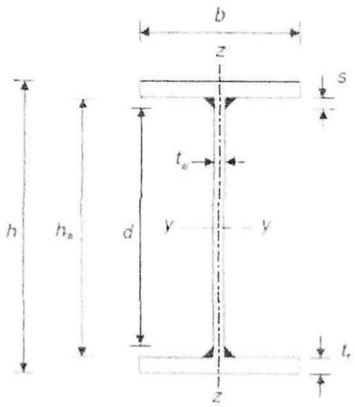
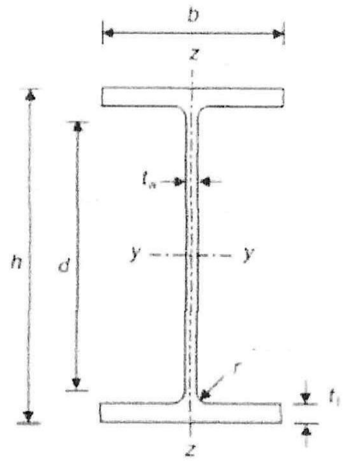


$b = 200.0$ mm
$t_f = 20.0$ mm
$h_w = 560.0$ mm
$h = 600.0$ mm
$t_w = 6.0$ mm
$s = 6$ mm
$W_{et,y} = 2536\ 248$ mm^3

Figure Q5 (a): Welded I Section Beam



$h = 402.6$ mm
$b = 177.7$ mm
$t_w = 7.7$ mm
$t_f = 10.9$ mm
$r = 10.2$mm
$A = 6900$ mm^2

Figure Q5 (b): Steel I Section Beam

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APPENDIX

Table 1: Fix End Moment Formula

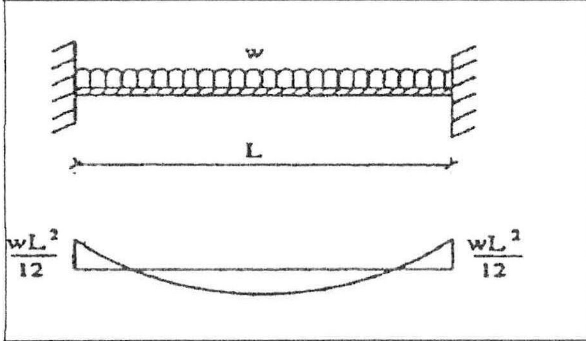
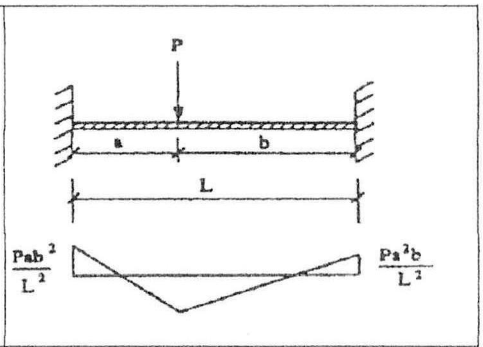
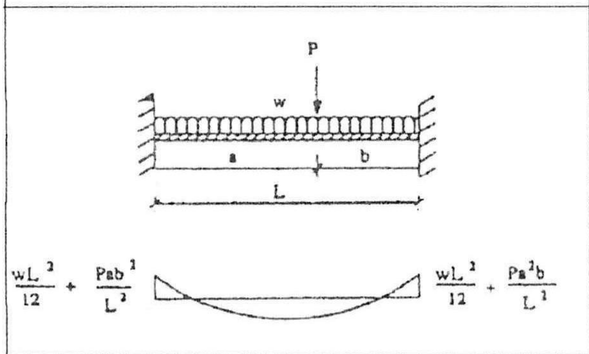
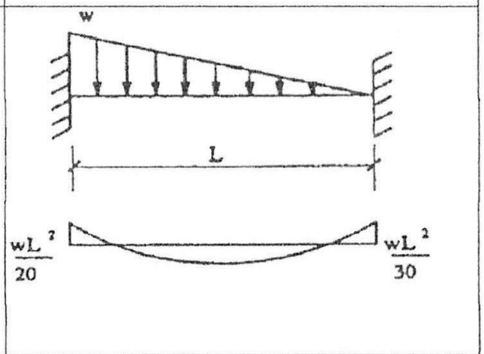
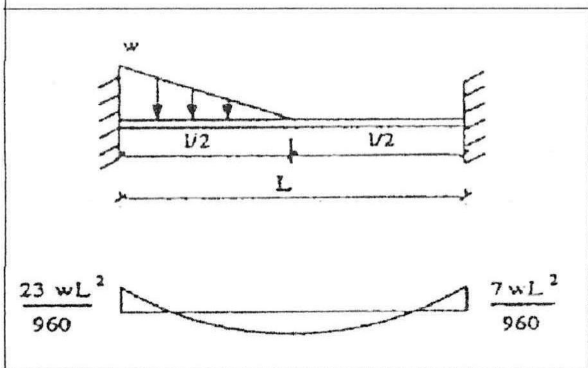
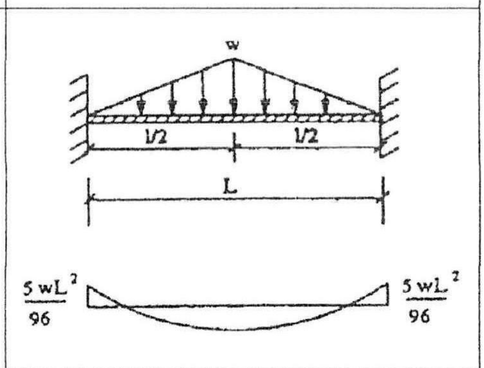
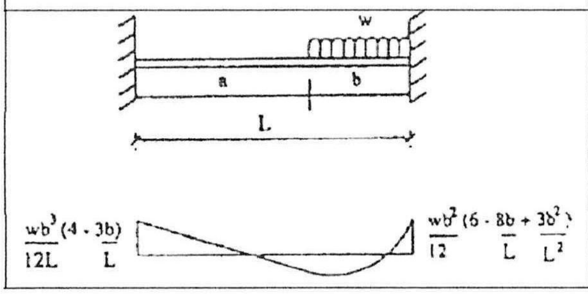
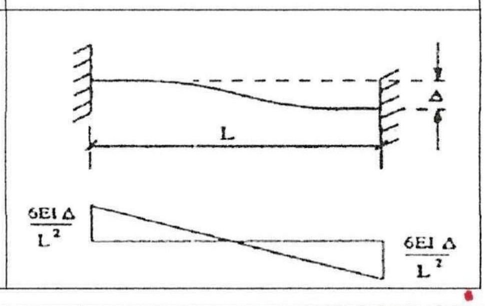
 $\frac{wL^2}{12}$; $\frac{wL^2}{12}$	 $\frac{Pab^2}{L^2}$; $\frac{Pa^2b}{L^2}$
 $\frac{wL^2}{12} + \frac{Pab^2}{L^2}$; $\frac{wL^2}{12} + \frac{Pa^2b}{L^2}$	 $\frac{wL^2}{20}$; $\frac{wL^2}{30}$
 $\frac{23\,wL^2}{960}$; $\frac{7\,wL^2}{960}$	 $\frac{5\,wL^2}{96}$; $\frac{5\,wL^2}{96}$
 $\frac{wb^3}{12L}\left(4 - \frac{3b}{L}\right)$; $\frac{wb^2}{12}\left(6 - \frac{8b}{L} + \frac{3b^2}{L^2}\right)$	 $\frac{6EI\Delta}{L^2}$; $\frac{6EI\Delta}{L^2}$

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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 + 10mm (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 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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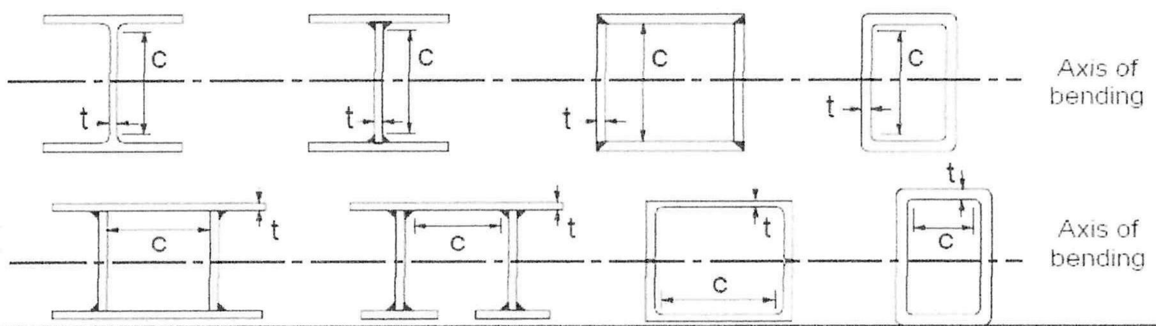
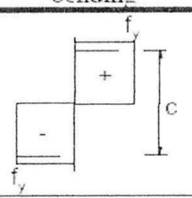
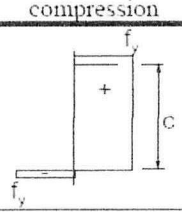
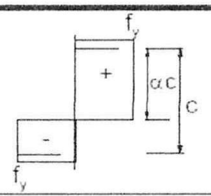
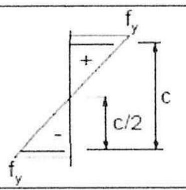
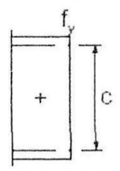
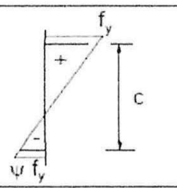
APPENDIX

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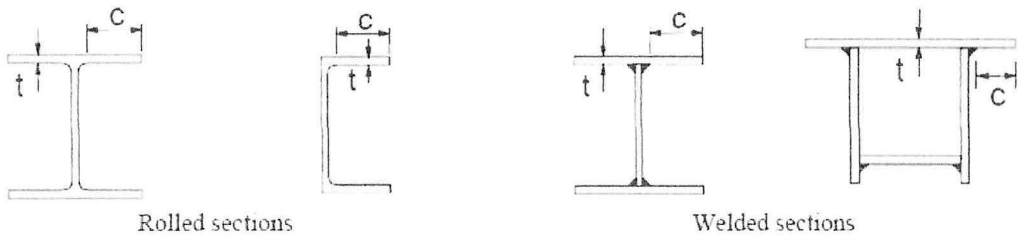
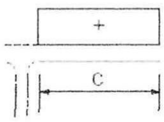
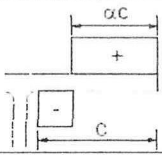
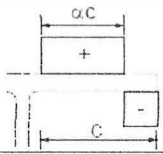
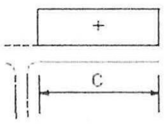
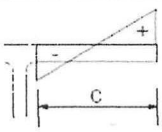
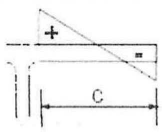
Table 5.2 (sheet 2 of 3): Maximum width-to-thickness ratios for compression parts

Outstand flanges



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	$c/t \le 9\varepsilon$	$c/t \le \dfrac{9\varepsilon}{\alpha}$	$c/t \le \dfrac{9\varepsilon}{\alpha\sqrt{\alpha}}$
2	$c/t \le 10\varepsilon$	$c/t \le \dfrac{10\varepsilon}{\alpha}$	$c/t \le \dfrac{10\varepsilon}{\alpha\sqrt{\alpha}}$
Stress distribution in parts (compression positive)			
3	$c/t \le 14\varepsilon$	$c/t \le 21\varepsilon\sqrt{k_\sigma}$ 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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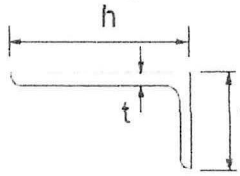
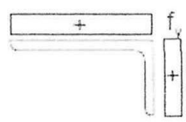
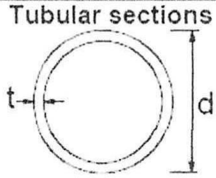
Table 5.2 (sheet 3 of 3): Maximum width-to-thickness ratios for compression parts

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	$h/t \le 15\varepsilon$ and $\frac{b+h}{2t} \le 11.5\varepsilon$
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

FINAL EXAMINATION

SEMESTER/SESI: SEM II/2018/2019 PROGRAMME: BNA/BNB/BNC

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FORMULA

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

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

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

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

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

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

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

$$As = \frac{M}{0.87 f_{yk} z}$$

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

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

$$As = \frac{K_{bal} f_{ck} bd^2}{0.87 f_{yk} z_{bal}} + As'\left(\frac{f_{sc}}{0.87 f_{yk}}\right)$$

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

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

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

$$\alpha = \frac{1}{c}\left(\frac{h}{2} + \frac{1}{2}\frac{N_{Ed}}{t_w.f_y} - (t_f + r)\right)$$

FINAL EXAMINATION

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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