Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	STRUCTURAL ANALYSIS & DESIGN
COURSE CODE	:	BNP20803
PROGRAMME CODE	:	BNA/BNB/BNC
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER **ALL** QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

Q1 **Figure Q1** shows a beam structure with a fixed connection at points A and B while supported by rollers at supports B and C. The Modulus of Elasticity (E) and moment of Inertia (I) of the beam are constant along the beam. Determine the moment at A, B, C, and D, then draw the moment diagram for the beam. Assume the supports at B and C are roller.

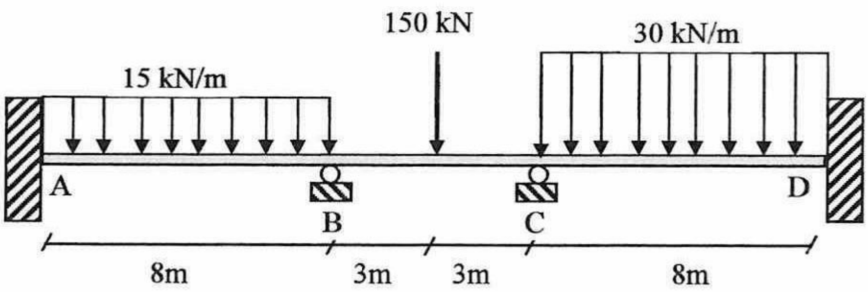


Figure Q1

(a) Determine all the stiffness factor (K), distribution factor (DF), carry-over factor (CO), and Fixed End Moment (FEM) of the beam members.

(11 marks)

(b) Using the moment distribution method for analysis, find all the end moments at AB, BA, BC, CB, CD, and DC.

(8 marks)

(c) Determine the reaction at support A, B, C, and D.

(6 marks)

Q2 Reinforced concrete is a composite material of concrete and reinforcing steel bars (rebar). Reinforced concrete beams are primarily used to support loads, such as those from floors, roofs, or other structural elements, over openings or spans.

(a) Describe the properties of concrete and steel reinforcement that lead to an economical structure.

(2 marks)

(b) **Figure Q2** shows the plan view of the slab-beam system in one building. Due to construction works, a beam and a part of the slab have to act as a pre-cast concrete slab.

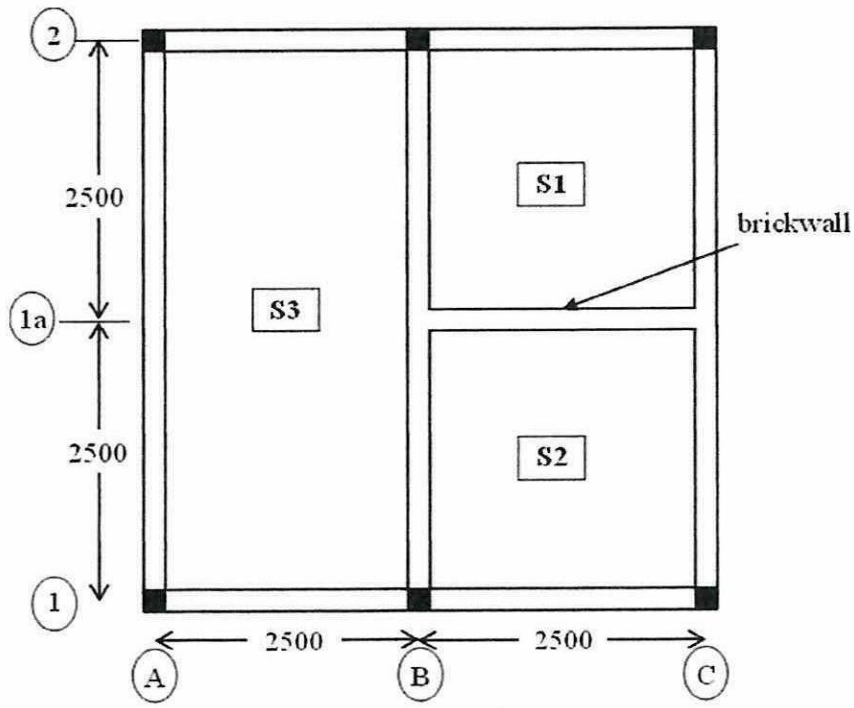


Figure Q2

Given:

Slab thickness	=	150 mm
Beam size	=	250 mm x 500 mm
Depth, d	=	350 mm
Finishes	=	1.0 kN/m^2
Ceiling	=	1.0 kN/m^2
Brickwall	=	2.6 kN/m^2 (3 m height)

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
K_{bal}	=	0.167

i. By referring to the simply supported beam **B/1-2**, determine the design action act on the beam.

(13 marks)

ii. Determine the maximum shear force and bending moment for beam **B/1-2**.

(5 marks)

iii. By using the maximum bending moment, check whether compression reinforcement is required.

(5 marks)

Q3 **Figure Q3** shows the layout plan for the part of the first floor of reinforced concrete buildings. Reinforced concrete slabs are assigned as a continuous slab. The concrete for slabs and beams is poured together, and the thickness of the slab is 150 mm. Detailed specification is given as follows::

Specification:

Fire resistance	= R90
Exposure class	= XC1
Design life	= 50 Years

Characteristic Action:

Finishes etc.(excluding selfweight)	= 1.0 kN/m²
Variable, q_k	= 3.5 kN/m²

Material

Unit weight of Concrete	= 25 kN/m³
Characteristic strength of concrete, f_{ck}	= 25 N/mm²
Characteristic Strength of steel, f_{yk}	= 500 N/mm²
Assumed size of bar , $Ø_{bar}$	= 10 mm

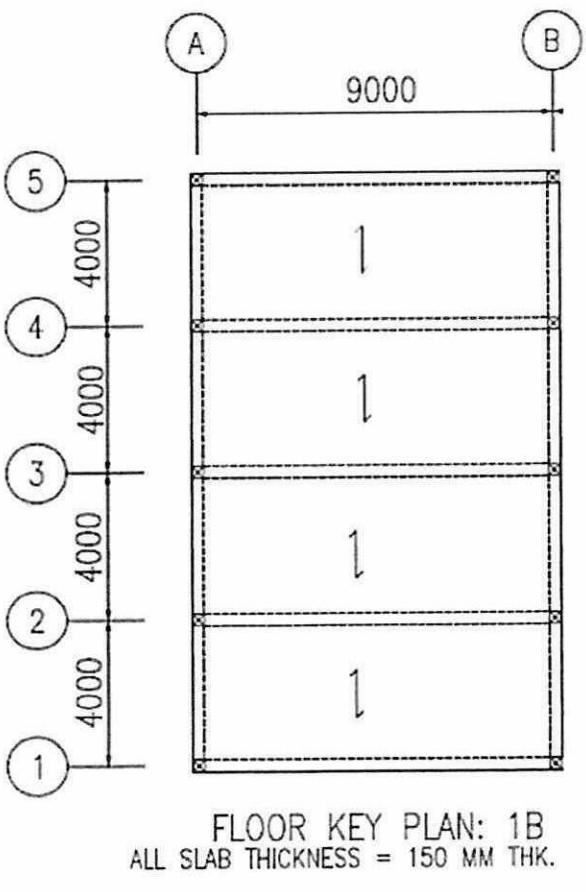


Figure Q3

(a) Determine the nominal concrete cover.

(3 marks)

(b) Determine the shear force and bending moment.

(3marks)

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

(3marks)

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

(10marks)

(e) Check the deflection for the slab panel.

(6 marks)

Q4 Consider a construction project requiring various steel sections for structural support and load-bearing purposes. As a structural engineer, you are tasked with selecting appropriate steel sections based on their shapes and dimensions.

(a) Provide **TWO (2)** examples of applications in construction for each steel section:

i. I-Beams (H-Beams)
ii. Channels
iii. Angles
iv. T-Sections

(8 marks)

(b) There are four classifications of steel cross-section: Plastic, compact, semi-compact, and slender. Explain in detail all **FOUR (4)** classifications of steel cross-section.

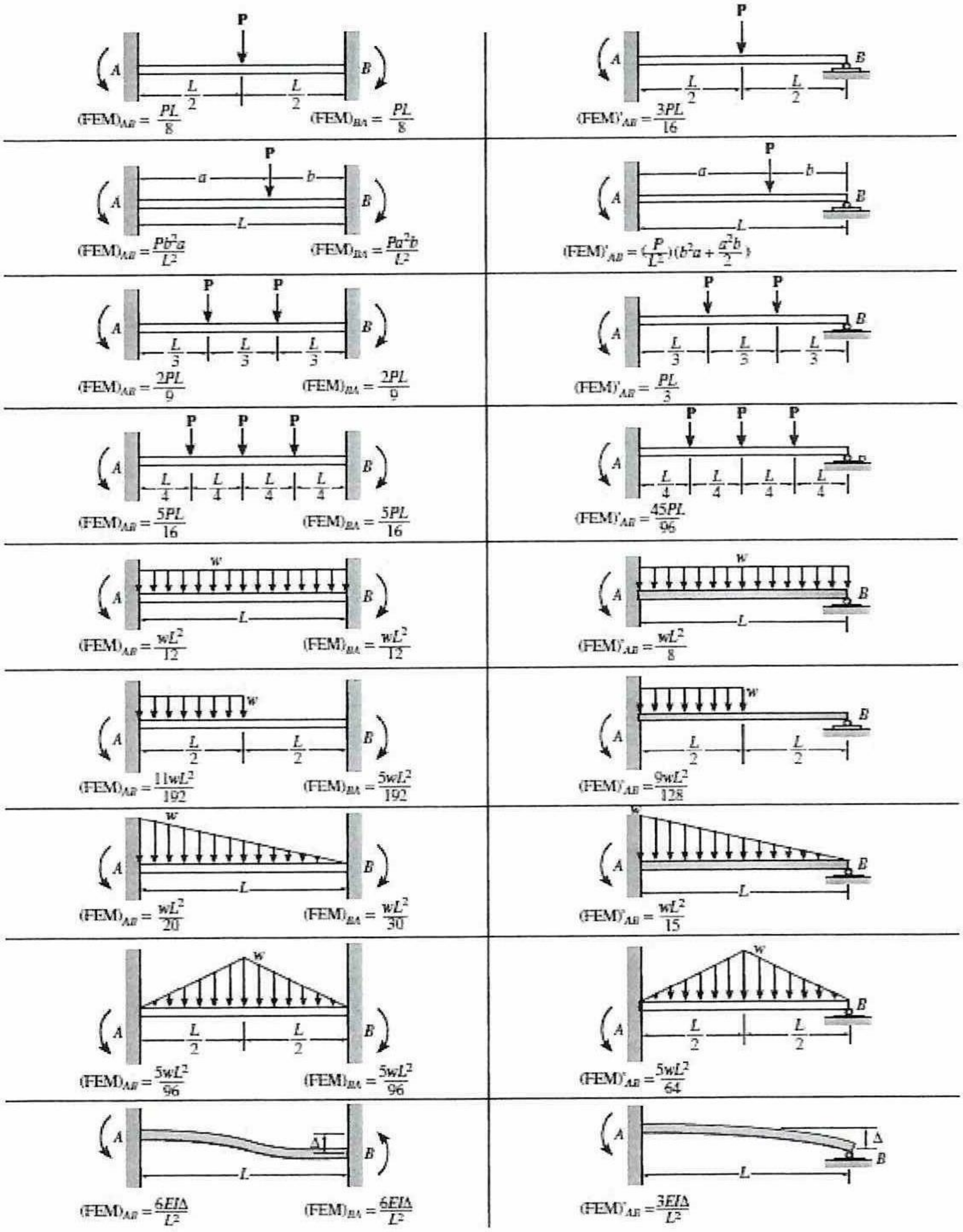
(8 marks)

(c) Classify the steel section 457 x 152 x 60 UB subjected to 700 kN axial compression and bending. The steel grade S355 is specified for the section.

(9 marks)

- END OF QUESTIONS -

APPENDIX A



(FEM)AB = PL/8
(FEM)BA = PL/8
(FEM)'AB = 3PL/16
(FEM)AB = Pb²a/L²
(FEM)BA = Pa²b/L²
(FEM)'AB = (P/L²)(b²a + a²b/2)
(FEM)AB = 2PL/9
(FEM)BA = 2PL/9
(FEM)'AB = PL/3
(FEM)AB = 5PL/16
(FEM)BA = 5PL/16
(FEM)'AB = 45PL/96
(FEM)AB = wL²/12
(FEM)BA = wL²/12
(FEM)'AB = wL²/8
(FEM)AB = 11wL²/192
(FEM)BA = 5wL²/192
(FEM)'AB = 9wL²/128
(FEM)AB = wL²/20
(FEM)BA = wL²/30
(FEM)'AB = wL²/15
(FEM)AB = 5wL²/96
(FEM)BA = 5wL²/96
(FEM)'AB = 5wL²/64
(FEM)AB = 6EIΔ/L²
(FEM)BA = 6EIΔ/L²
(FEM)'AB = 3EIΔ/L²

APPENDIX B

Table 3.15 — Shear force coefficient for uniformly loaded rectangular panels supported on four sides with provision for torsion at corners

Type of panel and location	β_{vx} for values of l_y/l_x								β_{vy}
	1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.0	
Four edges continuous									
Continuous edge	0.33	0.36	0.39	0.41	0.43	0.45	0.48	0.50	0.33
One short edge discontinuous									
Continuous edge	0.36	0.39	0.42	0.44	0.45	0.47	0.50	0.52	0.36
Discontinuous edge	—	—	—	—	—	—	—	—	0.24
One long edge discontinuous									
Continuous edge	0.36	0.40	0.44	0.47	0.49	0.51	0.55	0.59	0.36
Discontinuous edge	0.24	0.27	0.29	0.31	0.32	0.34	0.36	0.38	—
Two adjacent edges discontinuous									
Continuous edge	0.40	0.44	0.47	0.50	0.52	0.54	0.57	0.60	0.40
Discontinuous edge	0.26	0.29	0.31	0.33	0.34	0.35	0.38	0.40	0.26
Two short edges discontinuous									
Continuous edge	0.40	0.43	0.45	0.47	0.48	0.49	0.52	0.54	—
Discontinuous edge	—	—	—	—	—	—	—	—	0.26
Two long edges discontinuous									
Continuous edge	—	—	—	—	—	—	—	—	0.40
Discontinuous edge	0.26	0.30	0.33	0.36	0.38	0.40	0.44	0.47	—
Three edges discontinuous (one long edge discontinuous)									
Continuous edge	0.45	0.48	0.51	0.53	0.55	0.57	0.60	0.63	—
Discontinuous edge	0.30	0.32	0.34	0.35	0.36	0.37	0.39	0.41	0.29
Three edges discontinuous (one short edge discontinuous)									
Continuous edge	—	—	—	—	—	—	—	—	0.45
Discontinuous edge	0.29	0.33	0.36	0.38	0.40	0.42	0.45	0.48	0.30
Four edges discontinuous									
Discontinuous edge	0.33	0.36	0.39	0.41	0.43	0.45	0.48	0.50	0.33

APPENDIX C

Table 3.12 — Ultimate bending moment and shear forces in one-way spanning slabs

	End support/slab connection				At first interior support	Middle interior spans	Interior supports
	Simple		Continuous				
	At outer support	Near middle of end span	At outer support	Near middle of end span			
Moment	0	$0.086Fl$	$-0.04Fl$	$0.075Fl$	$-0.086Fl$	$0.063Fl$	$-0.063Fl$
Shear	$0.4F$	—	$0.46F$	—	$0.6F$	—	$0.5F$

NOTE F is the total design ultimate load ($1.4G_k + 1.6Q_k$);
l is the effective span.

Cross Sectional Area of Reinforcement

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

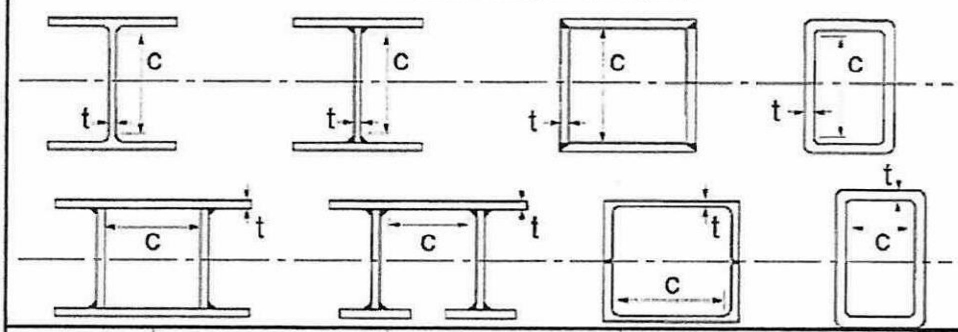
Table 2: Cross Sectional Area (mm^2) for every meter width at distance between bar

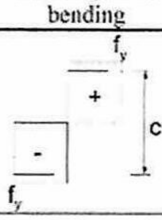
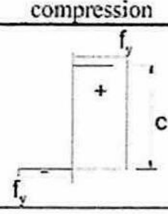
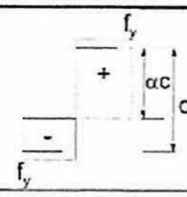
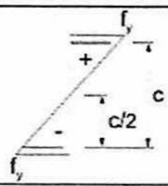
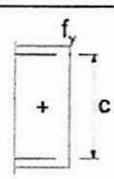
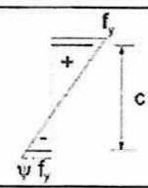
Bar Size (mm)	Distance between Bar (mm)								
	50	75	100	125	150	175	200	250	300
6	566	377	283	226	189	162	141	113	94
8	1006	670	503	402	335	287	251	201	168
10	1571	1048	786	629	524	449	393	314	262
12	2263	1509	1131	905	754	647	566	453	377
16	4023	2682	2011	1609	1341	1149	1006	805	670
20	6286	4190	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

APPENDIX D

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 $\psi \le -1^{*)}$: $c/t \le 62\varepsilon(1-\psi)\sqrt{(-\psi)}$

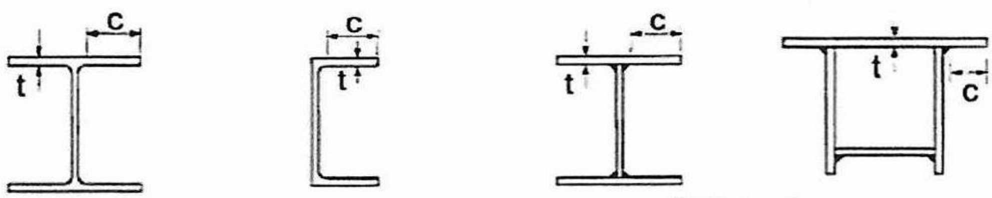
$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71

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

APPENDIX E

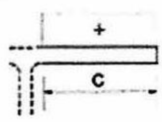
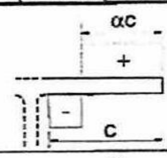
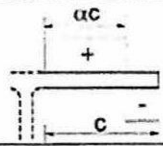
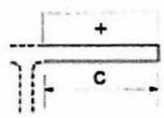
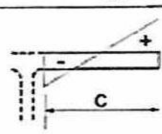
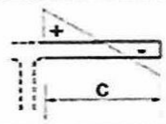
Table 5.2 (sheet 2 of 3): Maximum width-to-thickness ratios for compression parts

Outstand flanges



Rolled sections

Welded sections

Class	Part subject to compression	Part subject to bending and compression	
		Tip in compression	Tip in tension
Stress distribution in parts (compression positive)			
1	$c/t \le 9\varepsilon$	$c/t \le \frac{9\varepsilon}{\alpha}$	$c/t \le \frac{9\varepsilon}{\alpha\sqrt{\alpha}}$
2	$c/t \le 10\varepsilon$	$c/t \le \frac{10\varepsilon}{\alpha}$	$c/t \le \frac{10\varepsilon}{\alpha\sqrt{\alpha}}$
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

FORMULA

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

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

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

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

* Formula deflection: refer Eurocode 2 CL 7.4.2 (2)