

Concrete Beam

Information Usually Given:

About the Beam	About Loads, Forces and Moments	From Design Standards (Eurocode 5)
- Beam span $L = 4.5\text{m}$ - Beam width $b = 150\text{mm}$ - Beam depth $h = 300\text{mm}$	Uniformly distributed load of $w = 5\text{kN/m}$	- Reinforcement yield strength, $f_{yk} = 500\text{ N/mm}^2$ - Steel material (safety) factor, $\gamma_{MS} = 1.15$ - Characteristic concrete strength, $f_{ck} = 40\text{ N/mm}^2$ - Concrete material (safety) factor, $\gamma_{MC} = 1.5$ - Link reinforcement diameter = 10mm - Nominal cover for reinforcement = 40mm $K' = 0.168$ - A flow chart for the calculations (see Figure 2 below). - A figure showing a typical reinforcement concrete beam with the various dimensions shown (see Figures 1 & 3 below) - A table with reinforcement bar areas

Figure 1 & 3: Reinforced concrete beam dimensions

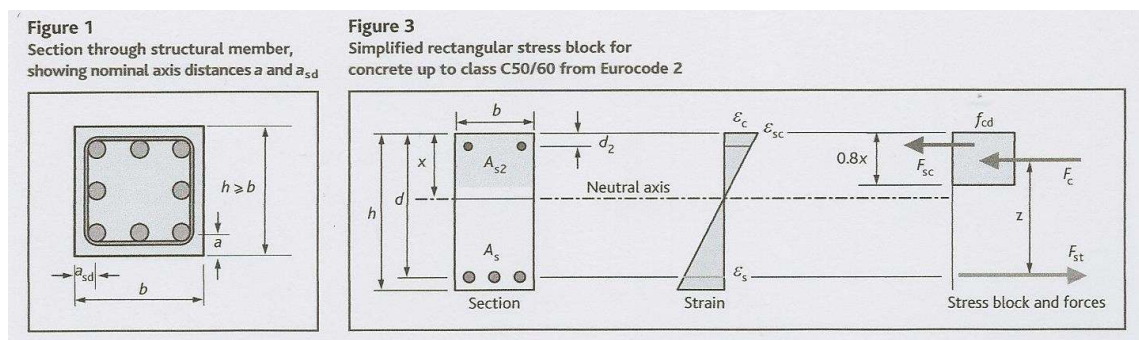


Figure 2 – Concrete design flow chart:

Figure 2
Procedure for determining flexural reinforcement

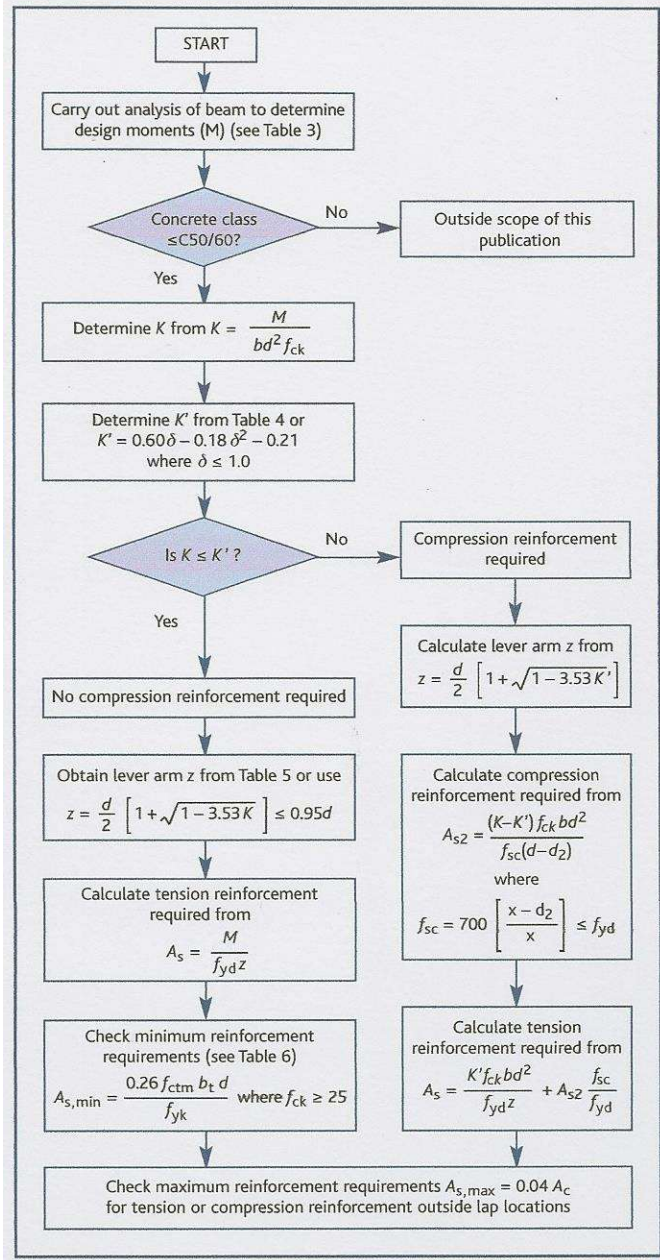


Table 1: Reinforcement bar areas

Metric bar size	Mass per unit length (Kg/m)	Nominal diameter	Cross sectional area (mm²)
6.0	0.222	6	28.3
8.0	0.395	8	50.3
10.0	0.617	10	78.5
12.0	0.888	12	113
16.0	1.579	16	201
20.0	2.467	20	314
25.0	3.855	25	491
32.0	4.830	32	804
40.0	9.868	40	1257
50.0	15.413	50	1963

Note: Sizes 14 and 28 are excluded as they are not normally used.

Calculations:

Calculations	Remember by Heart (will not be given at the exam)	For information only. No need to remember.
Characteristic concrete strength, $f_{ck} = 40 \text{ N/mm}^2$		
Concrete material (safety) factor, $\gamma_{MC} = 1.5$		
Therefore, design concrete strength, $f_{cd} = \frac{f_{ck}}{\gamma_{MC}} = \frac{40}{1.5} = 26.67 \text{ N/mm}^2$		
Reinforcement yield strength, $f_{yk} = 500 \text{ N/mm}^2$		
Steel material (safety) factor, $\gamma_{MS} = 1.15$		
Therefore, design steel strength, $f_{yd} = \frac{f_{yk}}{\gamma_{MS}} = \frac{500}{1.15} = 434.78 \text{ N/mm}^2$		
Uniformly distributed load of, $w=5\text{kN/m}$		
Beam span $L=4.5\text{m}$		
Calculate the maximum bending moment, $M = \frac{wL^2}{8} = \frac{5 \times 4.5^2}{8} = 12.656 \text{ kNm} = 12656000 \text{ Nmm}$	You got to remember that the maximum moment for a UDL is given by, $M = \frac{wL^2}{8}$	
Referring to Figure 3, $d = h - \text{nominal cover} - \text{link diameter} = 300\text{mm} - 40\text{mm} - 10\text{mm} = 250\text{mm}$		
$K' = 0.168$		
Follow the flow chart from here:		
1. Start		
2. Moment M calculated? = yes, see above		
3. Concrete class $\leq \text{C50/C60}$? = Yes, C40 selected here		
4. $K = \frac{M}{bd^2 f_{ck}} = \frac{12656000}{150 \times 250^2 \times 40} = 0.0337$		
5. $K \leq K'$? Yes ($0.0337 \leq 0.168$)		
6. No compression reinforcement required		
7. $Z = \frac{d}{2} [1 + \sqrt{1 - 3.53K}] = \frac{250}{2} [1 + \sqrt{1 - 3.53 \times 0.0337}] = 242.33\text{mm}$		
8. $A_s = \frac{M}{f_{yd} Z} = \frac{12656000}{434.78 \times 242.33} = 120.12\text{mm}^2$		

Calculations	Remember by Heart (will not be given at the exam)	For information only. No need to remember.
Use 2 of 10mm bars ($2 \times 78.5 = 157$), or 3 of 8mm bars ($3 \times 50.3 = 150.9$) so we can achieve this 120mm^2 area from the table 1 given above.		

Highlighted boxes of calculations are what you usually need to do.