29 Years

Previous Solved Papers

Civil Services Main Examination

(1995-2023)

Civil Engineering

Paper-I

Topicwise Presentation

Also useful for
Engineering Services Main Exam
and **Indian Forest Service Main Exam**

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Civil Services Main Examination Previous Years Solved Papers : Civil Engineering (Paper-I)

First Edition: 2017
Second Edition: 2018
Third Edition: 2019
Fourth Edition: 2021
Fifth Edition: 2022
Sixth Edition: 2023

Seventh Edition: 2024

Preface

Civil Service is considered as the most prestigious job in India and it has become a preferred destination by all engineers. In order to reach this estimable position every aspirant has to take arduous journey of Civil Services Examination (CSE). Focused approach and strong determination are the pre-requisites for this journey. Besides this, a good book also comes in the list of essential commodity of this odyssey.

B. Singh (Ex. IES)

I feel extremely glad to launch the revised edition of such a book which will not only make CSE plain sailing, but also with 100% clarity in concepts.

MADE EASY team has prepared this book with utmost care and thorough study of all previous years papers of CSE. The book aims to provide complete solution to all previous years questions with accuracy.

On doing a detailed analysis of previous years CSE question papers, it came to light that a good percentage of questions have been asked in Engineering Services, Indian Forest Service and State Services exams. Hence, this book is a one stop shop for all CSE, ESE, IFS and other competitive exam aspirants.

I would like to acknowledge efforts of entire MADE EASY team who worked day and night to solve previous years papers in a limited time frame and I hope this book will prove to be an essential tool to succeed in competitive exams and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

With Best Wishes
B. Singh (Ex. IES)
CMD, MADE EASY Group

Previous Years Solved Papers of

Civil Services Main Examination

Civil Engineering : Paper-I

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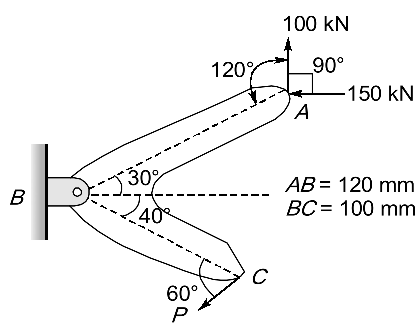
1 Engineering Mechanics

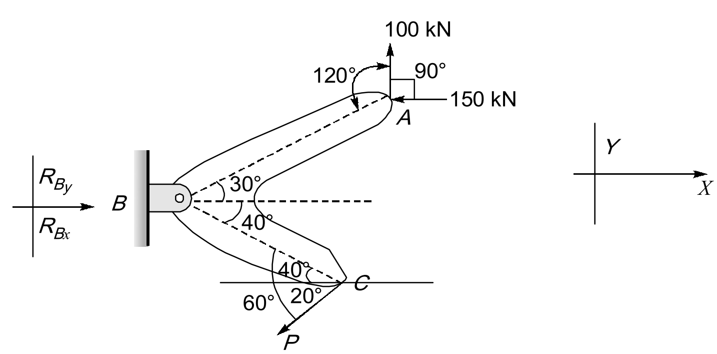
1. Composition, Resolution and Equilibrium of Forces

1.1 A component of a machine is subjected to a system of coplanar forces shown in the figure. Neglecting friction, determine the magnitude of force *P* to keep the component in equilibrium. Also determine the magnitude and direction of the reaction at the hinge at *B*.



[2005 : 12 Marks]

Solution:



Let R_{Bx} and R_{By} be the reaction component at *B* in *X* and *Y* direction respectively.

For equilibrium $\Sigma F_x = 0$

$$-150 - P\cos 20° + R_{Bx} = 0 \quad \text{...(i)}$$

$$\Sigma F_y = 0$$

$$100 + R_{By} - P\sin 20° = 0 \quad \text{...(ii)}$$

$$\Sigma M_B = 0$$

$\Rightarrow$ $-100 \times (AB\cos 30°) - 150 \times (AB\sin 30°) + P\cos 20° (BC\sin 40°) + P\sin 20° (BC\cos 40°) = 0$ ...(iii)

Given, $AB = 120$ mm

$BC = 100$ mm

In equation (iii), put value of *AB*, *BC*

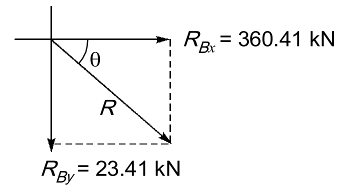
we get, $P = 223.92$ kN

Now, from eqn. (i) and (ii), $R_{Bx} = 150 + P\cos 20°$

$= 150 + 223.92 \times \cos 20° = 360.41$ kN

$$R_{By} = -100 + P \sin 20° = -100 + 223.92 \times \sin 20° = -23.41 \text{ kN}$$

Now, At hinge B,



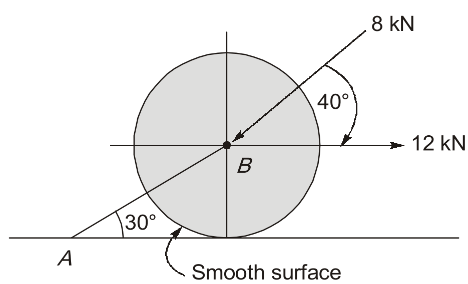
Resultant reaction, $R = \sqrt{(R_{B_x})^2 + (R_{B_y})^2}$

$= \sqrt{(360.41)^2 + (23.41)^2} = 361.17 \text{ kN}$

Direction of resultant force, $\tan\theta = \dfrac{R_{B_y}}{R_{B_x}} = \dfrac{23.41}{360.41} = 0.065$

$\theta = \tan^{-1}(0.065) = 3.72° \simeq 3°43'8.38''$ clockwise from x-axis

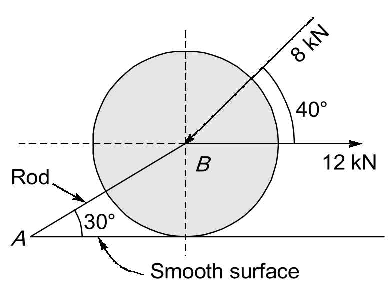
1.2 A roller of weight 20 kN rests on a smooth horizontal floor and is connected to the floor by the bar *AB* as shown in figure. Determine the force in the bar *AB* and reaction from the floor, if the roller is subjected to a horizontal force of 12 kN and inclined force of 8 kN as shown in the figure.



[2006 : 12 Marks]

Solution:

Given: Weight of roller = 20 kN



Let F_{AB} be the force in the rod *AB* and *R* be the reaction from floor.

Consider equation of roller

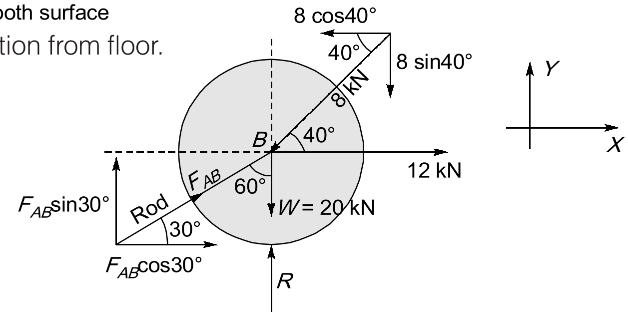
Resolving the forces horizontally, $\Sigma F_x = 0$

$12 - 8 \cos 40° + F_{AB} \cos 30° = 0$

$F_{AB} = -6.78 \text{ kN}$

Resolving the forces vertically

$\Sigma F_y = 0$



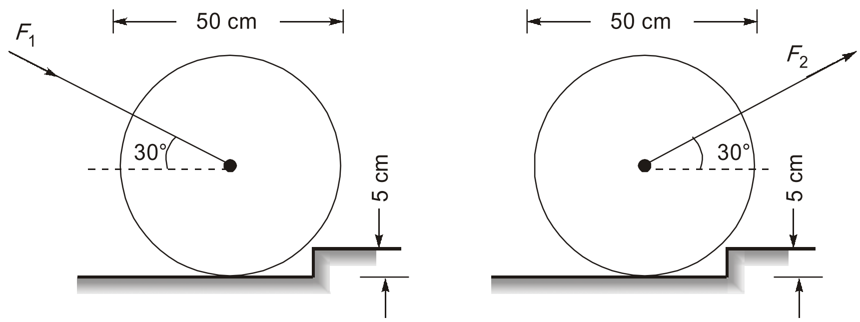
$$8 \sin 40° + 20 - F_{AB} \sin 30° = R$$

$$R = 5.14 + 20 - (-6.78) \sin 30°$$

$$R = 28.53 \text{ kN}$$

Hence, force in road AB is 6.78 kN (Tensile) and reaction from the floor is 28.53 kN. (Upwards)

1.3



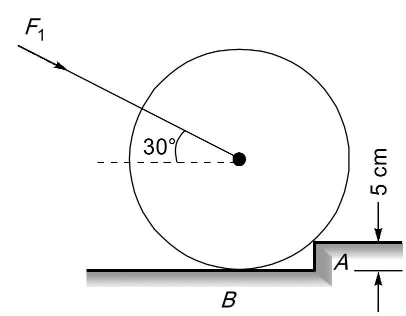
Compute the forces F_1 and F_2 required to just start a 100 kg lawn mower over a 5 cm step when

(b) the mower is pushed and

(c) the mower is pulled. (Above Figure)

[2007 : 20 Marks]

Solution:



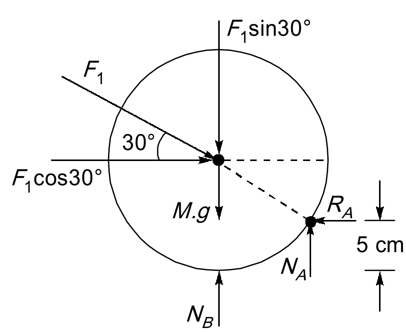
Given: Mass of lawn mower = 100 kg

Height of step = 5 cm

Dia. of mower = 50 cm

Case-I: When the mower is pushed

F.B.D



In limiting case $N_B = 0$ and $\Sigma M_A = 0$

Computing $\Sigma M_A = 0$

$$F_1 \cos 30° \times (25 - 5) = (F_1 \sin 30° + 100 \times 9.8) \times \sqrt{(25)^2 - (25-5)^2}$$

$$F_1 \times \frac{\sqrt{3}}{2} \times 20 = \left(\frac{F_1}{2} + 980\right) \times 15$$

$$\Rightarrow \quad F_1 = 1496.86 \text{ N} = 1.496 \text{ kN}$$

Given,

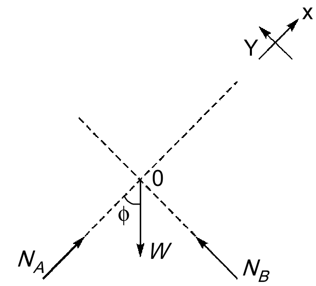
$$N_B = \frac{1}{2}N_A$$

$$700 \sin(45-\theta) = \frac{700}{2}\cos(45-\theta)$$

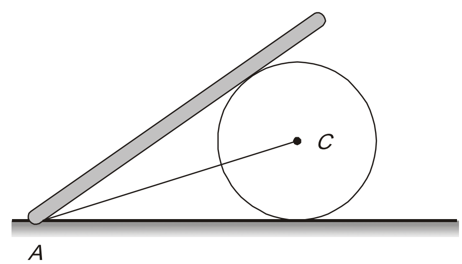
$$\Rightarrow \quad \tan(45-\theta) = \frac{1}{2}$$

$$\Rightarrow \quad (45-\theta) = 26.565°$$

$$\Rightarrow \quad \theta = 18.435°$$



1.7 A smooth right circular cylinder of radius 0.5 m rests on a horizontal plane and is kept from rolling by an inclined string AC of length 1.0 m. A prismatic bar of length 1.5 m and weight 125 N is hinged at point A and leans against the cylinder as shown in the figure below. Find the tension S that will be induced in the string AC.



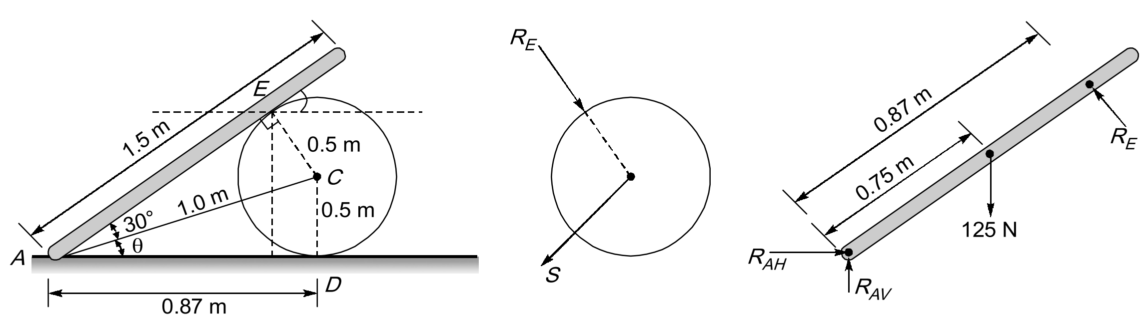
[2009 : 12 Marks]

Solution:

$$\sin\theta = \frac{0.5}{1}$$

$$\theta = 30°$$

FBD of roller:



$$\text{Length of } AD = \sqrt{1^2 - 0.5^2} = 0.866\text{ m}$$

$$AD = AE = 0.866 \text{ m} \approx 0.87 \text{ m}$$

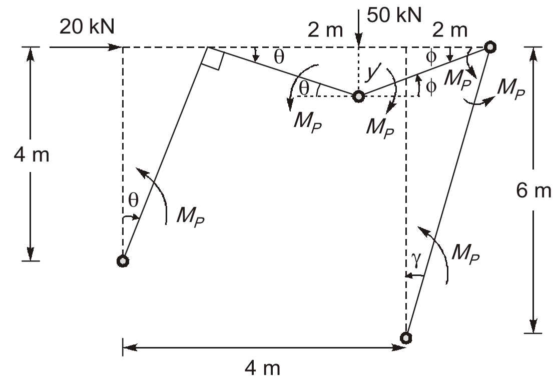
$\Sigma F_A = 0$ (i) $\quad R_E \times 0.87 = 125\,(0.75 \times \cos 60°)$

$$R_E = 54.13 \text{ N}$$

$\Sigma F_{cylinder} = 0; \quad -S\cos 30° + R_E \cos 30° = 0$

$$S = R_E = 54.13 \text{ N}$$

1.8 Find the resultant of the force system acting on a Lamina of equilateral triangle of sides 200 mm. Find also its direction and position w.r.t. point A as shown in the figure, D and E are mid points of BC and AC respectively.



or, $2M_P \times (1.5\,\phi) + 2M_P\phi = 20 \times 4 \times 1.5\,\phi$

or, $5\,M_P\phi = 120\,\phi$

$\therefore$ $M_P = 24$ kNm

Combined Mechanism:

$$y_1 = y_1$$
$$2\theta = 2\phi$$
$$\theta = \phi$$
$$4\theta = 6\gamma$$
$$\theta = 1.5\,\gamma$$

Total work done by Internal force = Total work done by External force

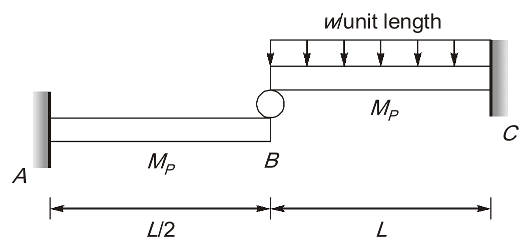
$$M_P\theta + M_P\theta + M_P\phi + M_P\phi + M_P\gamma + M_P\gamma = 20 \times 4\theta + 50 \times 2\theta$$

or, $2\,M_P \times (1.5\,\gamma) + 2M_P(1.5\,\gamma) + 2M_P\gamma = 80 \times 1.5\,\gamma + 100 \times 1.5\gamma$

$\therefore$ $M_P = 33.75$ kNm

$\therefore$ Fully plastic moment of frame is maximum of all = 33.75 kNm

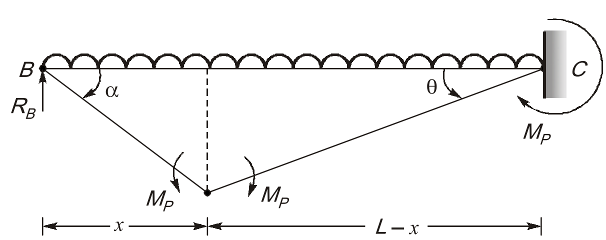
5.8 Two cantilevers beams of same cross-section and separated by a roller jointly support a uniformly distributed load as shown in figure. Determine the collapse load.



[2014 : 20 Marks]

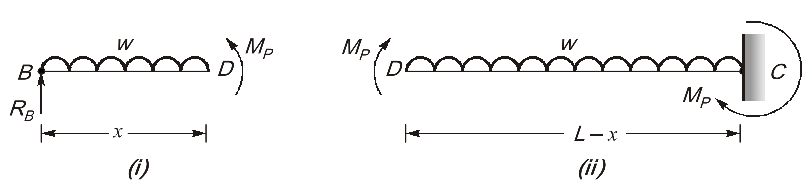
Solution:

Case-1: For BC part of beam



Plastic hinge will form at D & C,

$$\alpha\,x = \theta\,(L - x)$$



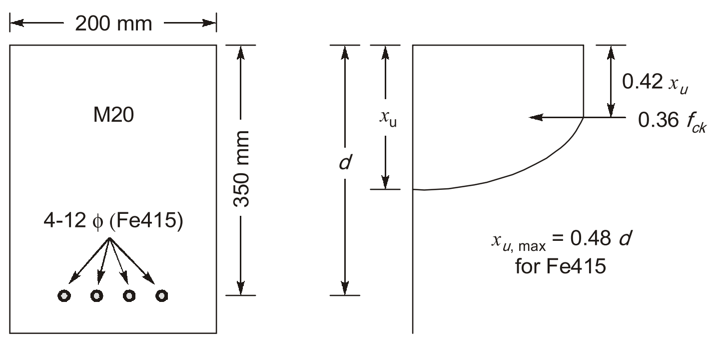
$\Sigma M_B = 0$ $\qquad\qquad$ $\Sigma M_C = 0$

$$M_P = \frac{wx^2}{2} \qquad ...(i) \qquad\qquad M_P = \frac{w(L-x)^2}{2} \qquad ...(ii)$$

5 Design of Concrete and Masonry Structures

1. Beams

1.1 Determine the moment of resistance for the given section by limit state method. The stress block parameters from IS : 456 are given:



[1995 : 20 Marks]

Solution:

Area of steel, $$A_{st} = 4 \times \frac{\pi}{4} \times 12^2 = 452.3893 \text{ mm}^2$$

$$x_{u,\,max} = 0.48 \times d = 0.48 \times 350 = 168 \text{ mm}$$

Actual depth of neutral axis,

$$x_u = \frac{0.87 f_y \cdot A_{st}}{0.36 f_{ck}.B} = \frac{0.87 \times 415 \times 452.3893}{0.36 \times 20 \times 200}$$

$$x_u = 113.4271 \text{ mm} < x_{u,\,max}$$

⇒ Section is under-reinforced.

$$\text{Moment of Resistance} = 0.36\, f_{ck}\,.\,B.\,x_u\,(d - 0.42\,x_u)$$
$$= 0.36 \times 20 \times 200 \times 113.4271\,(350 - 0.42 \times 113.4271)$$
$$= 49386078.8 \text{ N-mm}$$
$$= 49.3861 \text{ kN-m}$$

1.2 A reinforced concrete beam section is 230 mm wide × 460 mm effective depth, reinforce with 2-14 mm diameter bars as compression reinforcement at an effective cover of 40 mm, and 4-20 mm diameter bars as tension reinforcement. Find the moment of resistance of this beam section using the limit state method, if the materials are M15 grade concrete and HYSD reinforcement of grade Fe415. Take x_u, max = 0.48 d and f_{sc} = 353 N/mm^2.

[1998 : 20 Marks]

Solution:

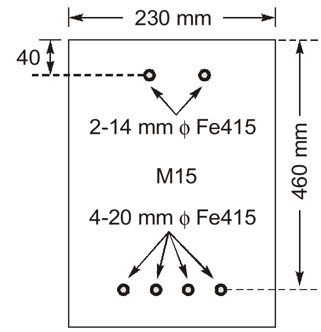
Area of compression steel, $A_{sc} = 2 \times \frac{\pi}{4} \times 14^2$

$= 307.8761 \text{ mm}^2$

Area of tension steel, $A_{st} = 4 \times \frac{\pi}{4} \times 20^2$

$= 1256.6371 \text{ mm}^2$

$x_{u, \text{lim}} = 0.48\, d = 0.48 \times 460 = 220.9 \text{ mm}$



Actual depth of Neutral axis, x_u:

$0.36\, f_{ck} \cdot B \cdot x_u + (f_{sc} - 0.45\, f_{ck})\, A_{sc} = 0.87\, f_y \cdot A_{st}$

$0.36 \times 15 \times 230 \times x_u + (353 - 0.45 \times 15) \times 307.8761 = 0.87 \times 415 \times 1256.6371$

$\therefore \quad x_u = 279.474 \text{ mm} > x_{u, \text{lim}}$

$\Rightarrow$ **Section is over-reinforced.**

$\therefore$ Design for balanced section

Moment of Resistance $= 0.36\, f_{ck} \cdot B \cdot (x_u)_{\text{lim}}\, (d - 0.42 (x_u)_{\text{lim}}) + (f_{sc} - 0.45\, f_{ck})\, A_{sc}\, (d - d_c)$

$= \{0.36 \times 15 \times 230 \times 220.9 \times (460 - 0.42 \times 220.9)\}$

$+ \{(353 - 0.45 \times 15) \times 307.8761 \times (460 - 40)\}$

$= 100750220 + 44772881.84$

$= 145523101.8 \text{ N-mm}$

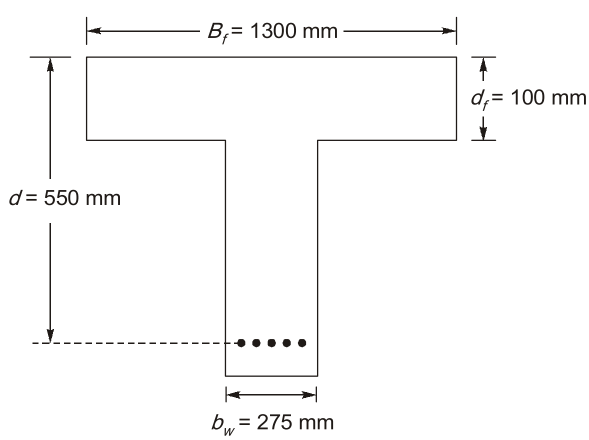
$= 145.5231 \text{ kN-m}$

1.3 A T-beam of flange width 1300 mm, flange thickness 100 mm, rib width 275 mm has an effective depth of 550 mm. The beam is reinforced with 5 bars of 25 mm diameter. Find the ultimate moment of resistance by the limit-state method. Use M15 concrete and Fe415 steel.

[1999 : 20 Marks]

Solution:

Assuming effective flange width, $B_f = 1300 \text{ mm}$



Area of steel, $A_{st} = 5 \times \frac{\pi}{4} \times 25^2 = 2454.3693 \text{ mm}^2$

Limiting depth of neutral axis, $x_{u, \text{lim}} = 0.48 d$

$x_{u, \text{lim}} = 0.48 \times 550 = 264 \text{ mm}$

Assuming actual depth of neutral axis $x_u < d_f$

$\Rightarrow \quad 0.36\, f_{ck} \cdot B_f \cdot x_u = 0.87\, f_y \cdot A_{st}$

$$0.36 \times 15 \times 1300 \times x_u = 0.87 \times 415 \times 5 \times \frac{\pi}{4} \times 25^2$$

$\Rightarrow$ $x_u = 126.23 > d_f$

Hence our assumption is wrong.

Assuming, $x_u > d_f$

and $\frac{3}{7}x_u < d_f$

$\therefore$ $y_f = 0.15\,x_u + 0.65\,d_f = 0.15\,x_u + 0.65 \times 100$

$= 0.15\,x_u + 65$

$$0.36\,f_{ck}\,.\,b_w.\,x_u + 0.45\,f_{ck}\,(B_f - b_w).y_f = 0.87 f_y.\,A_{st}$$

$$0.36 \times 15 \times 275 \times x_u + 0.45 \times 15\,(1300 - 275)(0.15\,x_u + 65) = 0.87 \times 415 \times 2454.3693$$

$\Rightarrow$ $x_u = 172.99 \text{ mm} > d_f$

$\frac{3}{7}x_u = 74.14 \text{ mm} < d_f$

Hence our assumption is correct.

$\therefore$ Depth of neutral axis, $x_u = 172.99 \text{ mm} < 264 \text{ mm}$ (under reinforced section)

$y_f = 0.15 \times 172.99 + 65 = 90.95 \text{ mm}$

Ultimate Moment of Resistance $= \left[0.36 f_{ck}.b_w.x_u(d - 0.42\,x_u) + 0.45 f_{ck}(b_f - b_w).y_f.\left(d - \frac{y_f}{2}\right)\right]$

$$(M.R)_u = [0.36 \times 15 \times 275 \times 172.99 \times (550 - 0.42 \times 172.99)]$$

$$+ \left[0.45 \times 15 \times (1300 - 275) \times 90.95 \times \left(550 - \frac{90.95}{2}\right)\right]$$

$= 440102582.3$ N-mm

$= 440.1026$ kN-m

1.4 Design by LSM the section of a cantilever beam 3.0 m long carrying a superimposed load of 10,600 N/m. Use M15 concrete and Fe415 steel.

[2001 : 30 Marks]

Solution:

Given: $l = 3.0$ m; L.L. = 10.6 kN/m; M15 and Fe415 used

As the beam is a cantilever, approximate depth based on deflection, $d = \frac{l}{7} = \frac{3000}{7} = 428.57$ mm

Let us assume effective depth d = 450 mm and effective cover of 50 mm.

$\therefore$ Total depth D = 500 m

Assuming width of section, $B = \frac{D}{2} = 250$ mm

D.L. $= 0.500 \times 0.250 \times 25 = 3.125$ kN/m

L.L. $= 10.6$ kN/m

Total factored load, $w_u = 1.5\,(3.125 + 10.6) = 20.5875$ kN/m

Maximum bending moment, $M_u = \frac{w_u l^2}{2}$

$$M_u = \frac{20.5875 \times 3^2}{2} = 92.64 \text{ kN-m}$$

Check for depth: $d = \sqrt{\frac{M_u}{QB}} = \sqrt{\frac{92.64 \times 10^6}{0.138 \times 15 \times 250}} = 423.101$ mm

$d = 423.101 \text{ mm} < 450 \text{ mm} \Rightarrow$ Hence safe.

With $d = 450$ mm, $M_{u,\lim} = 0.138\, f_{ck}\, bd^2$ (For Fe 415)

$$M_{u,\lim} = 0.138 \times 15 \times 250 \times \frac{450^2}{10^6} = 104.79 \text{ kN-m} > 92.64 \text{ kNm}$$

∴ **Section is under-reinforced.**

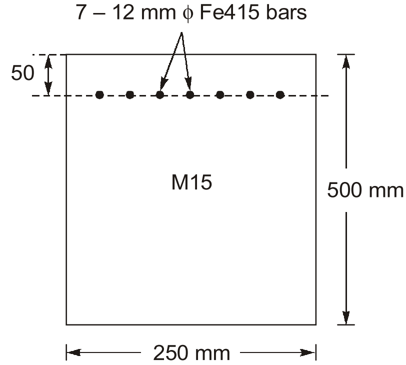
Area of steel, $$A_{st} = \frac{0.5 f_{ck}}{f_y}\left[1 - \sqrt{1 - \frac{4.6 M_u}{f_{ck}.b.d^2}}\right] bd$$

$$A_{st} = \frac{0.5 \times 15}{415}\left[1 - \sqrt{1 - \frac{4.6 \times 92.64 \times 10^6}{15 \times 250 \times 450^2}}\right] 250 \times 450$$

$$= 686.31 \text{ mm}^2$$

Number of 12 mm ϕ bars $= \dfrac{686.31}{\frac{\pi}{4} \times 12^2} = 6.06$, say 7

Provide 7 – 12 mm ϕ bars at top of the section as it is a cantilever with effective cover of 50 mm.



1.5 **Use limit state method to design a reinforced concrete beam of rectangular cross-section to support a uniformly distributed service load of 25 kN/m, inclusive of self weight, over an effective simply supported span of 6 m. The materials used are M20 grade concrete and HYSD steel of grade Fe415. Assume $d = 2b$.**

[2002 : 20 Marks]

Solution:

$$w = 25 \text{ kN/m}$$

Factored load, $w_u = 1.5 \times w$

$$w_u = 25 \times 1.5 = 37.5 \text{ kN/m}$$

Bending moment at mid-span $= \dfrac{w_u l^2}{8}$

$$M_u = \frac{37.5 \times 6^2}{8} = 168.75 \text{ kN.m}$$

Let us design a singly reinforced balanced section.

$$M_{u,\text{bal}} = Q.B.d^2$$

$$168.75 \times 10^6 = 0.138 f_{ck} \cdot \frac{d}{2} \cdot d^2$$

$$\Rightarrow \quad 168.75 \times 10^6 = 0.138 \times 20 \times \frac{d^3}{2}$$

$$\Rightarrow \quad d = 496.35 \text{ mm, say } d = 500 \text{ mm}$$

Assuming 50 mm effective cover.

$$\therefore \quad b = \frac{d}{2} = \frac{500}{2} = 250 \text{ mm}$$

$$\text{Depth of beam} = 500 + 50 = 550 \text{ mm}$$

Since, provided depth is higher then that required for balanced section. Hence, section in under-reinforced.

$$A_{st} = \frac{0.5 f_{ck} bd}{f_y}\left(1 - \sqrt{1 - \frac{4.6 BM_u}{f_{ck}\, bd^2}}\right)$$

$$= \frac{0.5 \times 20 \times 250 \times 500}{415}\left(1 - \sqrt{1 - \frac{4.6 \times 168.75 \times 10^6}{20 \times 250 \times (500)^2}}\right)$$

$$= 1157.74 \text{ mm}^2$$

Provide (3-20ϕ + 2-12ϕ); $(A_{st})_{provide} = 1162 \text{ mm}^2$

$$(A_{st})_{lim} = (0.048\, f_{ck}\%) \times bd$$

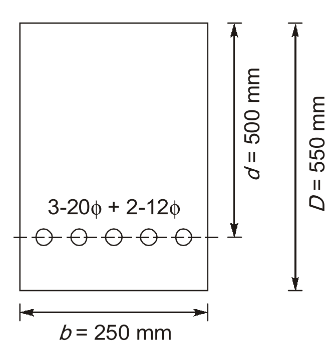
$$= \frac{0.048 \times 20}{100} \times 250 \times 500 = 1200 \text{ mm}^2$$

$$(A_{st})_{min} = \frac{0.85}{f_y} bd = \frac{0.85}{415} \times 250 \times 500 = 256.024 \text{ mm}^2$$

$$A_{st,\ max} = 0.04\ bD = 0.04 \times 250 \times 550 = 5500 \text{ mm}^2$$

$$\therefore \quad A_{st,\ min} = A_{st,\ required} < A_{st,\ provided} < A_{st,\ lim} < A_{st\ max.} \qquad \text{(OK)}$$

Design details:



1.6 **Determine limiting moment of resistance and maximum percentage of steel required for the concrete cross-section shown in figure below. Use limit state method, and M15 and Fe415 steel.**