AKGEC/IAP/FM/01

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DEPARTMENT OF CIVIL ENGINEERING
Sessional Test–2 (SOLUTION)

Course:	B.Tech.	Semester:	V
Session:	2017-18	Section:	CE-1& 2
Subject:	Design of Concrete Structures-I	Sub. Code:	NCE-505
Max Marks: 50		Time:	2 hours

Answer all the sections. Any data if missing may be assumed suitably.

Section- A

QNS 1(a) what do you mean by anchorage length? And also write its maximum value for simply supported Beam.

QNS 1. (a) ANS:- "Anchorage length" - This is the additional length of bar. for example - main bar of the beam in column at beam column junction. This is represented by Lo. And maximum Anchorage length for simply supported beam is subjected to a maximum of 12ϕ or d.

where ϕ - diameter of main bar.
d - effective depth of beam.

QNS 1(b) When the shear reinforcement is necessary in a beam?

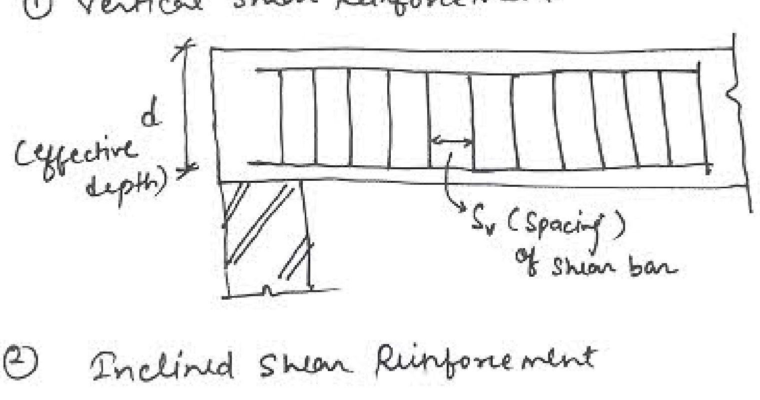
QNS 1. (b) ANS:- If the value of τ_v is greater than τ_c. Then shear reinforcement is needed.

where,
τ_v = Nominal shear stress
τ_c = Shear strength of concrete.

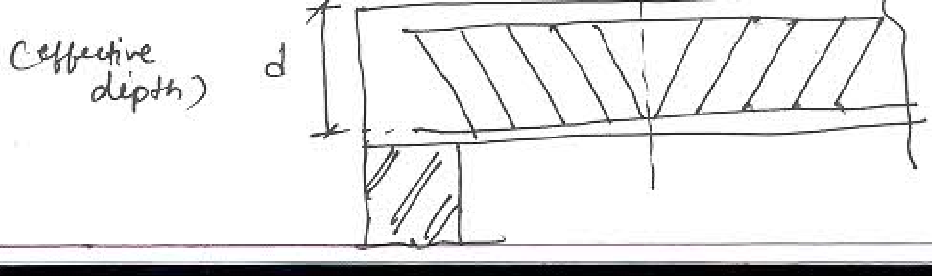
QNS 1 (c) Enumerate types of shear reinforcement with neat sketch.

QNS 1. (c) ANS:- There are three types of shear reinforcement

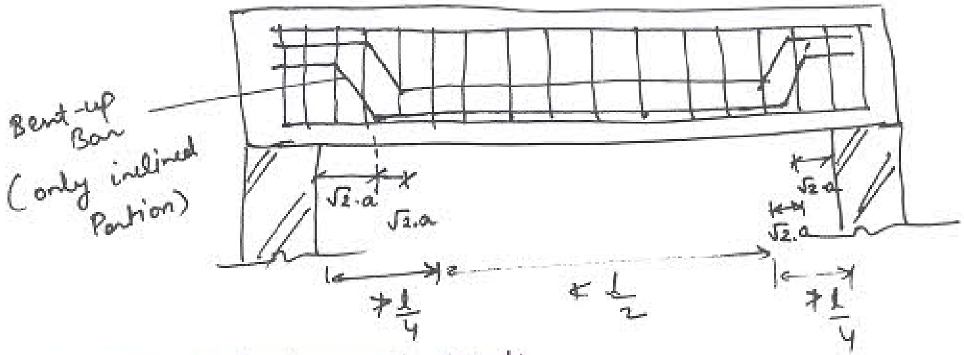
① vertical shear Reinforcement



② Inclined shear Reinforcement



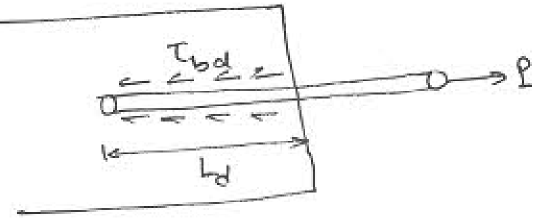
(3) Bent-up Bars



QNS1(d) Define Devlopment length.

QNS1. (d) ANS:-

"Devlopment length":- This is the minimum length of reinforcement required to be provided inside concrete, so that the strength of bond is not less than strength of reinforcement. This is denoted by L_d.



$$\boxed{L_d = \frac{0.87 f_y \phi}{4 \tau_{bd}}}$$

where,
- f_y - characteristic strength of steel.
- ϕ - diameter of bar.
- τ_{bd} - bond stress.
- L_d - devlopment length.

QNS1(e) Under what circumstances a doubly reinforced beam is designed?

QNS1. (e) ANS:- If the size of beam is restricted (width and depth both) and if the beam has to sustain a higher value of B.M more than M_R of the singly reinforced limiting section, Doubly reinforced beam is required.

SECTION-B

QNS2:-(a) Determine ultimate moment of capacity of a doubly reinforced beam of 300mm x 600 mm overall depth. Area of steel in compression is equal to 804 mm², area of steel in tension is equal to 2060 mm². If M20 concrete & Fe-415 steel are used. Take the value of effective cover 50 mm.

QNS(2) (a)

ANS:-

Step① limiting depth of Neutral Axis (N.A):- $(x_{u\,lim})$ $= 0.48d$

$= 0.48 \times 550 = 264$ mm

Step② Actual depth of N.A :- (x_u)

$$C_1 + C_2 = T$$

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

$$0.36 \times 20 \times 300 \times x_u + (f_{sc} - 0.45 \times 20) \times 804 = 0.87 \times 415 \times 2060$$

$$2160 x_u + 804 f_{sc} = 750999 \quad \text{—— ①}$$

Trial ①

Consider $f_{sc} = 350 \frac{N}{mm^2}$

$x_u = 217.4$

Strain in compressive steel, $\varepsilon_{sc} = \frac{x_u - d_c}{x_u} \times 0.0035$

$= \frac{217.4 - 50}{217.4} \times 0.0035$

$\varepsilon_{sc} = 0.00269$

By Interpolation Rule,

$$f_{sc} = 342 + \frac{351 - 342}{0.00276 - 0.00241} \times (0.00269 - 0.00241)$$

$$= \overline{349.2}$$

$x_u = 217.6$

$\because x_u < x_{u\,lim}$ {It is a under reinforced section}

Step③ Moment of Resistance (M_{R_u}):-

$$M_{R_u} = 0.36 f_{ck} B x_u (d - 0.42 x_u) + (f_{sc} - 0.45 f_{ck}) \cdot A_{sc} (d - d_c)$$

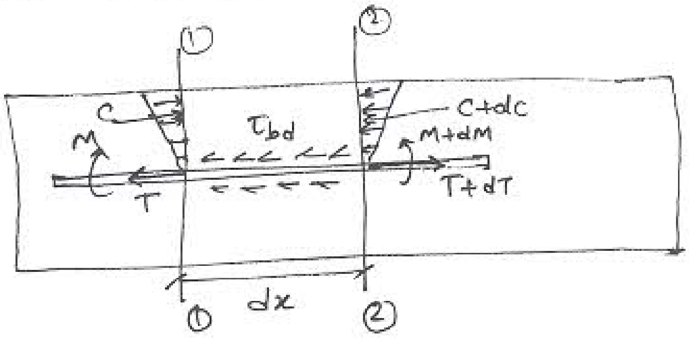
$$= [0.36 \times 20 \times 300 \times 217.6 (550 - 0.42 \times 217.60)$$

$$+ (349.2 - 0.45 \times 20) \times 804 \times (550 - 50)] \times \frac{1}{10^6}$$

$M_{R_u} = 352.32$ KN-M

QNS:- 2(b) What is the bond strength of concrete? Derive the expression for bond stress in reinforced concrete.

QNS:- 2 (b) ANS:- Bond strength is the measure of effectiveness of the grip between concrete and steel. and



Consider two cross-section ①-① and ②-② very close to each other at dx distance.

In reinforced there will be a (dT) unbalanced force that creates bond stress between steel and concrete. This bond stress is also called longitudional shear stress.

At section ①-① $M = T \cdot jd$ or $C \cdot jd$ —①

At section ②-② $M+dM = (T+dT) \cdot jd$ —②

Eqn ② − Eqn ①

$$dM = dT \cdot jd$$

$$\boxed{dT = \frac{dM}{jd}} \quad —③$$

Resisting Bond force $dT = \tau_{bd} \cdot n\pi\phi \cdot dx$ —④

Equating ③ & ④

$$dT = \frac{dM}{jd} = n\pi \times \phi \, dx \times \tau_{bd}$$

$$\tau_{bd} = \frac{dM}{jd \cdot n\pi\phi \, dx} = \frac{V}{jd \cdot n\pi\phi}$$

$\left\{ \frac{dM}{dx} = V \right.$ S.F

$$\boxed{\tau_{bd} = \frac{V}{jd \, \Sigma O}}$$

ΣO = sum of perimeter all reinforcement = $n\pi\phi$

QNS:- 2 (c) A simply supported beam is 25 cm by 50 cm and has 2-20 mm HYSD bars going into the support if the shear force at the centre of support is 110 kN at working loads, determine the anchorage length. Assume M-20 mix and Fe-415 steel.

QNS 2:-(C) ANS:-

factored shear force $= 1.5 \times 110 = 165$ kN

Assuming 25 mm clear cover to the longitudinal bars

$$d = 500 - 25 - \frac{20}{2} = 465 \text{ mm}$$

$$\sigma_y = 415 \text{ N/mm}^2.$$

moment of resistance (M_1)

$$= 0.87 \sigma_y A_{st} (d - 0.42 x_u)$$

$$x_u = \frac{0.87 \sigma_y A_{st}}{0.36 f_{ck} b} = \frac{0.87 \times 415 \times 628}{0.36 \times 20 \times 250}$$

$$= 126 \text{ mm} < x_m \quad [\text{O.K}]$$

$$M_1 = 93.45 \times 10^6 \text{ N.mm}$$

$$\tau_{bd} = 1.2 \text{ N/mm}^2 \text{ for M20 mix}$$

it can be increased By 60% in case of HYSD Bars

$$L_d = \frac{\phi f_y \times 0.87}{4 \tau_{bd}}$$

$$= \frac{0.87 \times 415 \times \phi}{4 \times 1.6 \times 1.2}$$

$$L_d = 47\phi$$

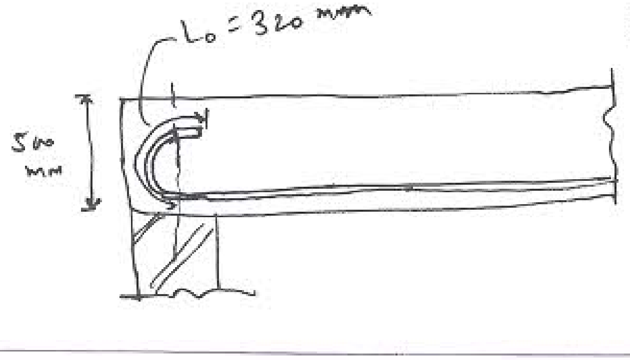
if we provided U-Bend at the centre of support its anchorage value.

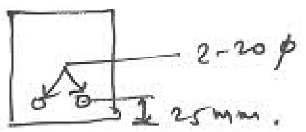
$$L_o = 16\phi = 16 \times 20 = 320 \text{ mm}$$

$$L_d \le 1.3 \frac{M_1}{V} + L_o$$

$$47\phi \le \left[\frac{1.3 \times 93.45 \times 10^6}{165 \times 1000}\right] + 320$$

$$\phi \le 22.47 \text{ mm}.$$





QNS:- 2(d) Write difference between LSM and WSM.

QNS:- 2 (d) ANS:-

WSM (Working stress method)	LSM (Limit state method)
① It is based on deterministic approach.	① It is based on probabilistic approach.
② Concrete	② Concrete
(a) stress factor of safety = 3.0	(a) stress factor of safety = 2.22
(b) load factor of safety = 1.0	(b) load factor of safety = 1.5
(c) Net factor of safety = 3.0	(c) Net factor of safety = 3.33 more than that of WSM
③ Steel	③ Steel.
Stress factor of safety = 1.8	Stress factor of safety = 1.15
load factor of safety = 1.0	load F.O.S = 1.5
Net F.O.S = 1.8	Net F.O.S = 1.15 × 1.5 = 1.725 less than that of WSM

QNS 2 (e) A simply supported beam of 5m effective span is subjected to 24 kN/m Live load. Size of beam 250 mm wide and 400 mm overall depth. Design reinforced Beam. Use M-20 & Fe-415.

QNS:- 2 (e) ANS:-

Step ① Load/B.M

Live load = 24 kN/m

Self wt. = 0.25 × 0.40 × 1.0 × 25 = 2.5 kN/m

Total w = 26.5 kN/m

factored w_u = 26.5 × 1.5
= 39.75 kN/m

Max^m B.M $(BM)_u = \frac{w_u l^2}{8} = \frac{39.75 \times 5^2}{8} = 124.21$ kN-m

Step ② MR of limiting (SR) section:-

$M_{u_l} = MR_{lim} = Q B d^2$

$= 0.138 f_{ck} B d^2$

$= 0.138 \times 20 \times 250 \times \frac{350^2}{10^6}$

$= 84.525$ kN-m

SECTION - C

QNS 3(a) A simply supported T-beam of span 6.0m in reinforced concrete has following dimensions:
width of flange = 1600 mm, Depth of flange = 100 mm.
Overall depth of beam = 850 mm, width of web = 400 mm
Effective cover to reinforcement = 50 mm, Use Fe-500 steel & M-30 Concrete.

Design the beam for a factored B.M of 1250 KN-m.

QNS (3) (a) Ans:-

(1) Calculate effective width of flange

$$B_f = \frac{l_o}{\left(\frac{l_o}{B}+4\right)} + b_w = \frac{6000}{\left(\frac{6000}{1600}+4\right)} + 400$$

$= 1174.2$ mm

(2) Calculate M.R (Mu_1)

when $x_u = d_f$

$Mu_1 = 0.36 f_{ck} B_f . x_u (d - 0.42 x_u)$

$= 0.36 \times 30 \times 1174.2 \times 100 \times (800 - 0.42 \times 100) \times \frac{1}{10^6}$

$= 961.25$ KN-M

(3) Calculate M.R (Mu_2)

when $x_u = \frac{7}{3} d_f$

$x_u = \frac{7}{3} \times 100 = 233.33$ mm (d_f Case)

$Mu_2 = 0.36 f_{ck} b_w x_u (d - 0.42 x_u) + 0.45 f_{ck} (B_f - b_w) \cdot d_f \cdot (d - \frac{d_f}{2})$

$= 0.36 \times 30 \times 400 \times 233.33 \times (800 - 0.42 \times 233.33]$
$+ 0.45 \times 30 \times [1174.2 - 400] \times 100 \times (800 - \frac{100}{2})$

$Mu_2 = 1491.48$ KN-m

(4) Calculate M.R at $x_u = x_{u\,lim}$

$x_u = 0.48 \times 800 = 384$ mm

$\boxed{d_f < \frac{3}{7} x_u}$ d_f case.

$Mu_{lim} = 0.36 \times 30 \times 400 \times 384 \times (800 - 0.42 \times 384) + 0.45 \times 30 \times (1174.2 - 400) \times 100 \times (800 - \frac{100}{2})$

$Mu_{lim} = 1843.42$ KN-m

$(BM)_u > MR_{SR\ lim}$

we need a doubly Reinforced section.

Step ③ A_{st_1} for M_{u_1}

$$A_{st_1} = \frac{M_{u_1}}{0.87 f_y (d - 0.42 x_{u\,lim})}$$

$$= \frac{84.525 \times 10^6}{0.87 \times 415 (350 - 0.42 \times 0.48 \times 350)}$$

$$= 837.78\ mm^2$$

Step 4 Remaining BM.

$$M_{u_2} = BM_u - M_{u_1}$$
$$= 124.21 - 84.525$$
$$= 36.685 \simeq 36.69\ kN\text{-}m$$

Step ⑤ $$A_{st_2} = \frac{M_{u_2}}{0.87 f_y (d - d_c)}$$

$$= \frac{36.69 \times 10^6}{0.87 \times 415 (350 - 50)}$$

$$= 366.43\ mm^2$$

Step ⑥ Total Ast $= A_{st_1} + A_{st_2}$

$$= 837.78 + 366.43$$
$$= 1204.21\ mm^2$$

Step ⑦ $$A_{sc} = \frac{M_{u_2}}{(f_{sc} - 0.45 f_{ck})(d - d_c)}$$

Considering $f_{sc} = 350\ N/mm^2$

$$= \frac{39.69 \times 10^6}{(350 - 0.45 \times 20)(350 - 50)}$$

Area of Compressive Steel $A_{sc} = 387.97\ mm^2$

QNS:- 3 (b) A simply supported beam 300 mm wide and 500 mm effective depth carries a uniformly distributed load 50 kN/m over an effective span of 6 m. Design the shear reinforcement in the form of vertical stirrups. Assume that the beam contain 0.78 % reinforcement throughout the length. The concrete is of M-20 grade & steel for stirrups is of Fe-250 grades. Take width of support as 400 mm.

ANS 3 (b) ANS:-

In case of simply supported beam the critical section for shear is taken at a distance 'd' from the face of the support we have.

$$W_u = 1.5 \times \text{working load}$$
$$= 1.5 \times 50 = 75 \text{ kN}.$$

$$V_{u\,max} = \frac{W_u l}{2} = \frac{75 \times 6}{2} = 225 \text{ kN}.$$

As per IS:456 the critical section for shear lies at a distance $d = 500$ mm from the face of support.
i.e at a distance $= 500 + \frac{400}{2} = 700$ mm
from centre of support.

V_{uD} = Design shear at the critical section
$= 225 - 75 \times 0.700 = 172.5$ kN

Now, $$\tau_v = \frac{V_u}{bd} = \frac{172.5 \times 10^3}{300 \times 500} = 1.15 \text{ N/mm}^2$$

$$P_t = \frac{100 A_{st}}{bd} = 0.75\,\% \text{ (given)}$$

Corresponding to this value of longitudinal reinforcement & for grade of concrete, we have

$$\boxed{\tau_c = 0.56 \text{ N/mm}^2}$$ from table (19)

Also, $\tau_{max} = 2.8$ N/mm^2 (from table 20)

$$\tau_c < \tau_v < \tau_{c\,max}$$

Hence shear reinforcement is needed.

Design of shear reinforcement.

$$V_{us} = V_{uD} - \tau_c \cdot bd$$
$$= 172.5 \times 10^3 - 0.56 \times 300 \times 500$$

$$\boxed{V_{us} = 88.5 \text{ kN}}$$

⑥ Design for $B.M_{u_2} = 1250$ kN-m

$$M_{u_1} < BM_{u_2} < M_{u_2}$$

$$d_f < x_{u_2} < \frac{7}{3} d_f$$

$$d_f > \frac{3}{7} x_{u_2}$$

so, it is a y_f case

$$y_f = 0.15 x_u + 0.65\, d_f$$
$$= 0.15\, x_{u_2} + 0.65 \times 100$$
$$y_f = 0.15\, x_{u_2} + 65$$

$$BM_{u_2} = 0.36 f_{ck}\, b_w\, x_{u_2} (d - 0.42 x_{u_2}) + 0.45 f_{ck} (B_f - b_w) y_f \cdot \left(d - \frac{y_f}{2}\right)$$

$$1250 \times 10^6 = 0.36 \times 30 \times 400\, x_{u_2} (800 - 0.42 x_{u_2}) + 0.45 \times 30 \times (1174.2 - 400) \times (0.15 x_{u_2} + 65) \times \left(800 - \frac{0.15 x_{u_2} + 65}{2}\right)$$

$$1569.1 x_{u_2}^2 + 4608299.92\, x_{u_2} + 728590816.2 = 0$$

$$x_{u_2} = 170.26 \text{ mm}$$

A_{st}

$$A_{st_1} = \frac{0.36 f_{ck}\, b_w\, x_{u_2}}{0.87 f_y} = \frac{0.36 \times 30 \times 400 \times 170}{0.87 \times 415}$$

$$= 2037.15 \text{ mm}^2$$

$$A_{st_2} = \frac{0.45 f_{ck} (B_f - b_w) y_f}{0.87 f_y}$$

$$= \frac{0.45 \times 30 \times (1170 - 400)(0.15 \times 170.26 + 65)}{0.87 \times 415}$$

$$= 2620.93 \text{ mm}^2$$

total $A_{st} = A_{st_1} + A_{st_2}$

$$\boxed{A_{st} = 4658.11 \text{ mm}^2}$$

Note

use

6 mm ϕ
8 mm ϕ
10 mm ϕ
12 mm ϕ } 2-legd for A_{sv}

Using 10 mm - 2 legged vertical stirrups

$$A_{sv} = 2 \times \frac{\pi}{4} \times (10)^2 = 157.1 \text{ mm}^2$$

Now the spacing of the vertical stirrups

$$S_v = \frac{0.87 f_y A_{sv} d}{V_{us}}$$

$$= \frac{0.87 \times 250 \times 157.1 \times 500}{88500}$$

$$\boxed{S_v = 193 \text{ mm}}$$

Check for spacing

maximum spacing $\not> 0.75 d$
$= 0.75 \times 500 = 375$ mm
$\not> 300$ [o.k]

Minimum Area of Shear Reinforcement

$$A_{sv} = \frac{0.4 b S_v}{0.87 f_y} = 106.48 \text{ mm}^2 < 157.1 \text{ mm}^2$$
[o.k]

Hence provide 10 mm ϕ - 2 legged vertical stirrups @ 190 mm Centre to centre.