Class – 1

Dt:- 19.01.24

RCC Design:-

1. **Concrete**:- Mixture of cement, coarse aggregate, fine aggregate, water

cement – Binder
Coarse aggregate – strength
fine aggregate – Void filler
water — workability + Hydration

IS sieve . 4.75 mm	→ passed is called fine aggregate Ex:- sand
	→ Retained is called coarse aggregate Ex:- Gravel.

Sand:- It has 4 zone.

Zone I	Zone II	Zone III	Zone IV
coarse sand like River sand ↓ PCC work	fine → Medium sand	fine → Fine sand	→ very fine sand ↓ Used for plastering and finishing work

Zone II and Zone III: Used for RCC work

Water:- pH value of water shall not be less than 6.

permissible limit for solids in water:-

(i) Organic water = 200 mg/L or ppm
(ii) Inorganic matter = 3000 mg/Lit
(iii) Sulphates = 400 mg/L for PCC, 500 mg/Lit for RCC
(iv) Chlorides = 2000 mg/L
(v) Suspended matter = 2000 mg/Lit

Reinforcement (Steel) :- MILD STEEL - Fe 250

→ HYSD STEEL (High yield strength deformation bars)
[Fe415, Fe500, Fe550]

→ Mild steel code book = **IS 432 (PART-1)** ⇒ HYSD bar code book - **IS 1786**

→ Surface of mild steel is plane ⇒ surface area of HYSD bar are angular.

→ Reinforcements are available in 8mm, 10, 12 mm, 16mm, 20mm, 25mm, 32mm, 36mm.

→ Building → Fe415

→ Govt project = Fe500, Fe550

∴ Modulus of Elasticity of Steel (E_s) = 200 KN/mm2 or 2×10^5 N/mm^2

∴ Poission Ratio of steel (μ) = 0.3

∴ Unit mass of Steel = 7850 kg/m3 or 7.85 ton/m3

∴ Co-efficient of Thermal Expansion $\alpha = 12 \times 10^{-6}$ /°C

∴ Length of bars :- 40ft / 12m

Unit weight of RCC in kg/cum = 2500 kg/m3

PCC = 2400 kg/m3

Q(1) The property of fresh concrete, in which the water in the mix tends to rise to the surface while placing and compacting, is called.

Ans (B)

(a) segregation (b) bleeding (c) bulking (d) creep

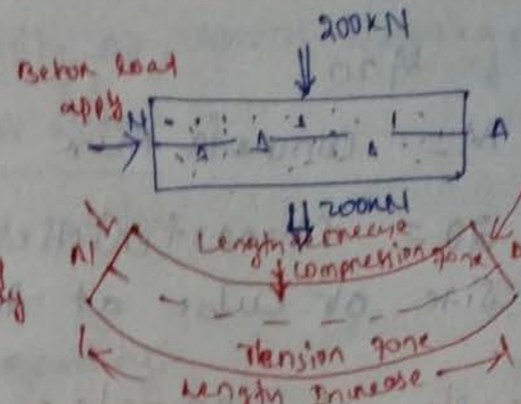
(2) The property of the ingredients to separate from each other while placing the concrete is called.

Ans (A)

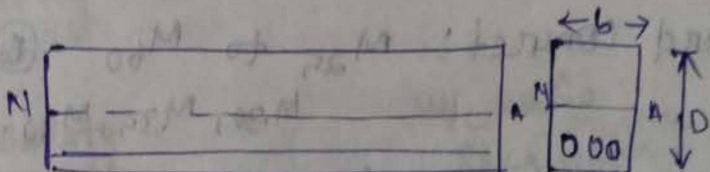
(a) Segregation (b) compaction (c) Shrinkage (d) bulking.

PCC (plain cement concrete)

→ Load carrying capacity = 100 KN



concrete weak in tension zone.
∴ we use provide reinforcement in tension zone. for strengthen in the beam. Reinforcement resist the adifional 100KN load



<Single Reinforced Beam>

Class-2

1 Q) the thermal expansion co-efficient of steel is :-

Ans (C)

(a) $12*10^{-6}/°C$ and closely resembles to α of concrete.

(b) $11*10^{-6}/°C$ and differs widely from α of concrete.

(c) $12*10^{-6}/°C$ and close to α of concrete

(d) $14*10^{-6}/°C$ but nearly equal to α of concrete.

(2) As per IS:456-2000, the organic content of water used for making concrete should not be more than: Ans (A)

(a) 200 mg/l (b) 250 mg/l (c) 100 mg/lit (d) 150 mg/l.

(3) Mild steel used in RCC structure conforms to :- Ans (A)

(a) IS:432 (b) IS:1566 (c) IS:1786 (HYSD bar) (d) IS:2062 (e)

(4) Unit weight of RCC in kg/cum is ——. Ans 2500 PCC = 2400.

(a) 1200 (b) 1800 (c) 2400 (d) 3000 (e) NOT

(5) M10 grade of concrete approximately —— mix. Ans (A)

(a) 1:3:6 (b) 1:1:2 (c) 1:2:4 (d) 1:1.5:3

M25 = 1:1:2 M15 = 1:2:4

M20 = 1:1.5:3 M10 = 1:3:6

M_ = 1:4:8 M5 = 1:5:10

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M 20

M = concrete mix

20 = Characteristic compressive strength of 150 mm size of cube at 28 days in 20 N/mm2.

Grade of concrete :-

(1) Ordinary concrete :- M_{10}, M_{15}, M_{20} (3)

(2) Standard concret :- M_{25} to M_{60} - (8)
M_{30}, M_{35}, M_{40}, M_{45}, M_{50}, M_{55}

(3) High strength concrete :- M_{65} to M_{100} (8)
(M_{65}, M_{70}, M_{75}, M_{80}, M_{85}, M_{90}, M_{95}, M_{100}) = 8 nos

Workability :- The ease with which the fresh concrete can be mixed, transported, placed and compacted is called as workability of concrete.

Factors of workability :-

(i) **Water cement ratio** (w/c) (f) It is ratio of mass of water (w) to the mass of cement (c)

$$w/c = \frac{w}{c}$$

⇒ Water cement ratio are generally lies in the interval **0.40 and 0.60**

⇒ M_{10}, M_{15} & M_{20} · w/c = 0.40 and 0.60

M_{20} the commonly use water, cement ratio = 0.45 to 0.50

M_{10} concrete min quantity of cement = 220 kg per cum

Given (w/c)

$$w/c = \frac{\text{Quantity of water}}{220}$$

$$\Rightarrow 0.40 = \frac{\text{Quantity of water}}{220}$$

$\Rightarrow 0.40 \times 220$ = water quantity

$\rightarrow \frac{40}{100} \times 220$

$\Rightarrow$ **88 kg = water** Ans

Required 88 kg water for M_{10} 1 cum.

Workability

w/c Ratio

88 kg water [cement 220 kg, w/c = 0.4]

If w/c = 0.2

If workability ↑ then workability ↑

0.2×220 = water required

$\rightarrow \frac{2}{10} \times 220$

$\Rightarrow$ 44 kg water.

(i) **workability ∝ w/c Ratio**

workability ↑ w/c ↑

workability ↓ w/c ↓

(ii) **Workability ∝ $\frac{1}{\text{Time}}$**

Time ↑ workability ↓

Time ↓ workability ↑

(iii) **Workability ↓ ∝ $\frac{1}{\text{Aggregate-cement Ratio}}$**

workability

Aggregate cement Ratio

(iv) **workability ∝ Grading of aggregate**

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⑥ Which IS code provides recommended guidelines for concrete mix design? Ans (D)

ⓐ IS 12813 ⓑ IS 800 ⓒ IS 1373 ⓓ IS 10262

If heavy loaded structure like overbridge, powerplant, flyover, river bridge required more strength like 35 N/mm2, 40 N/mm2, 30 N/mm2. After M_{10}, M_{20}, after M_{20} all concrete mix design are designed by IS code IS:10262.

⑦ pick up the correct statement from the following. Drying shrinkage is affected by.

ⓐ The relative humidity of the atmosphere when the concrete is placed. Ans (D)

ⓑ the length of time.

ⓒ The water/cement ratio of the concrete.

ⓓ All options are correct.

Concrete Shrinkage :- The volumetric change of the concrete structure due to loss of capilary water by evaporation is known as concrete shrinkage.

Factors :- Time, Relative humidity, w/c Ratio, type of aggregate, admixture, composition & fineness of cement.

Class-3

Working Stress Method :-

1. Min^m grade for PCC = M_{15} } concrete under Normal condition.
Min^m grade for RCC = M_{20}

2. If concrete in sea water or nearer to sea water or water bodies.
Min^m grade for PCC = M_{20}
Min^m grade for RCC = M_{30}

3. Grade of concrete (IS 456-2000) :-

		Latest Amendment No-4, 2013
ordinary grade	= M_{10}, M_{15}, M_{20}	→ M_{10} to M_{20}
standard grade	= M_{25}, to M_{55}	M_{25} to M_{60}
High strength grade	= M_{60} to M_{80}	M_{60} to M_{100}

4. Concrete mix proportioning :-
(i) Nominal Mix concrete. – Mix directly on site used on site work (IS 456:2000)
(ii) Design Mix concrete – mix only on Batching plant (IS 10262)

5. properties of concrete :-
(i) Compressive strength :-

⇒ Compressive strength measured by compressive Testing machine (CTM) or UTM (universal Testing machine)

cube samples	cylindrical sample
⇒ size = 150×150×150	size = d = 150 mm, l = 300 mm
⇒ After applying load	⇒ First cylinderical sample fail.
⇒ cube has more frictional resistance as compare to cylinder	
⇒ that why it does'n't fail easily.	

(i) cube sample strength = 1.25 time of strength of cylinder sample.
(ii) 0.8 times of cubical sample = cylindrical sample strength.

⇒ cylindrical sample's $\frac{L}{D}$ Ratio = $\frac{300}{150}$ = 2 or

Compressive strength of concrete :- Mpa or N/mm2

M_{20}, F_{ck} = 20 N/mm2 at 28 days.

Take M_{25} 7 cube sample :- cube 1 2 3 4 5 6 7

⇒ 17.5 Mpa, 19.5 Mpa, 21.5 Mpa, 25 Mpa, 28 Mpa, 29 Mpa, 30 Mpa

↓ after 28 days.

Compressive strength become = F_{ck} = 25 N/mm2

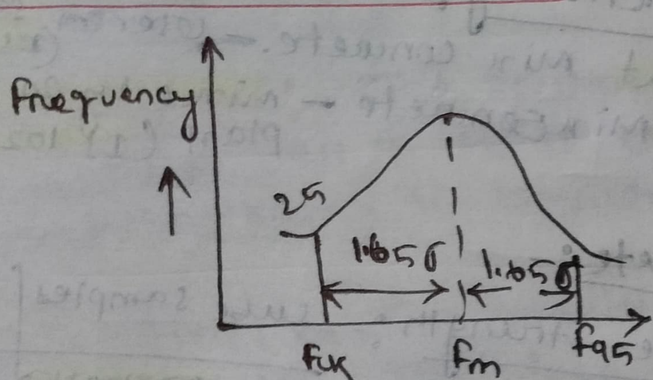
Cube fail 17.5 < 25 Mpa; cube fail 19.5 < 25; cube fail 21.5 < 25

Not more than 5% test Result are likely to be fail

95% test Result of cube passed above 25 N/mm2

Normal distribution curve :- strength of concrete.

M_{25}



F_{ck} = 25 Mpa compressive strength →

f_m = Target mean strength

$$f_m = f_{ck} + 1.65\sigma$$

Standard deviation :-

For M_{10} & M_{15} = σ = 3.5

$M_{20} - M_{25}$ = σ = 4.0

$M_{30} - M_{50}$ = σ = 5.0

Mathematical Formula, $\sigma = \sqrt{\frac{\sum_{i=1} (x_i - \bar{x})^2}{n-1}}$

x_i = Individual sample
$\bar{x}$ = Mean sample
n = No. of sample

Q. Avg. strength of concrete is 31.6 Then calculate the characteristic strength of concrete if $\sigma = 4$

Sol^n Avg strength = Target mean strength = 31.6 mpa

$f_m = f_{ck} + 1.65\sigma$

$\Rightarrow 31.6 = f_{ck} + (1.65 \times 4)$

$\Rightarrow 31.6 - 6.60$

$f_{ck} = 25$ Mpa Ans

(2) Avg strength of concrete is 38.25 mpa, then calculate characteristic strength of concrete if $\sigma = 5$.

Sol^n $f_m = 38.25$

$\Rightarrow f_m = f_{ck} + 1.65\sigma$

$\Rightarrow f_{ck} + 1.65 \times 5$

$\Rightarrow 38.25 = f_{ck}$

$\Rightarrow 38.25 - 8.25$

$\Rightarrow$ 30 mpa = f_{ck} Ans.

Cube sample :-

1 days — 16%.
3 days — 40%
7 days — 2/3 th of 28 day strength. (65%)
14 days — 90%.
28 days — 99%. after 1 year as compare to 28 days = 20 to 25%

[Class-4]

Q) What is the 7 days strength of concrete if the 28 day strength is 25 mpa. (a) 13.3 (b) 16 (c) 17 (d) 19.5

Ans (c)

Soln

$F_{ck} = 25$ Mpa

7 day strength = $2/3 \times 28$ days strength

$= 2/3 \times 25 = \frac{50}{3}$ 16.67 Mpa. ≃ 17 mpa

Tensile strength of concrete:-

1. Tensile strength in flexure or Bending $f_{cr} = 0.7\sqrt{f_{ck}}$
   It is also called modulus of rupture.
2. In ~~direct tension~~ splitting strength $f_{cs} = \frac{2P}{\pi DL}$
   $= 0.67\ f_{cr}$
   $f_{cs} = 2/3\ f_{cr}$
3. In direct tension $= f_{ct} = 0.50 f_{cr}$

$\therefore\ f_{cr} > f_{cs} > f_{ct}$ *

Young's Modulus of Concrete:-

E_c or Modulus of Elasticity of concrete (short term)

$E_c \Rightarrow 5700\sqrt{f_{ck}}$ as per IS 456:1978

$E_c \Rightarrow 5000\sqrt{f_{ck}}$ as per IS 456:2000.

∴ For all practical purposes, Modulus of Elasticity of concrete is taken as Secant Modulus.

Modulus of Elasticity of concrete (Long term)

$$E_L = \frac{E_C}{1+\theta}$$

θ = Creep co-efficient

$$E_L = \frac{5000\sqrt{f_{ck}}}{1+\theta}$$

$$\theta = \frac{\text{Creep Strain}}{\text{Elastic strain}}$$

$$\theta = \frac{\text{Creep Strain}}{\text{Elastic Strain}} \text{ or } \frac{\text{Ultimate creep strain}}{\text{Instanteneous Elastic strain}}$$

creep co-efficient value as per age of concrete at the time of loading.

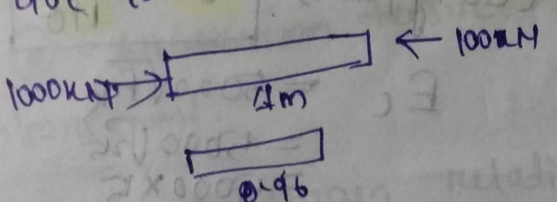
θ_1 = 7 days - 2.2
= 28 day - 1.6
1 year - 1.1

*Imp

$$\theta = \frac{\text{Creep Strain}}{\text{Elastic Strain}} =$$

$$\text{Strain} = \frac{\text{change in length}}{\text{original length}}$$

creep strain :- It is a time dependent strain in concrete due to sustained loading or parmanent loading.



$$\varepsilon = \frac{\Delta l}{l} = \frac{1-0.96}{1} = 0.04m$$
= 40mm

If Load is applied 50 years or long period.

Strain = Total deformation = 40mm = 0.04m

Strain = Elastic strain + creep strain.

40mm = Elastic strain + creep strain

⇒ 40mm = 30mm + creep strain

creep strain = 40 - 30 = 10mm = 0.01m

After removal of load creep strain not comes again.

∴ creep strain = ~~parmanan~~ permanent deformation.

Creep can be controlled by:-

1. Using high strength of concrete.
2. Adding steel against it.
3. Steam curing under pressure.
4. Dealying the Application of finishes.

Testing of hardened concrete:-

① Destructive Testing. → Load test, Core cut test.

② Non-destructive Testing. → Rebound Hammer test, Ultrasonic pulse velocity test.

Q) For M_{25} grade concrete with creep co-efficient 1.5 the long term modulus of Elasticity in Mpa as pe IS 456: 2000.

Sol) $M_{25} = f_{ck} = 25$ Mpa

Modulus of elasticity (Long term) = $E_L = \frac{E_c}{1+\theta}$

$E_c = 5000\sqrt{f_{ck}}$
$= 5000\sqrt{25}$
$= 5000 \times 5$
$= 25000$ Mpa

$\theta = 1.5$

$E_L = \frac{25000}{1+1.5} = \frac{25000}{2.5} = \frac{25000 \times 10}{25}$
$= 10{,}000$

$E_L = 10{,}000 \ N/mm^2$

Q. The flexural tensile strength of M_{30} grade of concrete in N/mm^2, as per IS 456-2000.

Sol) Flexural tensile strength $f_{cr} = 0.7\sqrt{f_{ck}}$

M_{30}, $f_{ck} = 30$

$= 0.7 \times \sqrt{30}$

$= \frac{7}{10} \times \sqrt{30}$ ~~12.1 Mpa~~

$= \frac{7}{10} \times 5.4$

$= \frac{37.8}{10} =$ **3.8 mpa**

Design ~~pho~~ philosophies :-

1. Working stress Method (WSM)
2. Limit stress Method (LSM)
3. Ultimate load method (ULM)

(1) WSM (Working stress Method)

Assumption:-

(1) plane section before bending will remain plane even after bending.

(2) All ~~tension~~ tensile stresses are taken up by reinforcement.

(3) Stress-strain relationship of steel & concrete under working load is a ~~straight~~ ~~line~~. straight line.

(4) Modular Ratio - ~~(m)~~ $(m) = \frac{280}{3\sigma_{cbc}}$

σ_{cbc} = permissible stress in concrete ~~to~~ due to bending compression.

(5) Concrete & steel are well bonded together.
concrete thermal expansion $= 12 \times 10^{-6}/°C$ concrete $= 10 \times 10^{-6}$

(6) Young's Modulus of concrete $= 5000\sqrt{f_{ck}}$

Value of σ_{cbc} (permissible stresses in concrete): Table no 21

Grade of concrete	Permissible stress in compression: Bending σ_{cbc}	Permissible stress in compression: Direct σ_{cc}	Permissible stress in Bond for plain Bars in tension τ_{bd}
Grade	5.0	4.0	0.6
M15	5.0	4.0	0.8
M20	7.0	5.0	0.9
M25	8.5	6.0	

Q) What is the modular Ratio of M25 or grade of common concrete.

Sol^n M25 $f_{ck} = 25$ Mpa

$\sigma_{cbc} = 8.5$

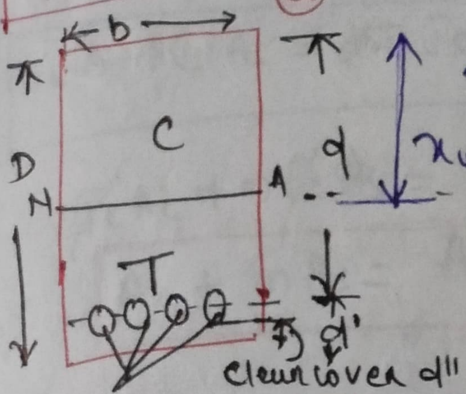
$$\text{Modular Ratio } (m) = \frac{280}{3\sigma_{cbc}} = \frac{280}{3 \times 8.5} = \frac{280 \times 10^2}{8.5 \times 3} = 10.98$$

$$\boxed{m = 10.98} \text{ Ans}$$

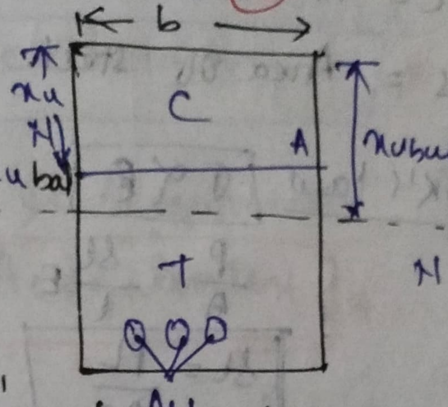
VVImp Permissible Stress in Steel (σ_{st}): TB-22

Type of stress in steel reinforcement	Mild steel	HYSD bar (Fe415)
(i) Tension (σ_{st})		
(a) upto and including 20 mm	140 N/mm2	230 N/mm2
(b) over 20 mm	130 N/mm2	230 N/mm2
(ii) Compression in column bars (σ_{sc})	130 N/mm2	190 N/mm2

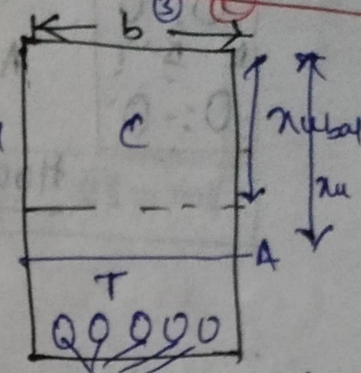
Class-6 ① ⓐ ② ⓑ Dt:- 20.1.2024 ③ ⓒ



Ast Rectangular Beam <Balanced secn>



Ast <Under Reinforced secn>



Ast <Over reinforced secn>

b = Width of beam.

D = Overall depth.

d = Effective depth.

d' = Effective cover

$D = d + d'$

d' = Distance betn outer most tension fibre to C.G. of Tension steel.

Ast :- Area of steel in Tension Zone

C = compression

T = Tension zone.

x_u = Depth of neutral axis.

x_{ubal} = Depth of neutral axis at balance secn.

ⓐ Balanced secn :-

$A_{st} = A_{st\,bal}$

$x_u = x_{ubal}$ *

⇒ steel and concret reach their permissible stress at same time. & both material will fail at same time.

ⓑ Under reinforced secn :-

$x_u < x_{ubal}$ | $A_{st} < A_{st\,bal}$

⇒ steel failure.

→ At some value of loads, stresses in steel is going to reach its permissible stress first & fail.

⇒ Under reinforce secn is going under ductile failure

ⓒ Over Reinforced Section :-

$x > x_{ubal}$ | $A_{st} > A_{st\,bal}$

⇒ At some value of loads so stress in concrete is going to reach first its permissible stress first & fails.

⇒ This secn going to under Brittle Failure

A_c = Area of concrete

A_s = Area of steel.

Hook's law $\sigma \propto \epsilon$

$$\frac{P}{A} = \frac{\delta l}{l} E$$

$$\delta l = \frac{PL}{AE}$$

$P = P_c + P_s$

P_c → load in concrete; P_s → load in steel

Deformation of steel = Deformation of concrete

$$\delta l_s = \delta l_c$$

$$\Rightarrow \frac{P_c L}{A_c E_c} = \frac{P_s L}{A_s E_s}$$

$$\sigma_c = \frac{P_c}{A_c} \qquad \sigma_s = \frac{P_s}{A_s}$$

$$\Rightarrow \frac{\sigma_c}{E_c} = \frac{\sigma_s}{E_s}$$

$$\rightarrow \sigma_s = \frac{E_s}{E_c}\sigma_c$$

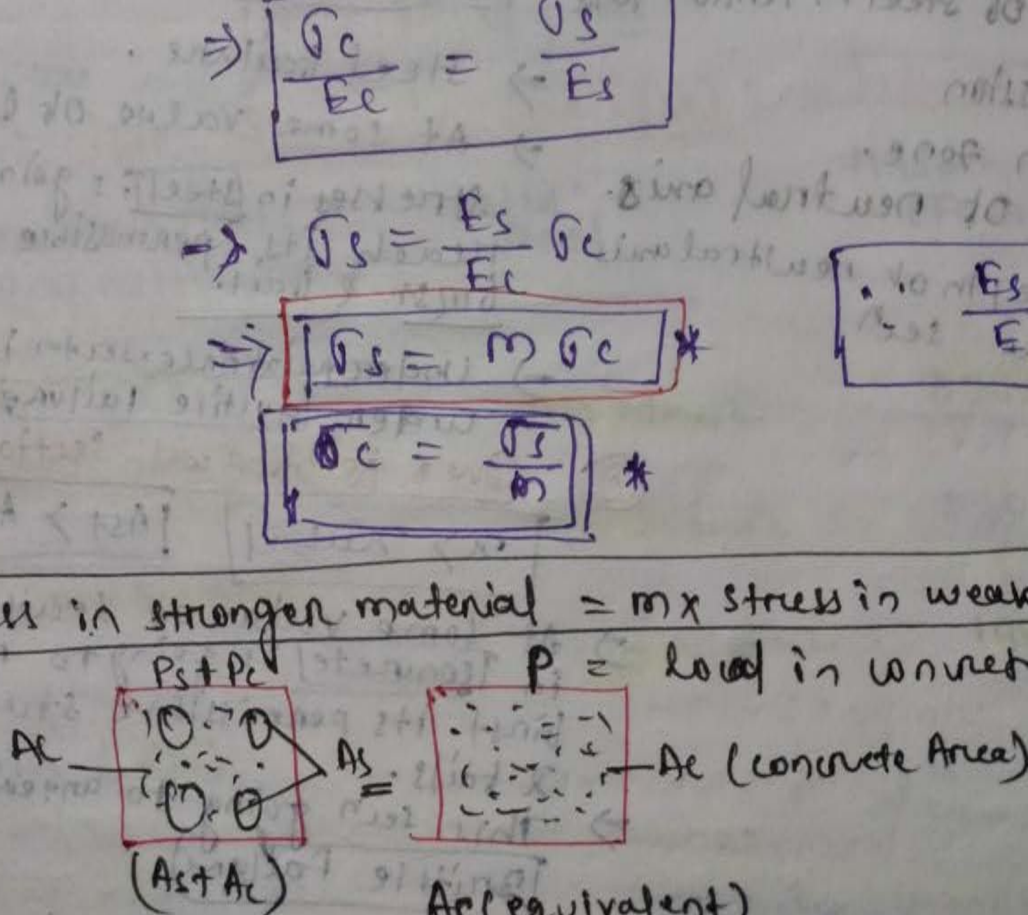
$$\because \frac{E_s}{E_c} = m$$

$$\Rightarrow \sigma_s = m\sigma_c \quad *$$

$$\sigma_c = \frac{\sigma_s}{m} \quad *$$

Stress in stronger material = m x stress in weaker material

P = load in concrete



$P_s + P_c = P$

$\sigma_c A_c + \sigma_s A_s = \sigma_c \times A_{c\,equivalent}$ *

$\sigma_c A_c + m\sigma_c A_s = \sigma_c A_{c\,equivalent}$ $\quad [\because \sigma_s = m\sigma_c]$

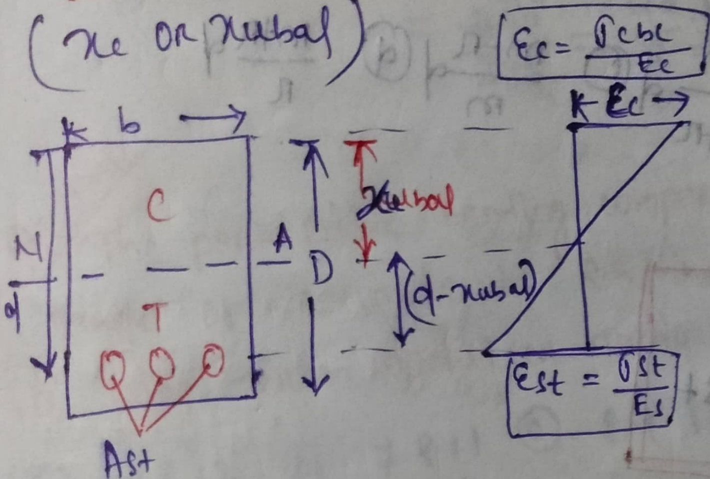
$\Rightarrow A_c + m A_s = A_{c\,equivalent}$ *

m (Area of stronger material) = Area of weak material.

Class-7

1. Calculate of critical or balanced depth of NA:-

(x_c or x_{ubal})



Rectangular Beam

<Strain diagram> $= \frac{\Delta L}{L}$

ε_c = strain of concrete in compression zone.

ε_s = " " steel in tension zone.

$$\frac{x_{ubal}}{d-x_{ubal}} = \frac{\varepsilon_c}{\varepsilon_s} = \frac{\varepsilon_c}{\varepsilon_{st}} = \frac{\frac{\sigma_{cbc}}{E_c}}{\frac{\sigma_{st}}{E_{st}}} = \frac{\sigma_{cbc}}{E_c} \times \frac{E_{st}}{\sigma_{st}}$$

$$= \frac{\sigma_{cbc}}{\sigma_{st}} \times \frac{E_{st}}{E_c}$$

$$= \frac{\sigma_{cbc}}{\sigma_{st}} \times m$$

$$\frac{x_{ubal}}{d-x_{ubal}} = \frac{m\sigma_{cbc}}{\sigma_{st}}$$

$$\Rightarrow x_{ubal} = \frac{m\sigma_{cbc}(d-x_{ubal})}{\sigma_{st}} = \frac{dm\sigma_{cbc} - m\sigma_{cbc}x_{ubal}}{\sigma_{st}}$$

Imp *

$$x_{u\,bal} = \frac{m\sigma_{cbc}}{m\sigma_{cbc}+\sigma_{st}} \times d$$ (or) $$x_{bal} = \frac{1}{1+\frac{\sigma_{st}}{m\sigma_{cbc}}} \times d$$

Q1) If modular ratio (m), effective depth is 'd' and stress ratio 'r' $\left(\frac{\sigma_{st}}{\sigma_{cbc}}\right)$, the depth of neutral axis of a balanced secn is,

Soln:

$$x_{u\,bal} = \frac{1}{1+r} \times d$$

(a) $\frac{m+r}{m} d$ (b) $\frac{m}{m+r} d$ (c) $\frac{m-r}{m} d$ (d) $\frac{m+r}{r} d$

$$x_{u\,bal} = \frac{1}{1+\frac{3}{280}\sigma_{st}}$$

Sol

$$= \frac{\frac{m\sigma_{cbc}}{\sigma_{cbc}}}{\frac{m\sigma_{cbc}}{\sigma_{cbc}}+\frac{\sigma_{st}}{\sigma_{cbc}}} \times d$$

Ans (B)

$$= \left(\frac{m}{m+r}\right) \times d \quad \text{Ans}$$

Q2) The depth of NA for a balanced secn is depend on.

(a) σ_{cbc} (b) σ_{st} (c) σ_{cbc} & σ_{st} (d) Modular ratio.

Ans (B)

Q3) Which of the following sections performs better on the ductility criteria.

(a) Balanced secn (b) Over-reinforced secn (c) Under-reinforced secn (d) NOT

Ans (C)

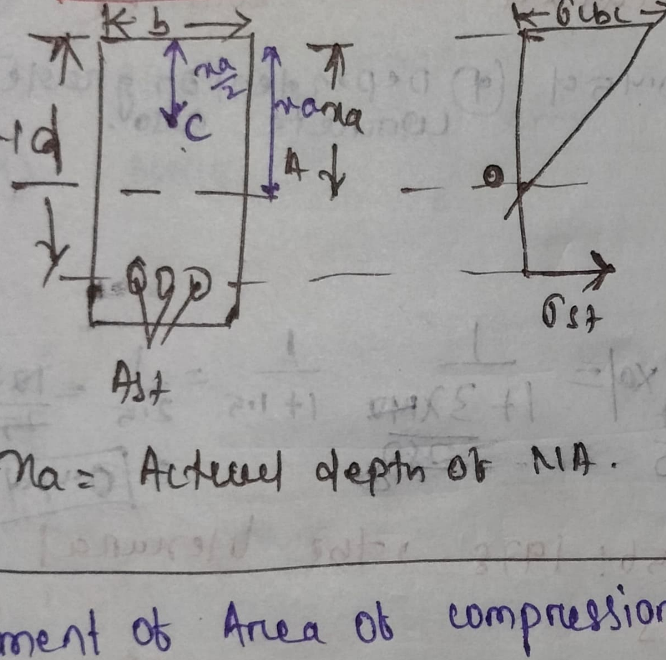
(13) The min^m cover in a slab should neither be less than the diameter of bar nor less than.

(a) 10 mm (b) 15 mm (c) 25mm (d) 13 mm Ans (B)

The recommended value of nominal or clear cover as per IS 456: 2000

Slab:- 15mm
Beams:- 25mm
Columns - 40 mm
Footing - 75mm

2. Calculate of actual depth of NA :-



xa = Actual depth of NA.

Moment of Area of compression side = Moment of Area in tension side, about

Moment = force x distance ⊥

Moment of area of compression zone about NT = $(b \times x_a) \times \frac{x_a}{2}$

Area x ⊥ distance

force = moment of area of compression zone