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Jai Mata Di

Name :- Akhilesh Jadoun

Subject :- Reinforced cement concrete

Subject 1 :- RCC → {By MK Singh Sir.}

CHAPTER 01 INTRODUCTION

Dated - 24/06/25

Nominal Mix :-

1 : 2 : 4 Fixed proportion.

- Ratio by volume.
- Nominal mix can be used for concrete ≤ M20.
- Quality of material doesn't change the ratio.

Design Mix :-

* Testing done in → lab

In lab

water → w kg
cement → x kg
Sand → y kg
Aggregate → z kg
Admixture → m kg

→ Design on paper

- Make cubes and testing :-

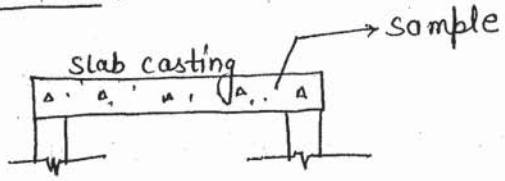
at 7 days → 1 2 3 → 3 cubes
at 28 days → 4 5 6

Test cubes after 28 days for design mix.

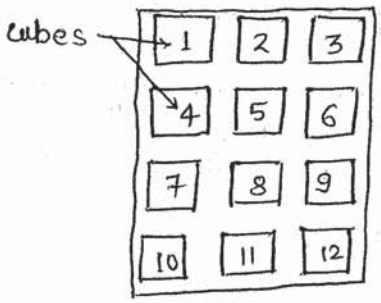
- Ratio by weight.
- Design mix can be used for any grade.
- for M25 and above must (only option is design mix.

After casting concrete prepared on site :-

6 → 



* Sampling is done on the day of casting.

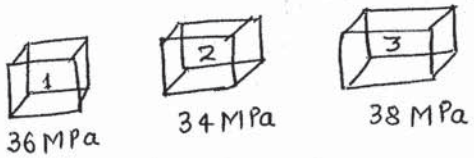


Testing is done after 28 days after casting of concrete

- Test to get strength of actual work done.
- Day to day testing of concrete for quality control. [Daily works के sample लेते रहते हैं और 28 days बाद testing करते हैं

(#) Test for design mix :- 3 cubes.

Assume M30 concrete testing



avg = 36 MPa Not ok

bcz we want to achieve fm for design mix not exact 30 MPa.

$$f_{avg\ (3\ cubes)} \geq f_m \geq 1.65\sigma + f_{ck}$$

$$= 30 + 1.65 \times 5$$

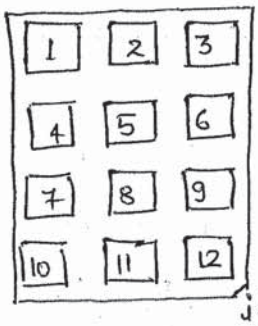
$$= 38.25\ MPa$$

Design mix की strength fck से ज्यादा चाहते हैं क्योंकि जब हम ज्यादा का design देंगे तो site पर अगर variation भी आयेगा strength मे तो भी वो fck से ज्यादा ही होगी।

Note:- self.

अगर M30 का concrete चाहिये site पे तो हम lab मे ज्यादा strength के लिये design करेंगे। अगर strenth ($f_m = f_{ck} + 1.65\sigma = 38.25$ MPa से ज्यादा या बराबर आयेगी test करने के बाद तब design safe मानेंगे, otherwise design repeat करेंगे।

Day to day testing at site for quality control :-



12 samples from Concrete

if avg = 32.5 not ok

bcz target strength of one group of 12 cubes

$$f_{avg\,(4\,sample)} \geq f_{ck} + \frac{1.65\sigma}{2}$$

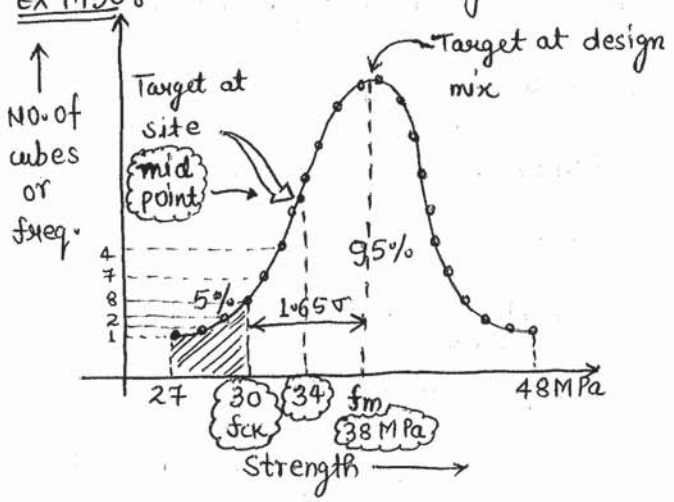
$= 34.125$ MPa ≈ 34 MPa

* M30 की strength site पर $\left(f_{ck} + \frac{1.65\sigma}{2}\right)$ or $(f_{ck} + 0.825\sigma)$ से या तो बराबर आये या ज्यादा तब safe मानेंगे नही तो fail.

Frequency distribution curve of concrete :-

This curve is drawn after large no. of sample testing around 500.

Ex M30 :-



* 1.65σ is a result of statics.
* σ की value 500 sample की testing से निकलती है।

Target mean strength (str. of design mix).

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

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

* σ is avg deviation of all values from mean :-

$$\sigma = \sqrt{\frac{\Sigma x (f_x - f_m)^2}{(\Sigma n - 1)}}$$

हम मान कर चलते है की एक का variation zero होगा वैसे एक से ज्यादा का भी हो सकता है।

Where,

f_m = mean strength.

5% results < f_{ck}

95% results > f_{ck}.

Grade	σ
M10, M15	3.5
M20, M25	4.0
M30 or above	5.0

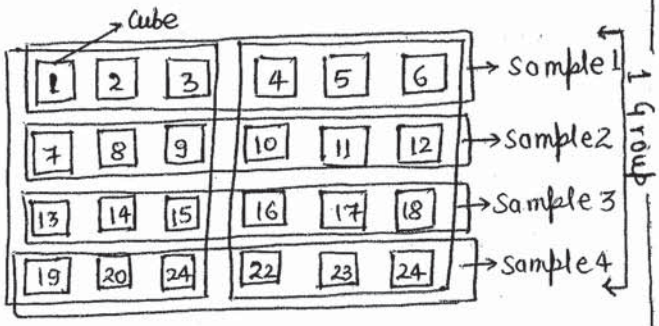
Sampling :-

1 sample = 6 cubes

1 Group = 12 cubes

* Minm. 4 samples required for a group. (12 cubes)

(#)  → Cube (150 mm × 150 mm × 150 mm)



Group 1 test on 7-day after casting

Group 1 test on 28th day

* Strength of cube $f_c = 0.67\ f_{ck}$

* Strength of concrete = f_{ck} if 30 so, ≥ 34 MPa

* 7th day testing is done to know the strength of concrete if sample strength comes less than 0.67 fck तो आगे जो concrete बनेगी उसे रोक देंगे आगे इस concrete से casting बंद हो जायेगी।.

Mivan shuttering :- const. technique using aluminium formwork for walls and slabs. It's known for its speed efficiency and smooth concrete surface.

No. of Samples (cubes)

Quantity of concrete casted (m^3)	No. of sample
1 - 5	1
6 - 15	2
16 - 30	3
31 - 50	4
next 50 → or last < 50 →	4 + 1 add one more

Pb :- No. of sample if 26 m^3 of concreting to be done.

Solu: 26 cumec → 3 samples

3 samples × 6 → 18 cubes

- 9 cube → Tested on 7th day.
- 9 cube → Tested on 28th day.

* Design mix prepared at either start of new work or source of material gets changed.

Pb :- 335 cumec concrete :-

1st 50 — 4
50 → 1
50 → 1
50 → 1
50 → 1
50 → 1
35 → 1

Total 10 samples

60 cubes

- 30 cubes • 7th day
- 30 cubes • 28th day.

Design mix of M40 :-

1] W/c ration for M40 [IS 456 : 2000]

2] Water content = W_w = 180 kg as per [10 262]

$$\frac{W_w}{W_c} = 0.40$$

$$W_c = 450 \text{ kg}$$

3] Assume ratio $\left(\frac{W_{fa}}{W_{ca}} = \frac{1}{2}\right)$

4] Total volume = 1 cumec.

$$\frac{W_w}{\gamma_w} + \frac{W_c}{\gamma_c} + \frac{W_{fa}}{\gamma_{fa}} + \frac{W_{ca}}{\gamma_{ca}} + V_v = 1.0 \text{ m}^3$$

$$\frac{180}{1000} + \frac{450}{3150} + \frac{W_{fa}}{2650} + \frac{2W_{fa}}{2750} + \frac{2}{100} = 1$$

3150 → without voids → with void 1440 kg/m³

absolute

$W_{fa} = 595$ kg

max^m 2% air content or voids is allowed in concrete.

* OPC is best as compared to PPC bcz no mixing of other material in OPC.
* but strength is almost similar at 28 days.

Steps in concreting work :-

1] Design mix → To know proportion

2] Collect the materials.

3] Batching and Mixing.

4] Form work → centering, shuttering.

5] Steel (Reinf.) → as per structural drawing.

6] Casting & compaction
↳ Collecting samples.

7] Curing → 7 to 14 days
Generally 7 to 10 days
If PPC go for 14 days.

8] Removal of farm work

9] Finishing and Plastering.

M40 – Site day to day testing . required = $f_{ck} + 0.825\sigma = 44.125$ MPa.

Sample No.	Cube result: cube 1	cube 2	cube 3	f_{avg}	variation (-ve)	variation (+ve)	Average of 12 cube 4 sample	Individual test result	
1]	45	47	52	48	-6.25%	+8.33%		all values $\geq (f_{ck}-3)$ $\geq (40-3)$ ≥ 37 MPa	
2]	42	48	51	47	-10.64%	+8.5%	$\frac{48+47+42+50}{4}$		
3]	38	47	41	42 ? <44.125	-9.52%	+11.90%	$= 46.75 > 44.125$ OK Passed.		
4]	46	49	55	50	-8 %	+10 %		Passed.	Acceptable RESULT

less than our target of 44.125 that's why questionable if over all average comes greater than 44.125 that OK.

This one.

For M40 f_{avg} (4sample) $\geq (f_{ck} + 0.825\sigma) = 40 + 0.825 \times 5 = 44.125$ MPa

on site target strength = 44.125 MPa. That means f_{avg} (4sample) always comes equal to greater than this value after test otherwise concrete is failed as per requirement of construction.

calculation for variation :- for Ist sample

$(-ve) = \frac{45-48}{48} \times 100 = -6.25\%$

$(+ve) = \frac{(52-48)}{48} \times 100 = +8.33\%$.

M40 → target = 40 + 0.25 × 5 = 44.125

Sample No.	Cube results: cube 1	cube 2	cube 3	favg	variation (-ve) $\left[\frac{f - favg}{favg}\right]$	variation (+ve)	Average of 12 cubes 4 sample	Individual test result.
5] ~~1~~	45	48	54	49	− 8.16 %	+10.20 %		
6] ~~2~~	~~38~~	~~43~~	~~54~~	~~45~~	−15.56 % > 15% Invalid	+ 20.0 % > 15 Invalid	→	
7] ~~3~~	42	49	50	47	−10.64 %	+ 6.38 %	$= \frac{49 + 47 + 48 + 49}{4}$	all value ≥ (fck − 3)
8] ~~4~~	44	46	54	48	− 8.33 %	+12.5 %	= 48.25 > 44.125	≥ (40 − 3)
9]	47	48	52	49	$= \frac{47-49}{49} \times 100 = -4.08$	$= \frac{52-49}{49} = 6.12\%$	OK Passed	≥ 37
								Pass

Acceptable result.

(*) If cube test result of any group is failed :- So, As per code :- provision > 1] Core cut samples are tested.

If failed

* 3 to 4 samples and done averaging.

Provision

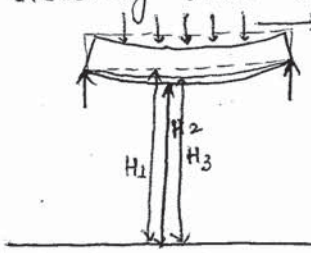
2] Deflection recovery load test. → If pass accept

load → 1.25 live load applied for 24 hours.

after removal of load wait another 24 hr for recovery.

$\delta = \frac{5 w l_{eff}^4}{38 E I_c}$

$E_c = 5000 \sqrt{f_{ck}}$



deflection recovery = $\delta_1 = (H_1 - H_2)$

recovery → $\delta_2 = (H_3 - H_2)$

* if $\delta_2 > 75\%$ of δ_1 → we accept the concrete.

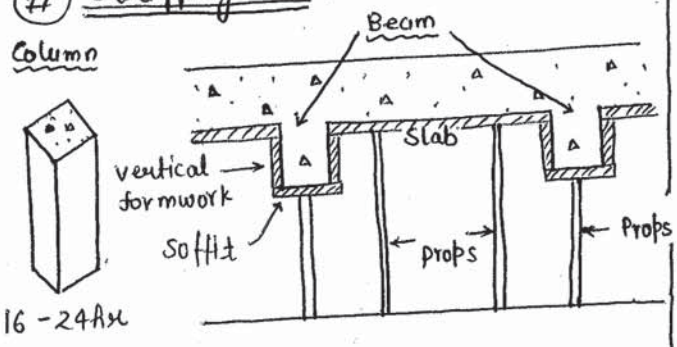
Provision

3] If failed → Repeat the test.

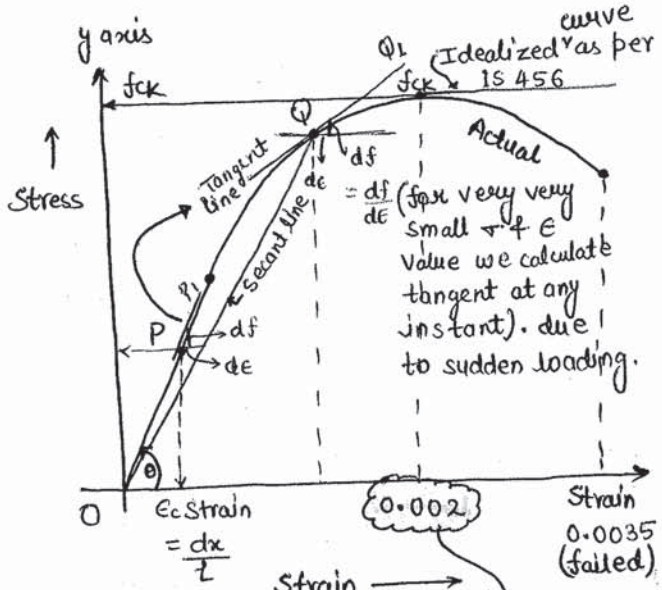
* $\delta_4 > 80\%$ δ_3 accept

4] If all results are failed dismentaled the concrete.

(#) Stripping time :-



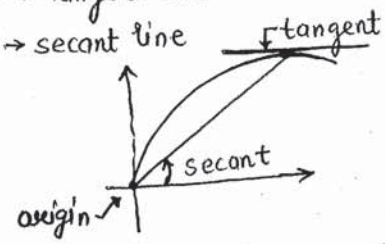
Modulus of Elasticity of concrete



QQ' → Tangent line

OQ → secant line

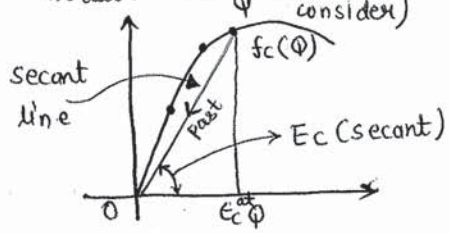
Strain → first strain की value जहाँ सबसे पहली बार fck पहुचेगी।



Ec value can be read as :-

(1) **Secant modulus** → Static modulus (bcz its due to static loading)

(Short term elastic modulus → creep doesn't consider)



Ec = Slope of secant line.

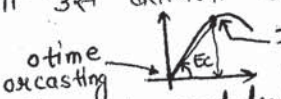
* जब से building बनी है उससे अब तक static loading से जो stress & ε develop हुआ उनका ratio. (short term ने ही देखते हैं)।

* OQ → line joining any point on curve to origin.

$$Ec(secant) = \frac{fc(Q)}{\varepsilon c(Q)} = \frac{\text{Total stress}}{\text{Total strain}}$$

* Total stress इसलिये क्योंकि starting से अब तक load की वजह से जो पूरा stress or strain आया उसे देखते है। उनका ratio Ec होगा।

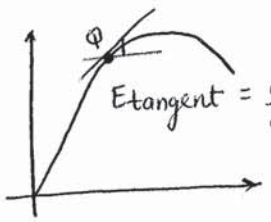
It is a Ratio of Past values. - मतलब उससे पिछे origin से अब तक जो stress or strain होगा उसे बतायेगा उनका ratio secant modulus



If we want to calculate Ec after 1 month of casting.

(2) **Tangent modulus** → Instantaneous modulus.

[due to impact load at any instant.]



* Tangent modulus is slope of tangent at any point.

* Ratio of very small increase of stress and strain just after due to impact loading any point on the curve.

$$Ec\,tangent = \frac{d\,fc}{d\varepsilon c}$$

* It is Ratio of future value.

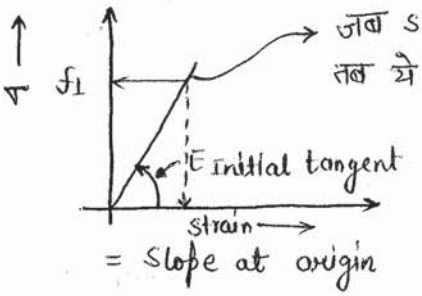
* मतलब जब निकाल रहें हैं उससे आगे क्या ratio होगा वो देख रहे हैं tangent modulus से।

उनका ratio. (short term → that's why short term Ec)

at Point Q beyond Elastic limit	Slope OQ = secant Ec Slope of QQ' = tangent Ec Esecant > Ec tangent
Point P within Elastic Limit	Slope of OP — secant Ec slope of PP' — tangnt Ec Ec(secant) = Ec(tangent)

3] Initial tangent Modulus :-

* also called dynamic modulus of Elasticity bcz it is due to impact or dynamic loading.



जब sudden loading होगी तब ये graph आयेगा।

= Slope at origin

Can be found by :-

* ultrasonic pulse velocity Test
* Resonant frequency Test.

Practical Significance :- सभी values almost बराबर ही होती है But अलग अलग इसलिये निकालते ताकी Ev अलग अलग loading मे अलग अलग behaviour देख सके. क्योकी structure diff. types of loadings मे design होता है।

* Impact loading मे → Initial tangent
* Static loading मे → secant modulus.
* Impact → Tangent modulus.

mostly designed value → secant modulus

$E_c = 5000\sqrt{f_{ck}}$

(#) Value of Ec → recommended by IS 456

* short term modulus of elasticity

$E_c = 5000\sqrt{f_{ck}}$ → IS 456 : 2000

∴ ±20% variation possible

→ It is a secant modulus.

→ code considers at :- $\frac{E_c}{f_{ck}}$ / 3

→ generally within elastic limit.

→ 3 is FOS.

→ f_{ck} = failure = 30 N/mm²

→ $\frac{f_{ck}}{3} = \frac{30}{3} = 10 \cdot N/mm^2$ = Design stress.

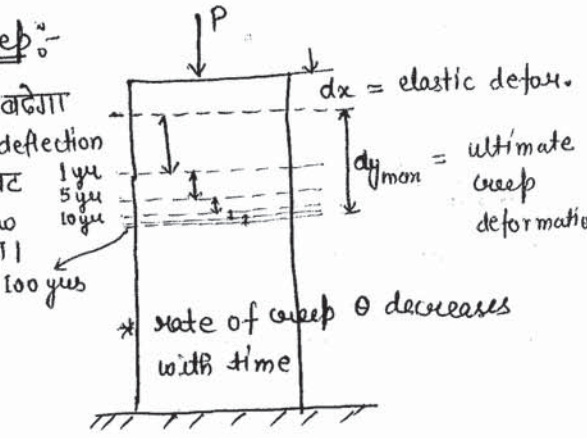
Pyq :- $5000\sqrt{f_{ck}}$ best at secant modulus.

Note = Ec secant value

* General life of RCC structure → 50/100 yrs

(#) Effect of creep on Ec value :-

Creep :-



* Creep coefficient = $\frac{\text{ultimat creep strain}}{\text{Elastic strain}}$
* ultimate creep strain = creep coefficient × Elastic strain
* $\frac{dy_{max}}{l} = \theta \cdot \frac{dx}{l}$

$dy_{max} = \theta \cdot dx$

Creep is due to :-

1] Stress

2] Time

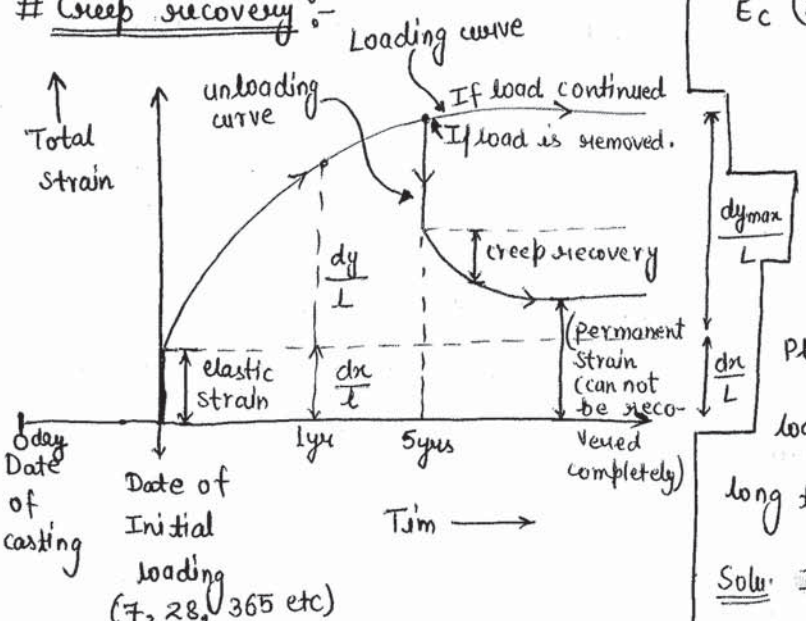
* **Value of creep coefficient or rate of creep deformation w.r.t elastic deform.**

Time of Initial loading of concrete after casting	Creep coefficient
7 days	2.20
28 days	1.60
1 year (365 days)	1.10

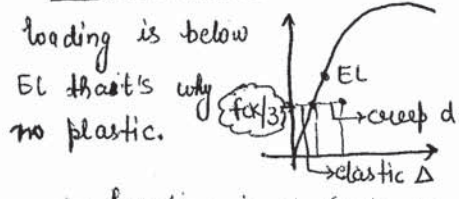
casting के कितने दिन बाद loading होगी

* Time increases — creep ε increases.
* Time increases → creep coefficient or rate of creep decreases.

 # Creep recovery :-



*** Diffrence b/n Plastic & creep :-**



* Loading is at fck/3 so, no plastic ε.

 # Long term value of Ecl :-

Short term $E_c = 5000\sqrt{f_{ck}}$

$= \frac{\text{stress}}{\text{elastic strain}} = \frac{P/A_c}{dx/L}$ ——— (1)

Long term $E_{cl} = \frac{\text{Stress}}{\text{Total strain}}$

$= \frac{P/A_c}{\left(\frac{dx}{L} + \frac{dy_{max}}{L}\right)}$

$= \frac{P/A_c}{\left(\frac{dx}{L} + \theta \cdot \frac{dx}{L}\right)} = \frac{P/A_c}{dx/L(1+\theta)}$

$$E_{cl} = \frac{E_c}{1+\theta} = \frac{5000\sqrt{f_{ck}}}{1+\theta}$$

Note :- Also called effective modulus of elasticity.

Pb 1] :- For M30 concrete calculate E_c (short term) & E_{cl} (long term)

$\phi = 1.60$

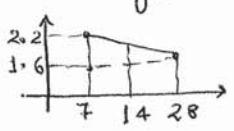
a] $E_c = 5000\sqrt{30} = 27386$ MPa

b] $E_{cl} = \frac{5000\sqrt{30}}{1+1.6} = 10533$ MPa

Pb2] if a M40 concrete was initially loaded after 14 days calculate long term modulus of elasticity (E_{cl})

Solu. Interpolation :- on log scale

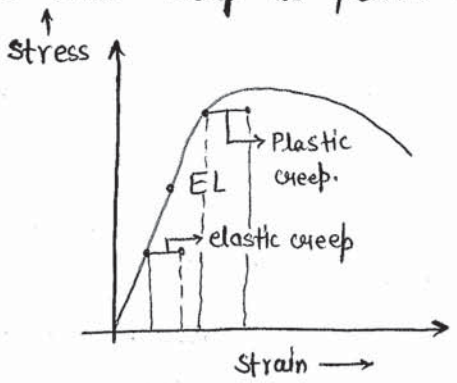
Time	θ
$\log_{10}(7)$ → 7 days	2.2
$\log_{10}(28)$ → 28 days	1.60



θ 14 days = 1.9

$E_{cl} = 10904.40$ MPa

(#) Creep behaviour is either elastic or plastic both if load below elastic limit creep is elastic if load above elastic limit creep is plastic creep.



Developed stress :-

(1) Bending compression :-

* Developed stress = $f_{cbc} = Ca$

$$Ca = \frac{BM}{Z} = \frac{BM \times 6}{BD^2}$$

* faiture stress = $f_{ck} = 30\ N/mm^2$ for M30

Permissible Stress in concrete in bending compression $\sigma_{cbc} = \frac{f_{ck}}{FOS} = \frac{30}{3}$

$\sigma_{cbc} = 10\ N/mm^2$ ## $\geq Ca$ (safe.)

Tensile strength of concrete (faiture strength :-

(1) Developed → $\frac{P}{A_c}$ from table

Direct tension → values as per IS 456.

2] Bending tension :-

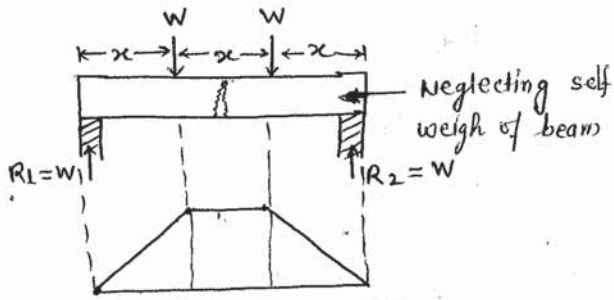
$$f_{cbt} = \frac{BM \times 6}{bd^2} \quad \text{— for PCC section}$$

failure strength in bending tension

$\sigma_{cbt} = f_{cr} = 0.7\sqrt{f_{ck}}$ (IS 456)

Tests :-

(1) Two point load test :-



$BM = R_1 x - \frac{wx^2}{2}$ → Neglected self weight

B.M = $R_1 \cdot x$

Bending tensile strength faiture strength :-

$$f_{cbt} = f_{cr} = \frac{BM}{Z} = \frac{Wx}{BD^2/6}$$

f_{ct} = Direct tension

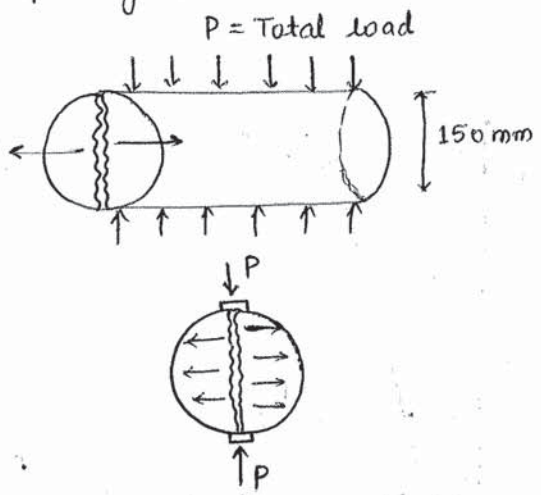
f_{cbc} = Stress in bending compression

f_{cc} = stress in direct compression

f_{cbt} = Stress in bending tension.

2] Split tensile strength :-

Split cylinder Test



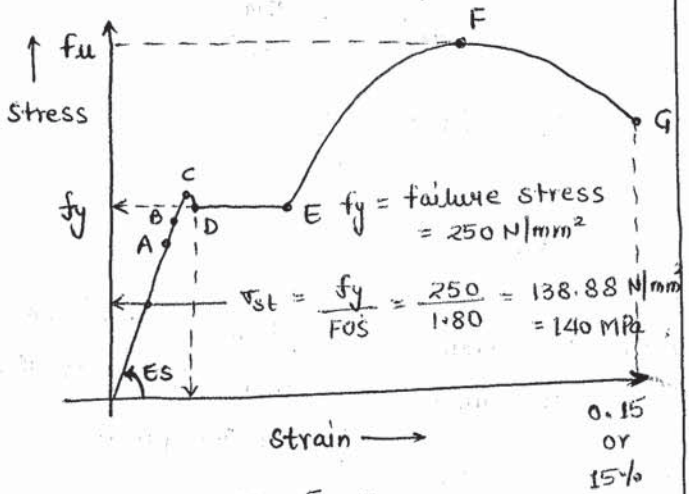
Split tensile strength = $\frac{2P}{\pi DL}$

Bending tensile strength = 1.5 f_{split}

$= \frac{3P}{\pi DL}$

Steel :-

Hot rolled Mild Steel :-



fy = failure stress = 250 N/mm²

$\sigma_{st} = \frac{f_y}{FOS} = \frac{250}{1.80} = 138.88$ N/mm² = 140 MPa

$E_s = 2 \times 10^5$ MPa

for all types of steel.

$\tan\theta = E_s = 2 \times 10^5$

$\theta = 89.9997^\circ$

Ratio of failure strain of concrete and steel :-

$\epsilon_c = 0.0035$

$\epsilon_s = 0.15$ $= \frac{\epsilon_s}{\epsilon_c} = \frac{0.15}{0.0035}$

Failure strain of steel is → 40 to 45 times → of concrete

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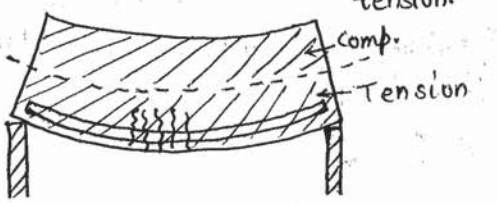
(#) Generally in RCC Beam :-

$C_a \leq \sigma_{cbc}$ (Permissible stress)

$t_a \leq \sigma_{st}$ (permissible stress).

$f_{cbt} \geq f_{cr}$

bcz steel takes tension.



* If stress goes beyond f_y –

→ Sudden large elongation in steel at yield plateau.

→ Concrete can not sustain this sudden increase of strain.

→ large cracking and deformation are seen in concrete.

(#) C_a $\frac{<}{=}$ σ_{cbc} ——— f_{ck} failure

Developed $= f_{ck}/FOS$ permissible

(#) $t_a \leq \sigma_{st}$, $f_y = 250$

$\frac{f_y}{FOS}$

Remedy of sudden yield of steel at yield plateu :-

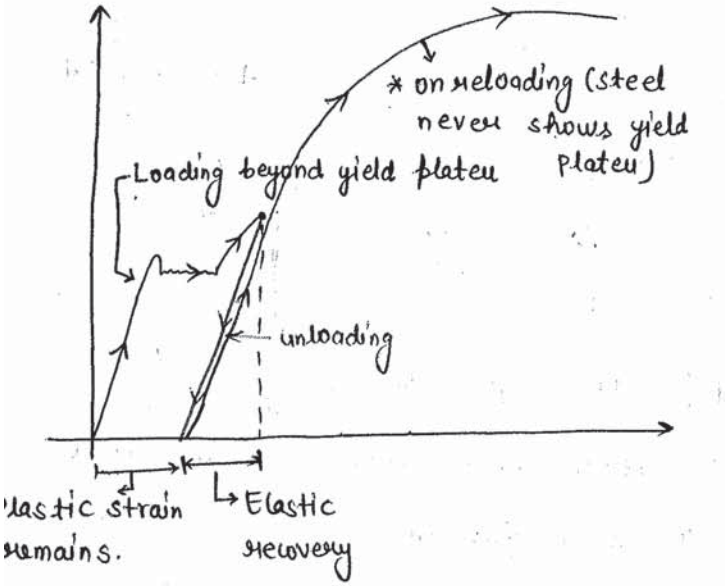
Cold working process before using the steel in structure.

Cold working process :-

1] Twist or elongate the bar beyond yield plateu.

2] Unloading the steel.

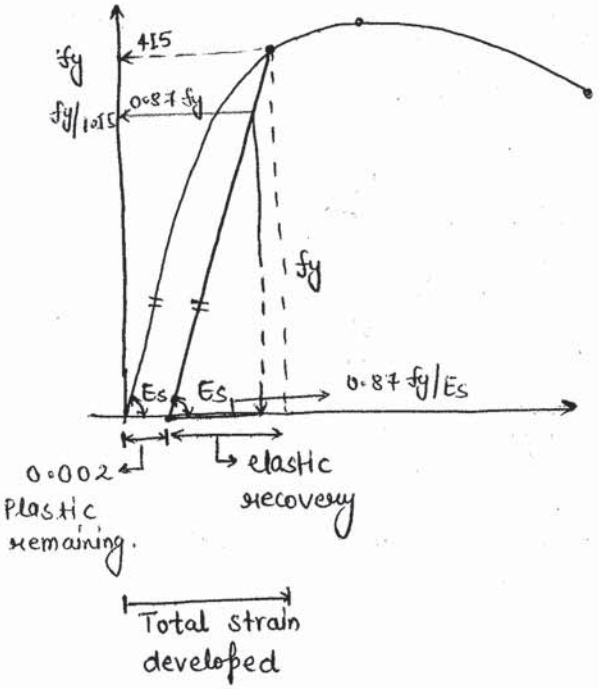
3] After this steel never shows yielding again.



अब इस process के बाद yield plateu नहीं आयेगा मतलब sudden elongation of steel इससे High stress आने पर भी concrete में cracking की problem नहीं आयेगी जो पहले extreme loading (earthquake) की वजह से आ रही थी।

Stress - Strain curve of :-

→ CTD Bars
→ HYSD Bars
→ TMT Bars



Total strain developed upto fy (yield stres) :-

$$= \left(\underbrace{0.002}_{\text{Plastic strain}} + \underbrace{\frac{fy}{Es}}_{\text{Elastic strain}} \right)$$

$$Es = \tan\theta = \frac{fy}{\epsilon_1}$$

$$\epsilon_1 = \frac{fy}{Es}$$

1] Total strain at yield limit $= 0.002 + \frac{Fy}{Es}$	2] Maxm strain in tension steel at the time of failure $= (0.002 + \frac{f}{1.15\,Es})$
a] for Fe 415 = 0.004075	a] for fe 415 = 0.00380
b] for fe 500 = 0.00450	b] for fe 500 = 0.00417