ToppersNotes

IES/GATE
CIVIL ENGINEERING

R C C

VOLUME-IV

Sierra Innovations Pvt. Ltd.

Contents

> RCC - Reinforced Cement Concrete

INTRODUCTION

RCC

① Cement Concrete
- → cement
- → sand (fine aggregate)
- → stone aggregate (coarse agg)
- → water (strength, workability)
- → Admixtures (↑se setting rate, plasticisers etc.)

② Reinforcement steel

I.S. code

① I.S 456 - 2000
② IS 875 - Loading IS code
③ IS 1893 - Earthquake
④ IS 13920 - Earthquake detailing

(A) Cement concrete :-

#① MIX
There are two types :-

(I) Nominal mix :- fixed proportions based on volumetric ratio are called NOMINAL MIX.
(for lower mix only - M-15 & M-20)

for e.g. 1 : 2 : 4 → M15

$1 : 1\frac{1}{2} : 3$ → M20

* The properties of different materials used are not considered.
* It is assumed that required strength will be obtained.

(3) Design Mix :- (For M-25 and higher grade only design mix should be used).

The proportion of materials to be mixed to get a particular strength of concrete, based on ~~the quality~~ of actual sample of materials to be used are designed.

* Actual sample of materials are used and mixed in design proportion. concrete is casted in cubes and tested at 28 days ~~Only that proportion is suggested that provide the~~ the proportion of required strength is suggested

(#) (2) Types of Grades of Concrete :-

As per IS-Code :

1. Ordinary Concrete : ~~M20~~ M10 to M20
2. standard Concrete : M25 to M55
3. HIGH STRENGTH CONCRETE : M60 to M80

* (3) For RCC.
  Minm grade of Concrete = M20
  max M40

* For PSC
  Minm grade of Pretension = M40.
  Post tensioned = M30

* Minimum grade of concrete at different exposure condition:

Table ⑤

① Mild → M20

② Moderate → M25

③ Severe → M30

④ Very severe → M35

⑤ extreme → M40

④ Table ③ (Table 16)

Exposure condition: (min^m Nominal ~~concrete~~ cover)	Min^m Nominal cover
① Mild (M20) → Protected from weather → Not exposed to Rain	20mm
② Moderate (M25) → ① sheltered from severe rain ② exposed to rain ③ concrete continuously under water	30mm
③ Severe (M30) ① exposed to severe rain ② Concrete subjected to alternate wetting and drying. ③ Completely immerse in sea water	45mm
④ Very severe (M35) ① Exposed to sea water (alternate wetting / drying) ② Severe freezing ③ Subjected to sub soil cond^n (foundation)	50mm

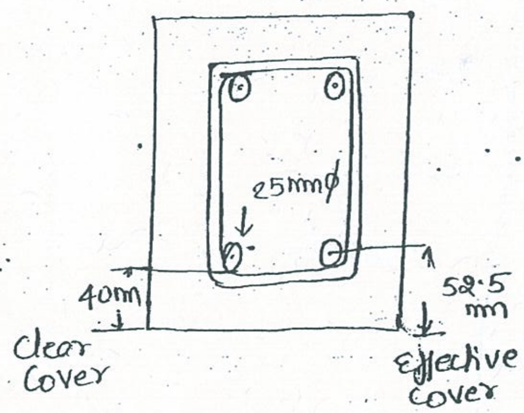
(5)	Extreme (M40)	(1) Member in tidal zone (2) Member subjected to chemical	75mm

5 NOMINAL COVER:

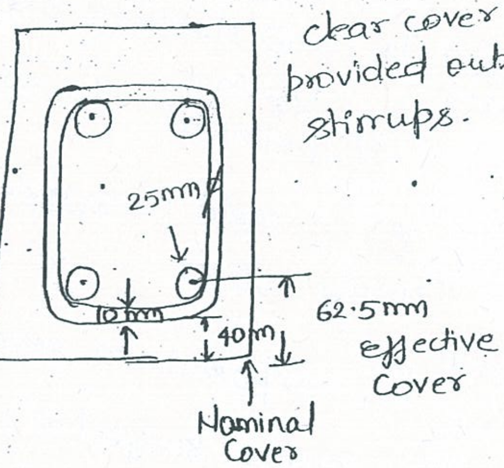
Pr. 26.4 / P-46

→ NOMINAL COVER is the design depth of concrete cover. (clear cover), provided to all types of steel reinforcement, including links.

Nominal cover is the minm ~~cover~~ clear cover provided to outermost steel reinforcement (Main reinforcement or lateral ties, stirrups etc.)



Column (Before 2000)



column (After 2000)

# Minm Nominal Cover (for different type)	Mild Exposure	Severe	extreme
(1) slab	20mm	45mm	75mm
(2) Beams	25mm	45mm	75mm
(3) Columns	40 mm	45mm	75 mm
(4) Foundn	50 mm	50 mm	75 mm

(#) Nominal cover have been suggested in IS code to avoid corrosion of reinforcement.

(#6) Characteristic strength of concrete :-

M 30 → Mix, characteristic strength

$f_{ck} = 30\ N/mm^2$

(#) - Characteristic strength is the value of strength of concrete below which not more than 5% of test results are expected to fall.

* If 100 test results are taken for a particular concrete

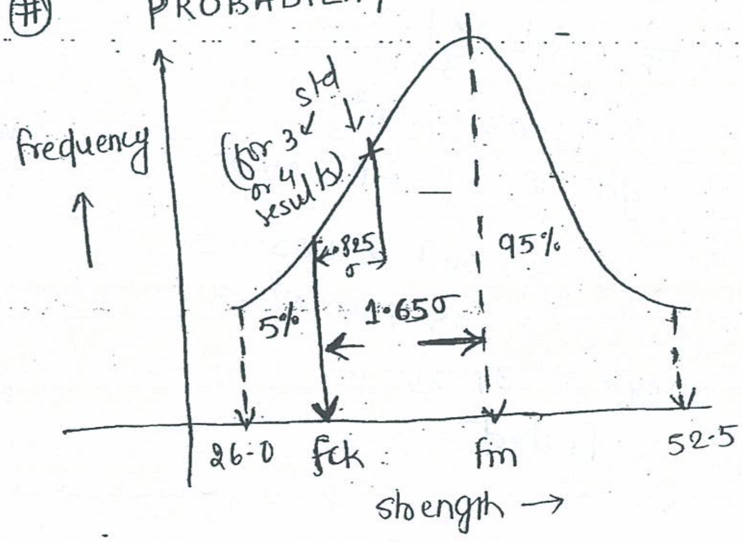
26.0, 27.5, 28.2, 29.4, 29.7, 30.6, 30.9, 31.2, 31.5, 32.0, 32.1 - - - - - - - 52.5 (100 test results)

30 is such value of strength
below which - 5% results
above which - 95% results

The above concrete is M30.

(#) PROBABILITY CURVE :-

fm → mean strength
higher frequency



It is a curve plotted for frequency of test results of different Values.

fck → characteristic strength (5% < fck < 95%)

fm → Mean strength (50% < fm < 50%)

$$f_m = f_{ck} + 1.65\sigma$$ → (A) Relation

↑ no. of test results.

σ → std deviation.

As per IS code

Grade	M10/M15	M20/M25	M30/ & above
σ	3.5 N/mm²	4.0 N/mm²	5.0 N/mm²

For e.g.
M30 Concrete
Mean strength

$f_m = f_{ck} + 1.65\sigma$
$= 30 + 1.65 \times 5.0$

$$f_m = 38.25 \ N/mm^2$$

Qu. For M30 Strength obtained
① 34.0 N/mm²
② 32.0 N/mm² failed
③ 33.1 N/mm²

fm → design → use

avg strength $= \frac{34+32+33.1}{3}$

$= 33.03 \ N/mm^2$

As per Is code, avg strength ≮ $f_{ck} + 0.825\sigma$

$= 30 + 0.825 \times 5$
$= 34.125 \ N/mm^2$

∴ avg strength < 34.125

∴ failed

* Type

I) Initial Tangent Modulus of Elasticity

→ slope of stress strain curve at origin is called initial tangent modulus of elasticity.

This Value $E_{IT} = 5000\sqrt{f_{ck}}$ → Value of E_c considered by IS code is this Value.

II) Tangent Modulus of Elasticity :-

The slope of tangent at any point of curve is called tangent modulus of elasticity.

It is an instantaneous value.

$$E_T = \frac{dy}{dx} = \frac{stress}{strain}$$

III) Secant Modulus of Elasticity :-

: slope of the line joining any point of curve with origin is called secant modulus.

$$E_S = \frac{\text{Total stress}}{\text{Total strain}} \text{ (measured from origin)}$$

(#) Secant modulus is also called static modulus of elasticity.

(Behaviour under sustained static loading for a long time).

* E_{IT} (Initial Tangent) is called Dynamic modulus of elasticity.

(Behaviour of concrete stress/strain in case of impact loading)

* Within elastic portion of curve :-

$E_T = E_S = E_{IT} = 5000\sqrt{f_{ck}}$

For M30 Permissible stress $= 0.67 f_{ck}$

* ~~Value considered is E_{TF}~~, for design purpose we should consider E_c Value at 1/3 of failure stress value)

say σ_{cbc} Value $= \frac{1}{3} f_{ck}$.

The value considered shall be static modulus of Elasticity.

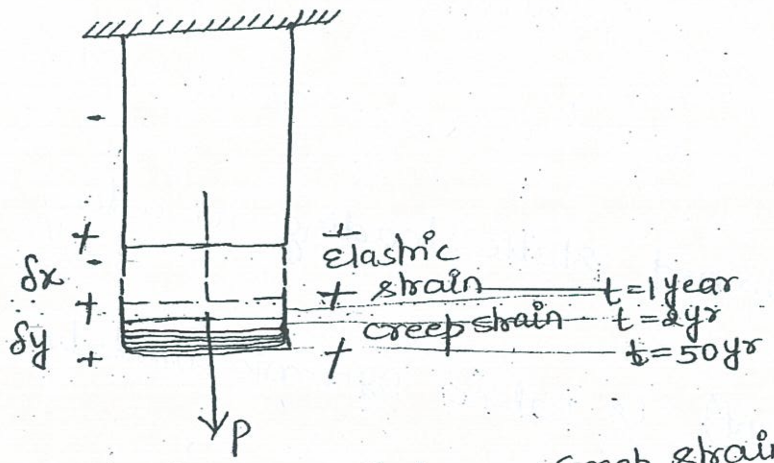
The value will be $E_C = 5000\sqrt{f_{ck}}$.

(#10) Effect of creep from Young's Modulus of Elasticity:-

Creep :-

Time dependent deformation under a constant loading, kept for a very long time.

*



* creep coefficient $= \frac{\text{Creep strain (ult.)}}{\text{creep stress}}$

* For concrete

* long term modulus of elasticity

Table No-11

#7 Acceptance criteria for concrete (for day to day Quality control at site)

As per 16.1 / Table 11

① Mean of the group of 4 (four) Non overlapping consecutive test result

whichever is more:

$\geq f_{ck} + 0.825\sigma$ (rounded off to nearest $0.5\ N/mm^2$)

or

$\geq f_{ck} + 4\ N/mm^2$

② Individual test result of any sample (ITR Value)

$\geq (f_{ck} - 3)\ N/mm^2$

③ As per 15.4

The test result of sample shall be average of three specimens.

The individual variation ≯ ±15% of average value.

Test Result	Average strength	ITR Value	Variation
① For M30 38.0 34.2 29.0 35.1	34.07 > 34 N/mm² (OK)	Min strength 29 > (fck−3) 29 > 30−3 = 27 (OK)	38−34.07 = 3.93 3.93 → 3.93/34.07 ×100 = 11.54 % 29−34.07 = −5.07 −5.07/34.07 ×100 = 14.88% (OK)
② for M30 42.0 38.0 36.4 34.1	37.624 N/mm² > 34 N/mm² (OK)	fck−3 = 27 34.1 > 27	4.376/37.624 ×100 = 11.63% −3.524/37.624 ×100 = −9.3% (OK)

#8 Acceptance Criteria for Design Mix :-
(at the time of design mix)

→ At the time of design mix avg strength of 3 or 4 sample tested ~~shall not be~~ less than mean strength value (f_m), called Target Mean strength of concrete :

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

#9 Young's Modulus of Elasticity of Concrete :→

$E_c = \frac{\text{Stress}}{\text{strain}} = 5000\sqrt{f_{ck}}$ (by IS code 456)

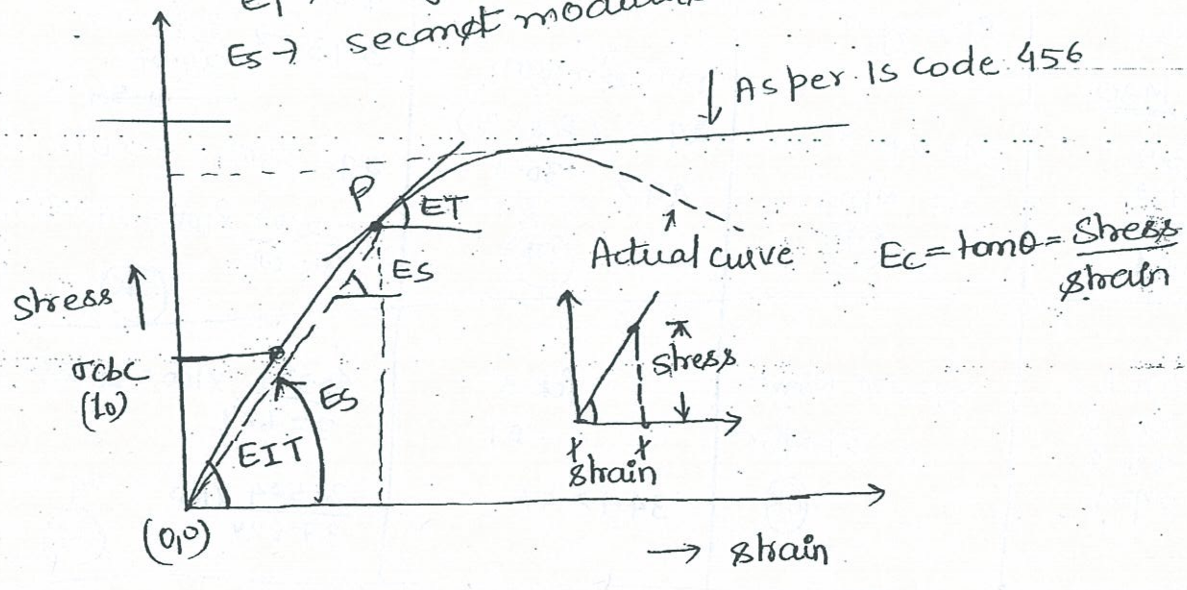
* The value suggested by code IS 456/2000

$E_c = 5000\sqrt{f_{ck}}$ is short term static modulus of elasticity for concrete in N/mm^2

Pr 6.2.3.1 / P-16

* Actual value may differ by ±20% from above value.

E_T → Tangent modulus
E_s → secant modulus



$$E_{cl} = \frac{E_c}{(1+\theta)} = \frac{5000\sqrt{F_{ck}}}{(1+\theta)}$$

where, $\theta \rightarrow$ creep coefficient

Age of concrete at the time of initial loading.	7 days (after 7 days loading)	28 days	1 year
Creep coeff (θ)	2.2	1.6	1.1

2.2 ↓ 2.2 times the creep coeff.

$$E_c = \frac{\text{stress}}{\text{strain}} = \frac{P/A}{(\delta x/l)}$$

Total strain after very long time

$= (\delta x + \delta y)$

Creep strain = $\theta \times$ Elastic strain

$\delta y = \theta \, \delta x$

$\delta x + \delta y = \delta x + \theta \delta x$

$$\Rightarrow E_{cl} = \frac{\text{Stress}}{\text{Total strain}} = \frac{P/A}{(1+\theta)\,(\delta x/l)} = \left(\frac{E_c}{1+\theta}\right) = \frac{5000\sqrt{F_{ck}}}{(1+\theta)}$$

whatever is the age of ~~loading~~ (e.g. for M30)

$$7 \text{ days} \Rightarrow E_{cl} = \frac{5000\sqrt{F_{ck}}}{1+\theta}$$

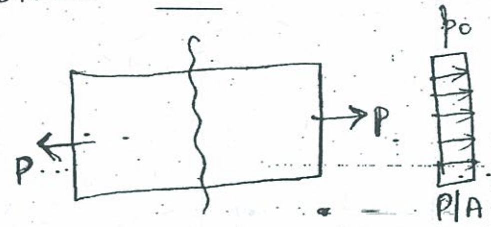
$$= \frac{5000\sqrt{30}}{1+2.2} = 8558.16 \text{ N/mm}^2$$

$$28 \text{ days} \Rightarrow E_{cl} = \frac{5000\sqrt{30}}{1+1.6} = 10533.126 \text{ N/mm}^2$$

Ec Value get reduced by 2 to 3 times due to Creep.

#11 Tensile strength of Concrete :-

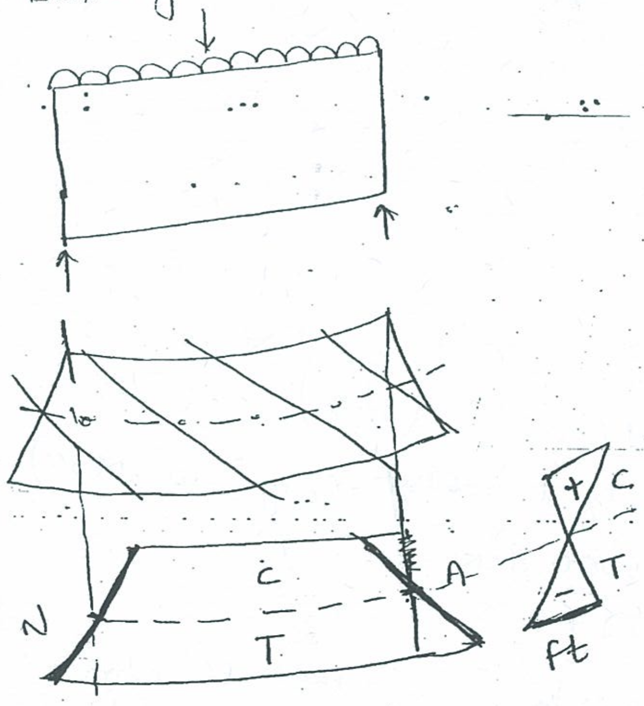
(1) Direct tensile strength :-



Due to a direct tensile force

Direct ~~strength~~ stress developed = $p_0 = P/A$

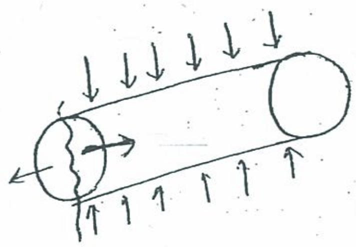
(2) Bending Tensile strength :



⇒ In case of bending maxm permissible stress that can be taken by concrete is called - flexural tensile strength.
also called modulus of rupture. (f_{cr})

$f_{cr} = 0.7\sqrt{f_{ck}}$ f_{ck} → char. strength

③ Split Tensile strength:

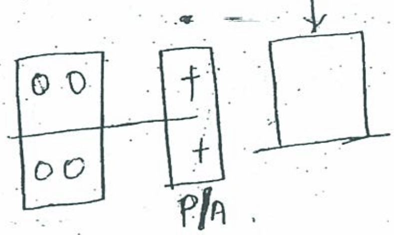


#12 Maxm Compressive strength

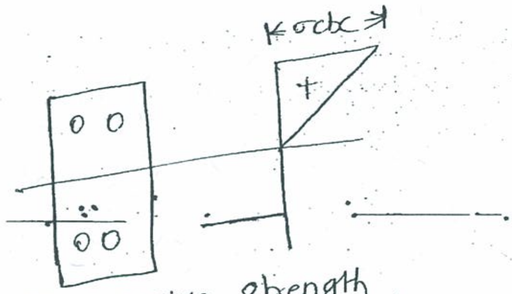
① In direct Compression (σ_{cc})

$\sigma_{cc} = P/A$

= Maxm permissible stress in direct compression



② In bending compression (σ_{cbc}) due to bending



WSM

	Tensile strength		Compressive strength	
	Direct	flexural (Bending) (fcr)	Direct (σ_{cc})	Bending (σ_{cbc})
M15	2	2.71	4.0	5.0]2
M20	~~2.8~~	3.13	5.0	7.0]1.5
M25	3.2	3.50	6.0	8.5]1.5
M30	3.6	3.83	8.0	10.0]1.5
M35	4.0	4.14	9.0	11.5]1.5
M40	4.4	4.43	10.0	13
	N/mm²	N/mm²		N/mm²

(5) Steel Reinforcement :-

Types :-

(1) Mild steel (Fe 250)

$f_y = 250\ N/mm^2$ = characteristic strength yield or stress

→ strength in tension (WSM)

$\sigma_{st} = 140\ N/mm^2$ (upto 20mm ϕ bars)

→ Low strength

→ High ductility

→ (Very good in earthquake) → deformn takes time

(2) Medium tensile steel

$\sigma_{st} = 190 N/mm^2$

→ medium strength

(3) Cold twisted bars (CTD)

or

HYSD (High Yield strength Deformed Bars)

Fe 415 or Fe 500 or higher

→ high strength

→ Low ductility

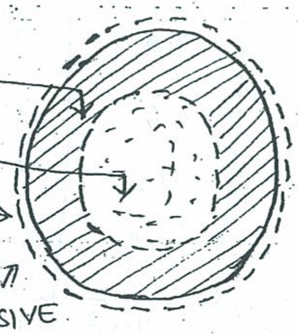
(4) TMT Bars (Thermo Mechanically Treated bars)

* Fe 415 / Fe 500 / Fe 550 / Fe 600 / or higher

→ High strength

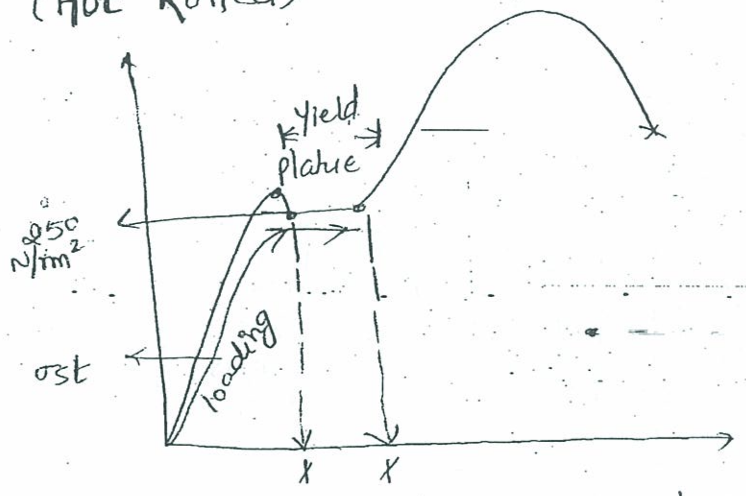
→ High ductility

→ Corrosion resistant



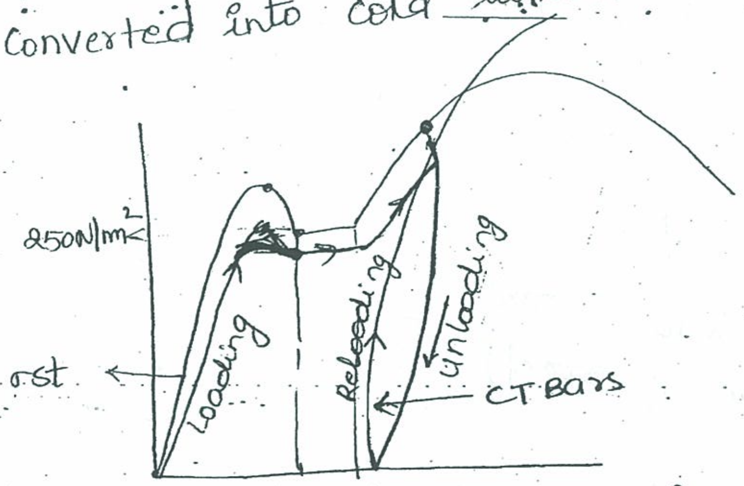
Stress-Strain Curve :-

(1) Mild steel (Hot Rolled)



→ Mild steel reinforcement undergo large amount of deformation at yield platue.

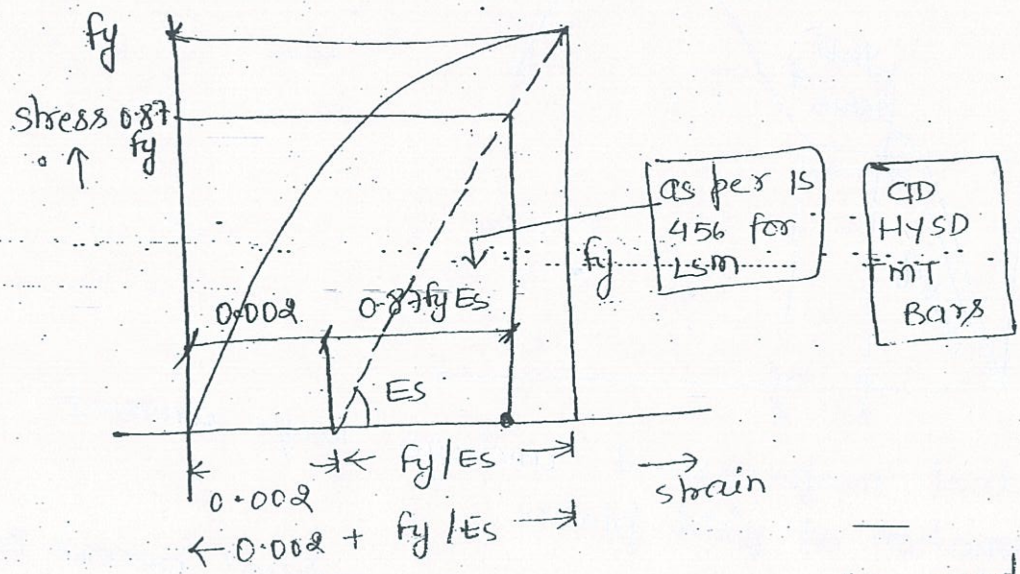
→ To avoid yield platue "cold working" process is used for Mild steel. By cold working mild steel is converted into cold twisted bars.



Cold working Process

* cold working: In cold working the steel reinforcement is stretched beyond yield platue either by stretching or by twisting and their by unloading it.

(7) A cold twisted bar does not show a well defined yield point.



* For such type of steel yield stress value is read at 0.002 strain (0.2 % strain) (Proof strain value) by drawing a parallel line to stress : strain curve

Total strain at yield stress value

$= 0.002 + f_y/E_s$

* Value of $E_s = 2 \times 10^5 \; N/mm^2$ (for all type of steel)

(1) For Fe 415

Total strain at yield limit

$= \left(0.002 + \frac{415}{2 \times 10^5}\right) = \boxed{0.004075}$

(2) For Fe 500

$= 0.002 + \frac{500}{2 \times 10^5} = \boxed{0.0045}$