SNS COLLEGE OF TECHNOLOGY

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COIMBATORE

DEPARTMENT OF CIVIL ENGINEERING

19CET302-DESIGN OF RC STRUCTURAL ELEMENTS

III YEAR / V SEMESTER

Unit 1 : Stress-strain curve for concrete & Load combination

What is a stress-strain diagram?

- It is a tool for understanding **material behavior under load.**
- A stress strain diagram **help engineers to select the right materials for specific loading conditions**. In other words, It is a graph that represents how a part behaves under an increasing load, and used by engineers when selecting materials for specific designs
- A stress-strain diagram generally contains three regions:
- **Elastic region**: This portion is generally represented as a linear relationship between stress and strain. If the load is released the specimen will return to its original dimensions.
- **Plastic region**: In this portion, the specimen begins to yield. The maximum strength of the specimen occurs in this zone. The specimen endures some permanent deformation that remains after the load is released.
- **Rupture**: The point at which a specimen breaks into two parts.

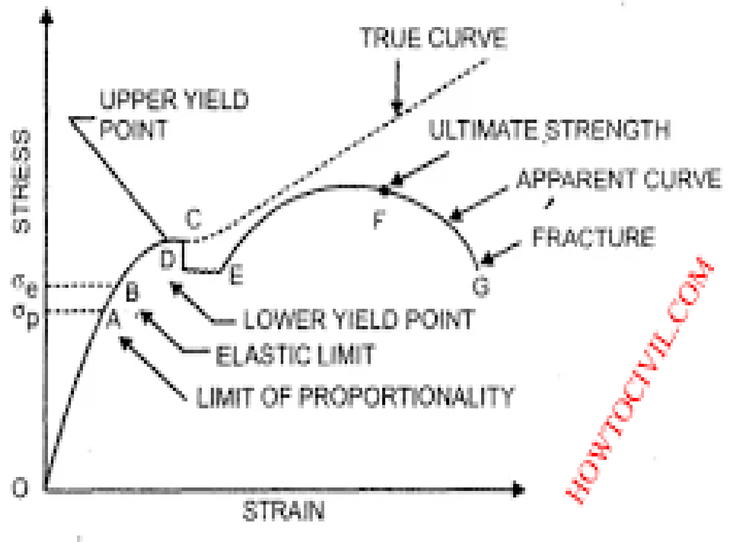


Fig. 1.13 Stress-strain diagram for mild steel.

Stress - Strain diagram of concrete

 Concrete is mostly used in compression that is why **its compressive stress strain curve is of major attention**.

 The stress and strain of concrete is **obtained by testing concrete cylinder specimen at age of 28 days**, using compressive test machine.

 The stress strain curve of concrete allows designers and engineers to **anticipate the behavior of concrete** used in building constructions.

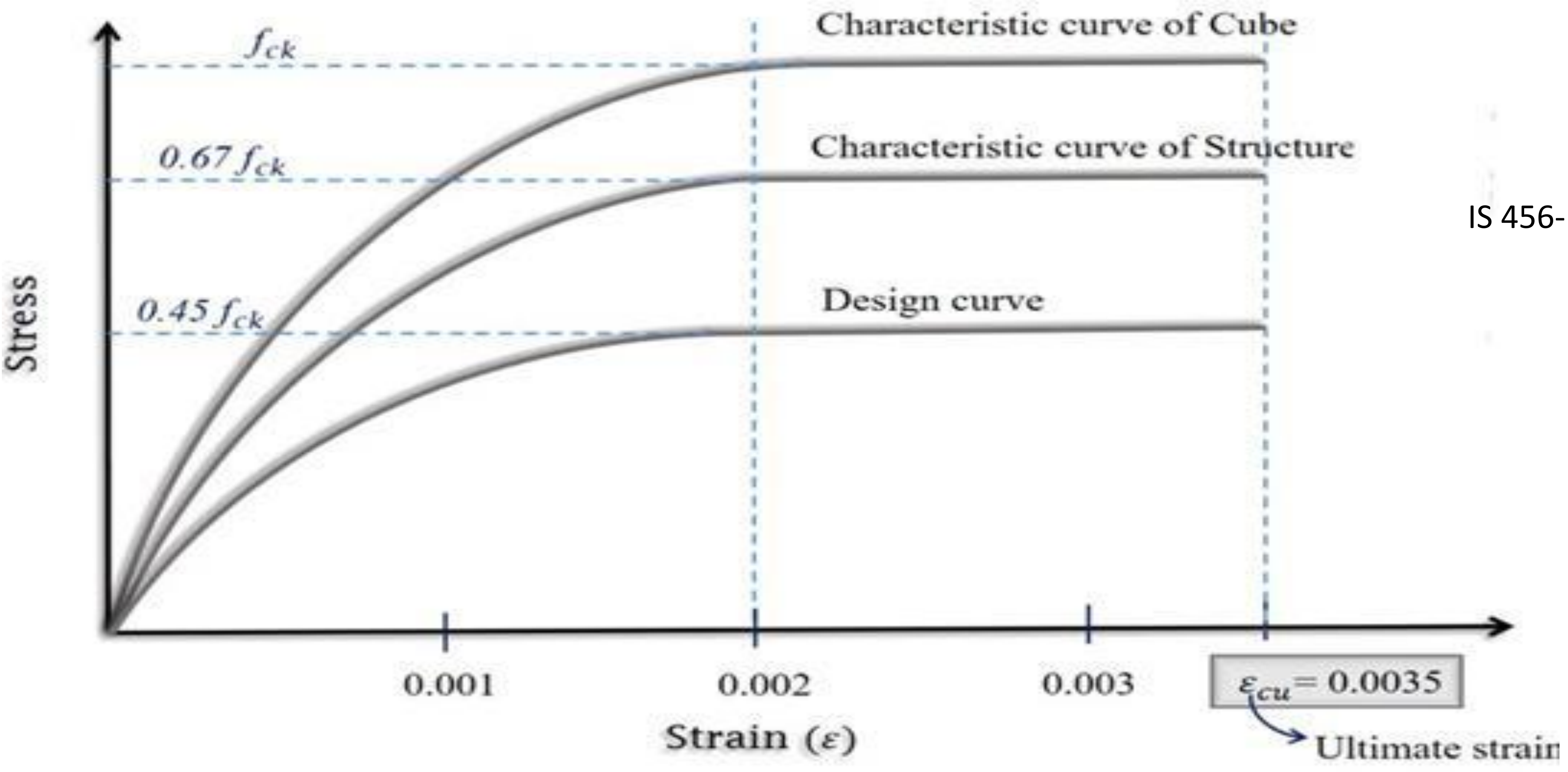
 Stress strain curve of concrete is a graphical representation of concrete behavior under load.

 It is produced by plotting **concrete compressive strain at various interval of concrete compressive stress** (which is the loading).

 The S-S curve for hardened concrete is **almost linear**.

 The aggregate is more rigid than the cement paste and will therefore deform less(that is it will have lower strain) under same applied stress.

 The **S-S curve of concrete lies between the aggregate and the cement paste**.



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- However, this relationship is **non-linear over the most of the range**, that is why micro cracks are formed.

- The cracks are formed
- at the interface between aggregate particles and cement paste as a result of the differential movement between the two phases
- Within the cement paste.
- These cracks are formed as result of **changes in temperature, moisture and application of load.**
- The experimental or actual stress strain curve for concrete is very difficult to use in design. Therefore, IS code 456:2000 has simplified as below

- For design purpose, the compressive strength of concrete in the structure in taken as 0.67 times the characteristic strength.

- The 0.67 factor is introduced to account for the difference in the strength indicated by a cube test and the strength of concrete in actual structure.

- The partial safety factor equal to 1.5 is applied in addition to this 0.67 factor.
- The initial portion of the curve is parabolic. After a strain of 0.002 (0.2%), the stress becomes constant with increasing load, until a strain of 0.0035 is reached and here the concrete is assumed to have failed.

As per IS specifications

a) The earlier given was for the characteristic strength of a standard 150x150x150 mm size of concrete cube.

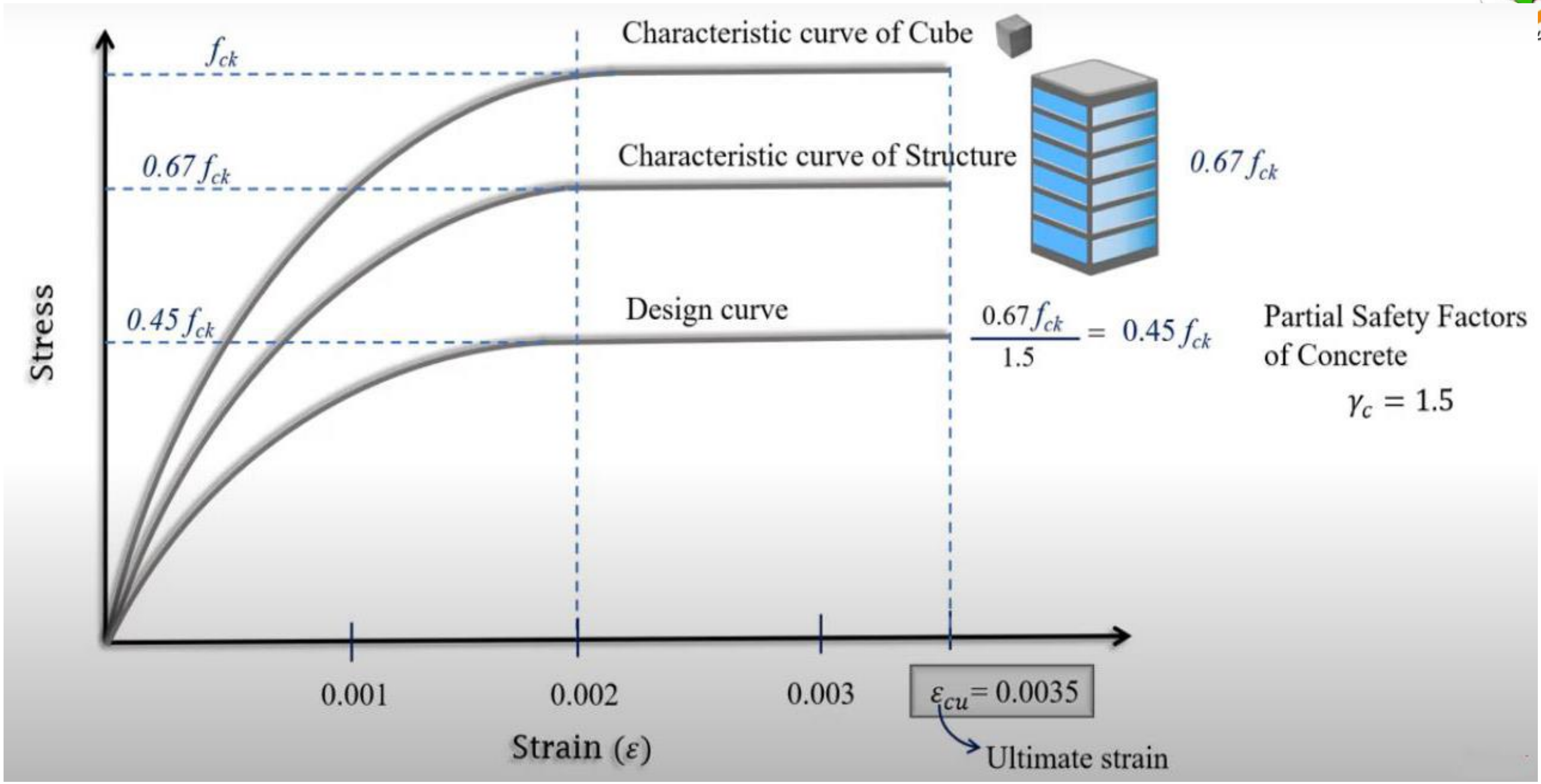
b) But when the design is for a entire structure then the compressive strength of the concrete will get reduced due to the influence of the soil as given in the figure.

c) For design purpose Limit state method is adopted as in IS codes. So a partial safety factor of 1.5 is considered.

d) Therefore the design stress of concrete is taken as $[(0.67*f_{ck})/1.5] = 0.45 f_{ck}$

e) Hence for the design problems the design stress of concrete is taken as 0.45 fck and the ultimate strain of concrete is taken as 0.0035.

f) Thus finally results in a design curve as shown in figure.


Characteristic curve of Cube
f_{ck}
$0.67\,f_{ck}$
Characteristic curve of Structure
$0.67\,f_{ck}$
$0.45\,f_{ck}$
Design curve
$\frac{0.67\,f_{ck}}{1.5} = 0.45\,f_{ck}$
Partial Safety Factors of Concrete
$\gamma_c = 1.5$
Stress
0.001
0.002
0.003
$\varepsilon_{cu} = 0.0035$
Ultimate strain
Strain (ε)

Stress - Strain diagram of mild steel

 If the force is considerably large the material will experience elastic deformation but the ratio of stress and strain will not be proportional. (Point A to B). This is the elastic limit.

 Beyond that point the material will experience plastic deformation.

 The point where plastic deformations starts is the yield point which is show in the figure as point B. 0-B is the upper yield point.

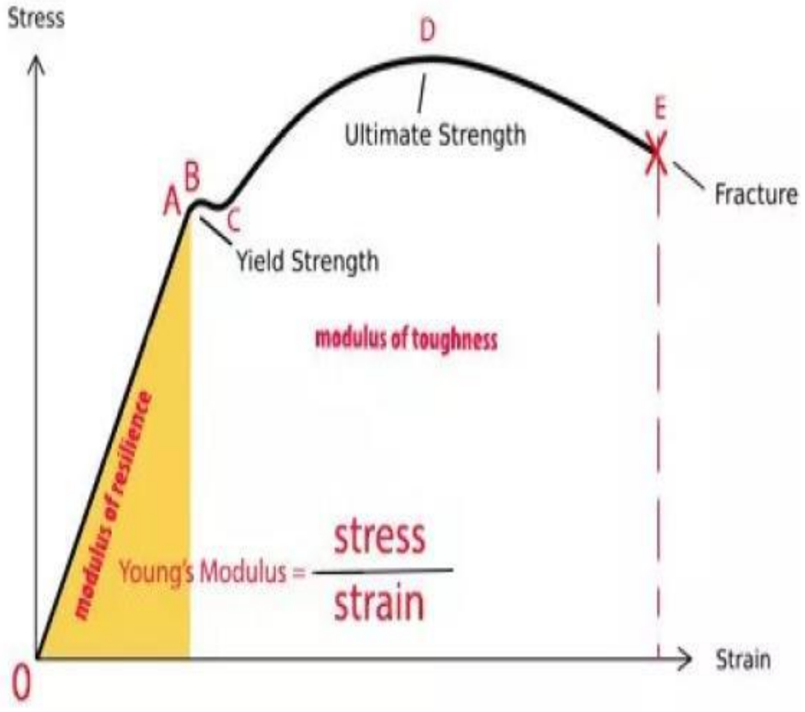
 Resulting graph will not be straight line anymore. C is the lower yield point.

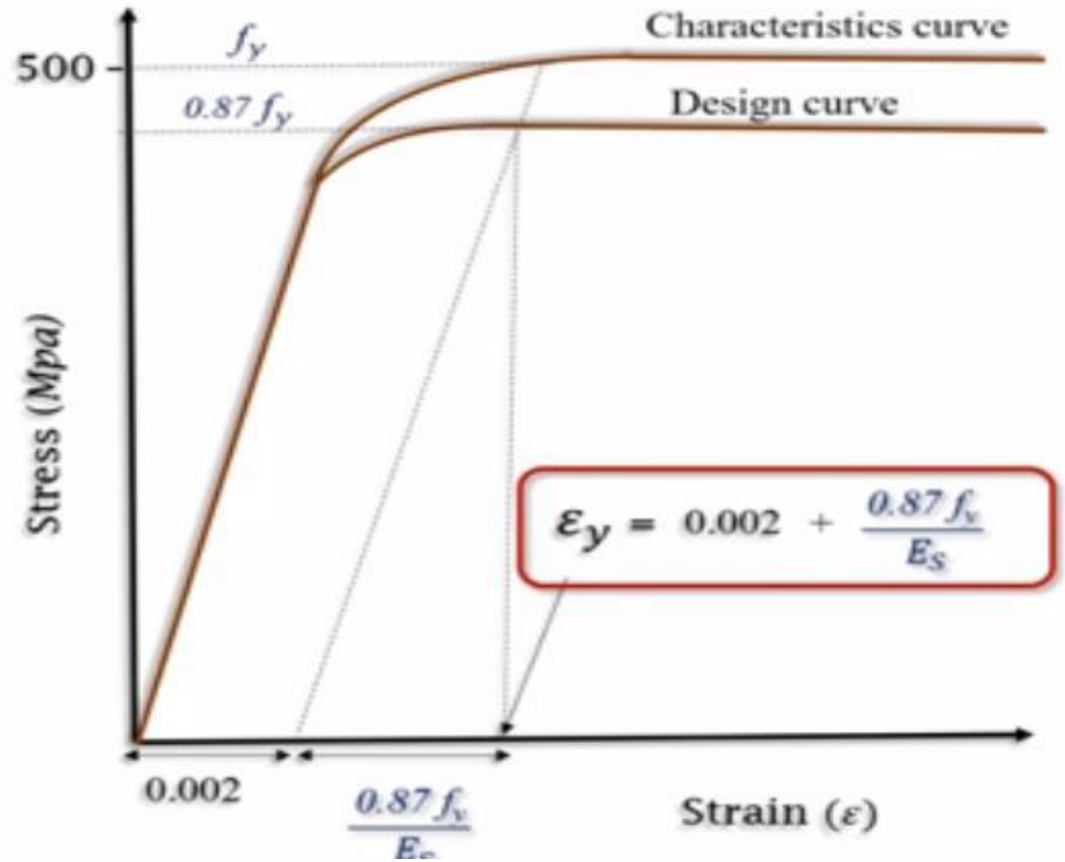
 D is the maximum ultimate stress.

 E is the breaking stress. It is the area of the whole curve (point 0-E). Ener absorbed at unit volume up to breaking point.

 If tensile force is applied to a steel bar it will have some extension.

 If the force is small the ratio of the stress and strain will remain proportional





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Stress - Strain diagram HYSD (High Yield Strength Deformed) bars

- There is no specified yield point for HYSD bars, the code gives the characteristic curve as given above.
- So considering the strain value of 0.002 the yield stress is noted.
- The design curve almost same as mild steel and the design stress is also 0.87 fy.
- But the strain at this point is different as given above

Load combination (IS 875 part5)

8.1 Load Combinations — Keeping the aspect specified in **8.0**, the various loads should, therefore, be combined in accordance with the stipulations in the relevant design codes. In the absence of such recommendations, the following loading combinations, whichever combination produces the most unfavourable effect in the building, foundation or structural member concerned may be adopted (as a general guidance). It should also be recognized in load combinations that the simultaneous occurrence of maximum values of wind, earthquake, imposed and snow loads is not likely.

a) DL
b) $DL+IL$
c) $DL+WL$
d) $DL+EL$
e) $DL+TL$
f) $DL+IL+WL$
g) $DL+IL+EL$

Load combination (IS 875 part5)

IS : 875 (Part 5) - 1987

h) $DL + IL + TL$

j) $DL + WL + TL$

k) $DL + EL + TL$

m) $DL + IL + WL + TL$

n) $DL + IL + EL + TL$

(DL = dead load, IL = imposed load, WL = wind load, EL = earthquake load, TL = temperature load).

Characteristic Loads (IS 456-2000 Cl-36.2

36.2 Characteristic Loads

The term 'characteristic load' means that value of load which has a 95 percent probability of not being exceeded during the life of the structure. Since data are not available to express loads in statistical terms, for the purpose of this standard, dead loads given in IS 875 (Part 1), imposed loads given in IS 875 (Part 2), wind loads given in IS 875 (Part 3), snow load as given in IS 875 (Part 4) and seismic forces given in IS 1893 shall be assumed as the characteristic loads.

Characteristic Loads (IS 456-2000 Cl-36.3

IS 456 : 2000

36.3 Design Values

36.3.1 *Materials*

The design strength of the materials, f_d is given by

$$f_d = \frac{f}{\gamma_m}$$

where

f = characteristic strength of the material (*see* 36.1), and

γ_m = partial safety factor appropriate to the material and the limit state being considered.

36.3.2 *Loads*

The design load, F_d is given by

$$F_d = F\gamma_f$$

where

F = characteristic load (*see* 36.2), and

γ_f = partial safety factor appropriate to the nature of loading and the limit state being considered.

Partial Safety Factors(IS 456-2000 Cl-36.4

36.4.1 *Partial Safety Factor* γ_f *for Loads*

The values of γ_f given in Table 18 shall normally be used

Table 18 Values of Partial Safety Factor γ_f for Loads
(*Clauses* 18.2.3.1, 36.4.1 *and* B-4.3)

Load Combination	Limit State of Collapse			Limit States of Serviceability		
	DL	*IL*	*WL*	*DL*	*IL*	*WL*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
DL + *IL*	1.5		1.0	1.0	1.0	–
DL + *WL*	1.5 or 0.9[1)]	–	1.5	1.0	–	1.0
DL + *IL* + *WL*		1.2		1.0	0.8	0.8

NOTES

1 While considering earthquake effects, substitute *EL* for *WL*.

2 For the limit states of serviceability, the values of γ_f given in this table are applicable for short term effects. While assessing the long term effects due to creep the dead load and that part of the live load likely to be permanent may only be considered.

[1)] This value is to be considered when stability against overturning or stress reversal is critical.

Partial Safety Factors(IS 456-2000 Cl-36.4)

36.4.2 *Partial Safety Factor γ_m for Mateiral Strength*

36.4.2.1 When assessing the strength of a structure or structural member for the limit state of collapse, the values of partial safety factor, γ_m should be taken as 1.5 for concrete and 1.15 for steel.

NOTE — γ_m values are already incorporated in the equations and tables given in this standard for limit state design.

1 GATE CE 2016 Set 2

MCQ (Single Correct Answer) +1 -0.3

As per IS 456 - 2000 for the design of reinforced concrete beam, the maximum allowable shear stress ($\tau_{c \ max}$) depends on the

A grade of concrete and grade of steel

B grade of concrete only — Correct Answer

C grade of steel only

D grade of concrete and percentage of reinforcement

2 GATE CE 2016 Set 1

MCQ (Single Correct Answer) +1 -0.3

In shear design of an RC beam, other than the allowable shear strength of concrete (τ_c),there is also an additional check suggested in IS 456-2000 with respect to the maximum permissible shear stress ($\tau_{c \ max}$). The check for $\tau_{c \ max}$ is required to take care of

A additional shear resistance from reinforcing steel

B additional shear stress that comes from accidental loading

C possibility of failure of concrete by diagonal tension v

D possibility of crushing of concrete by diagonal compression — Correct Answer

2 GATE CE 2015 Set 1
MCQ (Single Correct Answer) +1 -0.3

Workability of concrete can be measured using slump, compaction factor and Vee bee time. Consider the following statements for workability of concrete:
(i) As the slump increases, the Vebe time increases

(ii) As the slum increases, the compaction factor increases
Which of the following is TRUE?

A Both (i) and (ii) are True

B Both (i) and (ii) are False

C (i) is True and (ii) is False

D (i) is False and (ii) is True — Correct Answer

3 GATE CE 2015 Set 1
MCQ (Single Correct Answer) +1 -0.3

Consider the following statements for air-entrained concrete:
(i) Air-entrainment reduces the water demand for a given level of workability

(ii) Use of air-entrained concrete is required in environments where cyclic freezing and thawing is expected.
Which of the following is TRUE?

A Both (i) and (ii) are True — Correct Answer

B Both (i) and (ii) are False

C (i) is True and (ii) is False

D (i) is False and (ii) is True

4 GATE CE 2014 Set 2

MCQ (Single Correct Answer) +1 -0.3

The modulus of elasticity, $E = 5000\sqrt{f_{ck}}$ where f_{ck} is the characteristic compressive strength of concrete, specified in IS:456-2000 is based on

A Tangent modulus

B Initial tangent modulus

C Secant modulus — Correct Answer

D Chord modulus

1 GATE CE 2014 Set 2

Numerical +1 -0

The flexural tensile strength of M25 grade of concrete, in N/mm^2, as per IS:456-2000 is _________.

Answer

Correct answer is 3.5

THANK YOU