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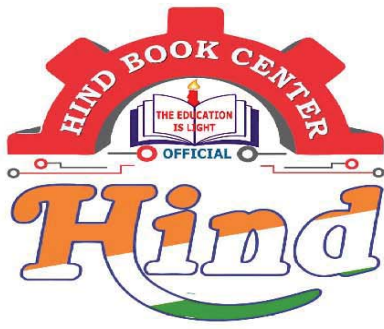
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# RCC & PSC

## Class Notes

(Last Updated On

**Vivek Gupta (Ex. IES)**

# CONTENT

	Page No
1. Basic Concepts	1-29
2. Limit State Method	30-39
3. Singly Reinforced Rectangular Section	40-58
4. Doubly Reinforced Rectangular Section	59-70
5. Flanged Section	71-87
6. Design of Beam	88-107
7. Shear	108-130
8. Bond and Detailing	131-148
9. Torsion	149-156
10. Compression Member	157-180
11. Slab	181-203
12. Foundation	204-222
13. Analysis of PSC Member	223-243
14. Pre-Stress Losses	244-257
15. Additional Topics of PSC	258-269
16. Retaining Wall	270-276
17. Working Stress Method	277-289
18. Water Tank	290-295
19. Staircase	296-306
20. Earthquake Design	307-313
21. Masonry Design	314-321
22. Important Tables and Graphs of IS 456: 2000	322- 326

*A very special thanks*

*to*

*Sagar Jagannath Mahurkar  
(Pune Batch)*

*for*

*Systematic & Exquisite*

*Class Notes*

# CHAPTER 1

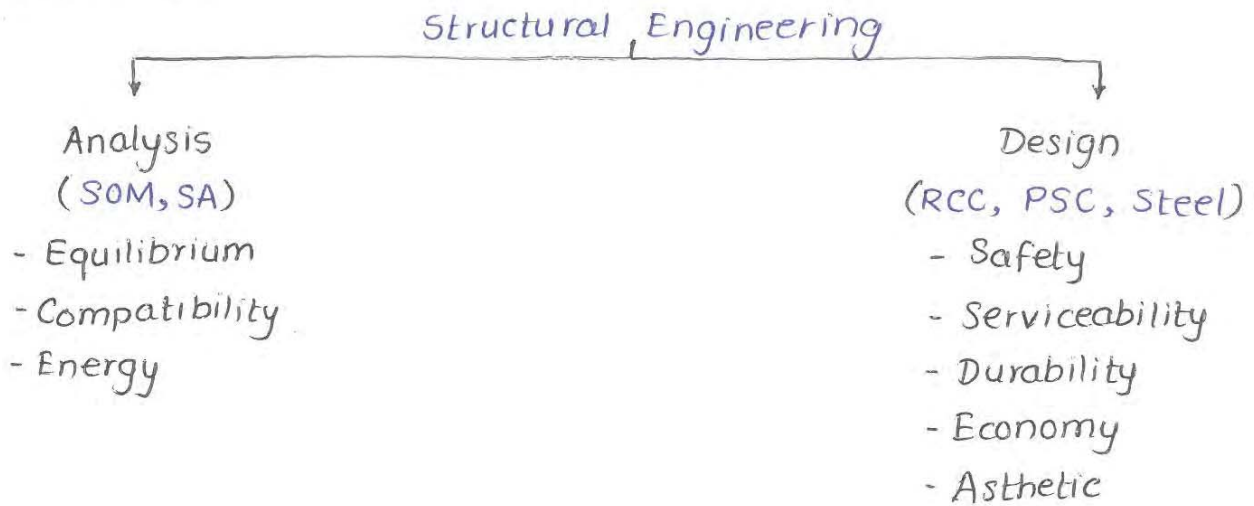
## Basic Concepts

### CONTENTS

1.1 Introduction	1-1
1.2 Cement Concrete	1-2
1.3 Reinforcement	1-24

# 1. Basic Concepts

## 1.1 Introduction:



### i) Safety:

A structure must be safe with appropriate factor of safety [FOS] for loading that may come on it during its intended life.

### ii) Serviceability:

A structure should provide the service for which it is constructed.

### iii) Durability:

A structure should sustain loading for which it was designed and should perform well with safety and serviceability upto its whole life

Durability without serviceability or less margin of safety [FOS]

iv) has no meaning

### iv) Economy:

Design and construction of any structure should be economical without affecting safety, serviceability and durability.

### v) Asthetic:

IF huge investment is involved in design and construction

of a structure then aesthetic also plays an important role.

Ex. Considering a beam:

- i) Safety: Reinforcement is provided.
- ii) Serviceability: Doubly reinforced section instead of singly reinforced section to reduce depth of section.
- iii) Durability: Nominal cover, selection of material.
- iv) Economy: Monolithic casting of beam and slab designed as T-section.
- v) Aesthetic: Half round section instead of rectangular section.

## 1.2 Cement Concrete:

It is a mixture of binding material [cement], fine aggregate [sand], coarse aggregate, water and admixture in proper proportion to achieve concrete of desired properties at fresh state and hardened state.

### 1.2.1 Concrete Mix:

a) Nominal Mix:

- Based on experience.
- Mixing may be by weight or by volume. By weight is preferable
- Quantity of water is not fixed. It is provided as per site requirement.
- Nominal mix is allowed for M5 to M20.

	C	FA	CA
M10	1	3	6
M15	1	2	4
M20	1	1.5	3



## b) Design Mix:

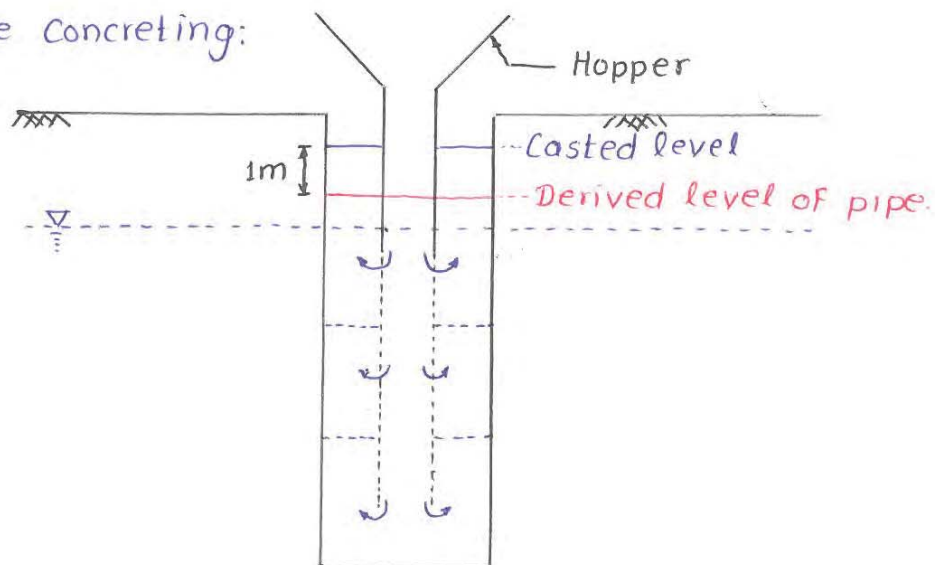
- Based on calculation as per IS 10262 (2009)
- Proportioning must be by weight.
- Quantity of water is also fixed.
- Design mix is allowed for M10 to M100.

## 1.2.2 Fresh Concrete:

Workability is the most important property of fresh concrete which is simply defined as "Ease to work with."

Sr. No.	Degree of Workability	Use	Slump	Compacting Factor	Vee-bee time (sec)
1.	Very low	- Road Construction. - Shallow Section.	-	0.75-0.8	10-20
2.	Low	- Mass concreting. - Lightly reinforced section	25-75	0.8-0.85	5-10
3.	Medium	- Heavily reinforced section - Concreting by concrete pump.	50-100	0.85-0.92	2-5
4.	High	- Piling	100-150	0.92-above	-
5.	Very High	- Tremie pipe concreting.	-	0.92-above	-

## \* Tremie Pipe Concreting:



\* Workability of Concrete can be measured by following methods.

1. Slump test

3. Vee-bee Test

2. Compacting factor Test

4. Flow Test

### 1.2.3 Hardened Concrete:

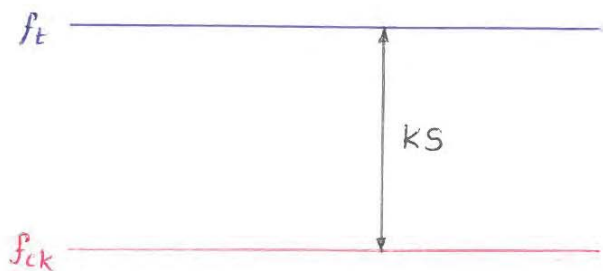
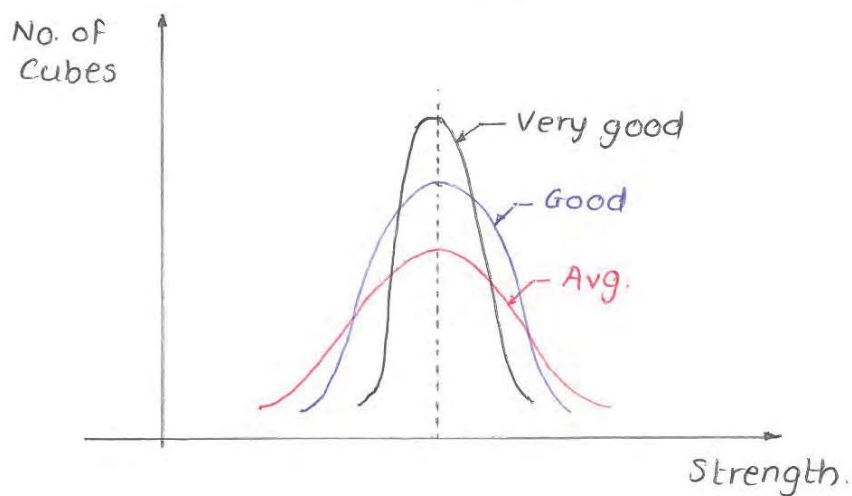
After final setting time, concrete is assumed to be hard and it keeps on gaining strength for very long time [1 to 5 years]

#### a) Compressive Strength of Cube:

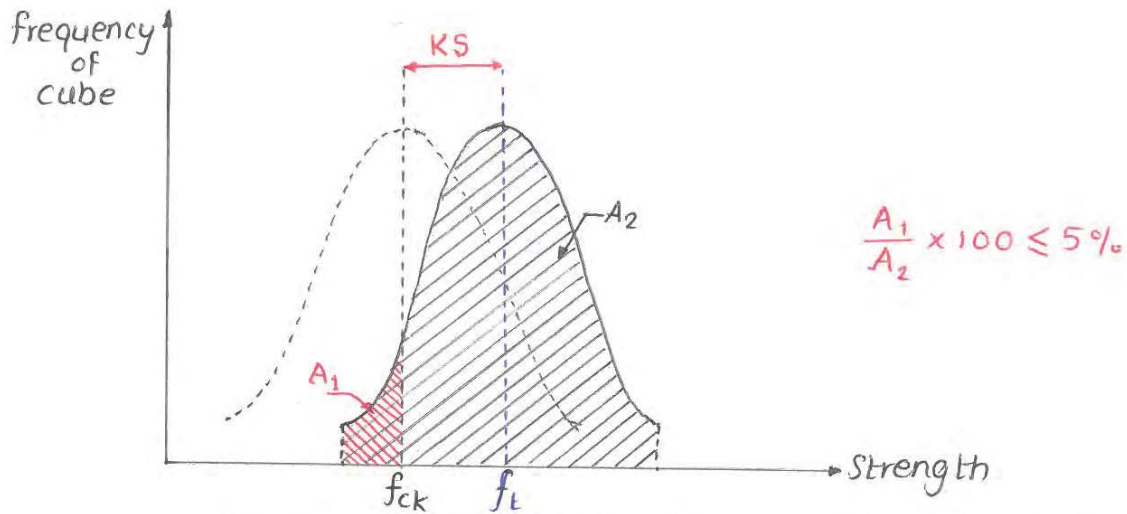
This is the compressive strength of cube size 150mm subjected to uniaxial compression after 28 days from day of casting.

#### b) Characteristic Compressive Strength of Cube:

It is the strength below which not more than 5% test results are expected to fall.



$$f_t = f_{ck} + KS$$



Area under curve represents number of cubes.

$K = 1.65$  (for 5% of definition)

% of definition	K
0%	$\infty$
5%	1.65
50%	0

$S$  = Standard deviation that depends on quality control.

Ex. Uniaxial compression test results of 100 cubes are listed below in increasing order. Find  $f_{ck}$

26, 26.5, 26.5, 27, 27.5,

28, 28.5, 29, 30, 30.5,

31, .....

....., 42.5 N/mm<sup>2</sup>

⇒ As per definition,  $f_{ck}$  should be 28 N/mm<sup>2</sup>. Since,  $f_{ck}$  always designated in multiple of 5, so answer should be 25 N/mm<sup>2</sup> or 30 N/mm<sup>2</sup>.

In this case, 8 samples (more than 5%) are below 30 N/mm<sup>2</sup>, so 30 N/mm<sup>2</sup> can not be  $f_{ck}$

Now, 25 N/mm<sup>2</sup> can be considered as  $f_{ck}$  because zero test results (less than 5%) is below 25 N/mm<sup>2</sup>

⇒  $f_{ck} = 25 \text{ N/mm}^2$

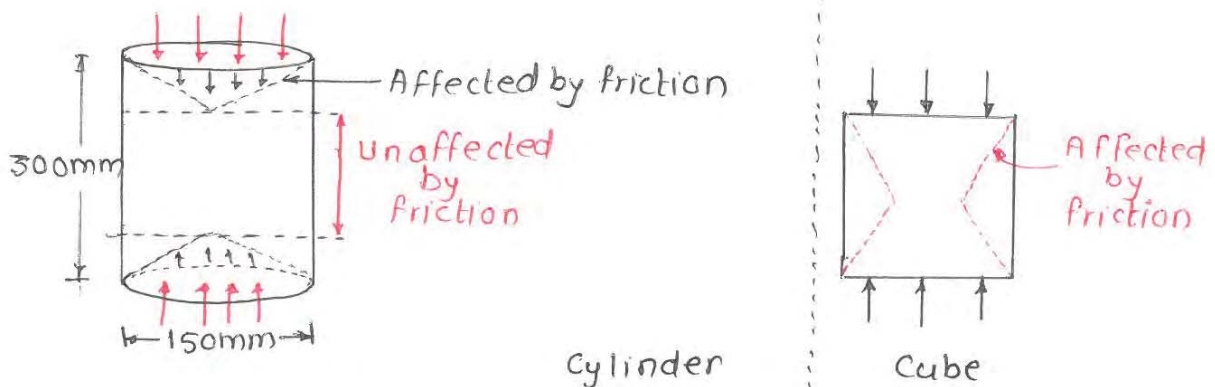
### c) Characteristic Compressive Strength of Concrete:

It is obtained by dividing characteristic compressive strength of cube by a factor 1.5 to account for variation in shape of concrete [other than cube] and variation in loading condition [other than uniaxial compression].

#### \* Note:

- Factor 1.5 used here is not partial F.O.S.
- For general conversation, characteristic strength of concrete represents value obtained from characteristic strength of Cube.

### 1.2.4 Comparison between Cube and Cylinder:



What should be used

✓

✗

Actually Used.

✗

✓

- Uniaxial compressive strength of concrete can be determined by using different shapes of specimen. (Cube, cylinder, prism, etc)

$$f_{\text{cube}} \approx 1.25 f_{\text{cylinder}}$$

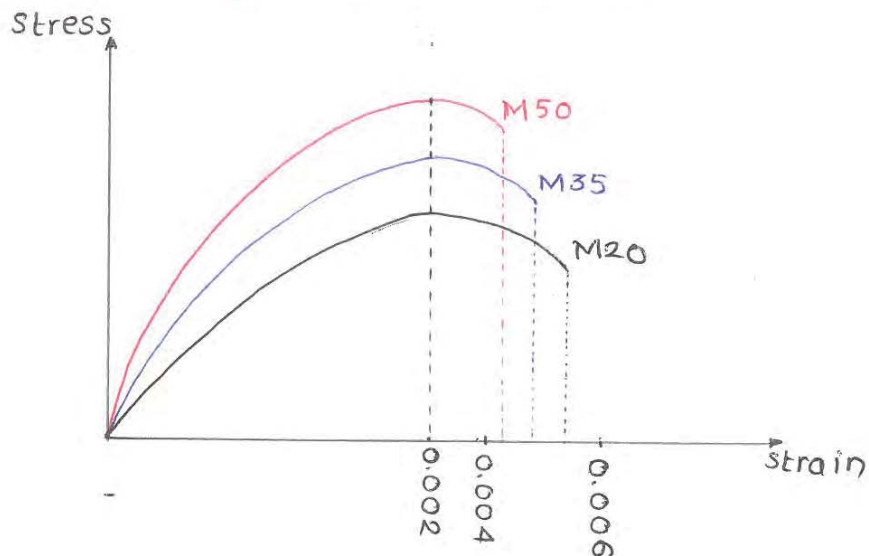
- Cylinder gives more appropriate results for uniaxial compressive strength of concrete because effect of friction between machine plates and specimen, is almost nil (zero).



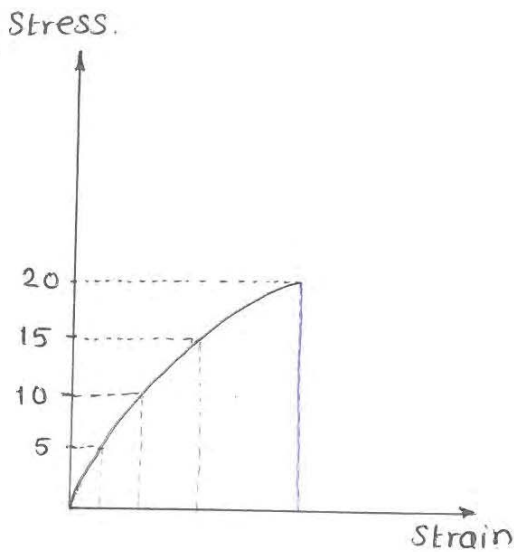
## \* Note:

- Cube of smaller size (assuming 100mm) gives more strength than standard cube.
- A smaller cylinder also gives higher strength than standard cylinder, provided ratio of height to diameter remains constant
- These results are experimental.

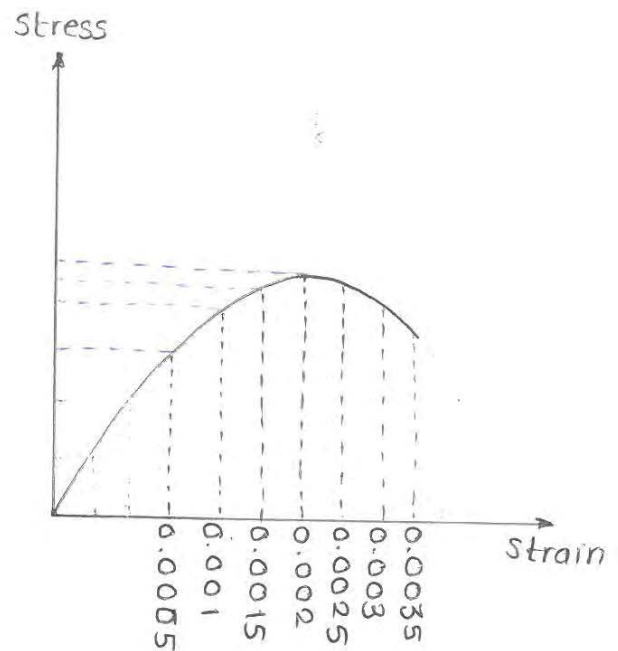
## 1.2.5 Stress-Strain diagram of Concrete under



- Stress-strain diagram is non-linear.
- Initial portion of stress-strain diagram can be considered as linear.
- Maximum compressive stress is corresponding to approx strain 0.002
- Ultimate strain lies between 0.004 to 0.006
- Modulus of elasticity increases with increase in grade of concrete.
- Brittleness increases with increase in grade of concrete.



Controlled Stress.



Controlled Strain

### 1.2.6 Grade of Concrete:

Mix  $\overbrace{M-25}^{\text{Characteristic compressive strength (N/mm}^2\text{)}}$

M5-M20  $\rightarrow$  Nominal Mix

M10-M100  $\rightarrow$  Design Mix [as per ammendment ④]

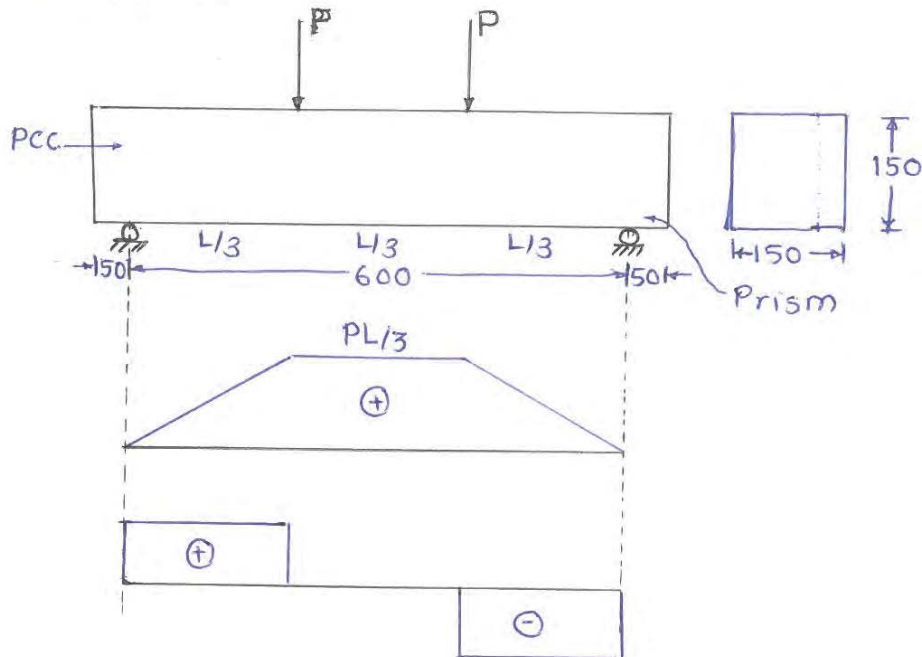
### 1.2.7 Tensile Strength of Concrete:

- It is approximately 10% (7% to 15%) of the compressive strength.
- Stress-strain diagram is almost linear.
- Ratio of compressive strength to tensile strength increases with increase in grade of concrete.
- Since tensile strength of concrete is ignored in RCC structure so it has very less importance. However, it is calculated to determine cracking moment.

## 1. Direct Tension Test:

Practically, it is very difficult to perform direct tension test because force never remains perfectly axial tension due to non-homogeneity of concrete.

## 2. Flexure Test



Flexure Formula:

$$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$$

$$\frac{P_{cr} \cdot L/3}{bD^3/12} = \frac{f_{cr}}{D/2}$$

$$f_{cr} = ??$$

- 3<sup>rd</sup> point loading is applied for pure bending condition. (flexure).
- Value of P is increased from 0 to value corresponding to which 1<sup>st</sup> crack develops in extreme tension fibre.
- Corresponding to cracking load, bending moment is calculated in central portion and tensile strength is calculated as illustrated above.

- IS 456 provides standard formula for flexure tensile Strength/Modulus of Rupture

$$f_{cr} = 0.7\sqrt{f_{ck}} \text{ N/mm}^2.$$

Ex. A PCC beam of section size 200x300 mm is made up of M30 concrete. Calculate cracking moment of section.

⇒

By Flexure Formula,

$$\frac{M_{cr}}{I} = \frac{f_{cr}}{y}$$

$$f_{cr} = 0.7\sqrt{f_{ck}}$$

$$f_{cr} = 0.7\sqrt{30} = 3.834 \text{ N/mm}^2$$

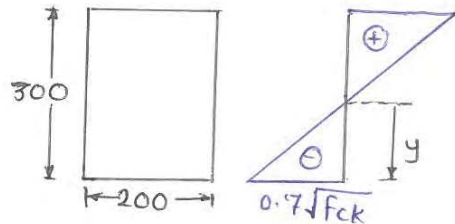
$$I = \frac{bD^3}{12} = \frac{200 \times 300^3}{12}$$

$$I = 450 \times 10^6 \text{ mm}^4$$

$$y = D/2 = 150 \text{ mm}$$

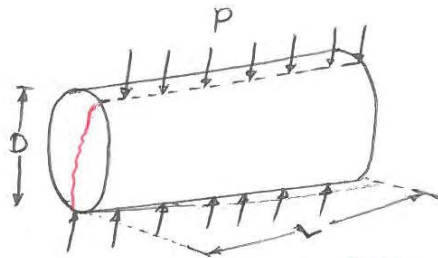
$$\frac{M_{cr}}{450 \times 10^6} = \frac{3.834}{150}$$

$$M_{cr} = 11.502 \text{ kN-m}$$



### 3. Cylinder Split Test:

- A line loading along length is applied at diametrically end points.
- Due to this loading, Cylinder splits into two parts.



$$f_{cr} = \frac{2P}{\pi DL}$$

$$f_{flexure} > f_{cylinder\ split} > f_{direct}$$