STEEL STRUCTURES (5±1 marks)

1. MATERIALS & SPECIFICATIONS OF STEEL

→ Advantages of Structural Steel vs. Concrete

(i) Higher strength

For M20 concrete, $f_{ck} = 20$ MPa.

For mild steel, $f_y = 250$ MPa. $\Rightarrow \frac{f_y}{f_{ck}} \approx 10$ to 12

Compressive & tensile strength of steel are equally good.

But for concrete, tensile strength is approx. $\frac{1}{10}$th compressive stren.

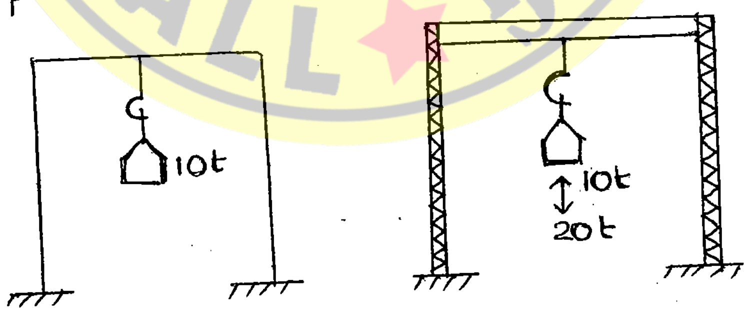
(ii) More economical.

Higher strength to weight ratio for steel compared to concrete. Tall buildings, large span buildings, bridges etc are therefore constructed with structural steel.

(iii) Rapid Construction.

Erection of structure can be completed quickly.

(iv) Easy repair or modification



(v) Ductile material.

$$\% \text{ elongation} = \frac{\delta l}{l} \times 100$$

% elongation > 15% → Ductile material.

5% – 15% → Intermediate material.

< 5% → Brittle material.

For steel, % elongation > 20%.; shows signs of failure.

(vi) 100% scrap value (reusage value).

Existing steel members can be dismantled and reused for another application with 100% strength.

(vii) Overall construction cost is lesser.

Cost of material, cost of man power, cost of maintenance, dismantling cost etc are cheaper.

(viii) High quality & reliability.

	Safety norms
Working stress method	FOS (= 3 for concrete = 1.7–1.8 for steel)
Limit state Design	Partial safety factor (= 1.5 for concrete = 1.15 for steel)

Lesser values of FOS, P.S.F for steel are because its a factory product; quality control is proper and uncertainities are less.

* Corrosion and proneness to catch fire are the two disadvantages of steel compared to concrete. To make them corrosive and fire resistant, its an expensive process.

Iron (>98%) + Small % of Carbon (0.1 – 1.1% By weight) + [Sulphur, Phosphorous, Silicon, Manganese, Nickel, Chromium] → STEEL (V)

* Nickel & Chromium content is more in Stainless steel giving it anti-corrosive properties

→ Mechanical Properties imparted by Carbon

(i) Yield strength
(ii) Ultimate tensile strength
(iii) Hardness.
(iv) Ductility.
(v) Toughness.

Carbon content : 0.23 % ⟶ $f_y = 250$ MPa.
0.27 % ⟶ $f_y = 350$ MPa.

→ Classification of Steel (based on Carbon Content)

(i) Low Carbon steel. — 0.1 to 0.25 %
(ii) Medium Carbon steel. — 0.25 to 0.6 %
(iii) High Carbon steel. — 0.6 to 1.1 %

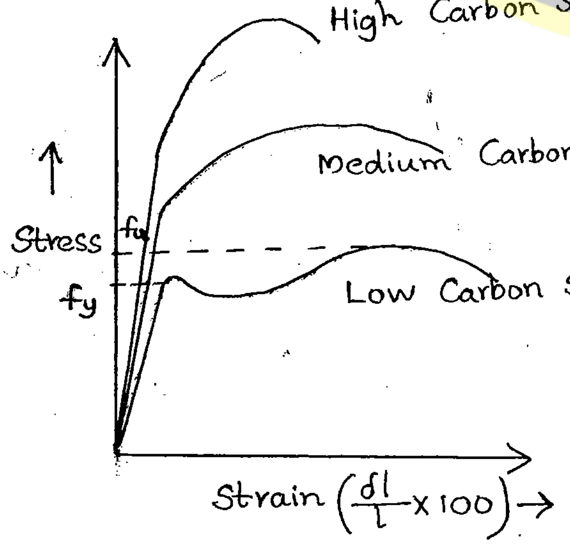
Mild steel used in RCC constructions as reinforcements (Fe 250, 0.25%)
Structural steel section used in steel building construction } Low Carbon

Rails, tyres, high tensile steels (Fe 415, 0.27 %), hammers etc. → Medium Carbon

Stone masonry tools, drills, punches etc. → High Carbon

As carbon content ↑, yield strength (f_y), ultimate tensile strength (f_u), Hardness of steel } ↑

Ductility, Toughness } ↓



⊙ Hardness must be lesser to improve weldability.

⊙ Ductility & toughness are very important for structural steel subj to dynamic & impact loads.

→ General Classification:

(i) Reinforcing Steels :– used as reinforcement in RCC constructions.

Fe 250, Fe 415, Fe 500 etc.
Steel ↗ ↖ Yield strength (MPa)

(ii) Structural Steels :– used in steel building and bridge constructions.

Fe 410, Fe 540, Fe 570 etc.
Steel ↗ ↖ Ultimate tensile strength (MPa).

For mild steel, $f_y = 250$ MPa.
$f_u = 415$ MPa.

→ Codes & Standards.

Failures of old constructions.
Performance of existing buildings.
Researches in various publications
} basis for CODE formulation.

⊙ IS 800
- 1956 – 1962 (1st)
- 1984 (2nd) WSM
- 2007 (3rd) LSD

} Code of practise for use of structural steel in general building construct

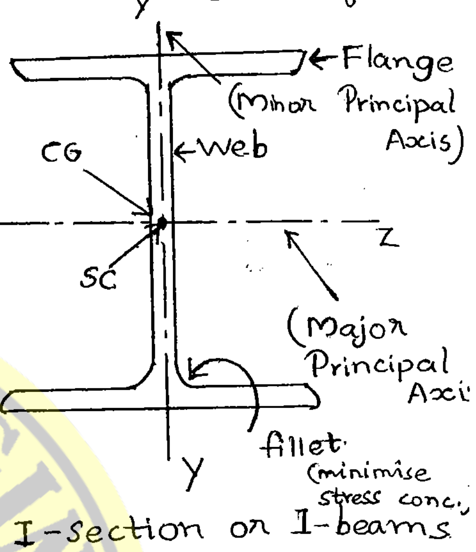
⊙ IS 875 : 1987 (Five parts) : code of practise for design loads for buildings & structur

⊙ IS Hand Book No. 1 (Steel tables) : a) weight / running meter.
b) c/s area.
c) radius of gyration.
d) Section modulus.

→ Rolled Steel Sections

(i) Rolled steel I-sections or I beams.
(ii) Rolled steel channel sections.
(iii) Rolled steel Tee sections or T-bars.
(iv) Rolled steel angle sections.
(v) Indian Standard tube sections.
(vi) Rolled steel bars.
(vii) Rolled steel plates.
(viii) Rolled steel sheets.
(ix) Rolled steel flats.
(x) Rolled steel strips etc

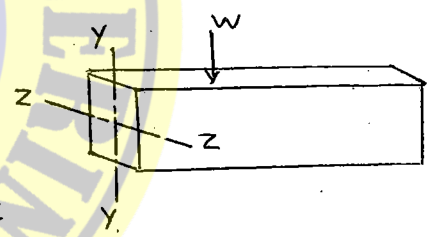
CG: Centre of Gravity.
SC: Shear centre. (Centre of Flexure)



I-section or I-beams

* Z-Z axis → Major Principal Axis.
Moment of inertia wrt Z-Z axis is more. (bending axis).

$I_{zz} = y^2\, dA$



* When only transverse loads acts on a rectangular beam, bending will be about Z-Z axis. ∴ I_{zz} should be more. For this, depth of beam is increased.

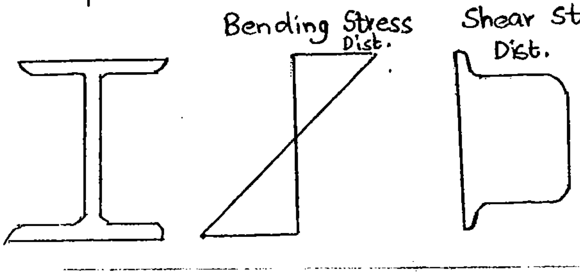
If lateral loads also act on the beam, there will be bending about y-y axis as well. In that case, width of beam is also increased.

* An I-section may be designated as:

ISLB 500 @ 735.6 N/m (≈ 75 kg/m)

Depth of I-section = 500 mm

Weight per running metre



* 90-92% Bending stress will be taken by Flanges
* Ily, shear by web.

→ Five Types of I-sections:

(i) ISJB — Indian Standard Junior Beams
(ii) ISLB — Indian Standard Light Weight Beams
(iii) ISMB — Indian Standard Medium Weight Beams
(iv) ISWB — Indian Standard Wide Flange Beams
(v) ISHB — Indian Standard Heavy beams Beams.

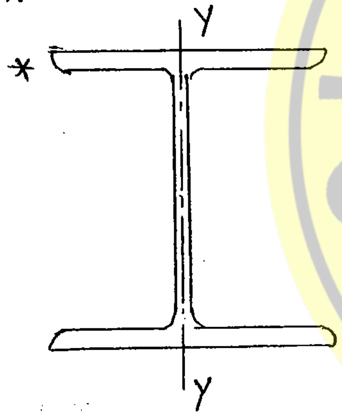
(Max. depth :- 600 mm)

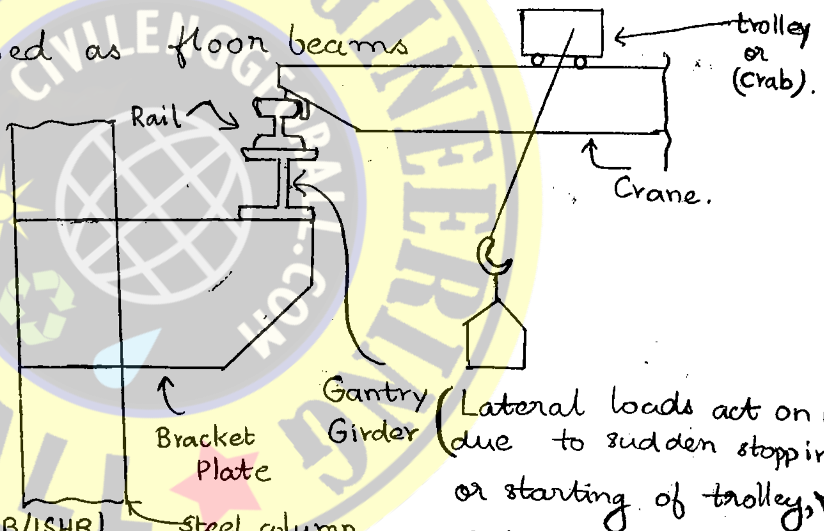
* Special I-section:

ISSC : Indian Standard Column Section

(Max. depth :- 250 mm)

* ISLB & ISMB are used as floor beams

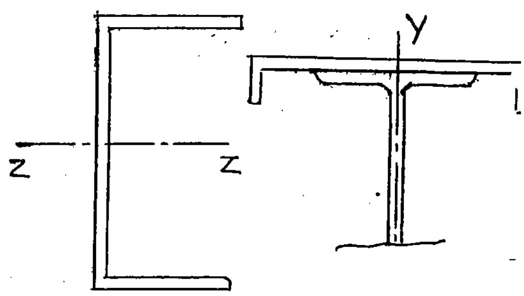




Gantry Girder (Lateral loads act on it due to sudden stopping or starting of trolley) ∴ ISWB is used

$I_{YY}(ISWB) > I_{YY}(ISLB/ISMB/ISHB)$

To increase I_{yy}, sometimes channel sections are also added to the flanges. ∴ I_{zz} of channel section will add to the I_{yy} of I section.



* ISHB is used for columns.

Sectional area & radius of gyration for ISHB are more compared to its counterparts

Critical load carrying capacity, $P_{cr} = \frac{\pi^2 EI}{l^2} = \frac{\pi^2 E A r^2}{l^2}$

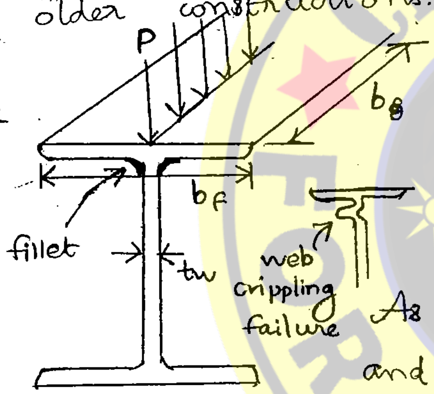
$$P_{cr} = \frac{\pi^2 EA}{(l/r)^2} = \frac{\pi^2 EA}{\lambda^2} \qquad \lambda = \frac{L}{r}$$

$$(P_{cr})_{zz} = \frac{\pi^2 EA}{(l/r_{zz})^2} \; ; \; (P_{cr})_{yy} = \frac{\pi^2 EA}{(l/r_{yy})^2}$$

$$r_{zz} = \sqrt{\frac{I_{zz}}{A}} \; ; \; r_{yy} = \sqrt{\frac{I_{yy}}{A}} \Rightarrow r_{zz} > r_{yy}.$$

$$(P_{cr})_{zz} > (P_{cr})_{yy}.$$

Columns are designed for $(P_{cr})_{yy}$ and failure will be along y-y axis. However, solid circular sections or hollow circular sections are most efficient column sections. So ISHB used in older constructions.

* 

For the flange, stress $= \dfrac{P}{b \times b_f}$.

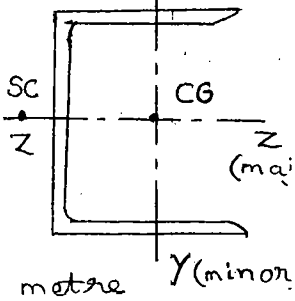
For the web, stress $= \dfrac{P}{b \times t_w}$

As $b_f > t_w$, stress conc. occurs in web.

and ∴ web crippling failure may occur.

∴ area is increased in fillets to avoid stress concentration.

→ Channel or C – Sections



- A channel section may be designated as

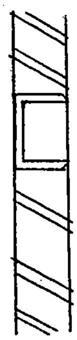
ISLC 350 @ 380.6 N/m

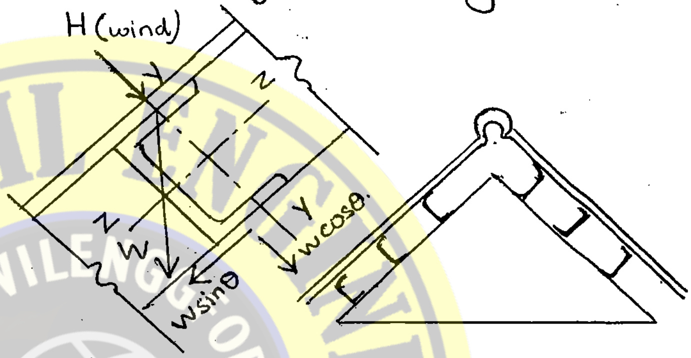
Depth of channel = 350 mm

Weight per running metre = 380.6 N/m (≈ 39.5 k[g])

* $(I_{zz})_{channel} < (I_{zz})_{I\text{-}section}$

∴ channel sections are used for light loadings like lintels, roof purlins.

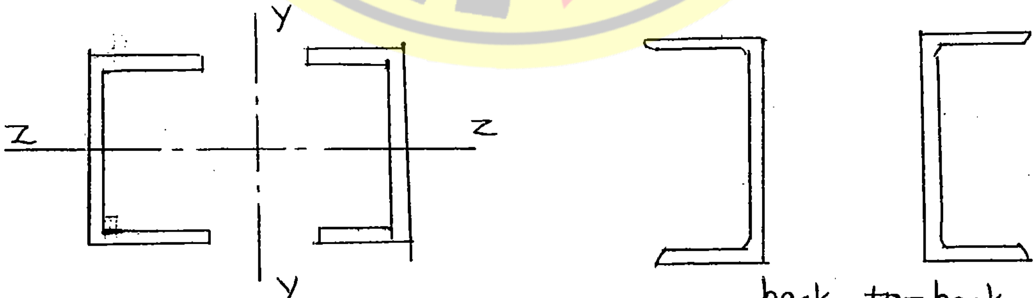




(H + Wcosθ) cause moment about major axis (Z-[Z])
Wsinθ cause moment about minor axis (y-y)

∴ channel sections are used for light loads as its more economical than I-sections

* Channel sections are also used as Built-up Column section[s]



face-to-face   back-to-back

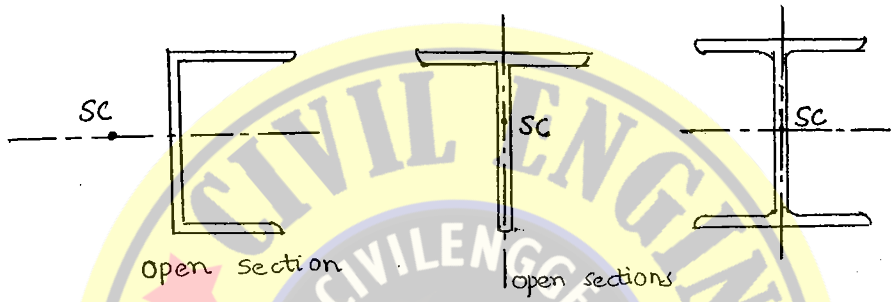
* Types of Channel Sections.

(i) ISJC – Indian Standard Junior Channels.
(ii) ISLC – Indian Standard Light Channels.
(iii) ISMC – Medium wt. channel with sloping fla[nges]
(iv) ISMCP – Medium wt. channel with parallel fla[nges]
(v) ISGC. – Gate Channels.

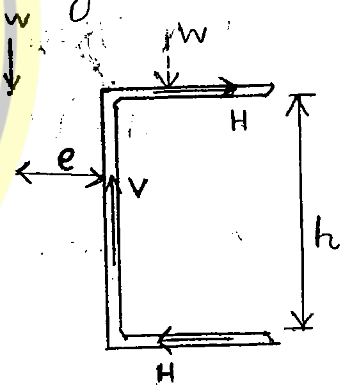
* SC is a point through which resultant transfer shear load must act if there is to be no twisting or torsion (section is subjected to BM only).

* If given member or section has axis of symmetry about both the principal axes, SC is coincident with CG of a section or member.

* If given section is symmetric about one axis, SC will be lying on axis of symmetry.

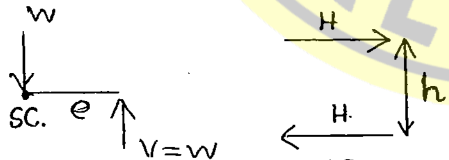


If load acts at a point different from SC, twisting moment occurs.



Shear stress, $q = \frac{VA\bar{y}}{I.b}$

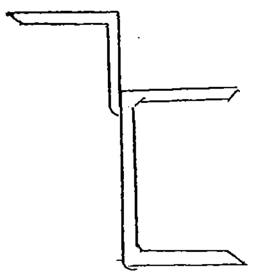
Shear flow, $Q = q.b = \frac{VA\bar{y}}{I}$



$M = We - Hh$

We (anti clockwise)   Hh (clockwise)

* If W acts through SC, the net moment will reduced.
* If W acts at a different point from SC, 'We' will be clockwise and Hh will also be. This will increase the net moment.

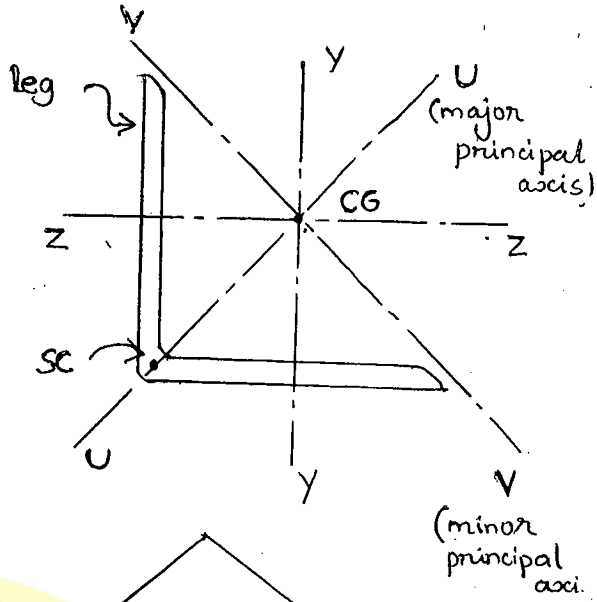


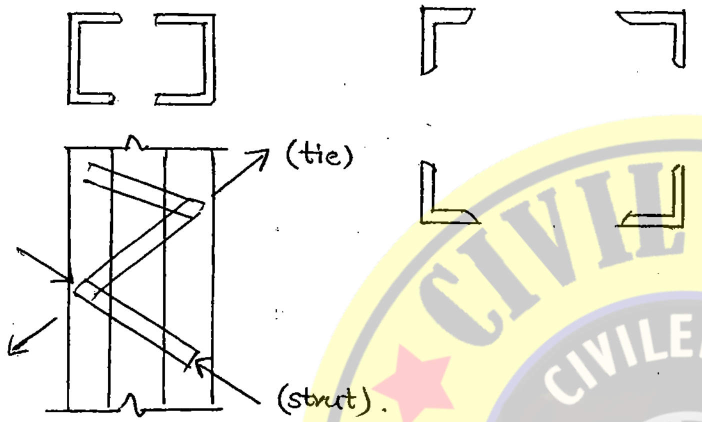
The purpose of angle section:

a) I_{zz} increases
b) I_{yy} increases $\Delta \propto \frac{1}{I}$
c) Deflection decreases
d) makes load pass through SC.

→ Angle Sections (or) L Section

* Angle sections are used as strut (compression) members or tie (tension) members in roof truss, built up colums, bracings etc.





* Three types of Angles.

(i) Equal Angles.

> Designated as ISEA or ISA.
> Eg: ISEA 100x100x10 .
> exccellent strut members

ISEA 100X100X10
$A = 1902\ mm^2$
$r_{vv} = 19.4\ mm.$

ISA 125X75X10.
$A = 1903\ mm^2$
$r_{vv} =$

rd Aug, TURDAY → Indian Standard Bars

(i) Indian Standard Round Bars.

Designated as ISRO 20

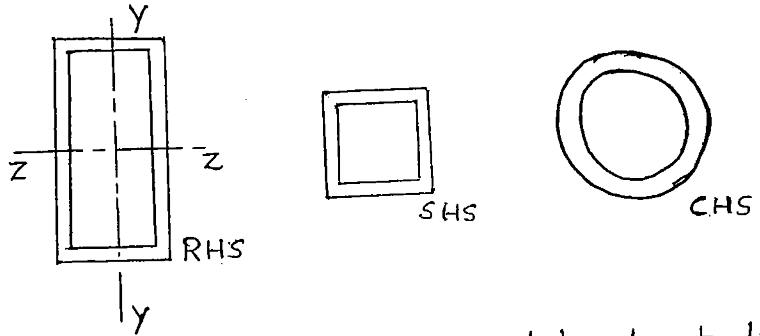
› rivets, bolts, welding rods.

(ii) Indian Standard Square Bars.

Designated as ISSQ 50

→ Indian Standard Tube Section.

(i) Rectangular Hollow Sections. (RHS)
(ii) Square Hollow Sections (SHS)
(iii) Circular Hollow Sections (CHS)



To withstand torsional loads, tubular sections are most efficient.

Polar moment of inertia, $I_p = I_{xx} = I_{zz} + I_{yy}$.

$$\frac{T}{J} = \frac{f_s}{r}$$

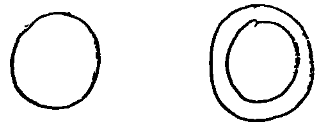
$$T = \frac{f_s}{r} \times J \qquad (J = I_p)$$

(I_{zz} & I_{yy} are very large for tubular section)

NOTE:

(i) The best section or economical section for column is Solid Circular section or hollow circular section.

(ii) For same weight (c/s area), hollow circular section will provide higher radius of gyration than solid circular section. Hence H.C.S will provide higher compressive strength than S.C.S.

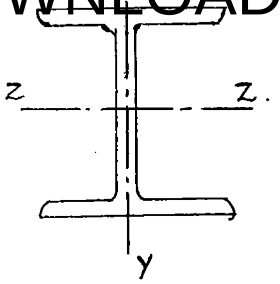


$r_{SCS} < r_{HCS}$.

$$P_{cr} = \frac{\pi^2 EI}{l^2} = \frac{\pi^2 E A r^2}{l^2}$$

$$\Rightarrow \underline{P_{cr} \propto r^2}$$

- For sections having symmetry about both the axes, bending will be about the axis of symmetry.
- For sections which are symmetric about only one axis, bending will be about the axis of symmetry or an axis normal to the axis of symmetry.



→ Indian Standard Plates (when $t \geq 5$ mm).

Designated as ISPL

Eg:- ISPL 2000 × 1000 × 10 mm.

Length L = 2000

Breadth B = 1000

Thickness t = 10

→ Indian Standard Sheets (when $t < 5$ mm)

Designated as ISSH

Eg: ISSH 1000 × 600 × 2 mm.

L = 1000

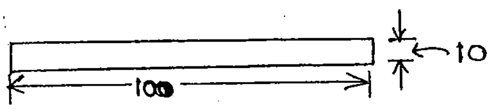
B = 600

t = 2

→ Indian Standard Flats. (when $t \geq 5$ mm)

Designated as. ISF.

Eg: 100 ISF 10



B = 100 mm

t = 10 mm