Design of steel structures:

(i) Steel is an alloy of iron and carbon (carbon content is around 0.23%)

(ii) As the carbon content increases, strength, hardness and brittleness will increase but ductility decreases.

Ductility:

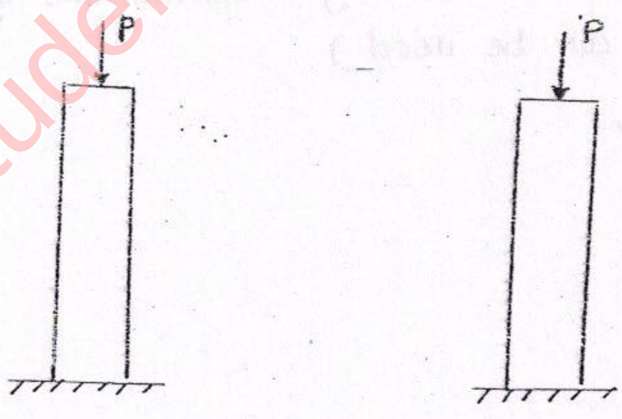
Ability of a material to elongate more beyond the elastic range or ability of material to be drawn into the wires.

Rubber is a brittle material because there is very little plastic deformation beyond elastic range.

(iii) Stainless steel is an alloy of iron and chromium.

(iv) Young's modulus E represents stiffness property of a material (because if E is more then δL - elongation will be less. i.e. it is a stiff material)

Example:



steel ($E_s = 2\times10^5\ N/mm^2$) rubber ($E_R = 2\ N/mm^2$)

$$\delta L = \frac{PL}{AE}$$

$$(\delta L)_{steel} <<< (\delta L)_{Rubber}$$

(v) $E_{Aluminium} = 70 \text{ GPa}$

$E_{steel} = 200 \text{ GPa}$

i.e. $$E_{Aluminium} \simeq \frac{E_{steel}}{3}$$

(vi) $1 \text{ Pa} = 1 \text{ N/m}^2$

$1 \text{ MPa} = 10^6 \text{ N/m}^2$

$$= 10^6 \frac{N}{(1000 \text{ mm})^2}$$

$1 \text{ MPa} = 1 \text{ N/mm}^2$

$1 \text{ GPa} = 10^9 \text{ N/m}^2$

$= 10^3 \text{ N/mm}^2$

(vii) The disadvantage of Aluminium is that the deformations are high for a given load (because $E_{Aluminium} \simeq \frac{E_{steel}}{3}$) again aluminium is also costlier than steel.

(viii) The advantage of aluminium is that it requires less maintenance (where high deformations are acceptable Aluminium can be used.)

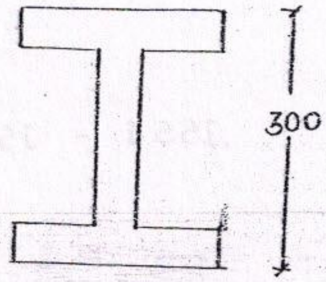
Standard structural steel sections:

(structural – made up of mild steel)

(1) Beam sections:

ISLB 300 @ 0.41 kN/m

(Indian Standard Light Beams)

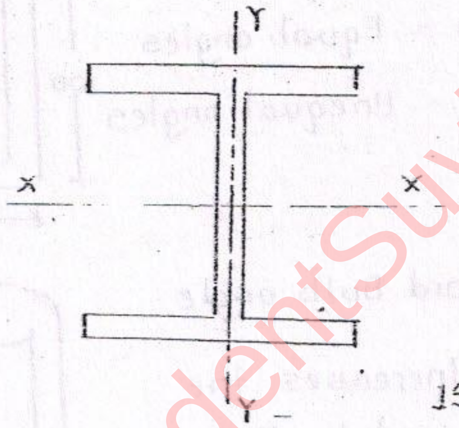


......

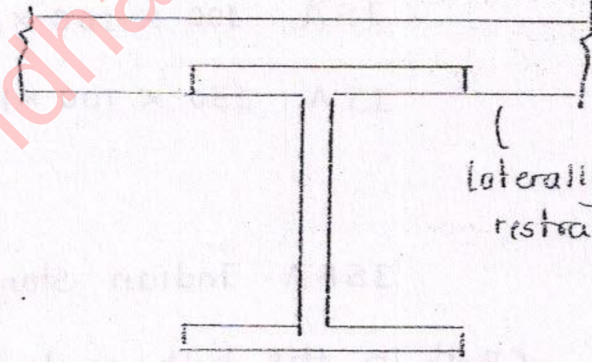
(i) ISLB are used as roof beams where loads are relatively less.

(ii) ISMB are used as floor beams

$I_{xx} >> I_{yy}$



ISMB

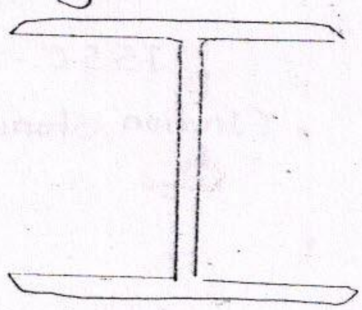


ISMB have high Moment of inertia about X-X when compared with Y axis. So the lateral buckling of beam takes place. This adisadvantange can be removed by restraining the compression flange of beam.

(iii) ISWB are used as columns. They have high M.I. about Y-axis also. so they have high lateral buckling strength.

ISWB → Wide flange

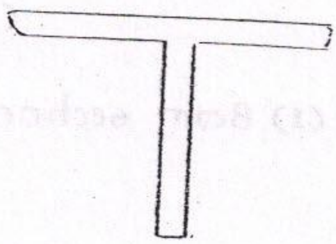
ISMB → Medium flange



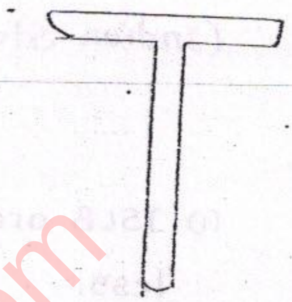
ISWB

(2) T- sections:

ISHT - I.S. wide flange T- section



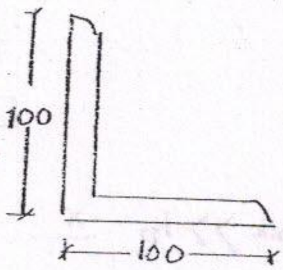
ISST - IS long legged T-section



(3) Angles.

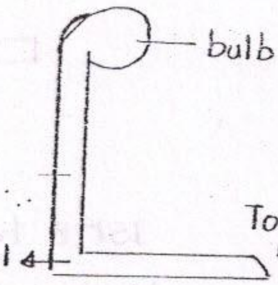
ISA 100 × 100 × 10 - Equal angles

ISA 150 × 100 × 10 - Unequal angles



ISBA - Indian Standard Bulb angle

(Bulb in the bulb angles Increases the stiffness of angles. It is used in the "Ship buildings)



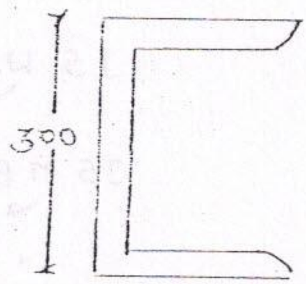
(4) Channel sections:

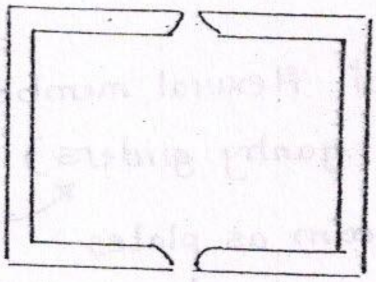
(i) They are used as Purlins, columns etc.

(ii) Purlin is the beam in roof truss which supports the roof covering material.

ISSC - 300

(Indian Standard Special Channel)





Box-section (used as column)

(5) Flats :

(Used as lacing or battening members) or stiffners.

50 ISF 8

width of flat ↗ ← thickness of flat

ISSH - Indian standard sheets

ISPL - Indian standard plates (Gusset plate, Base plate)

ISRO - Indian standard round bars (e.g. ISRO 10 ← dia 10mm)

ISSQ - Indian standard square bars (e.g. ISSQ 10 ← 10mm)

Permissible stresses in steel structures:

(Working stress method)

(i) Maximum permissible axial compressive stress = σ_{ac}

$= 0.6 f_y$.

(Used in the design of columns & struts)

columns ↗ compression member in frames

struts ↖ compression member in truss.

(ii) Maximum permissible axial tensile stress = σ_{at}

$= 0.6 f_y$

(Used in the design of tension members and ties)

ties ↙ tension members in roof trusses

(iii) Maximum permissible bending compressive stress = σ_{bc}

$= 0.66 f_y$

(Used in the design of flexural members like beams, purlins, plate girders, gantry girders)

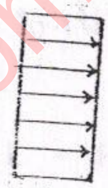
beam in supporting roof covering — beam as plates are used — beams supporting cranes.

(iv) Maximum permissible bending tensile stress = σ_{bt}

$= 0.66 f_y$

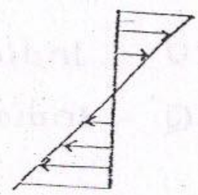
∴ Direct compression :

$$\sigma_{cc} = \frac{f_{ck}}{4} = 0.25 f_{ck}$$



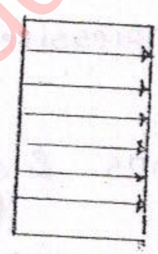
Bending compression :

$$\sigma_{cbc} = \frac{f_{ck}}{3} = 0.33 f_{ck}$$



(v) Maximum permissible average shear stress = τ_{vavg}.

$= 0.4 f_y$.

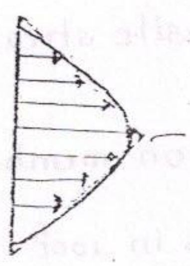


τ_{va} = avg. shear stress

$$= \frac{V}{bd}$$

(vi) Maximum permissible maximum shear stress = $\tau_{v\,max}$

$= 0.45 f_y$.



$$\tau_{v\,max} = 1.5\, q_{avg}$$

$$= 1.5 \left(\frac{V}{bd}\right)$$

(vii) Maximum permissible bearing stress = σ

$= 0.75 f_y$.

(used in design of slab base etc.)

Factors of safety for different stresses:

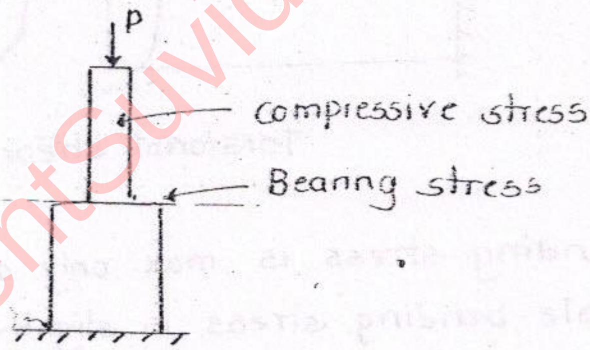
(i) F.O.S. for axial compressive stress $= \frac{f_y}{f} = \frac{f_y}{0.6 f_y} = 1.67$.

(ii) F.O.S. for bending compressive stress $= \frac{f_y}{f} = \frac{f_y}{0.66 f_y} = 1.5$

(iii) F.O.S. for shear stress $= \frac{f_y}{f} = \frac{f_y}{0.4 f_y} = 2.5$

Note:

(i) Bearing stress:

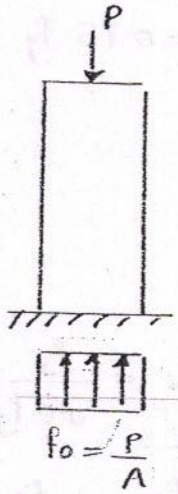


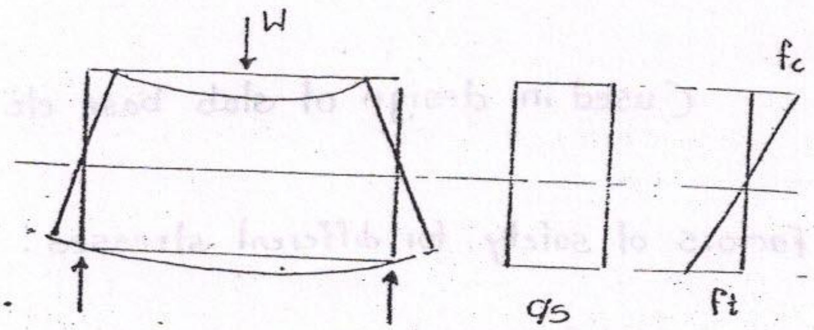
It is nothing but the compressive stress developed at the contact surface of two different material.

(ii) Ductile materials like mild steel are very weak in shear. So permissible shear stress is very less.

(iii) Stresses

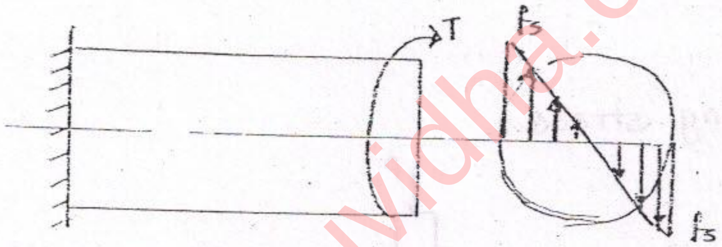
- Direct stress
  - Direct tensile
  - Direct compressive
  - Direct shear
- Indirect stress
  - Bending stress
  - Torsional shear stress





Bending stress is developed indirectly

Direct compressive stress is developed due to direct application of load



Torsional shear stress.

(iv) Since bending stress is max. only at extreme fibres, the permissible bending stress is slightly more than permissible axial compressive stress

(v) Hoop's stress:

Hoop is a small pin used to connect wooden planks to form cylinders. Stresses developed in these Hoop's are called Hoop's stresses.

The nature of Hoop stress is tensile or compresive depending on the pressure acting inside the cylinder or outside the cylinder.

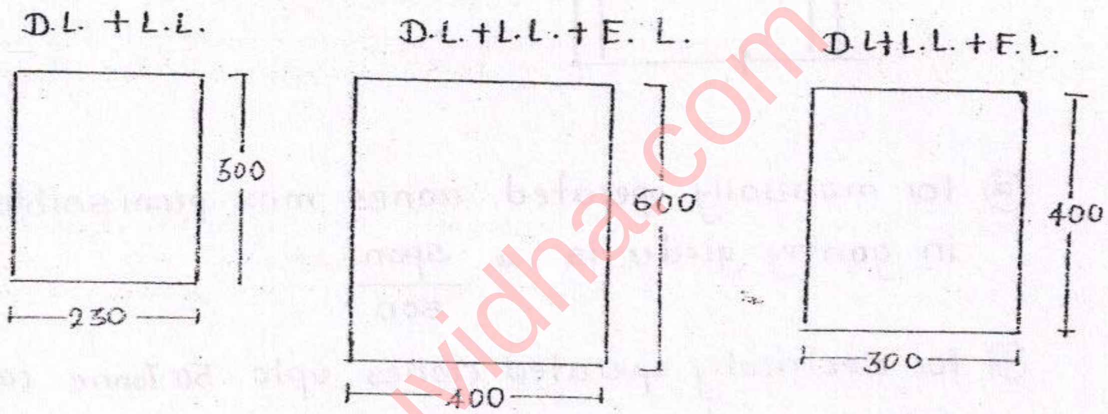
(vi) Column is compression member used in frames. It can be subjected to B.M. also. Strut is a compression member used in trusses. It can only be subjected to compression and B.M. is zero in strut.

Increase of permissible stresses:

(i) When wind and Earthquake loads are considered, the permissible stresses in steel structure are increased by 33.33 %.

(ii) When wind and Earthquake loads are considered, the permissible stresses in connections (rivets and welds) are increased by 25 %.

Example:



Without increase in stress

with increase in permissible stress

Permissible deflections:

(from stiffness consideration)

(i) Maximum permissible horizontal and vertical deflection

$$= \frac{span}{325} \quad \text{(in W.S.M.)}$$

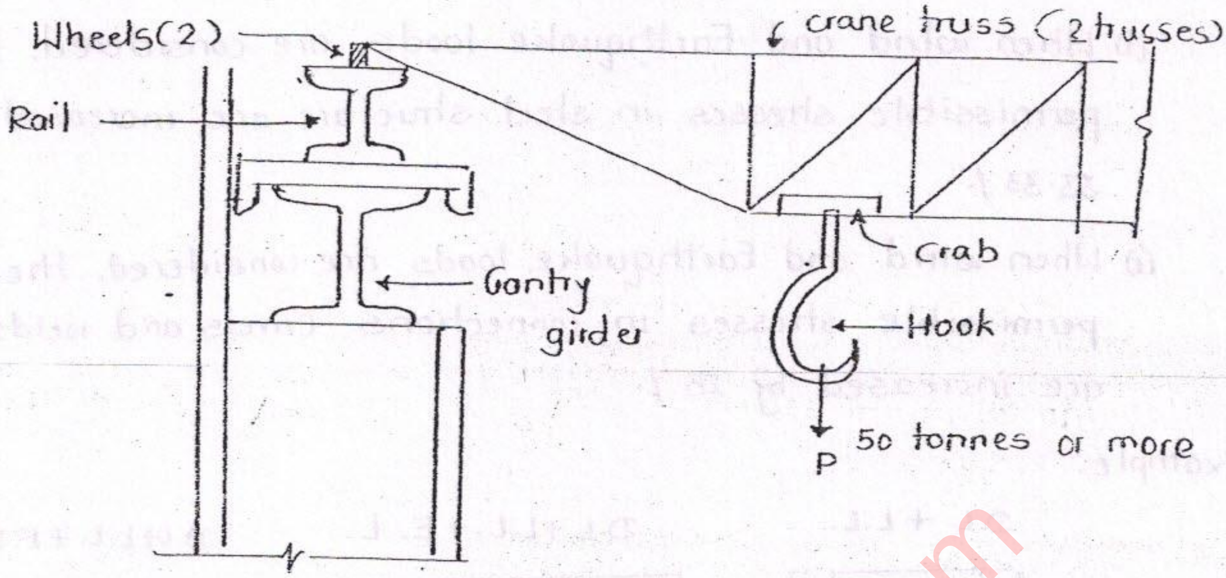
(ii) Maximum permissible deflection $= \frac{span}{300}$ (in L.S.M.)

(if supported elements are not susceptible to cracking)

$$= \frac{span}{360} \quad \text{(in L.S.M.)}$$

(if supported elements are susceptible to cracking)

(iii) Gantry girders.



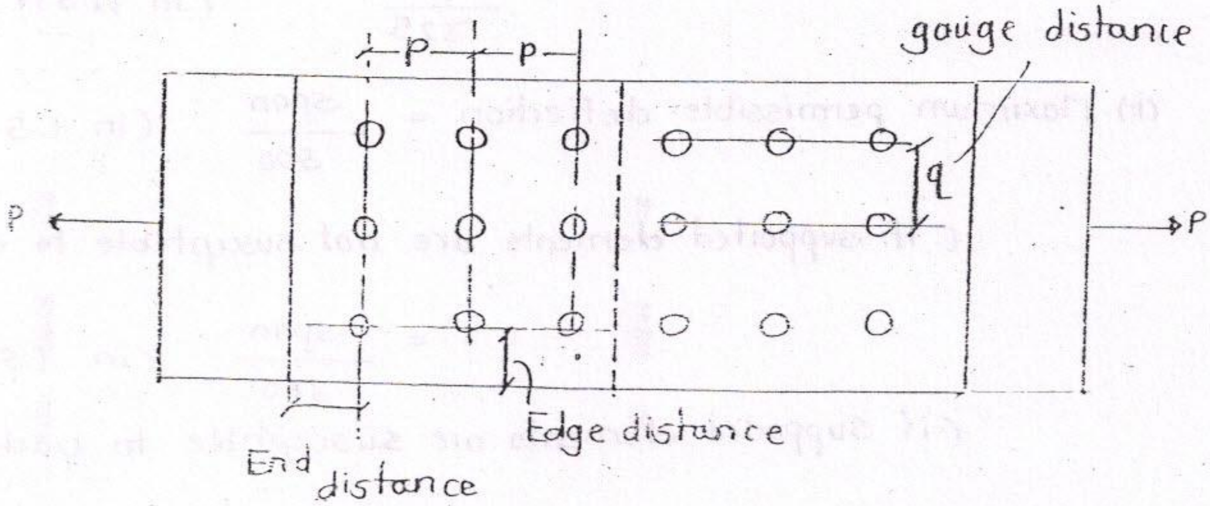
ⓐ For manually operated cranes max. permissible deflection in gantry girder is $= \frac{\text{span}}{500}$

ⓑ For electrically operated cranes upto 50 Tonne capacity, max. deflection is $= \frac{\text{span}}{750}$

ⓒ For electrically operated cranes more than 50 tonne. the max. deflection is $= \frac{\text{span}}{1000}$

Note:

(i) Pitch of a rivet (p)



The distance between two consecutive rivets measured parallel to the force direction is called pitch of rivets (p)

(ii) Gouge distance (q)

It is distance between two consequtive rivets which is measured perpendicular to the direction of force

(iii) End distance:

It is distance between centre of rivet and edge of the plate element, measured parallel to direction of force.

(iv) Edge distance:

It is distance between centre of rivet and edge of the plate element, measured perpendicular to direction of force.

Types of joints:

(1) Lap joints:

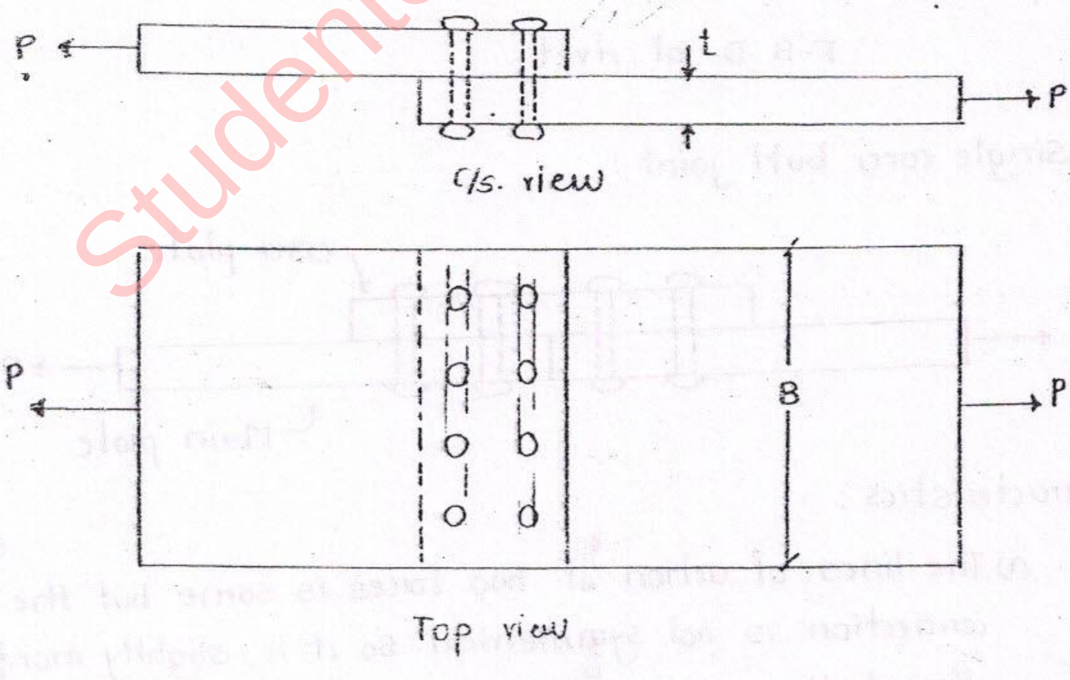


Fig. Lap joint