SUMMER -2017 EXAMINATION

Model Answer

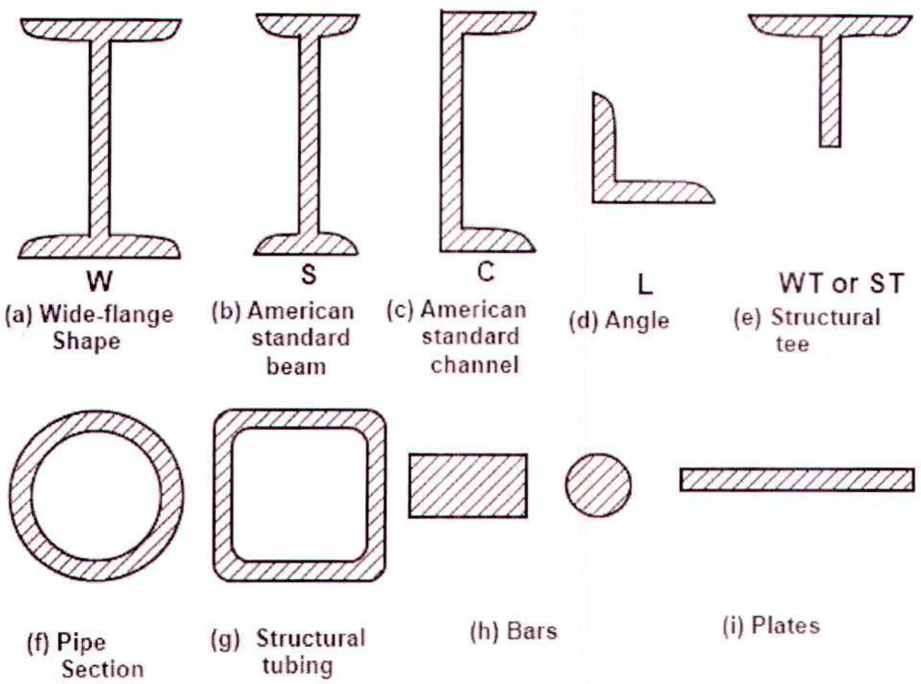
Subject code: 17505 Subject : (Design of Steel Structure)

Important Instructions to examiners:

1) The answer should be examined by keywords and not as word-to- word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language error such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and communication skill).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figure drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In the some cases, the assumed constants values may vary and there may be some difference in the candidates answer and model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidates understanding

Que.	Model Answer	Marks
Q. 1 (A)	**Attempt any Three**	**12 M**
a)	**State six advantages and two disadvantages of steel as a construction material**	
	Advantages of Steel as a construction material:- i) Mechanical Properties :-Steel as a good mechanical properties such as ductile ,malleability, Elastic Plasticity ii) Large span :-Steel is very useful for large span bridges ,Industrial structures .towers iii) Fabrication:- Steel is easy to fabricate at desired shape and size ,It can be easily joined iv) Earthquake Resistance :- Steel as construction material has good earthquake resistant capacity due to its ductility and elastic Plasticity v) Force Resistance:-Steel can be easily resistance tensile, Compressive , shear bending , torsional forces vi) Scrap Value:-Steel scrap value is considerable vii) Reuse :- Steel as construction material can be recycled easily . viii)Gas Resistance :- Steel is a gas resistance	**3 M Any six (½ M each)**

	Disadvantages of Steel as a construction material:- i) Cost:- Steel is very costly material ii) Corrosion:- Steel is susceptible to corrosion and it requires maintenance. iii) Skilled labours For construction of steel structure it required skilled labor iv) Maintenance:- The cost of the Maintenance of steel structure is comparatively high	**1M Any two (½ M for each)**
b)	**Explain the limit states of serviceability applicable to steel structure**	
	Limit states of serviceability applicable to steel structure- The acceptable limit for the safety and serviceability of the structure before failure occur is called as Limit State. To assure the serviceability of structure throughout its lifetime. It is related to the satisfactory performance of the structure at working load . The following limit state of serviceability is considered. i) Deflection and deformation Which may adversely affect the effective use of the structure or may cause improper functioning of equipment or services or may cause damages to finishes and non structural members ii) Corrosion durability iii) Repairable damage or crack due to the fatigue iv) Fire	**1 M** **3 M**
c)	**State types of loads to be considered while designing of steel structure And with respective IS codes**	
	Types of loads to be considered while designing of steel structure And with respective IS codes **i) Dead Load – (IS 875 : 1987Part I)** It include the weight of all permanent construction for extra weight of roof floors column, beams, finishing, material etc unit wt of building material **ii) Imposed load or live load – (IS 875 : 1987Part II)** The loads which keeps on changing from time to time are collect as live load **iii) Snow Load – (IS 875 : 1984 Part IV)** Specifies the snow loads on roofs of building .It is considered for the area where snowfall is possible. **iv) Impact load – (IS 875 : 1987Part V)** Gives specification for impact load due to a) Vehicle	**Any 4 (one mark for each)**

	b) Dropped object c) Crane failure d) Flying fragment **v) Seismic Forces – (IS 1893 :2002)** Earthquake shocks cause movement of foundation and due to inertia forces; additional loads are developed on the structure. The vibration caused by earthquake is resolved into three mutually perpendicular directions. The behavior of the structure is the function of foundation, soil size, duration, shape of construction and Intensity of Earthquake forces.	
d)	**Enlist four types of section used as tension member along with sketches**	
	Types of section used as tension member with sketch  **(*Note- if any four sections drawn credit is given to students accordingly)**	**Any 4 (one mark for each)**
B)	**Attempt any ONE**	**6M**
a)	**Design the lap joint for the plates of sizes 100 x 12 mm and 1100 x 8 mm thick connected, so as to transmit a factored load of 80 kN of 16 mm dia bolts of grade 4.6 and plates of 410 grade**	

	Given : **t = 8 mm** **Pu = 80 KN** **d= 16 mm** **d0 = 18 mm** **fub =400 N/mm²** **fu = 410 N/mm²** Solution :- i) To calculate nominal shear strength of bolt = **Vnsb = fub /√3 (nn Anb + ns Asb)**	**1 M**
	Anb = 0.78 x Ag = $0.78 \times \Pi /4 \times 16^2$ $=156.82\ mm^2$ Vnsb = 400/√3 (1x 156.82) = **<u>36..21 kN</u>**	**1 M**
	ii)To calculate design of shear strength of bolt :- Vdsb = Vnsb/1.25 = 36.21 /1.25 =28.97 kN Bolt Value Bv =**<u>28.97 kN</u>**	**1 M**
	iii) To calculate no of bolt = $\frac{\text{Factored Load}}{\text{Bolt Value}}$ $= \frac{80}{28.97}$ = 2.85 = **<u>3 Nos</u>**	**1 M**
	. iv)To calculate Pitch (p) $Tdn = \frac{0.9\ fu\ (P - d_0)\ t}{\gamma m_b}$ $28.97 \times 1000 = \frac{0.9 \times 410\ (P - 18) \times 8}{1.25}$ P = 30.267 mm . . But P min = 2.5 x d = 2.5 x 16 = **<u>40 mm</u>**	**1 M**
	v)To calculate nominal bearing strength of bolt:- Vnpb = 2.5 Kb * d * t *fu $e = 1.5 * d_0 = 1.5 * 18 = 27$ $Kb_1 = e / 3 d_0 = 0.5$ $Kb_2 = (p / 3 d_0) - 0.25 = 0.490$ $Kb_3 = fub / fu = 0.97$ $Kb_4 = 1$ Whichever is minimum value of Kb = 0.49	**1 M**

	$V_{npb} = 2.5\ K_b * d * t * f_u$ $= 2.5 * .49*16 * 8 * 410$ $=$ **<u>64.28 kN</u>** iv) To calculate design bearing strength of bolt $V_{dpb} = V_{npb} / \gamma m_0$ $= 64.28\ /\ 1.25$ $=$ **<u>57.43 kN</u>**	**1M** **1M**
Q.1 B (b)	**The longer leg of a single angle 100 x 75 x 8 mm is connected to the gusset plate with 3 bolts in a line of 20 mm dia at a pitch of 60 mm , for this tension member. Determine block shear strength**	
	Given : **ISA = 100 x 75 x 8 mm** **d= 20 mm** **d0 = 22 mm** **P = 60 mm , 3 Bolts in a line of 20 mm dia** **End distance e = 2d = 2 x 20 = 40 mm** Solution :- $L_v = (60 + 60 + 40) = 160$ mm Assum $L_t = 40$ mm 1) $A_{tg} = (L_t \times t)$ $= 40 \times 8 = 320\ mm^2$ 2) $A_{tn} = (L_t - 0.5\ d_0) \times t$ $= 232\ mm^2$ 2) $A_{vg} = (L_v \times t)$ $= (160 \times 10) = 1280\ mm^2$ 3) $A_{vn} = (L_v - 2.5\ d_0) \times t$ $= (160-2.5 \times 22) \times 8$ $= 840\ mm^2$ **To calculate Block shear strength** $T_{db1} = \dfrac{A_{vg} \times f_y}{\sqrt{3} \times \gamma m_0} + \dfrac{0.9 \times A_{tn} \times f_u}{\gamma m_1}$ $\gamma m_0 = 1.10$ $\gamma m_1 = 1.25$ fub =400 n/mm^2 fu = 410 n/mm^2 $T_{db1} = \dfrac{1280 \times 250}{\sqrt{3} \times 1.10} + \dfrac{0.9 \times 232 \times 410}{1.25}$ $= 236.43$ kN	½ M ½ M ½ M ½ M **2 M**

	Tdb2 $= \dfrac{0.9\ Avn \times fu}{\sqrt{3} \times \gamma m_1} + \dfrac{Atg \times fy}{\gamma m_0}$ $= \dfrac{0.9 \times 840 \times 410}{\sqrt{3} \times 1.25} + \dfrac{232 \times 250}{1.10}$ = **195..88 kN** **Block shear strength of member is 195..88** kN	2 M
Q.2	**Attempt any TWO of the following**	**16 M**
a)	**A lap joint consists of two plates 180 x 10 mm connected by means of 20 mm dia bolts of grade 4.6 . All bolts are in one line . Calculate strength of single bolt and no. of bolts to be provided.**	

Given

t = 10 mm

d= 20 mm

d0 = 22 mm

fub =400 N/mm^2

fu = 410 N/mm^2

Solution :-

i) To calculate nominal shear strength of bolt =

Vnsb = fub /√3 (nn Anb + ns Asb) ½ M

Anb = 0.78 x Ag

= 0.78 x Π /4 x 20 ^{2}

=245 mm^2

1 M

Vnsb = 400/√3 (1x 245) = **56.58 kN**

ii) To calculate design of shear strength of bolt :-

Vdsb = Vnsb/1.25

= 56.58 /1.25

= **45.26 kN**

1 M

iii) To calculate nominal bearing strength of bolt:-

Vnpb = 2.5 Kb * d * t *fu

P = 2.5 x d = 2.5 x 20 = 50 mm

e = 1.5 * d_0 = 1.5 * 22= 33

$$\left.\begin{array}{l} Kb_1 = e / 3\ d_0 = 0.5 \\ Kb_2 = (p / 3\ d_0) - 0.25 = 0.5 \\ Kb_3 = fub / fu = 0.97 \\ Kb_4 = 1 \end{array}\right\}$$ 1 M

Whichever is minimum value of K b = 0.50

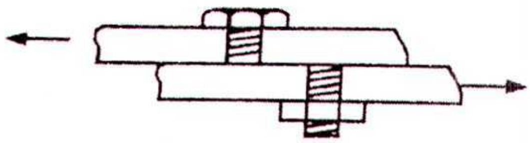
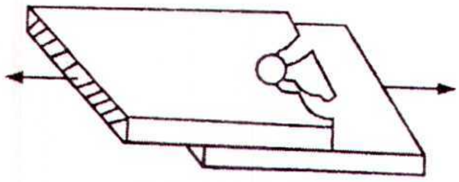
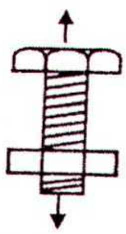
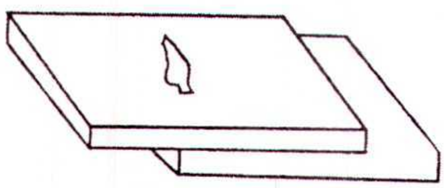
	$Vnpb = 2.5\ Kb * d * t * fu$ $= 2.5 * 0.5 * 20 * 10 * 410$ $=$ **<u>102.50 kN</u>**	**1 M**
	iv) To calculate design bearing strength of bolt $Vdpb = Vnpb / \gamma m_b$ $= 102.50 / 1.25$ $=$ **<u>82 kN</u>**	**1 M**
	Bolt Value = Minimum strength of shearing and bearing strength of bolt B v = 45.26 kN To calculate no.of bolt = $\frac{\text{Full strength of bolt}}{\text{Bolt Value}}$	**½ M**
	Full strength of bolt = $(0.9\ fu / \gamma m_b) *$ Area of plate Area of plate $= (180 - 22) \times 10$ $= 1580\ mm^2$ Full strength of bolt = $(0.9 \times 410 / 1.25) * 1580$ = **<u>466.416 KN</u>**	**1 M**
	No of Bolt $= \frac{466.416}{45.26}$ $= 10.30$ $=$ **<u>11 Nos</u>**	**1 M**
b)	**A discontinuous compression member consists of @ISA 90 x 90 x 10 mm connected back to back on opposite sides of 10 m thick gusset plate. Tacking rivets are provided along the length with one bolt at each end .Determine the design compressive strength og the member. The centre to centre distance of connection is 2.8 m For single ISA 90 x 90x 10 mm,** **$A = 1703\ mm^2$ $rx = 27.3$ $Cx = Cy = 25.9$ $I x = Iy\ 12.67 \times 10^5\ mm^4$**	

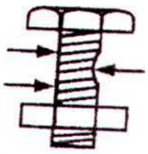
KL/γ	80	90	100	110	120	130
Fcd (Mpa)	136	121	107	94.6	83.7	74.4

	Given **ISA 90 x 90 x 10 mm** **A = 1703 mm^2** **rxx = 27.03 mm** **L = 2800 mm** **cx = cy = 25.9 mm** **I_{XX} =Iyy = 12.67 x 10 ^{5} mm ^{4}** **Solution :-** 1) r min = 27.03 mm 2) L eff = 0.85 x 2800 = 2380 mm 3) $\lambda = \frac{L\ eff}{rmin} = \frac{2380}{27.03}$ $= \underline{\mathbf{87.17}}$ 4) $\lambda 1 = 80$ fcd1 = 136 $\lambda 2 = 90$ fcd 2 = 121 To calculate the Fcd for λ by interpolation 5) Fcd = 125.240 **N/mm^2** **6) Design Strength** Pd = fcd x Ag Pd = fcd x Ag = 125.24 x 2 A = 125.24 x 2 x 1703 = **<u>426.56 kN</u>**	**1 M** **1 M** **1 M** **2M** **2 M** **1 M**
c)	**An ISMB 400 @ 6043 N/m is used as a simply supported beam for 3 m span . The compression flange of beam is laterally through out the span . Determine design flexural strength of member . Also calculate working u.d.l. the beam can carry per m span** **Take Zp=1176.18 x 10 ^{3} mm ^{3} $\gamma m_0 = 1.1$,βb = 1 fy = 250 N/mm^2**	
	Given : **ISMB 400 wt 6043 N/m** **L = 3000 mm** **Zp 1176.18 x 10 ^{3} mm ^{3}** **γm_0 = 1.1** **βb = 1** **fy = 250 N/mm^2**	

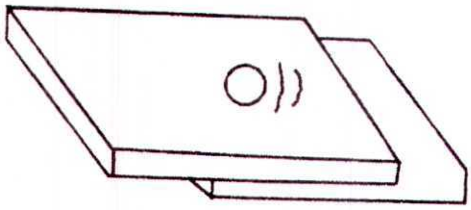
	Solution :- Assuming UDL = w kN/m 1) To calculate the design flexural strength Md = $$Md = \frac{\beta b \times Zp \times fy}{\gamma m_0} = \frac{1 \times 1176.18 \times 10^3}{1.10}$$ $$= \underline{\mathbf{267.27 \times 10^6 \ kN\text{-}m}}$$	**4 M**
	2. $Mu = \frac{w\, l^2}{8}$ $= \frac{w \times 3^2}{8} = 1.125\ w\ \ kNm$ Md = Mu $267.27 \times 10^6 = 1.125\ w$ **w = 237.57 kN/m**	**4M**

P.T.O.

Question and sub Question	Model Answer	Marks
Q.3	Attempt any **FOUR**	**16 Marks**
a)	**Explain any two types of failure of bolted joint along with drawing of respective sketches.** **i) Shear failure – shear failure of bolt or tearing failure of plate.**	Any Two. (Two marks each)
	Plates bolted together and subjected to tensile load may result in the shearing of bolts. In case of lap joint when the shearing of bolt occurs at one cross section, same is refered as single shear failure. If it occurs at two cross sections, as in case of butt joint with two cover plates, it is called as double shear failure. When the strength of the plate is less than the shearing strength of bolt, the tearing failure of plate may occur. To avoid this type of failure minimum edge distance shall be provided.	1 Mark
	 *Shear failure of bolt*  *Shear failure of plate*	1Mark
	ii) Tension failure – Tension failure of bolt or tension failure of plate. The bolt subjected to tensile force fails if factored tensile force is greater than the tensile capacity of the bolt. The tensile capacity depends upon the tensile strength of the bolt and minimum cross sectional area of the threaded length of the bolt. When the tensile strength of plate is less than tensile force acting on the plate then the plate will fails in tension.	1 Mark
	 *Tensile failure of bolt*  *Tensile failure of plate*	1 Mark
	iii) Bearing Failure – Bearing failure of bolt or bearing failure of plate. Normally the bolt material is of much higher strength than that of steel plate through which the bolt passes. As a result bearing failure takes place in the plate material. The bolt may deform due to high local bearing stresses between the bolt and the plate.	1 Mark



Bearing failure of bolt



Bearing failure of plate

1 Mark

b) **State two advantages of welded joints and two disadvantages of bolted joints.**

Advantages of welded Joints-

i) As no holes are required for welding, the gross sectional area of member is effective, hence more effective in taking loads.
ii) Welded joints provides rigidity and strength
iii) Welded structures are comparatively lighter than same type of bolted structures.
iv) A welded joint has a better finish and appearance.
v) No noise is produced in welding process as in case of bolting process.
vi) Welded joints are often economical as less labour and material are required for a joint.
vii) The welding process offers an airtight and water tight joint hence used in fluid retaining structures.
viii) Welding process is quick and saves time of construction and requires less working space.

Any Two for Two marks

Disadvantages of bolted joints-

i) In bolted joints holes are required in the members hence reduces gross cross sectional area of member.
ii) Lot of noise is produced in bolting process.
iii) Skilled labour and material required is more as compared to welded joints.
iv) Bolted connection is not useful in fluid retaining structures.
v) The overall weight of structures is increased due to weight of bolts.

Any Two for Two marks

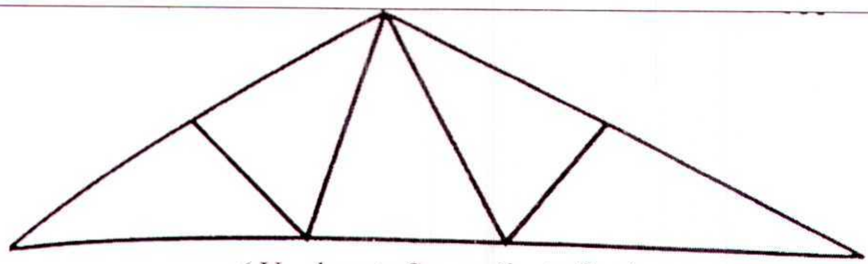
c) **Draw neat sketch of PRATT and FINK type trusses. Mark panel, panel point, rafter and tie in any one truss.**

(Used up to Spans 6m to 30m)

Pratt truss

2 Mark

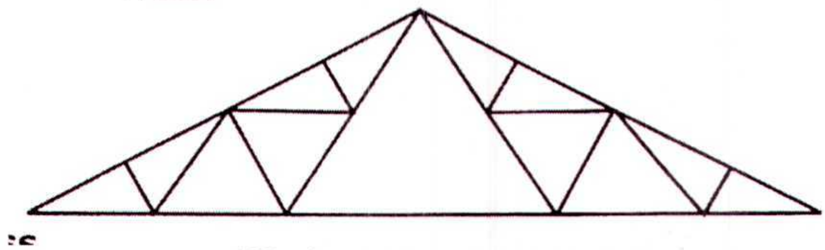
2 Marks



(Used up to Spans 6m to 9m)

Fink truss

OR



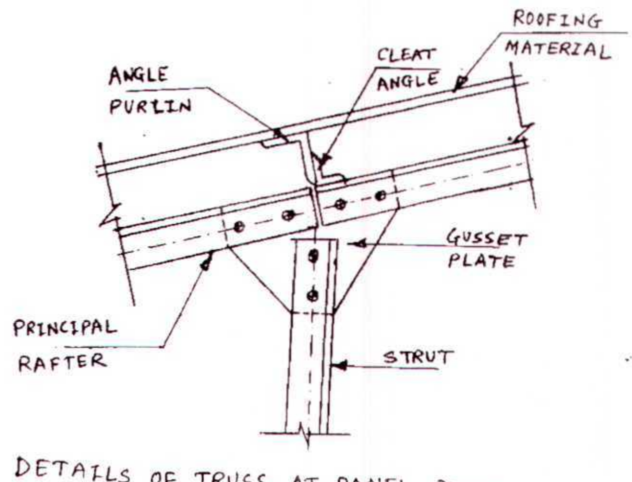
(Used up to Spans 6m to 20m)

Compound fink truss

OR

2 Marks

d) **Draw neat sketches connection of an angle purlin with principal rafter at panel point.**



DETAILS OF TRUSS AT PANEL POINT

e) **Write any four selection criteria of type of roof truss.**

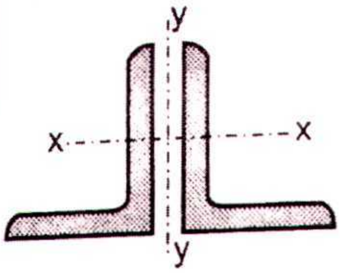
1. Climatic condition -: Rainfall, snowfall, drainage required (Affects pitch of roof)
2. Type of roof covering-: Galvanised iron or asbestos cement sheeting. It affects pitch of truss.
3. Span-: As per required span, the selection of type of truss depends.
4. Asthetic view-: from asthetic point of view the truss is to be selected.
5. Transportation-: Feasibility of transportation of truss depends upon the depth and span of the truss.
6. Purpose of the structure-: depending upon purpose and utility of structure type of truss is selected.

Any four for Four marks.

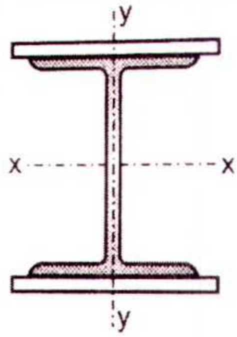
Q.4 (A) Attempt any **THREE** — **12Marks**

i) Draw and Label any four form of built up compression member.

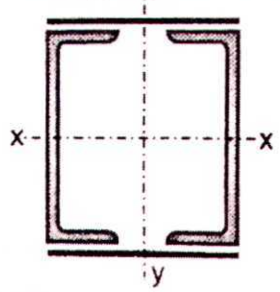
Any four for one mark each.



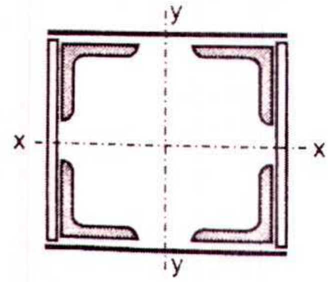
i)Two angles back to back



ii) I section with two plates on flanges



iii) Two channels placed toe to toe



iv)Four angles placed toe to toe with two plate

if any other four built up sections drawn credit is given to students accordingly

ii) Define radius of gyration and slenderness ratio. Also state maximum values of slenderness ratio for any two condition of compression member.

Answer-

Radius of Gyration (K)-The radius of gyration of a given area about a given axis is that distance from the given axis at which all elemental areas of given area should have to be placed so as not alter the moment of ineria about given axis. OR

It is the square root of ratio of moment of inertia to the cross sectional area. — 1 Mark

Slenderness Ratio (λ) - It is the ratio of effective length of column to its least radius of gyration. — 1 Mark

$\lambda = L_{eff}/r_{min}$

Maximum values of slenderness ratios.

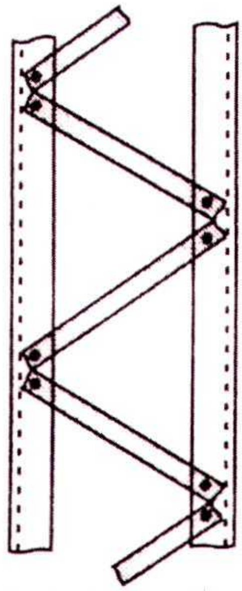
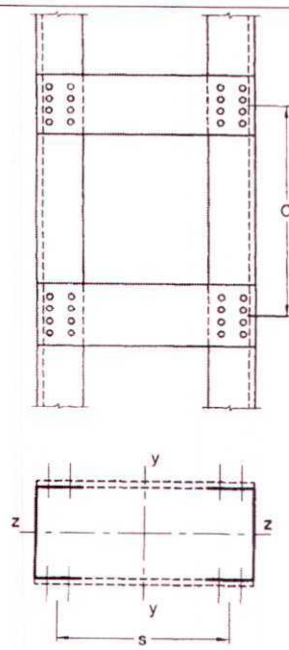
Type of member	**Maximum slenderness Ratio**
i) A member carrying compressive load resulting from dead loads and imposed loads	180
ii)A member subjected to compressive forces resulting from wind or earthquake forces.	250

2 Mark

iii) State the functions of lacing and battening. Draw neat sketches of single lacing and battening.

Answer-

Function of lacing and battening -Function of lacing and battening is to hold the main components of the members of built up section in their respective positions and equalize the stresses in them. — 1 Mark

		 i) Single lacing System  ii) Battening system	one and half Mark for each sketch
	iv)	**State IS requirements of lacing to be used.** **Answer-** **IS requirements of Lacing-** a) Radius of gyration about axis of cross section perpendicular to plane of lacing should not be less than radius of gyration about the axis parallel to plane of lacing. b) Lacing system shall be uniform throughout the length of column i.e. inclination of lacing flat with axis of column should be equal on its either side. Cross section should be uniform for all lacing flats. c) Lacing system should not be combined with tie plates except at the end of column. d) Effective slenderness ratio of laced column shall be taken as 1.05 times actual maximum slenderness ratio in order to account for shear deformation. e) Width of lacing flat shall be three times nomial diameter of bolt/rivet. This is to provide edge distance = 1.5d from the centre of bolt. f) Thickness of lacing flat shall not be less than 1/40 times effective length for single lacing system and 1/60 times for double lacing system. g) Angle of inclination for lacing bar with axis of column must not be less than 40^0 nor it should be more than 70^0. h) Maximum slenderness ratio of single main member over two consecutive connections of lacing flat should not be greater than 50 or 0.7 times the maximum slenderness ratio of member as a whole, whichever is less. i) Lacing flats to be designed for transverse shear V_t = 2.5% of axial force in member and it shall be divided equally among all lacing parallel planes. j) Slenderness ratio of lacing flat shall not exceed 145. Effective length in case of single lacing is length measured between inner ends of weld or rivet/bolt.	Any four for one mark each.

Q. 4(B)	Attempt any **ONE**	**6 Marks**
i)	**Explain gross yielding and net section rupture in case of design strength of tension member. Also write two measures to be taken to prevent rupture.** **Answer-** **Yielding of gross cross section** - In a member subjected to uniaxial tension, a stage is reached at which elongation increases without increase in load. At this stage yielding of gross section causes excess elongation and member fails in gross yielding of cross section.	2 Marks
	Rupture of net cross section- A tension member is usually connected to other members by bolt or welds. The fibers adjacent to the bolt hole yield due to stress concentration. However the ductility of steel permits the initially yielded zone to deform without fracture. At this stage the entire net section reaches the ultimate stress and section fails in rupture.	2 Marks
	Measures to be taken to prevent rupture- i) To prevent rupture sufficient amount of Edge distance as per IS is provided. ii) The grade of plate is provided more or equal to the grade of bolt. iii) As far as possible less number of bolts are provided. To reduce bolts High strength bolts are provided.	Any Two for Two Marks
ii)	**Design a tie member using suitable equal angle section to carry a tensile factored load of 200 kN. The connection are with 20 mm dia. Bolts and 12mm thick gusset plate. Design strength of 20mm dia. Bolts = 45.3 kN, fu = 410 Mpa,** $\alpha = 0.8$.	

P.T.O.

Question	Description	Marks
Q.4(B) ii)	Answer —	
	Given - $P_u = 200\ kN$, Bolt dia(d) = 20mm	
	Design strength of bolt = 45.3 kN, $f_y = 250\ N/mm^2$	
	$f_u = 410\ N/mm^2$, $\alpha = 0.8$	
	step 1 - Approximate Gross c/s Area required	
	$A_{g\,reqd.} = \frac{T}{f_y} \times \gamma_{mo}$	
	$= \frac{200 \times 10^3}{250} \times 1.1$	
	$A_g = 880\ mm^2$	
	step 2 - select ISA 100 X 75 X 6mm having	
	$A_g = 1014\ mm^2$	
	step 3 - No. of bolts reqd. = $\frac{\text{Factored load}}{\text{Design strength of Bolt}} = \frac{200}{45.3}$	
	$= 4.41 \simeq 05$	1 Mark
	Provide 5 bolts of 20mm dia.	
	step-4 - Check for Design strength	
	i) Design tensile strength governed by gross section yielding	
	$T_{dg} = \frac{A_g \cdot f_y}{\gamma_{mo}} = \frac{1014 \times 250}{1.1}$	
	$T_{dg} = \underline{\underline{230.45\ kN}}$	1 Mark
	ii) Design tensile strength governed by Net section rupture	
	$T_{dn} = \frac{0.9\ f_u\ A_n}{\gamma_{m1}}$	
	Net Area of connected leg.	
	$A_{nc} = \left[100 - 22 - \frac{6}{2}\right] \times 6 = 450\ mm^2$	
	Net Area of outstanding leg	
	$A_{go} = \left[75 - \frac{6}{2}\right] \times 6 = 432\ mm^2$	
	Net Area $A_n = A_{nc} + A_{go} = 450 + 432 = 882\ mm^2$	

Question	Description	Marks

$$T_{dn} = \frac{0.9 f_u A_n}{\gamma_{m1}} = \frac{0.9 \times 410 \times 882}{1.25}$$

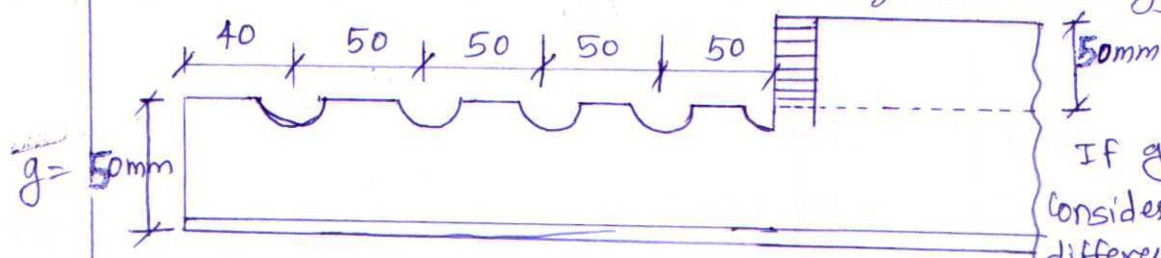
$T_{dn} = \underline{260.36\ KN}$ — 1 Mark

iii) Design tensile strength Governed by block shear

$P = 2.5d = 2.5 \times 20 = 50mm$

$e = 1.7 d_0 = 1.7 \times 22 = 37.4 \simeq 40mm$

If P & e ~~and~~ considered different marks given Accordingly.



If g is considered different marks given Accordingly

$A_{vg} = [4 \times 50 + 40] \times 6 = 1440 mm^2$

$A_{vn} = [4 \times 50 + 40 - 4.5 \times 22] \times 6 = 846 mm^2$

$A_{tg} = 50 \times 6 = 300 mm^2$

$A_{tn} = [50 - 0.5 \times 22] \times 6 = 234 mm^2$

$$T_{db1} = \frac{A_{vg} \cdot f_y}{\sqrt{3}\,\gamma_{m0}} + \frac{0.9 A_{tn} \cdot f_u}{\gamma_{m1}}$$

$$= \frac{1440 \times 250}{\sqrt{3} \times 1.1} + \frac{0.9 \times 234 \times 410}{1.25}$$

$$= 188.97 + 69.07 = \underline{\underline{258.04\ KN}}.$$

1 Mark

$$T_{db2} = \frac{A_{tg} \cdot f_y}{\gamma_{m0}} + \frac{0.9 A_{vn} \cdot f_u}{\sqrt{3}\,\gamma_{m1}}$$

$$= \frac{300 \times 250}{1.1} + \frac{0.9 \times 846 \times 410}{\sqrt{3} \times 1.25}$$

$$= 68.18 + 144.19 = \underline{\underline{212.37\ KN}}$$

1 Mark

T_{db} = minimum of T_{db1} & T_{db2}

The design tensile strength of the angle

= least of T_{dg}, T_{dn}, T_{db}

= 212.37 KN > 200kN.

Hence Design is safe.

1 Mark

Q.5 a) **Design of slab base.**

Given

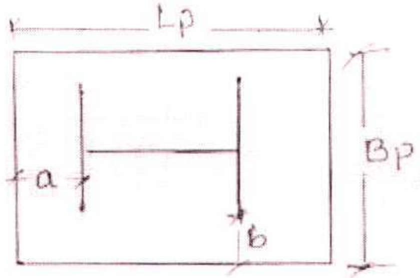
Column = ISHB350 @ 710.2 N/m $\quad t_f = 11.6\,mm \quad b_f = 250\,mm$

Factored Load = P_u = 1500 kN

Grade of Concrete = M20

$f_y = 250\,MPa \qquad f_u = 410\,MPa \qquad \gamma_{mo} = 1.1$

Soln → 1) Calculation for Base Plate Area (L_p & B_p)



Required Area of Base Plate = A_b = $\dfrac{\text{Factored load}}{\text{Bearing strength of concrete}}$ (1M)

$$A_b = \frac{1500 \times 10^3}{0.6 \times 20} = 125000\ mm^2$$

For equal projections ($a = b$)

Length of base plate $(L_p) = \left(\dfrac{350-250}{2}\right) + \sqrt{\left(\dfrac{350-250}{2}\right)^2 + 125000}$ (1M)

$$L_p = 407.07\,mm$$

$$L_p \simeq 408\,mm$$

∴ Width of base plate $(B_p) = \dfrac{A_b}{408} = \dfrac{125000}{408}$ (1M)

∴ $B_p = 306.37\,mm$

∴ $B_p \simeq 308\,mm$

Hence Provide Base Plate (408 mm x 308 mm) (1M)

Q.No.	Question and Model Answers	Marks
	2) Calculation of thickness of base plate (t_s)	
	longer Projection $= a = \frac{408-350}{2} = 29mm$	
	& smaller Projection $= b = \frac{308-250}{2} = 29mm$	(1m)
	∴ Net upward pressure on base plate	
	$w = \frac{1500 \times 10^3}{(408 \times 308)}$	
	$w = 11.94 \ N/mm^2$	(1m)
	Thickness of base Plate	
	$t_s = \sqrt{\frac{2.5w(a^2 - 0.3b^2)}{fy/1.1}}$	
	$t_s = \sqrt{\frac{2.5 \times 11.92 \times ((29)^2 - 0.3(29)^2)}{250/1.1}}$	
	∴ $t_s = 8.79$ mm	(1m)
	thickness must be more than $t_f = 11.6$ mm	
	∴ Provide thickness of Plate is 12mm	
	Provide size of bearing or Base Plate	
	(408mm × 308mm × 12mm)	(1M)

Q.5 b) Load Analysis of DL & LL of Roof Truss

Given :-

Pratt Roof Truss span = 12 m

GI sheet covering weight = 160 N/m^2

Weight of Purlin = 60 N/m^2

self wt. of Truss = 100 N/m^2

No. of Pannels = 8

Pitch of roof = 1/6

* Assume spacing betn roof Trusses = 4m

Soln → Slope of Roof = $\theta = \tan^{-1}(2 \times \text{Pitch}) = \tan^{-1}(2 \times 1/6)$

$\therefore \theta = 18.44°$

Pannel point Plan Area = $\left(\frac{12 \times 4}{8}\right) = 6 m^2$ (1M)

1) Dead Load Calculation

Total Dead load coming on plan area of truss

$= 160 + 60 + 100 = 320 \; N/m^2$ (1M)

DL on each interior panel point $= 320 \times 6$

$= 1920 N = \boxed{1.92 \; kN (\downarrow)}$ (1M)

DL on each end panel point $= \frac{1.92}{2} = \boxed{0.96 \; kN (\downarrow)}$ (1M)

2) Live Load Calculation

LL on Purlins $= 750 - (18.44 - 10) 20$ (1M)

$= 581.2 \; N/mm^2 > \text{min } 400 \; N/mm^2$

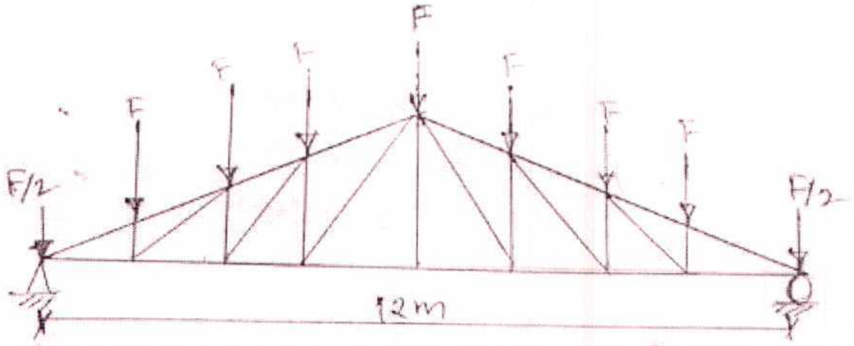
LL on Truss $= \frac{2}{3}(581.2)$

$= 387.47 \; N/mm^2$ (1M)

LL on each interior Pannel (on plan Area of Truss) $= (387.47 \times 6)$

$= 2324.82 N = \boxed{2.32 \; kN (\downarrow)}$ (1M)

LL on each end Panel $= \frac{2.32}{2} = \boxed{1.16\ kN}$ (1M)



DL & LL on Pratt roof Truss

For DL (F) = 1.92 kN & For LL (F) = 2.32 kN

(* Appropriate Assumption of spacing betn truss will change Answers)

Q.5C) LL & WL calculation for roof Truss

Given :- Span of roof truss = 16m

Spacing betn the Trusses = 4m

Rise of truss = 3.5m

No. of panels = 12

Soln → Slope of roof truss $\theta = \tan^{-1}\left(\frac{3.5}{16/2}\right) = 23.63^\circ$ (1M)

Panel point Plan Area $= \left(\frac{16 \times 4}{12}\right) = 5.33\ m^2$

Panel point Actual Area $= \left(\frac{5.33}{\cos 23.63^\circ}\right) = 5.82\ m^2$ (1M)

Live load (LL) Calculations

LL on purlin $= 750 - [(23.63 - 10)\ 20] = 477.4\ N/mm^2$ (1M)

> 400 N/mm² minimum.

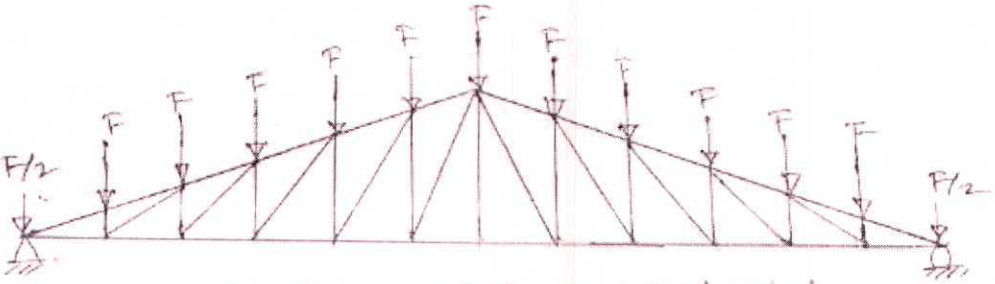
LL on Truss $= \frac{2}{3}(477.4) = 318.27\ N/mm^2$

LL is coming on Plan area.

∴ LL on interior pannel point $= 318.27 \times 5.33$

$= 1696.36\ N \approx \boxed{1.7\ kN}$ (1M)

∴ LL on end pannel point $= \frac{1.7}{2} = \boxed{0.85\ kN}$ (1M)



LL (F) = 1.7 kN on panel point

2) Wind Load Calculations :-

Given design wind pressure = P_d = 1.2 kPa = 1.2 kN/m^2

Coefficient of external wind action = − 0.7

Coefficient of internal wind action = ± 0.2

Max wind pressure distribution on Truss

$C_{pe} - C_{pi} = -0.7 - (+0.2) = -0.9$ } select max -0.9 (1M)

OR $= -0.7 - (-0.2) = -0.5$

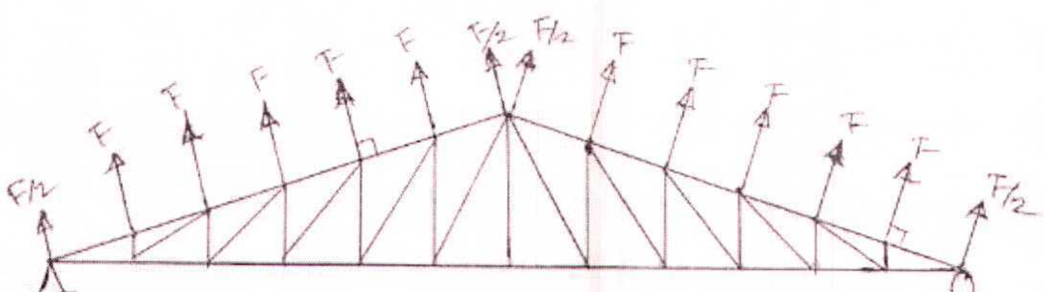
(−ve sign indicates uplift)

WL on intermidiate panel point (on actual area)

$F = [C_{pe} - C_{pi}] \, P_d \cdot A = -0.9 \times 1.2 \times 5.82$ (1M)

$\therefore F = \boxed{-6.285 \text{ kN}}$ (uplift)

W.L on end panel point $= \frac{F}{2} = \boxed{-3.143 \text{ kN}}$ (uplift) (1M)

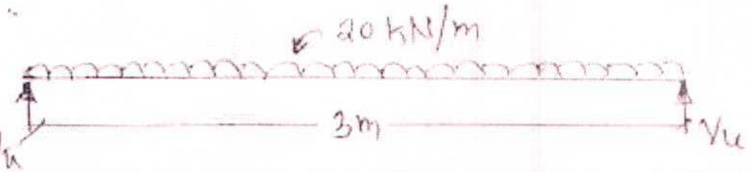


WL (F) = 6.285 kN on panel point

Q.6 Attempt Any FOUR.

Q.6a) Check for shear

Soln → Given ISMB250 $h = 250mm$ $t_w = 6.4mm$.



Assuming UDL carried by beam with self wt = 20 kN/m

factored Shear force developed max. at support equal to support reactions. (1M)

$$\therefore V_u = \frac{1.5(w \times l)}{2}$$

$$\therefore V_u = \frac{1.5 \times 20 \times 3}{2}$$

$$\therefore V_u = 45kN.$$ (1M)

Design shear capacity resisted by web of given beam section, (1M)

$$V_d = \frac{f_y \times h \times t_w}{\gamma_{mo} \times \sqrt{3}}$$

$$\therefore V_d = \frac{250 \times 250 \times 6.4}{1.1 \times \sqrt{3}}$$

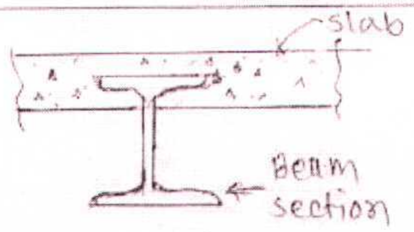
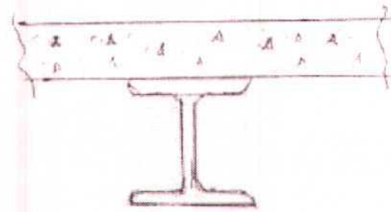
$$\therefore V_d = 209.95 \times 10^3 N$$

$$\therefore V_d = 209.95 kN \nless V_u$$ (1M)

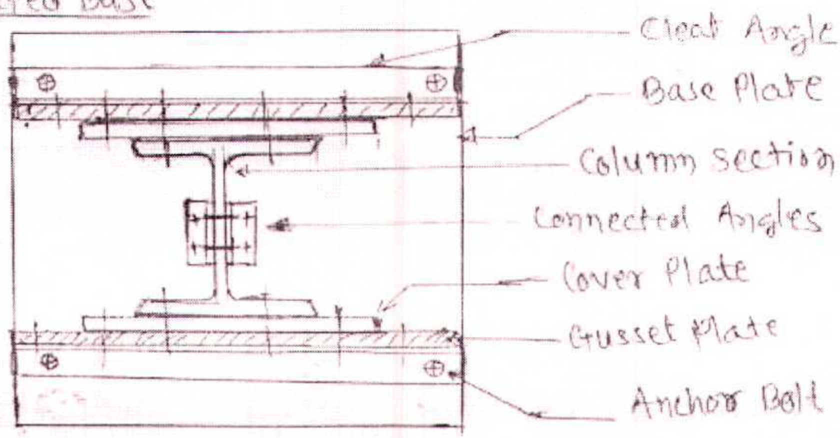
∴ Design shear capacity is very large than factored max. shear developed hence beam is safe in shear.

Q6b) Differentiate between laterally supported & laterally unsupported beam.

Soln. → Any four as bellow.

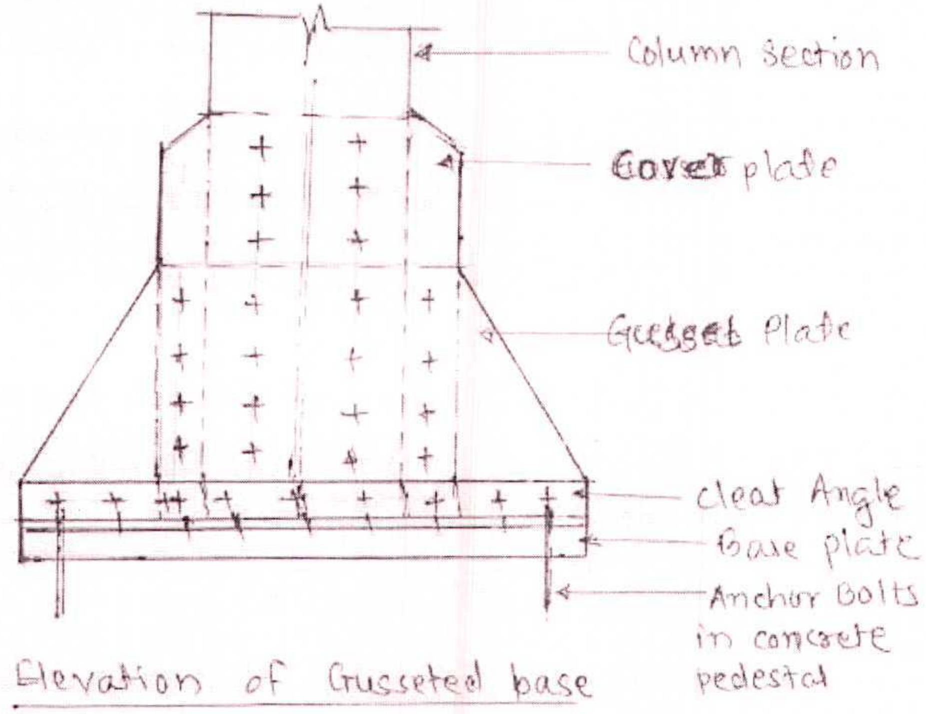
Laterally Supported Beam	Laterally Unsupported Beam.	Marks
① Lateral Deflection of compression flange is totally avoided	① Torsional buckling of beam before failure may occure.	4M
② Compression flange of beam is supported i.e embeded in concrete etc.	② Compression flange of beam is not supported.	(1M) for every point
③ Beam is restrain against rotation & takes more Load avoiding premature failure	③ Beam is not restrain against rotation & take less load with premature failure may occure	
④ Lateral deflection of compression flange is not possible	④ Lateral deflection of compression flange may be occure.	
⑤ 	⑤ 	

Q.6 c) Sketch of Gusseted Base



(2M)

Plan of Gusseted Base



Elevation of Gusseted base

(2M)

Q.6 d) Necessity of Column Base

As steel columns carrying heavy loads on small cross sectional area which creates cutting edge or punching effect. To spread loads on large area within permissible limit / Bearing Limit of bellow material i.e concrete or soil column base is used. (2M)

Function of cleat Angle

To fix the position of gusset plate or column section to base plate or bearing plate cleat angles are used. (1M)

Function of Anchor bolt in slab base

To fix the position of base plate / bearing plate with concrete pedestal and some times to take tensile stresses of uplift of base plate anchor bolt is used. (1M)

Q.No.	Question and Model Answers	Marks
Q.6 e)	Four classification of cross sections of beam on moment - rotation behaviour as per IS 800 2007.	
Soln →	1) Plastic or Class-I : Develops plastic hinges with large rotation capacity (θ_p), unaffected by local buckling at failure ($M \geq M_p$ & $\theta \geq \theta_p$)	(1M)
	2) Compact or Class-II : Develops full plastic moment (M_p) but fails by local buckling due to inadequate rotation capacity (θ_p) ($M = M_p$ but $\theta < \theta_p$)	(1M)
	3) Semicompact or Class-III : Extreme fibers reaches the yield stress but local buckling prevents further moment. ($M = M_y$)	(1M)
	4) Slender or class IV : Premature local buckling prevents yield moment also (i.e $M < M_y$)	(1M)
		END.