SUMMER– 18 EXAMINATION

Subject Name: DESIGN OF STEEL STRUCTURES **Model Answer** Subject Code: 17505

Important Instructions to examiners:

1) The answers should be examined by key words 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 errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures 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 some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q. N.	Answers	Marking Scheme
Q.1	(A) (a) Ans	***Attempt any three:*** ***State the functions of : i) Transmission tower ii) Steel water tank iii) Roof truss iv) Steel chimney.*** Following are the function of : i) Transmission tower: – To support high tension electric cable ii) Steel water tank – Steel tanks are used to store water and other liquids like acids, alkali, alcohol, gasoline and benzene. iii) Roof truss – Trusses are used to support purlins and roofing materials ***iv)*** Steel chimney – Steel chimney are used for the emission of flue gases and to reduce pollution.	***(12)*** 01 M for each
Q.1	(A)(b) Ans	***List different types of loads coming on steel structures and explain anyone.*** Following are the various types of loads coming on steel structures - i. Dead load ii. Live load (imposed load) iii. Wind load iv. Snow load v. Seismic load i. **Dead load: -** Dead load in steel structures is gravity loads and are relatively constant over the time. They are permanent known as permanent loads. They are the self-weight of the structural members or materials used for construction. These include weight of beam, slab, column etc. and elements such as weight of walls, partitions, floors and roofs. ii. **Live load: -** Live loads are also called as imposed loads or superimposed loads. Those are not permanent and may change in position and magnitude. The loads of furniture, equipment and occupants of the structure etc. are the examples of live load. Live loads on floors and roofs are given in IS:875-1987. iii. **Wind load: -** The wind load is more significant in case of tall structures. The	 02 M Any one 02 M

		wind pressure intensity at any height if structure depends upon basic wind speed, shape and height of structure, topography of surrounding ground surface and angle of wind attack. It is considered as per specifications given in IS:875-1987(Part 3) iv. **Snow load:-**In the areas of snow fall, an allowance for snow load is considered. It depends upon shape of the roof as well as the roofing material. It is variable load that may cover entire roof or part of it. *v.* **Seismic load:-** When a structure is subjected to ground motions in an earthquake, it responds in vibratory fashion. These loads shall be assumed as per IS: 1893-2002. (Part 1) "Criteria for Earthquake Resistant Design of Structures "	
Q.1	(A)(c) Ans	***List any four common standard types of steel sections used with their applications.*** Following are the steel section :- **i. I-sections :-** I sections are used as a beam and column in steel structure **ii. Channel sections: -** Channels sections are used for column in steel structures. **iii. Angle sections: -** Angle sections are used as tension and compression members for steel trusses. **iv. T-Section: -** T Section are used for various steel structural members	01 M for each
Q.1	(A)(d) Ans	***Define and explain shear lag effect.*** **Shear lag :-** While transferring the tensile force from gusset plate to tension member through one leg by bolts or welds, the connected leg of section (such as angle, channel) may be subjected to more stress than the outstanding leg and finally the stress distribution becomes uniform over the section away from the connection. Thus one part lags behind the other, this is called as shear lag.	04 M
Q.1	(B) (a) Ans	***Attempt anyone:*** ***Design a suitable fillet weld to connect plate 60 mmx 10mm to 150 mmx 12mm thick plate. Design the joint for full strength of the plate and assume welding on all three sides. Take fy = 250 MPa, and fu =410 MPa.*** **1. Design strength of 60 x 10 mm plate:** $P_{dw} = f_y \times A_g / \gamma_{m0} = 250 \times 60 \times 10 / 1.10 = 136363.63$ N **2. Size of weld:** Minimum size = 3 mm Maximum site = 10 – 1.5 = 8.5 mm Provide 6 mm site weld. **3. Design stress for site weld:** $f_{wd} = f_y / SQRT(3) \times 1.50 = 410 / SQRT(3) \times 1.50 = 157.80$ N/mm^2 **4. Design strength per mm length of weld:** $P_q = f_{wd} \times t_t = 157.80 \times (0.7 \times 6) = 662.6$ N/mm. **5. Effective length of weld required:** $L = P_{dw} / P_q = 136363.63 / 662.6 = 205.80$ Say 206 mm. In such arrangement the distance between longitudinal weld shall not exceed 16t i.e. 16 x 10 = 160 mm. Let us provide two longitudinal and one transverse weld. Length of transverse weld = 60 mm. (< 160 mm) Length of each longitudinal weld = (206 – 60) / 2 = 73 mm.	***(06)*** 01 M 01 M 01 M 01 M 01 M 01 M
Q.1	(B)(b)	***The double angle 60 x 60 x 8 mm tension member is connected to the both sides of 10mm gusset plate with 2 blots in a line with 18mm diameter bolt at a pitch of 50 mm and gauge of 35 mm. Determine the block shear strength of given tension member. Take fy= 250 MPa, and fu = 410 MPa.***	

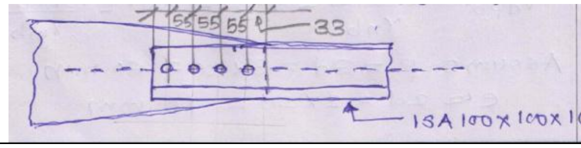
	Ans	Design strength by block shear: Diameter of bolt hole dn = 18 + 2 = 20 mm e = 40 mm A_{vg} = Minimum gross area in shear along bolt line = (50 + 40) x 8 = 720 mm^2 -- A_{vn} = Minimum net area in shear along bolt line = (50 + 40 – 1.5 x 20) = 60 mm^2 -- A_{tg} = Minimum gross area in tension from bolt hole to toe of angle perpendicular to line of force. = 35 x 8 = 280 mm^2 --- A_{tn} = Minimum net area in tension from bolt hole to toe of angle perpendicular to line of force. = (35 – 0.5 x 20) x 8 = 200 mm^2 -- T_{db1} = {(A_{vg} x f_y) / [SQRT(3) x y_{m0}]} + [(0.9 x A_{tn} x f_u) / y_{m1}] = {(720 x 250) / [SQRT(3) x 1.1]} + [(0.9 x 200 x 410) / 1.25] = 68948 N -- T_{db2} = [(A_{tg} x f_y) / y_{m0}] + {(0.9 x A_{vn} x f_u) /[SQRT(3) x y_{m1}]} = [(280 x 250) / 1.1] + {(0.9 x 720 x 410) / [SQRT(3) x 1.25]} = 147105 N -- T_{db} = Minimum of T_{db1} and T_{db2} = 68948 -- For two angles, T_{db} = 2 x 68948 = 137896 N i.e. 137.896 kN. ---------------------------------- Design shear strength of double angle section is 137.896 kN.	 1/2 M 1/2 M 1/2 M 1/2 M 01 M 01 M 01 M 01 M
Q.2	 (a) Ans	***Attempt any two :*** ***Design suitable bolted connection for a single angle strut made up of ISA 100 x 100 x 10mm using 12mm gusset plate for a factored compressive load of 175 kN .Assume 20 mm bolts of grade 4.6. Draw connection details.*** **Data: -** ISA 100 x 100 x 10 mm; 12 mm gusset plate; factored load = 175 kN; 20 mm bolt. Assume Fe410 grade of angle; fy = 410 mPa. For bolts of grade 4.6, fub = 400 mPa. For 20 mm bolt Anb = 245 mm2 Diameter of hole dn and do = 22 mm. y_{mb} = y_{m0} = partial safety factor for bolt and angle = 1.25 **Shear strength of bolt:-** V_{dsb} = V_{nsb} / y_{mb} = [f_{ub} / SQRT(3)] x [(n_n x A_{nb} + n_s x A_{sb}) / 1.25] = [400 / SQRT(3)] x [(1 x 245 + 0) / 1.25] 45264 N = 45.26 kN. --- **Bearing strength of plate: -** V_{dpb} = V_{npb} / V_{nb} = 2.5 x k_b x d x t x (f_{ub} / y_{mb}) -- Assume P = 3d = 3 x 20 = 60 mm. e = 2d = 2 x 20 = 40 mm. k_o is least of [e/3d_o; (P/3d_o)-0.25; f_{ub}/f_y; 1.0] i.e.{40/(3 x 22); [60/(3 x 22)] – 0.25; 400/410; 1.0} [0.60; 0.65; 0.97; 1.0] Hence k_o = 0.60 --- Vdpb = 2.5 x 0.60 x 22 x 12 x 400/1.25 = 126720 N = 126.72 kN -- Least bolt value B_v = Least of V_{dsb} or V_{dpb} B_v = 45.26 kN. ---	***(16)*** 01 M 01 M 01 M 01 M 01 M

No. of bolts required = P_u/B_v = 175 / 45.26

= 3.86 Say 4 Nos. --- 01 M

Minimum pitch = 2.5d = 2.5 x 22 = 55 mm

Edge distance = 22 x 1.5 = 33 mm. 01 M



01 M

Q.2 (b) ***A discontinuous strut 3.2m long of a roof truss consists of a double angle section 90x 90x 8mm connected to 10mm thick gusset plate by welding. Calculate load carrying capacity. Assume - Properties of ISA 90 x 90 x 8 mm; fy = 250 N/mm2 Area = 1380mm^2, Cxx= Cyy = 25.1 mm rxx= ryy = 27.5mm rvv = 17.5mm Ixx= Iyy = 104 x 10^{4}mm.***

KL/r	***80***	***90***	***100***	***110***	***120***	***130***
Fcd (N/mm^2)	***136***	***121***	***107***	***94.6***	***83.7***	***74.4***

Ans

Data: - ISA 90 x 90 x 8 mm

A = 1380 mm2; $r_{xx} = r_{yy}$ = 27.5 mm

L = 3200 mm; $C_{xx} = C_{yy}$ = 25.1 mm

$I_{xx} = I_{yy} = 104 \times 10^4\ mm^4$

r_{xx} for double angle section = r_{xx} for single angle section = 27.5 mm.

$I_{yy} = 2(I_y + Ah^2)$

$I_{yy} = 2[104 \times 10^4 + 1380 \times (25.1 + 5)^2]$

$= 4.58 \times 10^6\ mm^4$

r_{yy} = SQRT(I_{yy} / 2A)

= SQRT[4.58×10^6 / (2 x 1380)] = 40.73 mm

For double angle section $r_{min} = r_{xx}$ = 27.5 mm --- 01 M

KL = 0.7L = 0.7 x 3200 = 2240 mm. (for discontinuous double angle) ---------- 01 M

S. R. = KL / r_{min} = 2240 / 27.5 = 81.45 -- 02 M

From given table;

f_{cd} = 136 – {[(136 – 121) / (90 – 80)] x (81.45 – 80)} ------------------------------- 01 M

= 133.825 mPa. -- 01 M

Design compressive strength = f_{cd} x A_g --- 01 M

= 133.825 x 2 x 1380 = 369357 N = 369.357 kN --- 01 M

Q.2 (c) ***A simply supported beam has span 5 m and it carries a load of 35 kN at its centre. Check whether ISLB 600 is suitable for i) shear and ii) deflection. The section properties of ISLB 600 are bf= 210 mm, tf= 15.5mm, tw = 10.5mm, R} = 20 mm, Zxx = 2430 x 10^3 mm. Zp = 2798.56 x 10^{3}mm^3, Ixx= 728 x 10^{6}mm^4 (Ignore self-weight of beam).***

Ans

Span of beam = 5 m.

Load on beam = 35 kN.

Factored load = W_d = 35 x 1.5 = 52.5 kN. -- 01 M

Factored S. F. = V_d = W_d / 2 = 52.5 / 2 = 26.25 kN. -- 01 M

Check for shear: -

V_{dr} = f_y x t_w x h / [γ_{mo} x SQRT(3)] -- 01 M

H = 600 and tw = 10.5 mm.

V_{dr} = 250 x 10.5 x 600 / [1.1 x SQRT(3)] = 826660.61 N

= 826.66 kN > V_d (26.25 kN) ------------------------ 01 M

Also V_d / V_{dr} = 26.25 / 826.66 = 0.032 < 0.6.

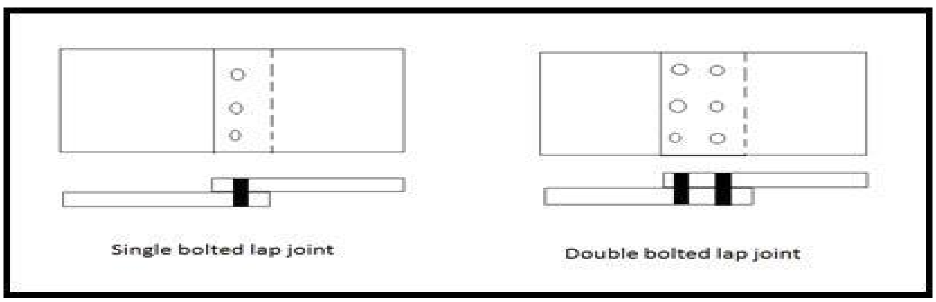
Hence shear check is satisfied. --- 01 M

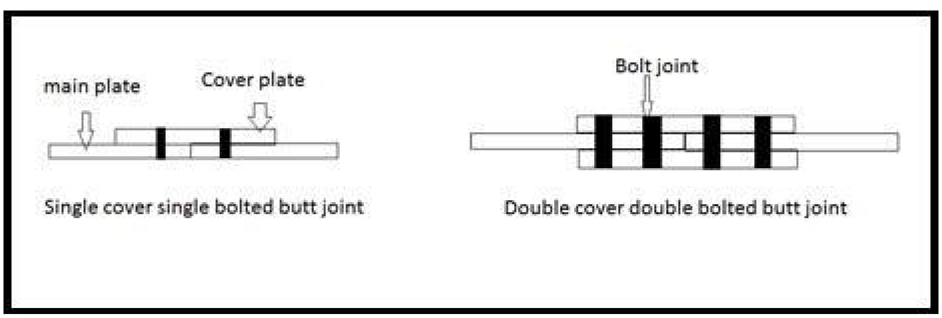
Check for deflection: -

<table>
<tr><td></td><td></td><td>$y_{allowable}$ = L / 300 = 5000 / 300 = 16.67 mm. --
y_{max} = W x L^3 / (48 x EI)
= 35 x 5000^3 / (48 x 2 x 10^5 x 728 x 10^6) = 0.000626 mm. ---------------------------------
As y_{max} < $y_{allowable}$ Deflection check is satisfied. --</td><td>01 M

01 M
01 M</td></tr>
<tr><td>Q.3</td><td>
(a)

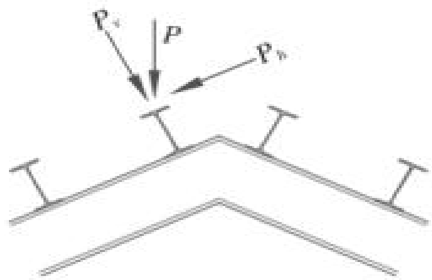
Ans</td><td>Attempt any four:
Define: i) Pitch ii) Gauge distance
iii) Edge distance iv) End distance in bolted connections.
i) Pitch: it is the centre to centre distance of the bolts in a row, measured along the direction of load.
ii) Gauge distance: it is the distance between the two consecutive bolts of adjacent rows and is measured at right angles to the direction of load.
iii) Edge distance: it is the distance from centre of bolt hole to the nearest edge of plate measured perpendicular to the direction of load.
iv) End distance: It is the distance from the center of bolt hole to the edge of a plate measured parallel to the direction of load.</td><td>(16)

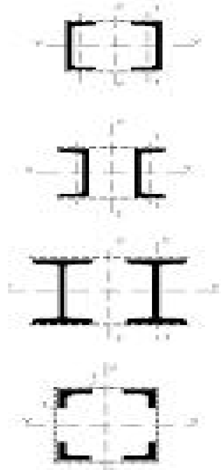
01 M for each</td></tr>
<tr><td>Q.3</td><td>(b)
Ans</td><td>Enlist with sketch types of joints
i)Lap joint:


ii) But joint


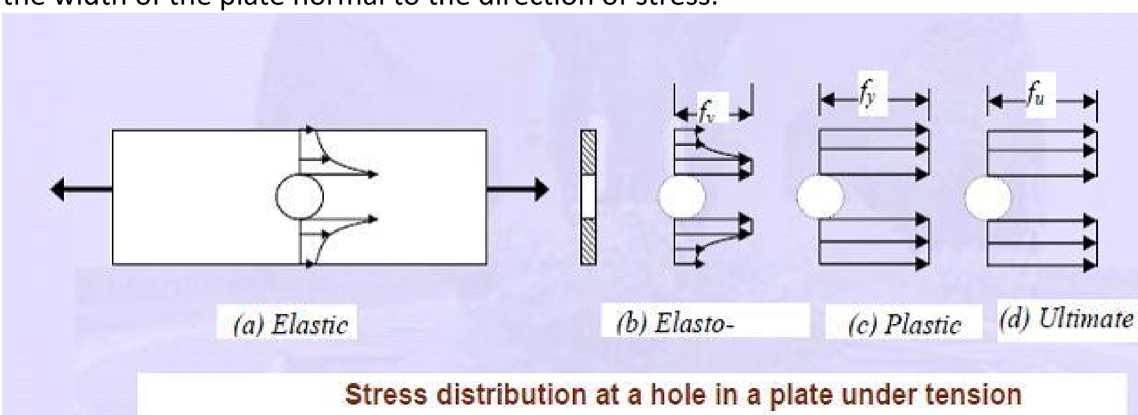
(Note: Marks are also to be given to fillet weld and butt weld types)</td><td>02 M

02 M</td></tr>
<tr><td>Q.3</td><td>(c)
Ans</td><td>Define: i) Roof truss ii) Purlin iii) Pitch of truss iv) Ridge.
i) Roof truss: - Roof trusses are triangular structures that provide the support and stability to the roof and distribute the weight of the roof away from the exterior walls of the building.
ii) Purlin: -Purlins are beams spanning between adjacent trusses, resting generally at joints on principal rafter.
iii) Pitch of truss:-it is defined as the ratio of rise to span of the truss.
iv) Ridge: - The ridge of a sloped roof system is the highest point of the roof truss where sloping sides meet.</td><td>01 M for each</td></tr>
<tr><td>Q.3</td><td>(d)
Ans</td><td>Purlin is subjected to bi-axial bending: Illustrate with diagram.
Biaxial bending is the bending of the beam about both axes (the x–x and y–y axes). In</td><td></td></tr>
</table>

		case of purlins it is subjected to self-weight, LL, weight of roof covering etc. in vertical downward direction and WL acts perpendicular to principal rafter. If these loads are resolved parallel and perpendicular to rafter then there exist biaxial bending of purlin section about its two major perpendicular axes. Pure biaxial bending occurs when the loads to each axis are applied directly through the shear center which is the point within a member such that when loads are applied through that point, twisting will not occur. When the applied loads do not pass through the shear center, as is often the case with singly symmetric shapes, torsion will occur. Examples of these beams are, purlins for roof framing, providing lateral support to exterior cladding.  b. roof purlins	04 M
Q.3	(e) Ans	***Explain the different selection criteria for type of truss.*** **Roof Covering:** the pitch of the truss depends upon the roofing material. The minimum recommended pitch of trusses with GI sheets is 1/6 with AC sheets it is 1/10 to 1 /12. **Fabrication and transportation:** this often guides the types of truss to be selected. Normally trusses are fabricated in the workshop and are transported to the site for erection. From the transportation consideration, depth of the truss becomes a controlling factor as it will not be feasible to transport a very deep truss. **Aesthetic:** from the aesthetic point of view the architect may give a very flat or deep truss, hereby limiting the choice. **Climate:** the climate of particular area plays an important role in the selection of truss. Drainage of water, ice and snow retention, etc. will have to be given due consideration.	01 M for each
Q.4	(A) (a) Ans	***Attempt any three:*** ***Draw four built up section forms of compression members.***	***(12)***

			01 M for each
Q.4	(A)(b) Ans	***State the functions of lacing and battening systems and general requirements for lacing as per IS 800.*** **Functions of lacing and battening systems:** To achieve maximum value for minimum radius of gyration, without increasing the area of the cross section, a number of elements are placed away from the principal axis using suitable lateral systems. Also, lacing and battening are primarily provided to hold the main components of the members of a built up section in their respective positions and equalize the stress distribution between its various parts. **General requirements for lacing as per IS-800.** a) Members comprising two main components laced and tied, should where practicable, have a radius of gyration about the axis perpendicular to the plane of lacing not less than the radius of gyration about the axis parallel to the plane of lacing. (b)As far as practicable, the lacing system shall be uniform throughout the length of the column. c) Except for tie plates double laced systems and single laced systems on opposite sides of the main components shall not be combined with cross members (ties) perpendicular to the longitudinal axis of the strut, unless all forces resulting from deformation of the strut members are calculated and provided for in the design of lacing and its fastenings. d) Single laced systems, on opposite faces of the components being laced together shall preferably be in the same direction so that one is the shadow of the other, instead of being mutually opposed in direction. e) The effective slenderness ratio, (kl/r)e., of laced columns shall be taken as 1.05 times the (Kl/ r)o, the actual maximum slenderness ratio, in order to account for shear deformation effects. f) Width of Lacing Bars In bolted/riveted construction, the minimum width of lacing bars shall be three times the nominal diameter of the end bolt rivet. g) Thickness of Lacing Bars The thickness of flat lacing bars shall not be less than one-fortieth of its effective length for single lacings and one-sixtieth of the effective length for double lacings. h) Rolled sections or tubes of equivalent strength may be permitted instead of flats, for lacings. i) Angle of Inclination: Lacing bars, whether in double. Or single systems, shall be inclined at an angle not less than 40° or more than 70^0 to the axis of the built-up member. j) The maximum spacing of lacing bars, whether connected by bolting, riveting or	 02 M Any two 01 M for each

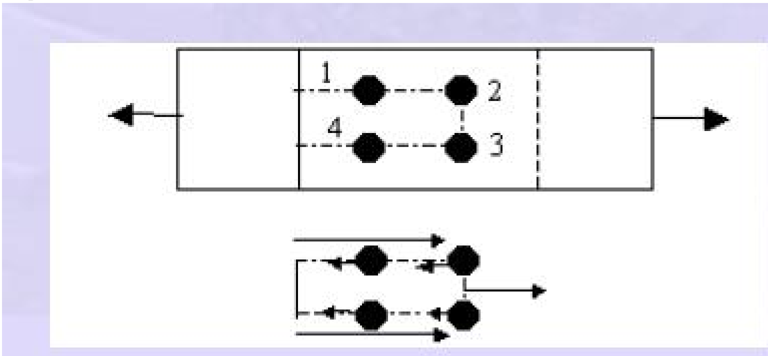
		welding, shall also be such that the maximum slenderness ratio of the components of the main member, between consecutive lacing connections is not greater than 50 or 0.7 times the most unfavorable slenderness ratio of the member as a whole, whichever is less, where al is the unsupported length of the individual member Between lacing points, and r, is the minimum radius of gyration of the individual member being laced together. k) Where lacing bars are not lapped to form the connection to the components of the members, they shall be so connected that there is no appreciable interruption in the triangulation of the system. l) The lacing shall be proportioned to resist a total transverse shear, Vt, at any point in the member, equal to at least 2.5 percent of the axial force in the member and shall be divided equally among all transverse lacing systems in parallel planes. m) For members carrying calculated bending stress due to eccentricity of loading, applied end moments and/or lateral loading, the lacing shall be proportioned to resist the actual shear due to bending. n) The slenderness ratio, Kl/r, of the lacing bars shall not exceed 145. In bolted/riveted construction, the effective length of lacing bars for the determination of the design strength shall be taken as the length between the inner end fastener of the bars for single lacing, and as 0.7 of this length for double lacings effectively connected at intersections. In welded construction, the effective lengths shall be taken as 0.7 times the distance between the inner ends of welds connecting the single lacing bars to the members.	
Q.4	(A)(c) Ans	***State with reason whether ISA 90 x 90x 8 is of semi-compact class or not. Take fy = 250 MPa.*** Ratio of width to thickness ratio =15.7 $(250/Fy)^{1/2}$ Width =90 mm and thickness =8 mm Therefore width to thickness ratio= 90/8= 11.25 Which lies in the range of 10.5$(250/Fy)^{1/2}$ to 15.7 $(250/Fy)^{1/2}$ **Hence ISA90x90x8 is of semi-compact class**	01 M 01M 02 M
Q.4	(A)(d) Ans	***Calculate effective length of a 7 m long column for the standard cases of end conditions i) both ends are fixed ii) one end is fixed and other is hinged.*** Restrained condition | length of column | effective length of column i)both ends are fixed | 7 m | = 0.65 x 7 = 4.55m ii) One end is fixed and other is hinged. | 7 m | = 0.8x 7 = 5.60 m	02 M for each
Q.4	(B) (a) Ans	***Attempt any one:*** ***Explain with sketches three modes of failure in axial tension member.*** Types of failure - Gross section yielding - Net section rupture - Block shear failure **1. Design Strength Governed By Yielding Of Section:** When a tension members is subjected to tensile forces although the net cross	***(06)***

		sectional yield first, the deformation within the length of connection will be smaller than the deformation in the remainder of tension member.it is because the net section exist within a small length of the member. And the total elongation is the product of the length of the member and the strain. Most of the length of the member will have an unreduced cross section , some attainment of yield stress on the gross area will result in larger total elongation. It is the larger deformation not the first yield that is the limit state. To prevent excessive deformation initiated by yielding the load on the gross section must be small enough so that the stress on the gross section is less than the yield stress. That is $\frac{T}{Ag} < \text{fy}$ $T = A_g$ fy Design strength = Ag fy /γ_{m0} Y_{m0} = partial safety factor = 1.1 **2. Design strength due to rupture of critical section:** Frequently plates under tension have bolt holes. The tensile stress in a plate at the cross section of a hole is not uniformly distributed in the Tension Member: Behavior of Tension Members elastic range, but exhibits stress concentration adjacent to the hole. The ratio of the maximum elastic stress adjacent to the hole to the average stress on the net cross section is referred to as the Stress Concentration Factor. This factor is in the range of 2 to 3, depending upon the ratio of the diameter of the hole to the width of the plate normal to the direction of stress.  In statically loaded tension members with a hole, the point adjacent to the hole reaches yield stress, fy, first. On further loading, the stress at that point remains constant at the yield stress and the section plastifies progressively away from the hole [Fig. (b)], until the entire net section at the hole reaches the yield stress, fy, [Fig. (c)]. Finally, the rupture (tension failure) of the member occurs when the entire net cross section reaches the ultimate stress, fu, [Fig. (d)]. Since only a small length of the member adjacent to the smallest cross section at the holes would stretch a lot at the ultimate stress, and the overall member elongation need not be large, as long as the stresses in the gross section is below the yield stress. Hence, the design strength as governed by net cross-section at the hole, Tdn, Ptn = 0.9fuAn / γ_{m1} Where, fu is the ultimate stress of the material, An is the net area of the cross section after deductions for the hole [Fig.4.4 (b)] and γ_{m1} is the partial safety factor against ultimate tension failure by rupture (ym1 = 1.25). Similarly threaded rods subjected to	02 M for each

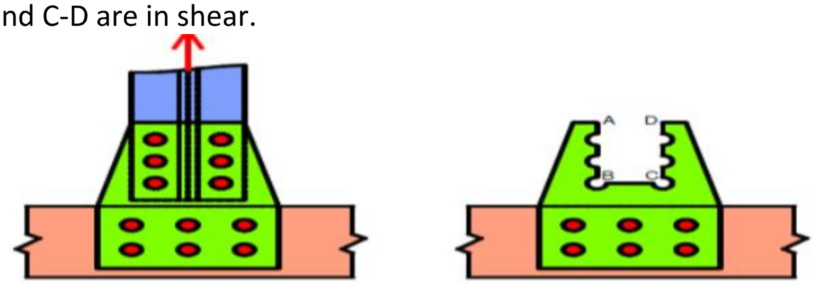
tension could fail by rupture at the root of the threaded region and hence net area, An, is the root area of the threaded section.

3. **Design strength due to block shear:**

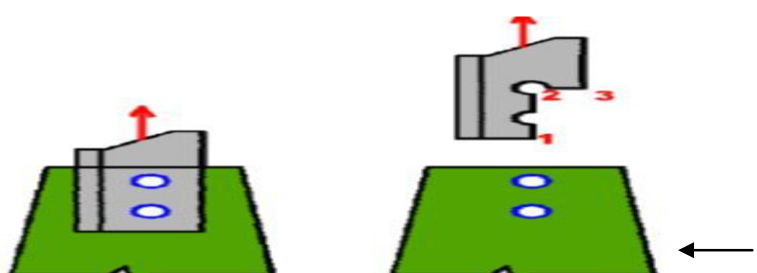
A tension member may fail along end connection due to block shear as shown in Fig.



The failure of the member occurs along a path involving tension on one plane and shear on a perpendicular plane along the fasteners. Block shear failure is considered as a potential failure mode at the ends of an axially loaded tension member. In this failure mode, the failure of the member occurs along a path involving tension on one plane and shear on a perpendicular plane along the fasteners. A typical block shear failure of a gusset plate is shown in fig. Here plane B-C is under tension whereas planes A-B and C-D are in shear.



Block shear failure in gusset plate



Block shear failure in angle with bolted connection

Fig. (b)**Welded connection**

The block shear failure is also seen in welded connections. A typical failure of a gusset in the welded connection is as shown in fig (b). The planes of failure are chosen around the weld. Here plane B-C is under tension and planes A-B and C-D are in shear.

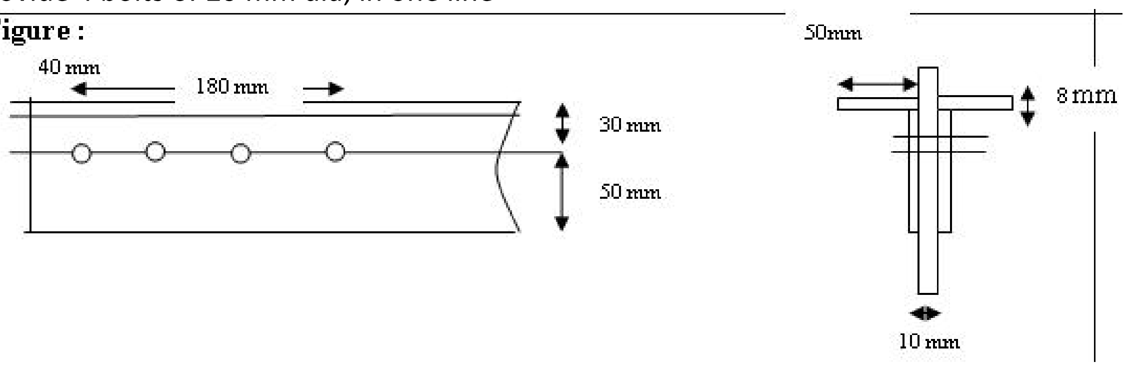
The block shear strength Tdb, at an end connection is taken as the smaller of

$T_{db} = [A_{vg} fy / 1.73\, \gamma_{m0}] + [fu\, A_{tn} / \gamma_{m1}]$

OR

$T_{db} = [fu\, A_{vn} / 1.73\, \gamma_{m1}] + [fy\, A_{tg} / \gamma_{m0}]$

Where, A_{vg}, A_{vn} = minimum gross and net area in shear along a line of transmitted force.

		A_{tg}, A_{tn} = minimum gross and net area in tension from the hole to the toe of the angle or next last row of bolt in plates, perpendicular to the line of force, respectively as shown in Fig and fu, fy = ultimate and yield stress of the material respectively	
Q.4	(B)(b) Ans	***Design a suitable angle section as a tie member in a truss to carry factored load of 350 kN. Use double angle section connected back to back on both sides of 10mm. thick gusset plate by means of 4 bolts of 20 mm dia. in one line. Given a = 0.8, fy = 250 MPa, fu = 410 MPa.*** ***Available sections — Gross Area (mm^2)*** ***ISA 80 x 50 x 8 — 978*** ***ISA 100 x 75 x 6 — 1014*** ***ISA 125 x 75 x 6 — 1166*** Area required from the consideration of yielding =1.1 x 350 x1000/250 =1540 mm^2 Try-2 ISA80X50X8 mm thick which has a gross area=2*978=1956 mm^2 Strength of 20 mm bolts: a) Strength in single shear = [π/4 x(20)2+0.78 x π/4 x(20)2]x400x1/1.25√3 =103314 N b)strength in bearing : e= 40 mm p=60mm kb is smaller of 40/(3x22); 60/(3x22)-0.25; 400/410; 1 i.e. kb=0.606 Vdpb=1x2.5x0.606x20x8x400=77568 N (Bolt Value =77568 N) Nos. of bolt required =350000/77568=4.5 Provide 4 bolts of 20 mm dia, in one line **Figure :**  Checking the design:a) Strength Against Yielding : Design strength = Ag fy /γ_{m0} = 1956 x 250/1.1=444545 N >350,000N (OK) b)Strength of Plate in Rupture : Area of connected leg, Anc =2{80-22-4)x8 =864 mm^2 Area of unconnected leg, Ago=2x{50-4}x8 =736 mm^2 β = 1.4 -0.076(w/t)*(fy/fu)*(bs/Lc) β = 1.4-0.076(50/8)*(250/410)*(75/180)=1.28 Design strength = {0.9 Anc fu /γ_{m1}}+{ β Ago fy /γ_{mo}} ={0.9x864x410/1.25} +{1.28 x 736 x250/1.1} =469161.89 >350,000N (OK) c)strength against block shear failure : per angle $T_{db} = A_{vg}fy$ /[SQRT3 γ_{m0} + fu A_{tn} / γ_{m1}] **OR**	01 mark 01 mark 01 mark 01 mark 02 mark

$T_{db} = fu\ A_{vn} / [SQRT3\ \gamma_{m1} + fy\ A_{tg} / \gamma_{m0}]$

$A_{vg} = (40+60x3)x8 = 1760\ mm^2$

$A_{tn} = (80-35)x8 = 360\ mm^2$

$A_{vn} = (40+60x3-3.5\ x22)x8 = 1144\ mm^2$

$A_{tg} = (80-35-0.5x22)x8 = 272$ mm2

$T_{db} = [A_{vg}fy / 1.732\gamma_{m0}] + [fu\ A_{tn} / \gamma_{m1}]$

$= [1760x250/1.732*1.1]+[410*360/1.25]=349026.88$ N

OR

$T_{db} = [fu\ A_{vn} / 1.732\ \gamma_{m1}] + [fy\ A_{tg} / \gamma_{m0}]$

$=[410*1144/1.732*1.25]+[250*272/1.1]=278464$ N

Strength of two angles against block failure = 2 x 278464 =556929 N >350,000N (OK)

Hence Use 2 ISA 80x50x8 With 4 BOLTS OF 20MM dia.

Q.5 ***Attempt any two:*** ***(16)***

(a) ***An industrial building of size 16m x 25 m is provided with Fink type trusses at 6 m c/c. Calculate panel point load in case of Dead load and Live load from following data:***

i) Unit weight of roofing material = 160N/m²

ii) Self weight of purlin = 115N/m²

iii) Weight of bracing = 50 N/m²

iv) Rise to span ratio = 1/5

v) No. of panels = 8.

Ans. **1. General design: -**

Effective span, L = 16 m.

Spacing of trusses, S = 6 m C/C

Rise of truss = L/5 = 16 / 5 = 3.2 m.

Slope of truss, $\theta = \tan^{-1}(Rise/0.5L) = \tan^{-1}(3.2/8) = 21.80^0$ — 01 M

2. Calculation of panel point DL: -

a) Weight of roof covering material on plan area = 160 N/m^2

b) Self weight of truss = [(L/3) + 5] x 10 = [(16/3) + 5] = 103.33 N/m^2

c) Weight of bracing = 50 N/m^2

d) Weight of purlin = 115 N/m^2

Total intensity of DL = 160 + 103.33 + 50 + 115 = 428.33 N/m^2 — 02 M

DL on one panel point = Intensity of DL x area under one panel point.

= 428.33 x 2 x 6 = 5139.96 N — 01 M

OR

Plan area = 16 x 6 = 96 m^2

Total DL = 428.33 x 96 = 41119.68 N

DL per panel point = Total DL / No. of panels = 41119.68 / 8 = 5139.96 N.

DL on end panel point = 5139.96 / 2 = 2569.98 N

3. Calculation of panel point LL: -

LL intensity on purlin = 750 – (θ – 10) x 20

= 750 – (21.8 – 10) x 20 = 514 N/m^2 > 400 N/m^2 OK. — 02 M

LL intensity on truss = (2/3) x 514 = 342.67 N/m^2 — 01 M

Total LL = Intensity of LL x Plan area

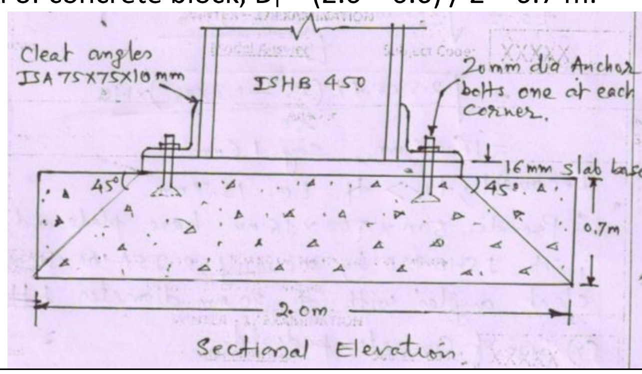
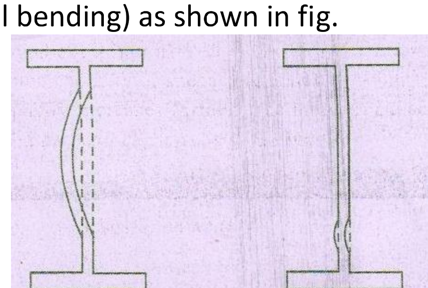
= 342.67 x 96 = 32896 N

LL on one panel point = 32896 / 8 = 4112 N

LL on end panel point = 4112 / 2 = 2056 N. — 01 M

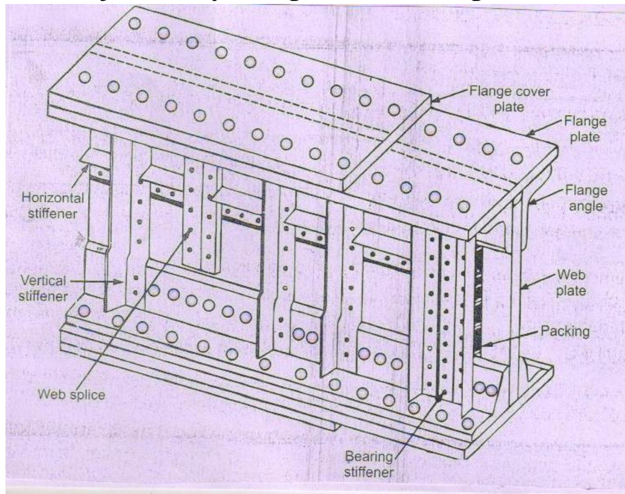
Q.5 **(b)** ***A hall has Howe truss of 6 panels for 15 m span, are spaced at 4.2 m C/C and rise of truss is 3 m. Calculate panel point load in case of Live load and Wind load. Given Data:***

		Vb = 39 m/s; probability factor K_1 = 1, terrain factor K_2 = 0.9, topography factor K_3 = 1; Coefficient of external wind pressure = -0.7 and normal permeability. (Cpi = ± 0.2).	
	Ans.	**1. Data: -** Span of truss, L = 15 m., No. of panels = 6, Spacing of trusses = 4.2 m. C/C Rise = 3 m., V_b = 39 m/sec, K_1 = 1, K_2 = 0.9, K_3 = 1, C_{pe} = 0.7, C_{pi} = ± 0.2 Slope of truss, $\theta = \tan^{-1}$(Rise/0.5L) = $\tan^{-1}$(3.0 /7.5) = 21.80^0 ----------------------------------	01 M
		2. Calculation of LL per panel point: - LL intensity on purlin = 750 – (θ – 10) x 20 = 750 – (21.8 – 10) x 20 = 514 N/m^2 > 400 N/m^2 OK. LL intensity on truss = (2/3) x 514 = 342.67 N/m^2 --	01 M
		Total LL = Intensity of LL x Plan area = 342.67 x 15 x 4.2 = 21588 N --	01 M
		LL on one panel point = 21588 / 6 = 3598 N LL on end panel point = 3598 / 2 = 1799 N. ---	01 M
		3. Calculation of WL per panel point: - Design wind speed = $V_z = V_b \times K_1 \times K_2 \times K_3$ = 39 x 1 x 0.9 x 1 = 35.1 m/sec. Design wind pressure = $p_d = 0.6 \times (V_z)^2 = 0.6 \times 35.1^2$ = 739.2 N/m^2 --------------------------	01 M
		Note: As the external wind pressure co-efficient is given for one condition (i.e. there is no mention of wind blowing normal or parallel or position along length of building) only one condition will be critical. Total intensity of design wind pressure = (Cpe – Cpi) x pd = (- 0.7 – 0.2) x 739.2 = - 665.28 N/m^2 (uplift) -------------------------------	01 M
		WL per panel point = Design wind pressure x Inclined panel length x S = - 665.28 x (2/cos21.80^0) x 4.2 = - 6018.78 N (uplift) -------------------	01 M
		WL at end panel point = - 6018.78 / 2 = - 3009.39 N. --	01 M
Q.5	(c)	***Design a suitable slab base for an ISHB 450 to transfer a factored load of 1300 kN to foundation stratum having bearing capacity 400 kN/m^2. Assume concrete of grade M20. Draw the details. For ISHB 450: bf= 250 mm, tf= 13.7 mm fy = 250 M.Pa, fu = 410 MPa .***	
	Ans.	Factored load, P_u = 1300 kN., f_{ck} = 20 N/mm2, B = b_f = 250 mm, t_f = 13.7 mm D = h = 450 mm, f_y = 250 mPa, q_u = 400 kN/m^2 **i. Bearing area of base plate,** A = Pu / (0.6 x fck) = 1300 x 10^3 / (0.6 x 20) = 108333 mm^2	01 M
		ii. Size of base plate, Lp = [(D-B) / 2] + SQRT{[(D-B) / 2]^2 + A} = [(450-250) / 2] + SQRT{[(450-250) / 2]^2 + 108333} = 443.99 mm Say 450 mm. Bp = 108333 / 450 = 240.74 mm Say 250 mm.	01 M
		Larger projection = a = (Lp – D)/2 = (450 – 450) / 2 = 0 This is not advisable because, thickness will become zero which is not possible, more ever cleat angles are to be accommodated, hence increase value of Lp and Bp by 150 mm each. Lp = 450 + 150 = 600 mm and Bp = 250 + 150 = 400 mm.	01 M
		Now larger projection = a = (600 – 450) / 2 = 75 mm. Smaller projection = b = (400 – 250) / 2 = 75 mm. Area of base plate = Lp x Bp = 600 x 400 = 240000 mm^2.	01 M

		iii. Ultimate pressure from below on the slab base: w = Pu / Area of base plate = $1300 \times 10^3 / 240000 = 5.417\ N/mm^2$.	01 M
		iv. Thickness of base plate: $t_s = SQRT\{[2.5 \times w\ (a^2 - 0.3b^2) \times \gamma_{m0}] / fy\}$ $= SQRT\{[2.5 \times 5.417\ (75^2 - 0.3 \times 75^2) \times 1.10] / 250\}$ = 15.31 mm Say 16 mm.	01 M
		Also $t_s > t_f$ i.e. 13.7 mm Hence provide 600 x 400 x 16 mm base plate and connect it to ISHB450 by securing 2ISA 75 x 75 x 10 mm cleat angle with 4 – 20 mm diameter bolts.	
		v. Size of concrete pedestal: $A_f = (Pu \times \gamma_{m0}) / q_u = (1300 \times 1.1) / 400 = 3.575\ m^2$ For equal projections, $L_f = [(Lp - Bp) / 2] + SQRT\{[(Lp - Bp) / 2]^2 + A_f\}$ $= [(0.6 - 0.4) / 2] + SQRT\{[(0.6 - 0.4) / 2]^2 + 3.575\}$ = 1.993 m Say 2.0 m.	01 M
		$B_f = A_f / L_f = 3.575 / 2 = 1.787$ m Say 1.8 m. Provide M20 concrete pedestal of size 2.0 m x 1.8 m. Provide depth of concrete block, $D_f = (2.0 - 0.6) / 2 = 0.7$ m.	
		 	01 M
Q.6		***Attempt any four :***	***(16)***
	(a)	***Why laterally supported beam always preferred? Explain any two methods to support beam laterally.***	
	Ans.	Laterally supported beams are always preferred because:	
		1. Thin projecting flange is susceptible to buckling under compression.	01 M
		2. In laterally supported beam, flange is restrained from buckling.	01 M
		We can support the beam laterally in many ways as fallows.	
		1. Embedding compression flange in the floor.	01 M
		2. Connection of compression flange to the floor with the help of shear connectors.	01 M
Q.6	(b) Ans.	***Explain with sketch: i) Web buckling ii) Web crippling*** A heavy concentrated load or end reaction produces a region of high compressive stresses in the web either at support or under the load. This causes the web either to buckle or to cripple (or local bending) as shown in fig.	02 M
		 (a) Web Buckling (b) Web Crippling	01 M for each

Q.6 (c) ***Draw neat labeled sketch of bolted plate girder showing details.***

Ans.



Note: Students may draw longitudinal sectional view and cross sectional view of bolted plate girder for which full marks shall be given if views are correct.

02 M for fig. and 02 M for labeling

Q.6 (d) ***Differentiate between gusseted base and slab base.***

Ans. Difference between gusseted base and slab base.

Sr. No.	Slab base	Gusseted base
1.	The load on column is directly transferred to the base plate. Hence thickness required for base plate is more.	The load on column is transferred through gusset plates and base plate together. Hence the thickness required is less than that of slab base.
2.	The cleat angles are used to fasten column section to base plate for the width of column.	The cleat angles are used to faster gusset plate to base plate on more width, so that stiffness of joint is increased.
3.	The bearing surfaces may be rough (not machined). Hence the moments due to transit, unloading and erection may be caused.	All bearing surfaces are machined to ensure perfect control between them.
4.	The slab bases are simple in construction and fastening the elements speedily.	The gusseted base is complex in construction and more fastening joints are required. Hence low speed of joints.
5.	Economical as material required is less.	Expensive but more stronger than slab base.

Any four 01 M for each

Q.6 (e) ***State components of a slab base with their functions.***

Ans. The components of a slab base are:

1. **Base plate: -** The column is properly secured to base plate by means of fastenings. It spreads the load of column onto the concrete pedestal uniformly and evenly.
2. **Cleat angle: -** These are used to connect column to base plate so that it will resist all moments and forces due to transit, unloading and erection.
3. **Anchor bolt: -** It is used to connect the base plate to concrete block, so that stability, stiffness and strength of foundation is achieved.

01 M for each

		4. **Concrete block: -** It is provided to transfer the load evenly onto the underlying soil such that the design stresses induced in the soil should not exceed the bearing capacity of soil.	