



Model Answer

End-Sem Examination-I, Winter 2025

Academic Year: 2025-2026	Semester: I
Class: F.Y.	Program: M. Tech
Branch Code: CIV	Pattern: 2024
Name of Course: Advanced Design of Steel Structures	Course Code:2404504(A)

Q. No.	Answer Details	Max. Marks
Q.1.	<p>a) Castellated beams and their advantages Number of regular openings in the web. Formed by flame cutting a single rolled wide flanged beam in a definite pattern and then re-joining the segments in such a way as to form a beam with several regular openings in its web Advantages-</p> <ul style="list-style-type: none">• Lightweight▪ Cheap▪ Relatively high resistance▪ Faster assembly▪ Higher moment carrying capacity with no added steel▪ Low maintenance	[6]
Q.2.	<p>Different types of bracings for microwave towers</p> <ol style="list-style-type: none">1. single diagonal bracings: This is the simplest form of bracing. The wind shear at any level is shared by the single diagonal of the panel. Such bracing is used for towers upto 30 m height.2. X-X bracing: This is a double diagonal system without horizontal bracing, and used for towers upto 50 m height. It is a statically determinate structure.3. X-B bracing: This is a double diagonal system with horizontal bracings. Such bracings are quite rigid, and may be used for towers upto 50 m height. The structure is statically indeterminate. The horizontal members are redundant members and carry only nominal stresses. can be used in lower panels where large head room is required.4. K-bracing: Such a bracing, gives large head room, and hence K-bracing determinate. Such bracing can be used for towers of 50 to 200 m height. In most of the transmission line towers, the lower panels is either K- or Y-braced and upper panels X braced or XB braced.5. X B X bracing: This is a combination of XX and XB bracing where horizontal members are provided only at the level of crossing of diagonals. The structure is statically indeterminate. However, the length of the diagonal is reduced. The system is suitable for towers of 50 to 200 m height. The system is statically indeterminate. However, the effective length of diagonals is reduced6. W - bracing: This system uses a number of overlapping diagonals. system is quite rigid and may be used for towers of 50 to 200 m height.	[6]



	<p>7. Y- bracing: This system, gives larger head room and can be used for lower panels. The system is statically determinate. In most of the transmission line towers, lower panels are either Y-braced on K- braced and upper panels are X-B braced or X-braced.</p> <p>8. Arch bracing: Such a bracing, can be adopted for wider panels This system also provides greater head room. The system is statically determinate.</p> <p>9. Subdivided V-bracing: Such a bracing, are used for tall towers of communication systems, radio and TV transmission etc; for heights between 50 to 200m.</p> <p>10. Diamond lattice system: a typical diamond lattice system used for towers of 100 to 200 m height. The base width is kept at 1/5 to 1/6 of the height. Rigid horizontal diaphragms are used at top and at intermediate sections, preferably at intervals of 25 to 30 m, to increase the torsional stiffness of the cross-section.</p>	
<p>Q.3.</p>	<p>a) Maximum sag of the conductor</p> <ol style="list-style-type: none"> i. Power conductor- <ol style="list-style-type: none"> a. 40 mm diameter A.C.S.R. consisting of 54 strands of 3mm diameter of aluminium and 7 strands of 3mm diameter of steel shall be used b. Unit weight of conductor- 25 N/m c. Permissible axial tension- 35 kN d. Young's modulus of elasticity- $0.85 \times 10^5 \text{ N/mm}^2$ e. Coefficient of thermal expansion- $0.00001992^\circ/\text{C}$ f. Shape factor for conductor = 0.67 ii. Variation of temp. range- 5°C to 60°C iii. Uniform intensity of wind = 1.50 kN/m^2 iv. Weight span of tower = Wind span = 235 m $T_2^2 \left[(T_2 - T_1) + \frac{W_1^2 L^2 EA}{24T_1^2} + (t_2 - t_1)\alpha EA \right] = \frac{W_2^2 L^2 EA}{24}$ <p>$T_1 = \text{permissible tension in the conductor} = 35 \text{ kN}$</p> <p>$W_2 = \text{weight of conductor without wind} = 0.025 \frac{\text{kN}}{\text{m}}$</p> <p>$L = \text{weight span} = 235\text{m}$</p> <p>$E = \text{Young's modulus} = 0.85 \times 10^2 \frac{\text{kN}}{\text{mm}^2}$</p> <p>$t_2 - t_1 = \text{variation of temperature} = 60 - 05 = 55^\circ\text{C}$</p> <p>$\alpha = \text{coefficient of thermal expansion} = 0.00001992^\circ/\text{C}$</p> <p>$A = \text{effective cross sectional area} = \frac{\pi}{4} \times D^2$</p> <p>$= \left(\frac{\pi}{4} \times 3^2 \times 54 \right) + \left(\frac{\pi}{4} \times 3^2 \times 7 \right) = 431.18 \text{ mm}^2$</p> <p>$W_1$ $= \text{weight of the conductor at minimum temperature with wind}$ $= \sqrt{[(\text{wind load}/\text{m})^2 + (w_2)^2]}$ $\text{wind} \frac{\text{load}}{\text{m}} = (\text{diameter}) \times \text{wind pressure} \times \text{shape factor} \times 0.75$</p>	<p style="text-align: right;">[8]</p>



	$= 0.04 \times 1.5 \times 0.67 \times 0.75 = 0.0302 \frac{kN}{m}$ $W_1 = \sqrt{0.0302^2 + 0.025^2} = 0.039 \frac{kN}{m}$ <p>To calculate T_2,</p> $T_2^2 \left[(T_2 - 35.25) + \frac{0.039^2 \times 235^2 \times 0.85 \times 10^2 \times 431.18}{24 \times 35.25^2} + (55) \times 0.00001992 \times 0.85 \times 10^2 \times 431.18 \right]$ $= \frac{0.025^2 \times 235^2 \times 0.85 \times 10^2 \times 431.18}{24}$ $(T_2)^2 [(T_2 - 35.25) + 103.23 + 40.15] = 52708.67$ $T_2 = 20.26 \text{ kN}$ $d = \frac{W_2 L^2}{8T_2} = \frac{0.025 \times 235^2}{8 \times 20.26} = 8.52 \text{ m}$	
	OR	
Q.3	<p>b) Maximum sag of the conductor</p> <ol style="list-style-type: none"> i. Voltage of transmission- 132 kV ii. Power conductor- <ol style="list-style-type: none"> g. 30 mm diameter A.C.S.R. consisting of 54 strands of 3mm diameter of aluminium and 7 strands of 3mm diameter of steel shall be used h. Unit weight of conductor- 20 N/m i. Permissible axial tension- 41.25 kN j. Young's modulus of elasticity- $0.85 \times 10^5 \text{ N/mm}^2$ k. Coefficient of thermal expansion- $0.00001992^\circ/\text{C}$ l. Shape factor for conductor = 0.67 iii. Variation of temp. range- 10°C to 50°C iv. Uniform intensity of wind = 2.50 kN/m^2 <p>Weight span of tower = Wind span = 250 m</p> $T_2^2 \left[(T_2 - T_1) + \frac{W_1^2 L^2 EA}{24T_1^2} + (t_2 - t_1)\alpha EA \right] = \frac{W_2^2 L^2 EA}{24}$ <p>$T_1 = \text{permissible tension in the conductor} = 41.25 \text{ kN}$</p> <p>$W_2 = \text{weight of conductor without wind} = 0.020 \frac{kN}{m}$</p> <p>$L = \text{weight span} = 250 \text{ m}$</p> <p>$E = \text{Young's modulus} = 0.85 \times 10^5 \frac{kN}{mm^2}$</p> <p>$t_2 - t_1 = \text{variation of temperature} = 50 - 10 = 40^\circ\text{C}$</p> <p>$\alpha = \text{coefficient of thermal expansion} = 0.00001992^\circ/\text{C}$</p> <p>$A = \text{effective cross sectional area} = \frac{\pi}{4} \times D^2$</p> $= \left(\frac{\pi}{4} \times 3^2 \times 54 \right) + \left(\frac{\pi}{4} \times 3^2 \times 7 \right) = 431.18 \text{ mm}^2$	(8)



	<p> W_1 $= \text{weight of the conductor at minimum temperature with wind}$ $= \sqrt{[(\text{wind load}/m)^2 + (w_2)^2]}$ $\text{wind } \frac{\text{load}}{m} = (\text{diameter}) \times \text{wind pressure} \times \text{shape factor} \times 0.75$ $= 0.03 \times 2.5 \times 0.67 \times 0.75 = 0.0377 \frac{kN}{m}$ $W_1 = \sqrt{0.0377^2 + 0.020^2} = 0.043 \frac{kN}{m}$ </p> <p>To calculate T_2,</p> $T_2^2 \left[(T_2 - 41.25) + \frac{0.043^2 \times 250^2 \times 0.85 \times 10^2 \times 431.18}{24 \times 41.25^2} + (40) \times 0.00001992 \times 0.85 \times 10^2 \times 431.18 \right]$ $= \frac{0.020^2 \times 250^2 \times 0.85 \times 10^2 \times 431.18}{24}$ $(T_2)^2 [(T_2 - 41.25) + 103.71 + 29.2] = 38177.40$ $T_2^3 + 91.66T_2^2 = 38177.40$ $T_2 = 18.61 \text{ kN}$ $d = \frac{W_2 L^2}{8T_2} = \frac{0.020 \times 250^2}{8 \times 18.61} = 8.40 \text{ m}$	
<p>Q.3</p>	<p>c) Explain following terms-</p> <ol style="list-style-type: none"> 1. Normal span- It is the center to center distance between two towers 2. Wind span- It is the sum of two half spans adjacent to the support under consideration 3. Weight span- It is the horizontal distance between the lowest point of conductor on the two span adjacent to tower under consideration. The lower point is defined as the point at which the tangent to sag curve is horizontal <div style="text-align: center;"> </div> <ol style="list-style-type: none"> 4. Maximum sag of the conductor <p>Sag is the distance between the highest point of electric poles or towers and the lowest point of a conductor connected between two poles or towers</p> $d = \frac{wL^2}{8P_H}$ $T_2^2 \left[(T_2 - T_1) + \frac{W_1^2 L^2 EA}{24T_1^2} + (t_2 - t_1)\alpha EA \right] = \frac{W_2^2 L^2 EA}{24}$	<p>(8)</p>



	Description of all the terms									
	OR									
	<p>d) Different loads acting on transmission line towers</p> <ol style="list-style-type: none"> 1. Vertical loads <ol style="list-style-type: none"> a. weight of tower structure b. weight of insulator strings and fittings c. weight of power conductors d. Weight of ground wire e. weight of ice coatings (if any) f. weight of maintenance crew with tools 2. Transverse or Horizontal loads <ol style="list-style-type: none"> i. Wind (or seismic) load on tower structure. ii. Wind (or seismic) load on power conductor. iii. Wind (or seismic) load on ground wire. iv. Wind (or seismic) load on insulator strings & fittings. v. Transverse component of tension in conductors and earth wire 3. Longitudinal loads <ol style="list-style-type: none"> a. Unbalanced pull due to broken power conductor. b. Unbalanced pull due to broken ground wire. c. Seismic loads on wire. d. Seismic loads on tower structure. e. Loads due to temperature variation 4. Torsional Load <ol style="list-style-type: none"> a. Due to earth wire broken condition b. Due to power conductor broken condition <p>Broken wire condition Any one power conductor broken or ground wire broken, whichever is more stringent for a particular member.</p>	(8)								
Q.4.	<p>a) Design member AB and joint A of a roof truss, as shown in the fig. for the following data</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-bottom: 10px;"> <thead> <tr> <th>Member</th> <th>Length</th> <th>Compressive force</th> <th>Tensile force</th> </tr> </thead> <tbody> <tr> <td>AB</td> <td>3.5m</td> <td>85 kN</td> <td>48 kN</td> </tr> </tbody> </table> <p>Solution-</p> <p>Design of member AB- Compressive member design</p> <ol style="list-style-type: none"> 1. Assume suitable f_{cd} 2. Required area calculation 3. Selection of suitable CHS & its properties 4. Slenderness ratio & f_{cd} 5. Design compressive strength, P_d 6. Check for design tensile force, T_{dg} 7. T_{dn} <p>Design Joint A assuming same cross section The length of the curve of intersection (see Fig. 2) may be taken as: $P = a + b + 3\sqrt{a^2 + b^2}$ $a = \frac{d}{2} \csc \theta$</p>	Member	Length	Compressive force	Tensile force	AB	3.5m	85 kN	48 kN	[8]
Member	Length	Compressive force	Tensile force							
AB	3.5m	85 kN	48 kN							



<p>Design stress in weld Size of weld</p>	$b = \frac{d}{2}$	
OR		
<p>b) Two channels 200mm x 80mm with bent lips are connected back to back with webs to act as column. The thickness of plate is 4 mm and the depth of lips is 25mm. Determine the safe load carrying capacity if the effective length of column is 6m. Take $f_y = 235 \text{ N/mm}^2$</p> <ol style="list-style-type: none"> 1. Properties of the column section 2. Computation of effective widths for unstiffened and stiffened elements 3. Determination of form factor Q 4. Determination of Cc and Slenderness ratio 5. Determination of safe load when $l = 6\text{m}$ 		
<p>c) Define stiffened element, flat-width ratio and effective design width for cold formed light gauged section along with suitable sketches</p> <p>Stiffened element-</p> <p>When any flat compression element is stiffened on both edges parallel to the direction of stress by connecting to a stiffening element offering a specified resistance to lateral deflection, then the element is considered as stiffened</p> <p>Flat width ratio- Measure of the shape of the section and is</p> <ol style="list-style-type: none"> 1. Defined as the ratio of the flat width to the thickness of the section. It is also sometimes referred to as the “width-to-thickness ratio” or “slenderness ratio” 2. For cold-formed steel sections, the FWR is an important parameter that influences the behaviour and strength of the section. 3. Generally, as the FWR increases, the section becomes more slender and susceptible to local and overall buckling, which can reduce its strength and stability. <p>Effective design width-</p> <p>Where the flat-width, w, of an element is reduced for design purposes, the reduced design width b is termed the effective width or the effective design width</p>		
		[8]



OR		
	<p>d) What are the important advantages of tubular structures?</p> <ol style="list-style-type: none">1. Excellent properties with regards to buckling and torsion2. Higher strength to weight ratio3. Lighter in material weight4. Closed shape of hollow structural sections reduces the cost of corrosion protection5. Excellent resistance to torsion and are therefore good choice for compression members. CHS have a uniform radius of gyration and for the same weight; their torsional strength is more6. For dynamic loads, CHS have a higher frequency of vibration other than rolled shapes. Due to a smooth finished surface, dirt and moisture do not collect over the surface, reducing the possibility of corrosion8. Varying the CHS thickness can accommodate the change in load with the floor levels and the external tube dimensions may be maintained9. SHS and RHS have an edge over CHS because they use simple connections with straight end cuts of the connecting members.	
Q.5	<p>a) The flat bottom overhead water tank of 80,000 litres capacity is to be erected. Design dimensions of tank, bottom plates and T-covers</p> <ol style="list-style-type: none">1. Dimensions of the tank<ul style="list-style-type: none">• Capacity of the tank(given)• Assume normal depth of tank and free board of 0.15m• Area of bottom of tank• Length of tank• Width of tank where width is provided by spacings between longitudinal beams plus overhangs of 0.4m on both sides.Capacity of tank > capacity of tank (given)<ul style="list-style-type: none">• Overall height of tank• Overall size of tankLength provides width of bottom of tank. Remaining length is bent on both sides which forms butt joints in the vertical sides.2. Thickness of plates<ul style="list-style-type: none">Plates are assumed to be simply supported at joint.Unit weight of water= 9.81 kN/m³Height of water columnWeight of water columnSelf-weight of plate = (1/20)* weight of water columnTotal weight acting = [(1/20)* weight of water column]+ weight of water columnMaximum Bending Moment= Total weight acting*width of plate/8Allowable bending stress= 0.8*0.66*f_ySection modulus= Max B.M. / allowable bending stressSection modulus of plate = (1/6)*width*thicknessHence thickness is found and provided3. Design of T-covers<ul style="list-style-type: none">Span of T-coversWidth of water column	[8]



	<p>Height of water column Weight of water column (a) (kN) = Span of T-covers* Width of water column* Height of water column*unit weight of water Assume T- Section from steel table as per requirement Weight of plates (b) Self-weight of T section(c) Weight of flat strip (d) Total weight= (a+b+c+d) Maximum B.M. = Total weight*width of plate/10 Section Modulus Req'd. = Max. B.M./ allowable bending stress T- section , flat strip and portion of plate sandwiched between two are considered effective in resisting the above B.M. These are joined using rivets. Total area (A)= $A\bar{y} =$ $y\bar{ =$ $I_{xx} =$ $Z_{xx} = I_{xx}/y\bar{ =$ $F_{max} = \text{Total weight}/2$ Horizontal shear per mm= $F * A\bar{y}/I$ Strength of rivets in shear Pitch of rivet = Strength of rivets in shear/ Horizontal shear per mm Spacing of rivets along the caulked edges should not be greater than 10 times the thickness of plate.</p>	
OR		
	<p>b) Staging of overhead water tank 1. Design of column a. Assume that wind pressure on tank and beam acts over a depth. b. Total P c. Divide the ht of column into no of panels d. Assume exposed area and calculate the effective e. wind pressure f. moment of wind forces at base g. thrust calculation h. permissible stress on column i. selection of trial section j. check for area 2. Design of bracings a. total shear= shear due to wind + 2.5% of force in column b. shear due to wind c. total horizontal shear d. design of horizontal brace e. design of diagonal brace b. shear due to wind c. total horizontal shear d. design of horizontal brace e. design of diagonal brace 3. Design of base plate of foundation</p>	



	4. Design of foundation and anchor bolts	
	c) i) loads acting on water tanks 1. dead 2. live 3. wind 4. seismic Types of tanks 1. surface with sketch 2. overhead with sketch	
	OR	
	d) Codal provisions 1. Scope and Applicability Clause 1.1, Page 1 IS 805 applies to the design, construction, and erection of steel gravity water tanks, including tanks supported on staging. Flat-bottom steel overhead water tanks fall within the scope of this code. 2. Materials and Workmanship Clause 3, Pages 3–4 <ul style="list-style-type: none">• Structural steel shall conform to relevant Indian Standards.• All steel plates shall be free from defects.• Welding and fabrication shall be carried out with proper workmanship to ensure strength and water tightness. 3. Loads to be Considered Clause 4, Pages 4–5 The following loads shall be considered in design: <ul style="list-style-type: none">• Dead load of tank plates and structural components• Load due to stored water• Live load on roof for maintenance• Wind load, where applicable• Seismic effects, when the tank is supported on staging 4. Permissible Stresses and Method of Design Clause 5, Pages 6–7 <ul style="list-style-type: none">• The design shall be based on the working stress method.• Permissible stresses in steel plates and joints shall not exceed values specified in the code.• For welded joints, joint efficiency shall be considered while calculating allowable stresses. 5. Design of Cylindrical Shell Plates Clause 6.1, Pages 7–9 <ul style="list-style-type: none">• Shell plates shall be designed to resist circumferential (hoop) tension due to hydrostatic pressure.• Thickness of shell plates shall increase from top to bottom.• Minimum thickness requirements are specified, including allowance for corrosion. 6. Design of Flat Bottom Plates Clause 6.2, Pages 9–10 <ul style="list-style-type: none">• Flat bottom plates shall be designed to resist radial tensile stresses induced by hydrostatic pressure.	[8]



	<ul style="list-style-type: none">• Proper connection between bottom plates and shell plates shall be ensured.• Lap joints or butt welds shall satisfy strength and watertightness requirements. <p>7. Design of Joints and Welding Clause 7, Pages 11–13</p> <ul style="list-style-type: none">• Welded joints shall be designed for the calculated forces and shall be watertight.• Welding procedures shall comply with the recommendations given in the code.• Inspection and testing of welds shall be carried out to ensure quality. <p>8. Corrosion Protection and Painting Clause 8, Pages 13–14</p> <ul style="list-style-type: none">• Adequate corrosion protection shall be provided for all steel surfaces.• Protective coatings or painting systems shall be applied as specified.• Additional plate thickness shall be provided as corrosion allowance. <p>9. Serviceability and Safety Provisions Clause 9, Pages 14–15</p> <ul style="list-style-type: none">• Tanks shall be designed to prevent leakage and excessive deformation.• Provisions for manholes, vents, ladders, and access platforms shall be made.• Tanks shall be maintained in serviceable condition throughout their design life.	
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