**Subject Name: DESIGN OF STEEL STRUCTURES**

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**Unit-I: (Materials)**

**Important points / Definitions:**

**The Various Types of Structural Steel Shapes**

* American Standard Beam (S-**Shaped**) Generally known as an S beam, the American standard beam has a rolled section with two parallel flanges, all connected by a web. ...
* Angle (L-**Shaped**) ...
* Bearing Pile (H-**Shaped**) ...
* Channel (C-**Shaped**) ...
* Hollow Steel Section (HSS) ...
* I-Beam. ...
* Pipe. ...
* Tee

**The Main Mechanical Properties of Steel are:**

* Mechanical Properties of Steel or physical properties of steel which include high strength, low weight, durability, ductility, Brittleness, Creep, and corrosive resistance.
* **Plasticity:** In physics and materials science, plasticity is the ability of a solid material to undergo deformation, a non-reversible change of shape in response to applied forces. For example, a solid piece of metal being bent or pounded into a new shape displays plasticity as permanent changes occur within the material itself.
* **Limit state method:**  refers to the method which considers the ultimate strength of the material at failure (which is ignored in working stress method) and also assures that the structure is serviceable for its intended period of design.
* **Serviceability:** refers to the conditions under which a building is still considered useful. ... Serviceability limit state design of structures includes factors such as durability, overall stability, fire resistance, deflection, cracking and excessive vibration.
* **Types of bolted:** There are two main types of bolted joint designs:

 1) Tension  joints and

 2) Shear  joints.

In the tension joint, the bolt and clamped components of the joint are designed to transfer an applied tension load through the joint by way of the clamped components by the design of a proper balance of joint and bolt stiffness

* **Riveted joints:** There are mainly of two types, namely,

Lap joints and 



Butt  joints.

Lap Joint: Two plates are said to be connected by a lap joint when the connected ends of the plates lie in parallel planes..

* **Welding joint:** A welding joint is a point or edge where two or more pieces of metal or plastic are joined together. They are formed by welding two or more workpieces (metal or plastic) according to a particular geometry.

* **Different Types of Welding Joints:** There are basically five types ofwelding joints and these are



* Butt joint
* Corner joint
* Lap joint
* Tee joint and
* Edge joint.

**Types of steel structures:** Main structural types

* Frame structures: Beams and columns.
* Grids structures: latticed structure or dome.
* Prestressed structures.
* Truss structures: Bar or truss members.
* Arch structure.
* Arch bridge.
* Beam bridge.
* Cable-stayed bridge

**I.SHORT ANSWER QUESTIONS [2M]**

1. What are the advantages and disadvantages of steel as a structural material?
2. State the physical and mechanical properties of steel as a structural material?
3. What loads and forces are considered for designing a structure or member?
4. Write a note on Ductility?
5. Explain the procedure for design strength due to block shear?
6. Write a note on limit state of serviceability?
7. Write a short note on geometric properties for steel member?
8. What are the possible limit states that are considered in the limit state method?
9. What are factors governing the ultimate strength?
10. What are the advantages of the bolted connections over riveted connections?

**II.LONG ANSWER QUESTIONS [5M]**

1. What a short note on factors governing the ultimate strength?
2. Design a single cover butt joint with grade of steel Fe410 and grade of bolt 4.6 diameter 20mm to resist a factored load of 70 KN thickness of main plate is 10mm and butt plate is 8mm.
3. Design a double cover butt joint with grade of steel Fe410 and grade of bolt 4.6 diameter 20mm to resist a factored load of 70 KN thickness of main plate is 10mm and butt plate is 8mm.
4. Explain why serviceability limit state is considered as important as failure limit states?
5. Design a lap joint with grade of steel Fe410 and grade of bolt 4.6 diameter 20mm to resist a factored load of 70 KN thickness of plate 10mm.
6. A 300 ISF 8mm of grade Fe410 is used as a tension member in a lattice girder. It is connected to a 12mm thick gusset plate by 18mm diameter bolts of grade 4.6 calculate the effective net area of the member if

 (a) Chain Bolting is done as shown in figure

 (b) Zigzag Bolting is done as shown in figure



1. Determine the block shear strength of the welded tension member shown in figure steel is of grade Fe410

 

1. Determine whether the joint shown in figure is safe or not 8-16mm diameter bolts of grade 4.6 have been used for making the connection at section 1-1 neglect the effect of prying action. Also , find the number of 16mm diameter bolts of grade 4.6 to connect the double angle section 8mm thick each member with the web of the Tee-bracket

 

1. Determine the effective net area of the section shown in figure. The angles are connected as shown in the figure the steel is of grade Fe410. The bolts holes have been punched.

 

1. Design a lap joint with grade of steel Fe410 and grade of bolt 4.6 diameter 20mm to resist a factored load of 100 KN thickness of plate 10mm.
2. What are the different loads and load combinations are to be considered to design member or a structure?
3. Write the different Types of steel structures?
4. Design joint B of a roof truss as shown in figure the members are connected with 16mm diameter bolts of grade 4.6 to the gusset plate 12mm thick.

 

**CHOOSE THE CORRECT ANSWER**

1. **The web crippling due to excessive bearing stress can be avoided by**
2. Increasing the web thickness
3. Providing suitable stiffeners
4. Increasing the length of the bearing plates
5. None of the above

 **Answer: C**

1. **The number of seismic zones in which the country has been divided is**
2. 3
3. 5
4. 6
5. 7

 **Answer: B**

1. **The critical stress on a column for elastic buckling given by Euler's formula, is**
2. *f*c = *π*2*E*/(*I*/*r*)2

1. *f*c = (*I*/*r*)2/*πE*
2. *f*c = (*I*/*r*)/*πE*
3. *f*c = *π*2*E*/(*I*/*r*)

 **Answer: A**

1. **Load factor is**
2. Always equal to factor of safety
3. Always less than factor of safety
4. Always greater than factor of safety
5. Sometimes greater than factor of safety

 **Answer: C**

1. **When two plates are placed end to end and are joined by two cover plates, the joint is known as**
2. Lap joint
3. Butt joint
4. Chain riveted lap joint
5. Double cover butt joint

 **Answer: D**

1. **For a standard 45° fillet, the ratio of size of fillet to throat thickness is**
2. 1 : 1
3. 1 : √2
4. √2 : 1

 D. 2:1

 **Answer: C**

1. **The strength of a riveted lap joint is equal to its**

 A. Shearing strength

 B. Bearing strength

 C.  Tearing strength

 D. Least of (a), (b) and (c)

 **Answer: D**

1. **The maximum spacing of vertical stiffeners is**
2. 1.33d
3. 1.25d
4. 1.5d
5. 1.75d

 Where ‘*d’* is the distance between flange angles

 **Answer: C**

1. **Minimum pitch provided in riveted steel tanks is**
2. 1.5d
3. 2.0d
4. 2.5d
5. 3.0d

Where *d* is diameter of rivets

**Answer: D**

1. **The mechanism method and the statical method give**
2. Lower and upper bounds respectively on the strength of structure
3. Upper and lower bounds respectively on the strength of structure
4. Lower bound on the strength of structure
5. Upper bound on the strength of structure

**Answer: B**

1. **Shear buckling of web in a plate girder is prevented by using**
2. Vertical intermediate stiffener
3. Horizontal stiffener at neutral axis
4. Bearing stiffener
5. None of the above

  **Answer: A**

1. **The net area of round bars to resist the tension, is the area of cross section at**
2. Mid-section
3. Root of the thread
4. Difference of (a) and (b)
5. None of these

  **Answer: B**

1. **The bracing provided in the plane of end posts is called**
2. Sway bracing
3. Portal bracing
4. Top lateral bracing
5. Bottom lateral bracing

 **Answer: B**

1. **The statical method of plastic analysis satisfies**
2. Equilibrium and mechanism conditions
3. Equilibrium and plastic moment conditions
4. Mechanism and plastic moment conditions
5. Equilibrium condition only

 **Answer: B**

1. **The risk coefficient *k*, depends on**
2. Mean probable design life of structures
3. Basic wind speed
4. Both (A) and (B)
5. None of the above

**Answer: C**

**FILLING THE BLANKS:**

1. Junction between the flange and web of a beam is know as………**Fillet**
2. The life period steel building is…………………..**50 years**
3. Poisson ratio of steel in elastic range is…………**0.25**
4. The value of Young’s modulus for mild steel is about……….**200KN/mm2**
5. The effective length of a fillet weld of length L and size is………**L-2s**
6. In welded joint, the throat of weld as compared to size of weld is**…..0.7 times**
7. In a welded joints, the side fillet is subjected to**……………….Shear Stresses**
8. The butt welds are very effective in resisting**………..Axial stress**
9. The fillet welds areeffective in resisting……….**Shear stress**
10. Which of the following equation is correct for bolt subjected to combined shear and tension**………………….(  (Vsb/Vdb)2 + (Tsb/Tdb)2 ≤ 1)**

**Unit-II: (Design of tension members)**

**Important points / Definitions:**

1. **Tension members:** A Structural member subjected to two pulling (tension) forces applied at its ends is called tension member.

**Examples:**  tension members are bracing for buildings and bridges, truss members, and cables in suspended roof systems.

1. **Compression members:** A Compression member is aStructural member which is straight and subjected to two equal and opposite compressive forces applied at its ends
* An ideal compression member is one which is perfectly straight, has no crookedness, no imperfections; and the loads are applied uniformly across it, with the centre of gravity of loads coinciding with centre of gravity of the member.
* Such a compression member will be a truly axially loaded member.
1. **Gross area:** When **tension members** are spliced or connected to a gusset plate by rivets or bolts, some material is removed from the cross-section due to bolt or rivet holes. The net **area** at any section is equal to the **gross area** minus the deduction for holes at that section.

1. **Types of tension members:**

 The types of structure and method of end connections determine the type of a tension member in structural steel construction. Tension members used may be broadly grouped into four groups.

1. Wires and cables,
2. Rods and bars
3. Single structural shapes and plates
4. Built-up members

### Wires and Cables: The wire types are used for hoists, derricks, rigging slings, guy wires and hangers for suspension bridges.

###  (ii) Rods and Bars:

###  The square and round bars are shown in figures are quite often used for small tension members. The round bars with threaded ends are used with pin-connections at the ends instead of threads.

###  C:\Users\Student\Desktop\2.jpg

### Figure: Square and circular rods and bars

The ends of rectangular bars or plates are enlarged by forging and bored to form eye bars. The eye bars are used with pin connections. The rods and bars have the disadvantage of inadequate stiffness resulting in noticeable sag under the self weight.

**(iii) Single Structural Shapes and Plates:**

The single structural shapes, i.e. angle sections and tee-sections as shown in figures are used as tension members. The angle sections are considerably more rigid than the wire ropes, rods and bars. When the length of tension member is too ling, then the single angle section also becomes flexible.

 

###  (iv) Built- up Sections

###  Two or more than two members are used to form built up members. When the single rolled steel section can not furnish the required area, then built-up sections are used.

1. **Bracing:** The main function of the bracing in steel structures that the lateral forces due to wind, earthquake and crane surge etc. are transmitted efficiently to the foundation of the building. A system of lateral or diagonal bracing is provided to prevent the building from twisting under the action of wind.
2. **Failures:** As the tensile load reaches the ultimate load the member reaches a failure state. A member in tension can reach a failure state due to excessive elongation or by rupture of its section. The analysis of a member subjected to tension is probably the most straight forward to all structural analysis
3. **Lug Angle:** It is one such development which can be used effectively in designing of tension member. Lug angle is small piece of angle used to connect outstand legs of the members to the gusset plate. The purpose of lug angle is to reduce the length of connection to the gusset plate and to reduce shear lag effect.



1. **Splice:** A splice joint is a method of joining two members end to end in woodworking. ... The most common form of the splice joint is the half lap splice, which is common in building construction, where it is used to join shorter lengths of timber into longer beams.

 

1. **Gusset plate:** itis a plate for connecting beams and girders to columns. A gusset plate can be fastened to a permanent member either by bolts, rivets or welding or a combination of the three.
2. **Slenderness ratio** is the ratio of the length of a column and the least radius of gyration of its cross section. Often denoted by lambda. It is used extensively for finding out the design load as well as in classifying various columns in short/intermediate/long. Short Steel column - lambda is less than 50.

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**SHORT ANSWER QUESTIONS [2M]**

1. What is buckling?
2. Write a note on eccentric beam connections?
3. What is radius of gyration?
4. What is slenderness ratio? State the relation between elastic critical stress and slenderness ratio.
5. What are semi-compact sections?
6. What is slenderness ratio?
7. Write the formula to calculate design compression stress?
8. Explain the types of tension members?
9. Explain the failures of tension members?
10. Explain the types of buckling in compression members?

**LONG ANSWER QUESTIONS [5M]**

1. Calculate the value of the least radius of gyration for a compound column consisting of ISHB 250@ 536.6 N/m. with one cover plate 300X20mm on each flange.
2. Calculate the design compressive load for a stanchion 350@710.2N/m high the column is restrained in direction and position at both the ends it is to be used as an uncased column in single storey building use steel grade of Fe410.
3. Design a column to support a factored load of 1050 kN. The column has an effective length of 7.0m with respect to Z axis and 5.0 m with respect to Y axis. Use steel grade of Fe410.
4. Design a stanchion 3.5m long in a building subjected to a factored load of 550kN. Both the ends of stanchion are effectively restrain in direction and position. Use steel grade of Fe410.

1. For a column section built up of shape as shown in figure. Determine the axial load capacity in compression for the data indicated against the figure.

fy = 250 Mpa

L= 6.0m

tw = 20mm

 tf = 30mm

Partial safety factor = 1.50



1. Design a single angle discontinues strut to carry a factored axial compressive load of 65kN. The length of the strut is 3.0m between intersections. It is connected to 12mm thick gusset plate by 20mm diameter 4.6 grade bolts. Use steel grade of Fe410.
2. Calculate the strength of a discontinuous strut of length 3.2m. The strut consist of 2 unequal angles 100mm x 75mm x 8mm (fy = 250N/mm2) with long legs connected and placed.

 a) On the opposite side of the gusset plate.

 b) On the same side of the gusset plate.



1. Why is it better to choose plastic or compact sections for columns?
2. Determine the load carrying capacity of the column section shown in figure, if its actual length is 4.5m. It’s one end may be assumed fixed and the other end hinged. The grade of steel is Fe410.

 

1. Design a laced column with two channels back to back of length 10m to carry an axial factored load of 1400KN. The column may be assumed to have restrained in position but not in direction at both ends (hinged ends).
2. Design a battened column with two channels back to back of length 10m to carry an axial factored load of 1400KN. The column may be assumed to have restrained in position but not in direction at both ends (hinged ends).
3. Design a built-up column 10 m long to carry a factored axial load of 1080 Kn. The column is restrained in position but not in direction at both the ends. Provide single lacing system with bolted connection. Assume steel of grade Fe410and bolts of grade 4.6.Design the column with two channels placed back-to-back
4. Design a built-up column 10 m long to carry a factored axial load of 1080 kN. The column is restrained in position but not in direction at both the ends. Provide single lacing system with bolted connection. Assume steel of grade Fe410and bolts of grade 4.6.Design the column with two channels placed toe-to-toe.
5. A column ISHB 300 @ 576.8 N/m is to support a factored load of 900KN.the column section is to be spliced at a height of 2.5 m > design the splice plate and connections using 4.6 grade bolts. Use steel of grade De410.
6. A stanchion ISHB 300 @ 618 N/m in the lower story of a building is to be jointed to a stanchion ISHB 200 @ 392.4 N/m of the next upper storey. A load of 600 KN is to be transferred from the top storey stanchion. Design the column splice. The column ends are made flush. Use steel of grade Fe4110 and bolts of grade 4.6
7. Design a single angle discontinuous strut to carry a factored axial compressive load of 65kN. The length of strut is 3m between intersections. It is connected to 12mm thick gusset plate by 20mm diameter 4.6 grade bolts. Use steel of grade Fe 410.
8. A column ISHB 300 @ 567.8 N/m is to support a factored load of 900 KN. The column section is to be spliced at a height of 2.5m. Design the splice plate and connecting using 4.6 grade bolts. Use steel of grade Fe410.
9. Design a double angle discontinuous strut to carry a factored axial compressive load of 135 kN, resulting from combination with wind load. The length of the strut is 3m between intersections. The two angles are placed back-to-back (with long legs connected) and are tack bolted. Use steel of grade Fe 4.6.
10. Design the column with two channels place back-to-back
11. Design the column with two channels place toe-to-toe
12. Which of the two systems is economical
13. Design the lacing system with site welded connections for channels back-to-back

 **CHOOSE THE CORRECT ANSWER**

1. For the calculation of net area of flat with staggered bolts, the area to be deducted from gross area is :
2. Nd
3. n’p2t/8g
4. ndt – n’p2t/4g
5. nd + n’p2t/4g
**Answer: C**
6. Which section to be considered in the design for the net area of flat?

 

 a)  1-5-6-3
 b) 2-7-4
 c) 1-5-7-4
 d) 1-5-7-6-3

 **Answer: D**

1. What is the net section area of steel plate 40cm wide and 10mm thick with one bolt if diameter of bolt hole is 18mm?
2. cm2
3. 20 cm2
4. c) 240 mm2
5. d) 480 mm2

 **Answer: A**

1. What is the net area for the plate 100 x 8 mm bolted with a single bolt of 20mm diameter in case of drilled hole?
2. 624 mm2
3. 756 mm2
4. 800 mm2
5. 640 mm2

 **Answer: D**

1. Maximum pitch distance = \_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. 16 x thickness of thinner plate
3. 32 x thickness of thinner plate
4. 40 x thickness of thinner plate
5. 20 x thickness of thinner plate

**Answer: B**

1. What is the minimum pitch distance?
2. 2.0 x nominal diameter of fastener
3. 3.0 x nominal diameter of fastener
4. 1.5 x nominal diameter of fastener
5. 2.5 x nominal diameter of fastener

**Answer: D**

1. High strength bolt is used for \_\_\_\_\_\_\_\_\_\_\_\_
2. shear connection
3. slip resistant connection only
4. bearing type connection only
5. both slip resistant and bearing type connection

**Answer: D**

1. Minimum edge distance and end distance for rolled, machine flame cut is
2. 1.7 x hole diameter
3. 1.2 x hole diameter
4. 1.5 x hole diameter
5. 2.0 x hole diameter

**Answer: C**

1. The design compressive stress of compression member in IS 800 is given by
2. Rankine Formula
3. Euler Formula
4. Perry-Robertson formula
5. Secant-Rankine formula

**Answer: C**

1. Which of the following is not a compression member?
2. Strut
3. Boom
4. Tie
5. Rafter

**Answer: C**

1. The best compression member section generally used is
2. single angle section
3. I-section
4. double angle section
5. channel section

**Answer: B**

1. The best double-angle compression member section is
2. unequal angles with short leg connected
3. unequal angles with long leg connected
4. unequal angles on opposite side of gusset plate
5. unequal angles on same side of gusset plate

**Answer: A**

1. Lug angles are found to be more effective at \_\_\_\_\_
2. end of the connection
3. middle of connection
4. beginning of connection
5. they are equally effective at all connections

**Answer: C**

1. What is the minimum thickness of gusset plate?
a) 5mm

b) 8mm

c) 10mm

d) 12mm

 **Answer: D**

1. Lateral buckling in beam is \_\_\_\_\_\_\_\_\_
2. does not occur in beam
3. one dimensional
4. two dimensional
5. three dimensional

 **Answer: D**

1. What is elastic critical moment?
2. bending moment at which beam do not fail by lateral buckling
3. bending moment at which beam fails by lateral buckling
4. shear force at which beam do not fail by lateral buckling
5. shear force at which beam fails by lateral buckling

**Answer: B**

1. Thickness of lacing member should be
2. less than 1/40th of the effective length for single lacing
3. not less than 1/60th of the effective length for double lacing
4. less than 1/60thof the effective length for double lacing
5. less than 1/60th of the effective length for single lacing

**Answer: B**

1. lacing bars shall be inclined at an angle of \_\_\_ to axis of built up member.
2. 20o
3. 35o
4. 50o
5. 90o

**Answer: C**

1. Minimum radius of gyration for lacing flats is
2. t/√12
3. t/12
4. t/√24
5. t/24

**Answer: A**

1. Depth of intermediate batten = \_\_\_\_\_\_\_ depth of end batten
a) 1/2

b) 3/4

c) 1

d) 2

 **Answer: B**