SNS College of Technology,
Coimbatore- 35(Autonomous)

Department of Civil Engineering

Academic Year 2024-2025 (Even)

VI Semester

19CET304 – DESIGN OF STEEL STRUCTURES

UNIT –IV BEAMS

1. What is a beam?

A beam is a structural member, which carries a load normal to the axis. The load produces bending moment and shear force in the beam.

2. What is meant by castellated beam?

A rolled beam with increased depth is to be castellated. To obtain such sections, a zigzag line is cut along the beam by an automatic flame-cutting machine. The two halves thus produced are rearranged so that the teeth match up and the teeth are then welded together.

3. How the beams are failed?
   - Bending failure
   - Shear failure
   - Deflection failure

The designs are based on these three failures which are to be determined.

4. What do you mean by bending failure?

Bending failure may be due to crushing of compression flange or fracture of the tension flange of the beam. Instead of failure due to crushing, the compression flange may fail by a column like action with side ways or lateral buckling. Collapse would follow the lateral buckling.

5. What is the maximum deflection that to be allowed in steel beams?

The deflection of a member, shall not be such as to impair the strength or efficiency of the structure and lead to finishing. The deflection is generally should not exceed 1/325 of the span.

6. What is web crippling?

Web crippling is the localized failure of a beam web due to introduction of an excessive load over a small length of the beam. It occurs at point of application of

concentrated load and at point of support of a beam. A load over a short length of beam can cause failure due to crushing and due to compressive stress in the web of the beam below the load or above the reaction. This phenomenon is also known as web crippling or web crushing.

7.Why is web crippling a critical consideration in the design of plate girders? Justify with an example?

Web crippling is a critical consideration in the design of plate girders because: the web—being thin relative to its depth—can fail locally under concentrated loads or reactions before the overall girder strength is reached. This localized buckling or crushing of the web near supports or under point loads can lead to sudden and brittle failure, even if the girder is globally adequate.

8. Why does buckling of web occur in beams?

- Diagonal compression due to shear
- Longitudinal compression due to bending
- Vertical compression due to concentrated loads

9. What are laterally supported beams?

A laterally supported beam is a beam that is supported along its length to prevent lateral buckling. Lateral support can be provided by bracing, sheathing, or other means to prevent the beam from deflecting laterally. This type of support is important in preventing the beam from failing under the influence of lateral loads, such as wind or seismic forces.

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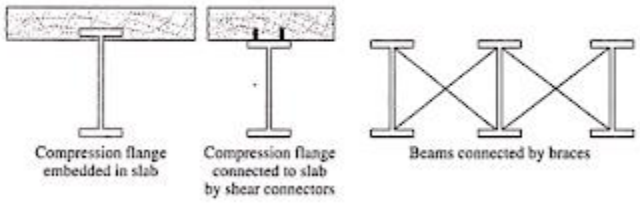


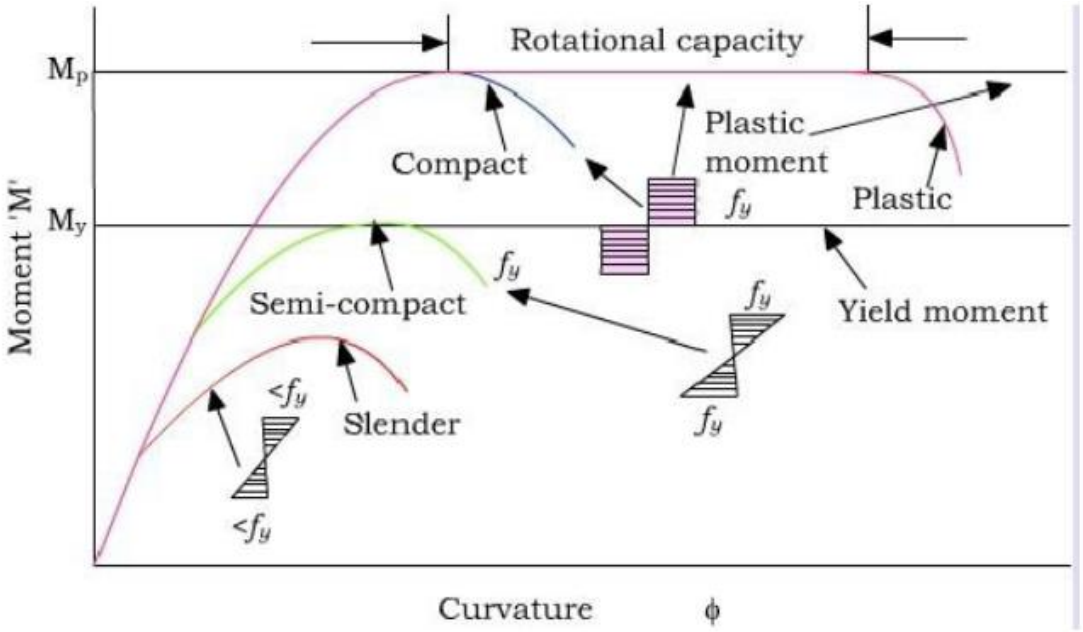
10. Mention the advantages of using rolled steel wide flange section as

Lesser area, Economical

11.Under what situations the plated beams are used?

- When a bending moment is large which cannot be resisted by the largest available rolled beam section
- The depth of the beam is restricted due to headroom requirements.

11. **Draw the curvature for flexural member performance and the classification of cross sections.**



12. Write a note on built up beams.

The built-up beams are also termed as compound beams or compound girders. The built-up beams are used when the span, load and corresponding bending moment are of such magnitudes that rolled steel beam section become inadequate to provide required section modulus. The built-up beams are also used when rolled steel beams are inadequate for limited depth.

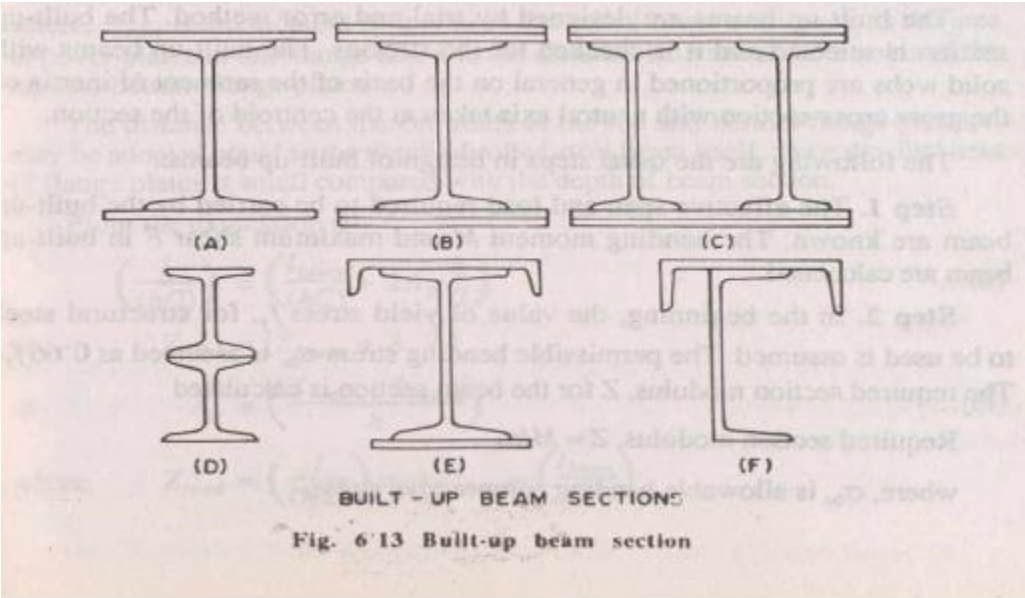


Fig. 6·13 Built-up beam section

13. Define laterally unsupported beam

An unsupported beam, also known as a simply supported beam, lacks sufficient lateral support along its length. It might have support only at its ends or have no lateral bracing, allowing it more freedom to move laterally. Unsupported beams are more prone to lateral buckling or deflection, especially when subjected to heavy loads or lateral forces. Without proper support, these beams might fail due to buckling rather than reaching their maximum load-carrying capacity.

14. How the laterally supported beam fails?

The laterally supported beam can fail by,

- Flexure

- Shear
- Bearing.

15. What is meant by lateral buckling of beam?

A long beam with laterally unrestrained compression flange when incrementally loaded, first deflects downwards and when load exceeds a particular value; it tilts sideways due to instability of compression flange, and rotates about longitudinal axis. This phenomenon is known as laterally buckling or torsional buckling of beam.

Web buckling occurs when the intensity of compressive stress near the centre of the section exceeds the critical buckling stress of web acting as a strut. This type of failure is more in the case of built up sections having greater ratio of depth to thickness of the web.

16. What are the different types of steel cross sections

As per IS 800-2007, the classification of the steel cross sections depends on the load that the section can carry before failing, local buckling, moment redistribution capacity and the width to thickness ratio of the sections in consideration.

The steel cross sections are mainly classified into four types based on the above criteria as per IS 800-2007.

1. Plastic section
2. Compact section
3. Semi-compact section
4. Slender section

PART B

1. Design a simply supported(laterally supported) of effective span of 12m to carry o factored load of 70 kN/m the depth of the beam is restricted to 500mm.

2. Design a simply supported beam of effective span 10m to carry factored load of 60kN/m, the depth of the beam is restricted to 500mm . Assume the beam is laterally unsupported.

3. Explain the step by step procedure for the laterally supported beam
4. Explain the step by step procedure for the laterally unsupported beam

5. Design a simply supported beam ISMB 350@52.4kg/m is used over a span of 5m. The beam carries an UDL live load of 20kN/m and dead load of 15kN/m. The beam laterally supported throughout.

6. Design a beam of effective span of 6m subjected to an UDL of 10kN/m with 100kN. The beam is laterally supported. The thickness of wall is 230mm.

7. A beam simply supported over a span of 6m it supports an beam @ mid span exerting 90kN. Design the beam with ISWB section section with flange plate .Assume the beam is laterally unsupported

UNIT – V – ROOF TRUSSES AND INDUSTRIAL BUILDINGS

1. What are Plate Girders?

Plate girders in steel structures are built-up beam sections designed to support massive vertical loads over long spans with bending moments greater than the moment resistance of readily available rolled sections. The plate girder is a built-up beam composed of two flange plates fillet welded to a web plate to form an I-section. A typical plate girder diagram depicting its components is shown below.

3. What are the Types of Plate Girders

The plate girders can be of two types:-

Riveted Plate Girders

- They are connected by a mechanical method, riveted, and plates are not welded together.
- In general, the web carries 90% of the shear acting on the riveted plate girders.
- The angle section riveted to the flange stabilises the connection between the web and the flange. Rivets must be designed to withstand horizontal shear.
- The rivets that connect the web and flange angles must be designed for horizontal shear and vertical loads that are applied to the flange when they transfer to the web.

Welded Plate Girders

- Welded plate girders are the most commonly used type of girder in construction due to their ease of manufacture and efficiency.
- These sections are primarily used in the construction of bridges. The plate girder bridge is extremely stiff and can withstand extremely high loads while resisting lateral movements. This action is visible on railway bridges. Welded Plate Girders are also used to create box type girders.
- There are empirical or approximation methods for determining the overall height, flange and web thickness of the welded plate girder.

4. What are the advantages of Plate Girders?

- They can transfer heavy loads.
- They have greater stability.
- Resistance to fatigue failures is high.
- When compared to truss bridges, they are simpler to build.
- Maintenance of the plate girders is simple.
- They facilitate speedy construction.

5. What are the disadvantages of Plate Girders?

- They are not suitable for supporting large spans.
- Architectural appearance is reduced by using plate girders.
- It becomes a little difficult to manage during the placement of the plate girders.
- The design must be strictly followed during production

6. What are the applications of Plate Girders

They are majorly used in the construction of bridges. Plate girders are most commonly found in railway and road bridges.

The majority of the old railway bridges can be identified as plate girder bridges

Apart from the construction of bridges, some other applications of plate girders are in the construction of:-

- Cranes
- Lifting structures
- Oil and gas platforms
- Load testing
- Ships
- Gantry beams

10. Why intermediate stiffeners are required for plate girders?

The web of the plate girder relatively being tall and thin it is subjected to buckling. Hence it is stiffened both vertically and horizontally using intermediate stiffeners.

11. What do you mean by curtailment of flanges?

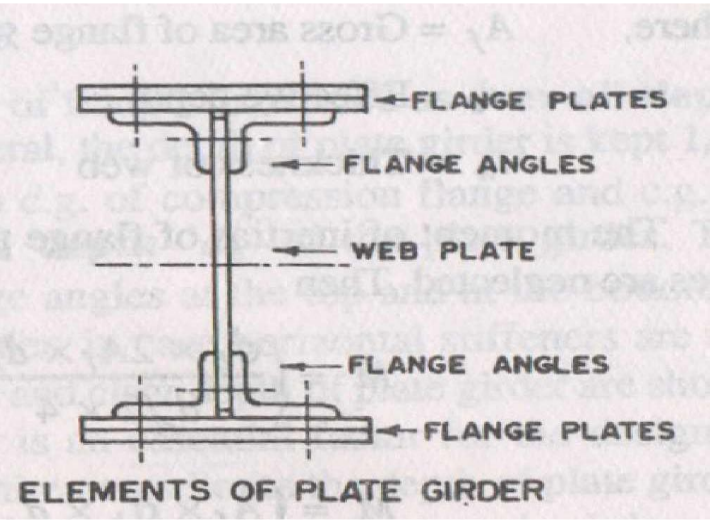
The section of a plate girder is to be designed first at mid span. The bending moment will goes on decreasing towards the supports. Hence the flange plates, provided at the maximum section can be curtailed.

14. What is the purpose of providing the bearing stiffener?

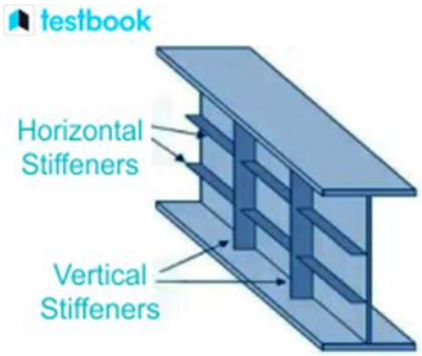
It prevents the web from crushing and buckling sideways, under the action of concentrated loads
It relieves the rivets connecting the flange angles and web, from vertical shear.

15. Name the components of a plate girder with neat sketch

Web plate	Vertical or transverse stiffeners
Flange plate	Bearing stiffeners
Flange angles	Longitudinal or horizontal stiffeners
Web splice plates	End bearings or end connections
Flange splice plates	



ELEMENTS OF PLATE GIRDER



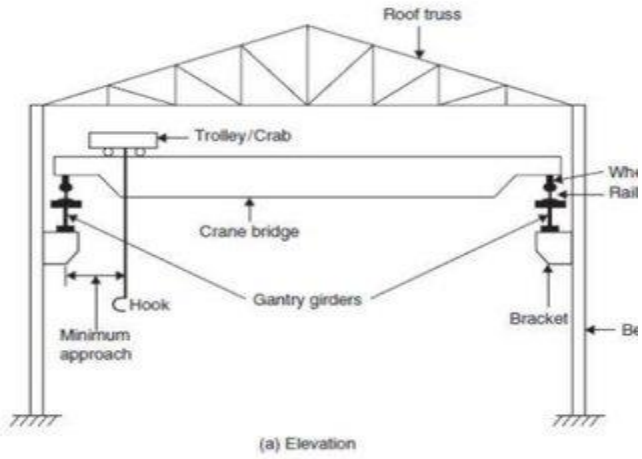
16. **Define gantry girder**

Gantry girders are laterally unsupported beams to carry. heavy loads from place to place at the construction sites, mostly these are of steel material. A **girder** is a support beam used in construction. It is the main horizontal support of a structure which supports smaller beams.

Gantry girders are provided in industrial buildings to support overhead cranes for the transportation and lifting of heavy load. These cranes may be manually (hand) operated overhead travelling cranes (MOT) or electrically operated overhead travelling (EOT) cranes.

17. Give the types of gantry girder
    1. Fixed Height gantry girder
    2. Adjustable Height gantry girder
    3. Single Girder **gantry girder**
    4. Double Girder **gantry girder**
    5. Rail Mounted **gantry girder**
    6. Cantilever Gantry Crane **gantry girder**

18. Draw Electric Overhead Travelling (EOT) crane and mark the components



1: Elevation of EOT crane

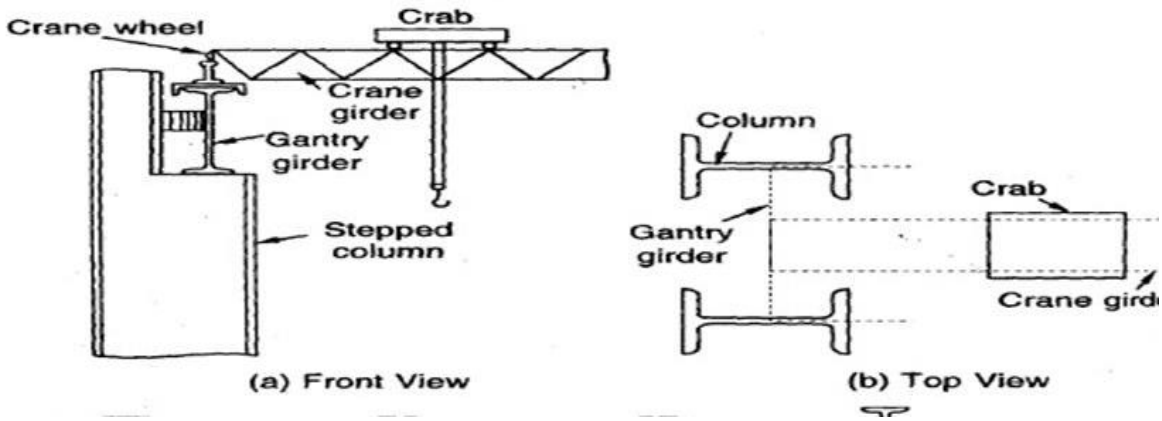
19. What is the main purpose of gantry girder?

It is the main horizontal support of a structure which supports smaller beams.Girders often have an I-beam cross section composed of two load-bearing flanges separated by a stabilizing web, but may also have a box shape, Z shape and other forms. A girder is

commonly used many times in the building of bridges.

20. What is surge load in gantry girder?
These are subjected to vertical loads from crane, horizontal lateral loads due tosurge of the crane, that is, the effect of acceleration and braking of the loaded crab and swinging of the suspended load in the transverse direction, and longitudinal force due to acceleration and braking of the crane as a whole.

21. Draw the gantry and truss girder arrangement



22. Write the components of crane system

The following are the main components of crane system
a) Hoist
b) Crane crab or trolley
c) Crane truss or crane girder (also 'crab girder' or 'crane bridge')
d) Gantry Girder

23. Write the Loads Acting on Gantry Girder

Gantry girder undergoes unsymmetrical bending due to the following forces:

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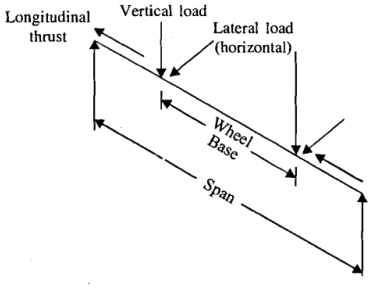


Figure 10.3: Loads Acting on Gantry Girder

24. Give the Loads Acting on Gantry Girder
a) Vertical reaction from the loads on the crane girder
b) Longitudinal forces due to starting or stopping of the crane.
c) Lateral force due to starting or stopping of the crab.
d) Fatigue effects
e) Impact effect

26. What is the difference between plate girder and gantry girder?

- **Function and Loading:**

  - **Gantry Girders:** Specifically designed to support moving loads from cranes (like electric overhead traveling cranes) and are subjected to dynamic, impact, and lateral loads due to crane movement.
  - **Plate Girders:** Primarily used to support static or distributed loads, such as those in bridges or floors, and usually experience vertical loading only.

- **Structural Features:**

  - **Gantry Girders:** Often have additional design elements like rail seats and stiffeners to handle wheel loads and lateral thrust from cranes.
  - **Plate Girders:** Are simpler in design, consisting of a web and flanges without special provisions for crane-related forces.

The gantry girder is a long steel beam that can carry heavy loads, especially moving loads. ... A plate girder is a girder which you develop using steelplates. And finally a gantry girder is also a plate girder which is most of the time laterally unsupported and used to support heavier loading like crane loading.

27. Name the types of roofing systems.

Flat roofing consists of either RCC construction or RSJ slab construction Sloping roofing

28. Where the steel roof trusses are used?

Industrial buildings, workshop buildings, storage godowns, warehouse and even for residential buildings, school buildings, offices where the construction work is to be completed in a short duration of time.

29. Mention the advantages of a roof truss.

Its mid-span depth is the greatest specially where bending moment in the span is the maximum

Great economy.

Sloping faces of trusses facilitate in easy drainage of rainwater.

30. What is the factor that is considered in the roof truss and why?

The factor, which is considered in the roof truss, is pitch, it is defined as the ratio of the span length to the depth of the truss, is governed by the roofing material and other requirements such as ventilation and light.

31. What is meant by purlins?

Purlins are structural members which are supported on the principal rafter, and which run transverse to the trusses. The span of the purlins is equal to the center-to-center spacing of the trusses. The purlins support the roof covering either directly or through common rafters. They are usually made of either an angle section or a channel section and are therefore subjected to unsymmetrical bending

32. Why the bracings are provided?

Bracing is required to resist horizontal loading in pin-jointed buildings, including roof trusses. Bracing of roof trusses and supporting columns provide still rigid structure. When wind blows normal to the inclined surface of the trusses, it is efficiently resisted by all the members of the truss and the wind forces are transferred to the supports at the ends of the truss

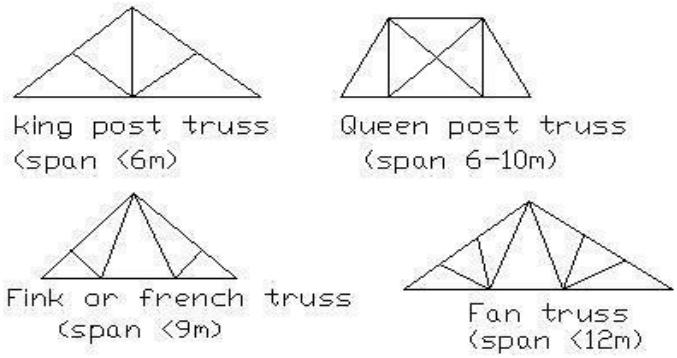
33. Name the most common roof covering materials.

Slates	Glass
Tiles	Corrugated aluminium sheets
Lead sheets	Galvanized corrugated iron sheets (G.I. sheets)
Zinc sheets	Asbestos cement sheets (A.C. sheets

34. How the trusses are classified according to the pitch?

Small pitch - span depth ratio is more than 12 m
Medium pitch - span depth ratio is between 5m to 12 m
Large pitch - span depth ratio is 5 or less.

35. Sketch the various types of roof truss



36. where a **roof truss system** is preferred over **portal frames** is:

For large-span industrial buildings (e.g., warehouses or aircraft hangars) where spans exceed 30 meters. Roof trusses are more efficient in covering large spans because they use a triangulated system that distributes loads effectively with minimal material, reducing overall weight and cost. In contrast, portal frames become uneconomical for very large spans due to heavier sections needed to resist bending and deflection.

PART B

1. Design a bearing stiffener for a welded plate girder with the following specifications. Web = 1000mm X 6mm thick. Flanges = 2 Nos. of 350X20mm plate on each side. Support reaction = 350kN.Width of the support = 300mm.
2. Design the step by step procedure for design of welded plate girder
3. Design the step by step procedure for design of gantry girder

4. Design a welded plate girder 24m in span and laterally restrained throughout. It has to support a uniform load of 100kN/m throughout the span exclusive of self-weight. Design the girder without intermediate transvers stiffeners. The steel for the flange and web plates is of gradeFe410. Design the cross section, the end load bearing stiffener and connections.