MUTHAYAMMAL ENGINEERING COLLEGE
(An Autonomous Institution)

(Approved by AICTE, New Delhi, Accredited by NAAC & Affiliated to Anna University)
Rasipuram - 637 408, Namakkal Dist., Tamil Nadu

LECTURE HANDOUTS

L - 01

CIVIL

III/ VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Structural Steel Sections

Introduction :

Steel structure is a metal structure which is made of structural steel components connect with each other to carry loads and provide full rigidity.Structural steel is steel construction material which fabricated with a specific shape and chemical composition to suit a project's applicable specifications.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Applications of Steel Sections.

Detailed content of the Lecture:

- ✓ This chapter will give you a brief overview of structural steel. Structural steel is used as the framework for many steel structures such as industrial and commercial buildings, advanced base structures, and bridges.

- ✓ Many different pieces go into fabricating and erecting the framework for a steel structure, and as a Seabee Steelworker, you must have a thorough knowledge of the various structural members.

- ✓ We will discuss the most common names of the steel members as well as how to fasten and secure the members to each other and to the concrete foundation they are built upon.

- ✓ We will also discuss where and how in the structure the steel members are used. Before any structural steel is fabricated or erected, a plan of action and sequence of events, or erection, needs to be set up. The plans, sequences, and required materials are predetermined by the engineering section and drawn up as a set of plans.

- ✓ This chapter describes the basics of structural steel: the terminology, use of the members, methods of connection, and basic sequence of events during erection.

Structural steel is a category of steel used for making construction materials in a variety of shapes.

Many structural steel shapes take the form of an elongated beam having a profile of a specific cross section.

Structural steel shapes, sizes, chemical composition, mechanical properties such as strengths, storage practices, etc., are regulated by standards in most industrialized countries.

Most structural steel shapes, such as **I**-beams, have high second moments of area, which means they are very stiff in respect to their cross-sectional area and thus can support a high load without excessive sagging.

Common structural shapes

The shapes available are described in many published standards worldwide, and a number of specialist and proprietary cross sections are also available.

A steel **I**-beam, in this case used to support timber joists in a house.

- **I**-beam (**I**-shaped cross-section - in Britain these include Universal Beams (UB) and Universal Columns (UC); in Europe it includes the IPE, HE, HL, HD and other sections; in the US it includes Wide Flange (WF or W-Shape) and **H** sections)
- Z-Shape (half a flange in opposite directions)
- HSS-Shape (Hollow structural section also known as SHS (structural hollow section) and including square, rectangular, circular (pipe) and elliptical cross sections)
- Angle (**L**-shaped cross-section)
- Structural channel, or **C**-beam, or **C** cross-section
- Tee (**T**-shaped cross-section)
- Rail profile (asymmetrical **I**-beam)
  - Railway rail
  - Vignoles rail
  - Flanged **T** rail
  - Grooved rail
- Bar, a long piece with a rectangular cross section, but not so wide so as to be called a sheet.
- Rod, a round or square section long compared to its width; see also rebar and dowel.
- Plate, metal sheets thicker than 6 mm or $\frac{1}{4}$ in.
- Open web steel joist

While many sections are made by hot or cold rolling, others are made by welding together flat or bent plates (for example, the largest circular hollow sections are made from flat plate bent into a circle and seam-welded).[1]

The terms *angle iron*, *channel iron*, and *sheet iron* have been in common use since before wrought iron was replaced by steel for commercial purposes.

They have lived on after the era of commercial wrought iron and are still sometimes heard today, informally, in reference to steel angle stock, channel stock, and sheet, despite that they are misnomers (compare "tin foil", still sometimes used informally for aluminum foil).

In formal writing for metalworking contexts, accurate terms like *angle stock*, *channel stock*, and *sheet* are used.

Video Content / Details of website for further learning (if any):
https://www.youtube.com/watch?v=HYpF_xsbLLk
https://www.youtube.com/watch?v=dEJk4xptsQQ

Important Books/Journals for further learning including the page nos.:
1.Dr.B.C.Punmia, Design of Steel Structures. P.No: 1 to 8

Course Teacher

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LECTURE HANDOUTS

L - 02

CIVIL **III/ VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Limit State Design Concepts

Introduction :

A limit state is a condition of a structure beyond which it no longer fulfills the relevant design criteria. The condition may refer to a degree of loading or other actions on the structure, while the criteria refer to structural integrity, fitness for use, durability or other design requirements.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Workingstress method
- ✓ Ultimate load method
- ✓ Concepts

Detailed content of the Lecture:

- ✓ Limit state design requires the structure to satisfy two principal criteria: the ultimate limit state (ULS) and the serviceability limit state (SLS).
- ✓ Any design process involves a number of assumptions. The loads to which a structure will be subjected must be estimated, sizes of members to check must be chosen and design criteria must be selected.
- ✓ All engineering design criteria have a common goal: that of ensuring a safe structure and ensuring the functionality of the structure.

Ultimate limit state (ULS)

- ✓ A clear distinction is made between the ultimate state (US) and the ultimate limit state (ULS). The US is a physical situation that involves either excessive deformations leading and approaching collapse of the component under consideration or the structure as a whole, as relevant, or deformations exceeding pre-agreed values.
- ✓ It involves, of course, considerable inelastic (plastic) behavior of the structural scheme and

residual deformations. Whereas the ULS is not a physical situation but rather an agreed computational condition that must be fulfilled, among other additional criteria, in order to comply with the engineering demands for strength and stability under design loads.

- ✓ The ULS condition is computationally checked at a certain point along the behavior function of the structural scheme, located at the upper part of its elastic zone at approximately 15% lower than the elastic limit.
- ✓ That means that the ULS is a purely elastic condition, located on the behavior function far below the real Ultimate point, which is located deep within the plastic zone.
- ✓ The rationale for choosing the ULS at the upper part of the elastic zone is that as long as the ULS design criteria are fulfilled, the structure will behave in the same way under repetitive loadings, and as long as it keeps this way, it proves that the level of safety and reliability assumed as the basis for this design is properly maintained and justified, (following the probabilistic safety approach).
- ✓ A structure is deemed to satisfy the ultimate limit state criterion if all factored bending, shear and tensile or compressive stresses are below the factored resistances calculated for the section under consideration. The factored stresses referred to are found by applying Magnification Factors to the loads on the section.
- ✓ Reduction Factors are applied to determine the various factored resistances of the section.
- ✓ The limit state criteria can also be set in terms of load rather than stress: using this approach the structural element being analysed (i.e. a beam or a column or other load bearing elements, such as walls) is shown to be safe when the "Magnified" loads are less than the relevant "Reduced" resistances.
- ✓ Complying with the design criteria of the ULS is considered as the minimum requirement (among other additional demands) to provide the proper structural safety.

Serviceability limit state (SLS)

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1) limit state of deflection

2) limit state of cracking

3) limit state of vibration

- ✓ In addition to the ULS check mentioned above, a Service Limit State (SLS) computational check must be performed. As for the ULS, here also the SLS is not a physical situation but rather a computational check.
- ✓ The aim is to prove that under the action of Characteristic design loads (un-factored), and/or whilst applying certain (un-factored) magnitudes of imposed deformations, settlements, or vibrations, or temperature gradients etc. the structural behavior complies with, and does not

exceed, the SLS design criteria values, specified in the relevant standard in force.

- ✓ These criteria involve various stress limits, deformation limits (deflections, rotations and curvature), flexibility (or rigidity) limits, dynamic behavior limits, as well as crack control requirements (crack width) and other arrangements concerned with the durability of the structure and its level of everyday service level and human comfort achieved, and its abilities to fulfill its everyday functions.
- ✓ In view of non-structural issues it might also involve limits applied to acoustics and heat transmission that might also affect the structural design. To satisfy the serviceability limit state criterion, a structure must remain functional for its intended use subject to routine (read: everyday) loading, and as such the structure must not cause occupant discomfort under routine conditions.
- ✓ This calculation check is performed at a point located at the lower half of the elastic zone, where characteristic (un-factored) actions are applied and the structural behavior is purely elastic.

Video Content / Details of website for further learning (if any):
https://www.youtube.com/watch?v=TefLaCKB8uM
https://www.youtube.com/watch?v=olqi5zoY_DU

Important Books/Journals for further learning including the page nos.:
1.S.S.Bhavikatti, Design of Steel Structures. P.No:27 to 33

Course Teacher

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LECTURE HANDOUTS

L - 03

CIVIL

III/ VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Connections bolted and welded joints

Introduction :

The following three types of connections may be made in steel structures 1.Riveted 2. Bolted 3.Welded.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Applications of Steel Sections.
- ✓ Types of Connections.

Detailed content of the Lecture:

- ✓ A bolted connection is a cold connection. The two pieces are fitted together closely, as in a welding or soldering, but they stay together because a hole is drilled in both of a precise shape, and a bolt or rivet is hammered in and fitted, again closely, to hold them together.
- ✓ Welded connections are stiff. Unlike snug-tightened bolted joints that may slip as they are loaded, welds are not expected to stretch and distribute the applied load to any great extent. In most cases, welds and bearing-type mechanical fasteners won't deform equally.

Bolted Connections

There are several types of bolts used to connect structural members. Some of them are listed as follows:

- Unfinished bolts or black bolts or C grade bolts (IS 1363 : 2002)
- Turned bolts
- Precision bolts or A grade bolts (IS 1364 : 2002)
- Semi-precision bolts or B grade bolts (IS 1364 : 2002)
- Ribbed bolts

- High strength bolts (IS 3757 : 1985 and IS 4000 : 1992)

Advantages of Bolted Connections

The black bolts offer the following advantages over riveted or welded connections:

- Use of unskilled labour and simple tools
- Noiseless and quick fabrication
- No special equipment/process needed for installation
- Fast progress of work
- Accommodates minor discrepancies in dimensions
- The connection supports loads as soon as the bolts are tightened
- HSFG bolts do not allow any slip between the elements connected, especially in close tolerance holes, thus providing rigid connections.
- Due to the clamping action, load is transmitted by friction only and the bolts are not subjected to shear and bearing.
- Due to the smaller number of bolts, the gusset plate sizes are reduced.
- Deformation is minimized.
- Since HSFG bolts under working loads do not rely on resistance from bearing, holes larger than usual can be provided to ease erection and take care of lack of fit. Thus the holes may be standard, extra-large, or short/long slotted. However, the type of hole will govern the strength of the connection.
- Noiseless fabrication, since the bolts are tightened with wrenches.
- The possibility of failure at the net section under the working loads is eliminated.
- Since the loads causing fatigue will be within proof load, the nuts are prevented from loosening and the fatigue strength of the joint will be greater and better than welded and riveted joints. Moreover, since the load is transferred by friction, there is no stress concentration in the holes.
- Unlike riveted joints, few persons are required for making the connections.
- No heating is required and no danger of tossing of bolt. Thus, the safety of the workers is enhanced.
- Alterations, if any (e.g. replacement of the defective bolt) are done easily than in welded or riveted connections.

Advantages Of Welding Joints

- A welded connection is the favored option for a useful purpose. With this type of connection, there is a 100% guarantee that the connection is strong enough to withhold pressure. Riveted joints usually come with at least 75% of the sturdiness connection.
- Steel structures can be complicated at times and in those steel structures, the most convenient way to make a connection is through welding. In cases of steel pipes, it is important to note that

complicated structures are more accessible to put together for a stronger connection by welding.

- Welding is a method that provides a more rigid connected for steel structures. This is a significant requirement in structural frames made of steel.
- While riveting may be a good strategy to put metal pieces together, it is not the best option for structures that will be sued on populated areas.
- Welded structures are more pleasing to the eye as their a connection between metals become aesthetically one. Compared to riveting where the connections can be distinctly identified, welding makes the whole structure made into one.

Disadvantages of Welding Joints

- Welded connections do not allow any form of expansion. Contractions in the connection could make it weak. It is prone to developing cracks after some time.
- Internal and external distortions can happen while the areas of connection are exposed to uneven heating during the process of welding.
- Due to possible extreme heating, fatigue may take place where a connection of steel is made. That's why it is essential that only an expert works with the steel connection through welding to ensure that the connection is not exposed to too much heat.
- Inspection work for welded steel requires more time and accuracy. Checking the stability of the connection requires more.
- Will you pursue welded connections over riveted ones? It surely is your best option, but you will have to bring the experts in. They will know exactly how to use the advantages of welded connections and work around the disadvantages and keep them to a minimum.

Video Content / Details of website for further learning (if any):
https://www.youtube.com/watch?v=XROv1xoLrKM
https://www.youtube.com/watch?v=iplUqUShey4

Important Books/Journals for further learning including the page nos.:
1.Dr.B.C.Punmia, Design of Steel Structures. P.No: 1 to 8

Course Teacher

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L - 04

LECTURE HANDOUTS

CIVIL **III/ VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Failure of Joints

Introduction :

A failure can occur if the structural engineer underestimates the design force the connection is to withstand. Common connections in steel structures may be made with bolts or welds or a combination of both. ... Flexural members typically fail when flexural loadings cause the element to buckle.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Possibilities of failures.

Detailed content of the Lecture:

Types of failure

1.Shear failure

2. Flexural failure

3. Compression failure

4.Tensile failure

Shear Failure

- **Shear failures will typically occur in connections between members (i.e. member to column connection, member to girder connection, etc…).**
- **Designing a connection is not an easy task. Connections typically have high shearing forces that an engineer must consider when designing the connection.**
- **A failure can occur if the structural engineer underestimates the design force the connection is to withstand. Common connections in steel structures may be made with**

bolts or welds or a combination of both.

Flexural Failures

- Flexural failures occur in flexural members such as members and girders, and, in some cases, compression members such as columns that are subjected to bending stresses.

- Flexural members typically fail when flexural loadings cause the element to buckle. Because steel is strong, steel members are designed to be slim and efficient which may put them at risk of buckling.

- Heavier, stocky members are less susceptible to buckling.

- Flexural loadings create tension and compression forces in members. Lateral torsional buckling occurs when the high compression forces causes an unrestrained section of the member to buckle and laterally displace.

- Providing lateral restraint to a member helps ensure it will not buckle. However, a member may still fail should the stresses resulting from a flexural loading condition exceed the material strength of the member.

Compression Failures

- Compression failures typically occur in compression members, such as columns and braces, when the compressive axial force applied to the element caused the element to either buckle or become overstressed.

- Similar to beams, column and brace members subjected to high compressive stresses may experience buckling.

- A consideration to take into account when designing a column is its slenderness ratio (ratio of cross sectional geometry to length of member); a member with a high slenderness ratio is more susceptible to buckling than one with a lower ratio.

- Members with low slenderness ratios may still fail when the compressive stresses exceed the material strength of the member.

Tensile Failures

- Tensile failures generally occur in brace members or hangers. This type of failure occurs when the steel member is stretched to a level that exceeds the material strength

of the member.

- **This occurs in stages, the first being yielding, necking and then the material fails at the point with the least cross section area.**
- Steel is a very strong material and very reliable in structural construction of buildings.
- **Its effectiveness, however, is only guaranteed when the steel is properly designed to withstand the imposed forces. Poor design can lead to the above-mentioned failures of steel structures.**

Video Content / Details of website for further learning (if any):
https://www.youtube.com/watch?v=PkXBtE6Ylbo
https://www.youtube.com/watch?v=xBExB5tAq-U

Important Books/Journals for further learning including the page nos.:
1.Dr.B.C.Punmia, Design of Steel Structures. P.No: 57 & 58

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L - 05

LECTURE HANDOUTS

CIVIL | **III/ VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Efficiency of joints

Introduction :

Joint efficiency is concept found in several API and ASME codes. It is a numerical value, which represents a percentage, expressed as the ratio of the strength of a riveted, welded, or brazed joint to the strength of the base material. ... Joint efficiency varies with weld type.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Applications of Steel Sections.

Detailed content of the Lecture:

It is defined as the ratio of strength of joint and strength of solid plate in tension . It is usually expressed in percentage. Thus

$$\text{Efficiency } \eta = \frac{\text{Strength of joint}}{\text{Strength of solid plate}} \times 100$$

Strength of solid plate is less than in yielding compared to tearing of solid plate.

Video Content / Details of website for further learning (if any):

https://www.youtube.com/watch?v=02csZHKvgj8

https://www.youtube.com/watch?v=aY_ITTot3Yw

Important Books/Journals for further learning including the page nos.:

1.S.S.Bhavikatti, Design of Steel Structures. P.No: 50&51

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LECTURE HANDOUTS

CIVIL **III/ VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Eccentric Connections

Introduction :

If the force applied does not passes through the CG of the joint then such joint carries moment in addition to an axial direct force. Such types of connections are called as eccentric connections.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Applications of Steel Sections.

Detailed content of the Lecture:

- In this lecture we are going to discuss about eccentric connections. In last few lectures, we have discussed about the different types of connections but mainly those are concentric.
- Now in case of eccentric connections center of gravity of the connection and centre of gravity of the load will be in different position so if it does not coincide then eccentricity will develop and because of eccentricity extra moment will come into picture and because of the moment extra stress will develop.
- So therefore we have to design the joint taking consideration of the direct load as well as due to eccentricity.
- In case of eccentric joint we have different type of joint like when load is lying in the plane of joint it will be one type of eccentricity again that can be designed by weld connection as well as by bolt connection and similarly
- when load is lying in the perpendicular to the plane of joint then another type of eccentricity come into picture means another type of load reaction will come and that also can be designed using bolt joint and using weld joint.

So basically four type of joints will be considered for design.
Video Content / Details of website for further learning (if any): https://www.youtube.com/watch?v=HYpF_xsbLLk https://www.youtube.com/watch?v=dEJk4xptsQQ
Important Books/Journals for further learning including the page nos.: 1.Dr.B.C.Punmia, Design of Steel Structures. P.No: 1 to 8

Course Teacher

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Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: problems

Introduction :

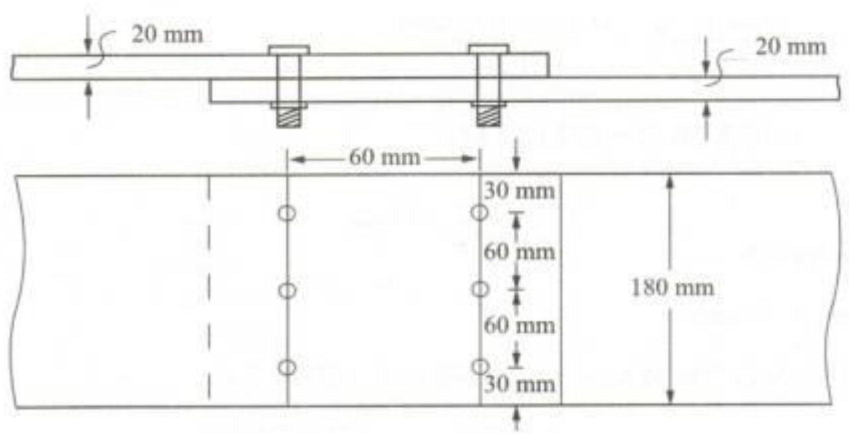
Steel structure is a metal structure which is made of structural steel components connect with each other to carry loads and provide full rigidity.Structural steel is steel construction material which fabricated with a specific shape and chemical composition to suit a project's applicable specifications.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Applications of Steel Sections.

Detailed content of the Lecture:

1. Find the efficiency of the lap joint shown in fig. given M20 bolt of grade 4.6 and plate of grade Fe410 [E250] are used.



Given Data:-

t = 20mm

Bolt:- M20

Grade 4.6 => fu = 400N/mm^2

fy = 250N/mm^2

Plate:-

Fe 410 [E250]

Fu = 410 N/mm^2

Fy = 250 N/mm^2 [Table 1 – I.S 800 – 2007]

Efficiency of the joint = $\frac{\text{strength of joint}}{\text{strength of solid plate}}$ x 100

Strength of connection is least of strength of plate at critical section and strength of bolt in shear & bearing.

Strength of plate @ the joint:-

Tensile force $T_{an}=\frac{0.9\,Anfu}{\gamma_{ml}}$

$A_n=(b-nd_o)t$

ps = 0 [∵ Bolts are on a straight line]

= (180 – 3x22) 20 [∵ d_o = 20+2=22]

An = 2280mm^2

γ_{ml} = 1.25 [from table 5- I.S 800-2007]

[d_o = Dia of bolt hole = 20+2=22mm]

(ii) Strength of bolt in bearing: [cls 10.3.4 IS]

Take

$\beta_{ij}=\beta_{ig}=\beta_{pk}=1$

$V_{dbp}=\frac{V_{nbp}}{\gamma_{mb}}$

V_{dbp} = 2.5 kb dt fu

Kb = least of e/3d_o, p/3d_o-0.25, $\frac{fub}{Fu}$, 1.0

E = end distance [centre of the extreme end bolt to the edge ¿ lr to direction of load.

$k_b \Rightarrow \frac{30}{3\times22},\frac{60}{3\times22}-0.25$

$k_b \Rightarrow 0.45, 0.659, 0.976, 1$

Take K_b value of whichever less [∴ K_b = 0.45]

$V_{nbp}=2.5\times0.45\times20\times20\times410$

V_{nbp} = 186.3 KN

$V_{dbp}=\frac{186.3}{1.25}$

V_{dbp} = 149.04 KN

∴ Design strength of bolt = 6 x 149.04

V_{dbp} bolt = 894.24 KN

Design strength of the joint = 271.58 KN

Design strength of jt is the least of strength of joint 673.06 KN, 271.58 KN & 894.24 KN

<u>Strength of Solid Plate:-</u>

Strength of Solid Plate = $\frac{fy \times Ag}{\gamma_{ml}}$

[yielding sides the strength of solid plate]

$= \frac{250}{1.1} \times 180 \times 20$

Strength of solid plate = 818.18 KN

∴ Efficiency of joint $\eta = \frac{271.58}{818.18} \times 100$

$\eta = 33.19$

Video Content / Details of website for further learning (if any):

1. http://fmcet.in/CIVIL/CE2352_uw.pdf

Important Books/Journals for further learning including the page nos.:

1.S.S.Bhavikatti,Design of Steel Structures. P.No: 55

Course Teacher

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LECTURE HANDOUTS

L – 08

CIVIL **III/ VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: problems

Introduction :

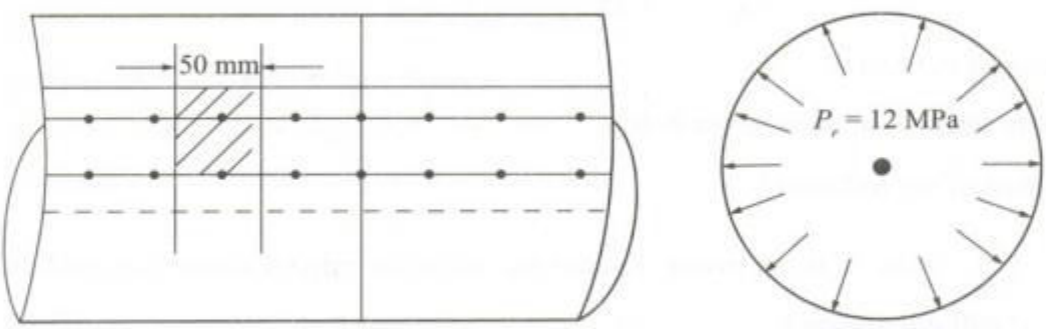
Steel structure is a metal structure which is made of structural steel components connect with each other to carry loads and provide full rigidity.Structural steel is steel construction material which fabricated with a specific shape and chemical composition to suit a project's applicable specifications.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Applications of Steel Sections.

Detailed content of the Lecture:

1. A boiler shell is made up of 14mm tk Fe415 plates. The jt is double bolted lap jt with bolts of grade 4.6 at distances of 500mm. Determine the strength of the jt. Per pitch width for a safe design if the internal dia of the shell is 1m and steam pressure is 12Mpa.



Given:-

Grade 4.6

Bolt:-

fu_b = 400 N/mm^2

fy_b = 240 N/mm^2

Plate:- fu = 410 N/mm^2 , fy = 250 N/mm^2

Sln:-

The strength of the plate is check for unit pitch [50mm width]

<u>Strength of Plate @ joint:-</u> [50mm width]

$$T_{dn} = \frac{0.9\,Anfu}{\gamma_{ml}}$$

$$An = [b - nd_o]t$$

Provide 18mm dia of bolt hole.

= [50 – 1x 18] x 14

An = 448 mm^2

$$T_{dn} = \frac{0.9 \times 448 \times 410}{1.25} [\gamma_{ml} \rightarrow table\, 5\, IS\, 800-2007]$$

T_{dn} = 132.25 KN

For lap joint n_n = 1

n_s = 0

$$A_{nb} = 0.78 \frac{\pi d^2}{4}$$

$$= \frac{0.78 \times \pi \times 16^2}{4}$$

Assume dia of bolt 16mm for IS

$$A_{nb} = 156.8\, mm^2$$

$$V_{nsb} = \frac{400}{\sqrt{3}} [2 \times 1 \times 156.8]$$

$$V_{nsb} = 72.422\, KN$$

$$V_{dsp} = \frac{72.422}{1.25}$$

$$\boxed{V_{dsp} = 57.94\, KN}$$

(b) Strength of bolt in bearing: [cls 10.3.4 IS 800-2007]

$$V_{dbp} = \frac{V_{nbp}}{\gamma_{mb}}$$

$$V_{nbp} = 2.5 kb . dt . fu$$

$$K_b = \frac{e}{3d_o}, \frac{e}{3d_o} - 0.25, \frac{fu_b}{fu}, 1.0$$

$$= \frac{54}{3 \times 18}, \frac{50}{3 \times 18} - 0.25, \frac{400}{410}, 1.0$$

$$K_b = 1, 0.676, 0.975, 1.0$$

[∴ e is not given, so it is assume that sufficient edge distance is provided]

Take K_b value whichever is less [K_b = 0.676]

$$V_{nbp} = 2.5 \times 0.676 \times 16 \times 14 \times 410$$

$$V_{nbp} = 155.210 \, KN$$

$$V_{dbp} = \frac{155.210}{1.25}$$

$$V_{dbp} = 124.16 \, KN$$

For 2 bolts $V_{dbp} = 2 \times 124.16$

$$\boxed{V_{dbp} = 248.32 \, KN}$$

∴ Design strength of bearing for 50mm width = 248.32 KN

∴ Design strength of the joint per 50mm width is the least of 57.94 KN
132.25 KN
248.32 KN

∴ Design strength of jt/50mm width = 57.94 KN

Video Content / Details of website for further learning (if any):

1. http://fmcet.in/CIVIL/CE2352_uw.pdf

Important Books/Journals for further learning including the page nos.:

1.Dr.B.C.Punmia, Design of Steel Structures. P.No: 123

Course Teacher

Verified by HOD

L – 09

LECTURE HANDOUTS

CIVIL | **III/ VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Problems

Introduction :

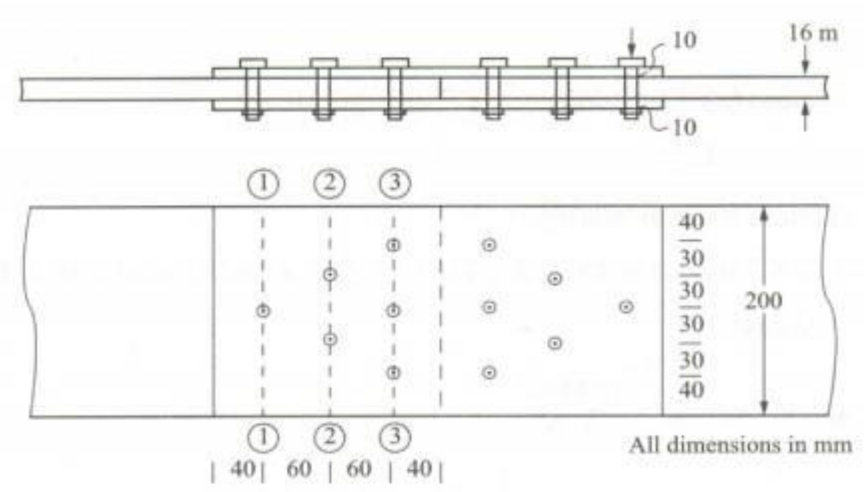
Steel structure is a **metal structure** which is made of **structural steel*** components connect with each other to carry loads and provide full rigidity. ... ***Structural steel** is **steel** construction material which fabricated with a specific shape and chemical composition to suit a project's applicable specifications.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Applications of Steel Sections.

Detailed content of the Lecture:

1. Find the bolt value of the connection b/w two plates of tks 16mm which are to be joint using M20 bolts of grade 4.6 by (i) Lap joint (ii) Butt joint [using 10mm cover plates]



Given Data:-

TKS of plate = 16mm

Bolt:-

M20 $\varphi = 20\,mm, fub = 400\,N/mm^2$

Grade 4.6

Sln:-

(i) **LAP JOINT:-**

1. Strength of bolt in shear: [cls 10.3.3 IS800-2007]

$$V_{dsp} = \frac{V_{nsb}}{\gamma_{mb}}$$

$$V_{snb} = \frac{fu}{\sqrt{3}}[n_n A_{nb} + n_s A_{sb}]$$

$n_n = 1$, $n_s = 0$

$$A_{nb} = \frac{0.78 \times 20^2 \times \pi}{4}$$

A_{nb} = 245 mm^2

$$V_{nsb} = \frac{400}{\sqrt{3}}[1 \times 245]$$

V_{nsb} = 56.58 KN

$$V_{dsp} = \frac{56.58}{1.25}$$

V_{dsp} = 45.26KN

2. Strength of bolt in bearing: [cls 10.3.4 IS 800-2007]

$$V_{dsp} = \frac{V_{nsb}}{\gamma_{mb}}$$

$$V_{nbp}=2.5k_b dt.fu$$

$$K_b=\frac{e}{3d_o},\frac{p}{3d_o}-0.25,\frac{fub}{fu},1$$

Take

$K_b=1$

V_{nbp} = 2.5 x 1 x 20 x 16 x 410

V_{nbp} = 328 KN

$$V_{dbp}=\frac{328}{1.25}$$

V_{dbp} = 262.4 KN

Design strength of bolt in bearing = 262.4 KN

Design strength of bolt = 45.26 KN [Least Value]

(ii) **BUTT JOINT:-**

1. Strength of the bolt in shear: [cls 10.3.3 IS 800-2007]

$$V_{dsp}=\frac{V_{nsb}}{\gamma_{mb}}$$

$$V_{snb}=\frac{fu}{\sqrt{3}}[n_n A_{nb}+n_s A_{n_{sb}}]$$

$$A_{nb}=\frac{0.78\times\pi d^2}{4}$$

$$=\frac{0.78\times\pi\times20^2}{4}$$

$$A_{nb}=245\,mm^2$$

$$A_{nsb}=\frac{\pi d^2}{4}$$

$$=\frac{\pi\times20^2}{4}$$

$$A_{nsb}=314.1\,mm^2$$

$$n_n=1,n_s=1$$

$$V_{nsb}=\frac{400}{\sqrt{3}}[1\times245+1\times314.1]$$

$$V_{nsb}=129.1\,KN$$

$$V_{dsp}=\frac{129.1}{1.25}$$

$$\boxed{V_{dsp}=103.28\,KN}$$

2. Strength of bolt in bearing : [cls 10.3.4 IS 800-2007]

$$V_{dsp} = \frac{V_{nsb}}{\gamma_{mb}}$$

$$V_{nbp} = 2.5 k_b dt . fu$$

$$K_b = \frac{e}{3d_o}, \frac{p}{3d_o} - 0.25, \frac{fub}{fu}, 1$$

Take

$K_b = 1$ ['t' is least of 16mm (2x10mm)]

↓

V_{nbp} = 2.5 x 1 x 20 x 16 x 410

V_{nbp} = 328 KN

$$V_{dbp} = \frac{328}{1.25}$$

V_{dbp} = 262.4 KN

Design strength of bolt in bearing = 262.4 KN

∴ Design strength of bolt = 103.28 KN

Video Content / Details of website for further learning (if any):

1. http://fmcet.in/CIVIL/CE2352_uw.pdf

Important Books/Journals for further learning including the page nos.:

1. S.S.Bhavikatti,Design of Steel Structures. P.No: 63

Course Teacher

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Rasipuram - 637 408, Namakkal Dist., Tamil Nadu

LECTURE HANDOUTS

L -10

CIVIL

III/ VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Problems

Introduction :

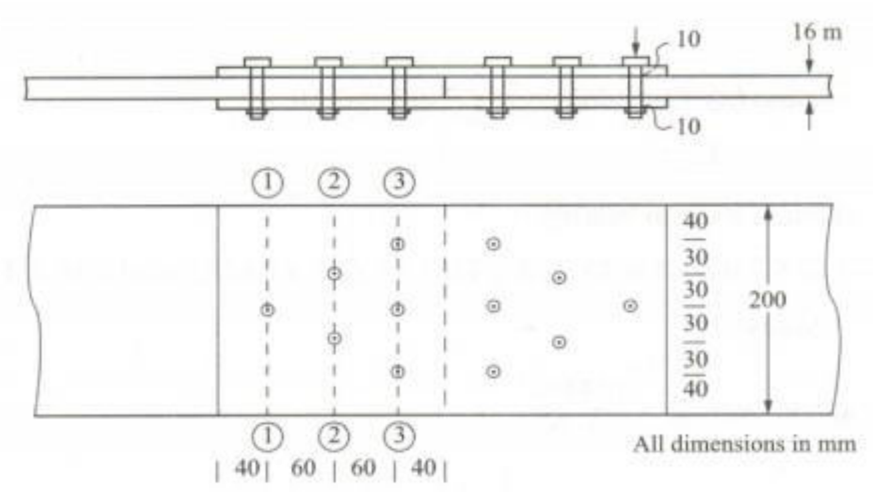
Steel structure is a metal structure which is made of structural steel components connect with each other to carry loads and provide full rigidity. Structural steel is steel construction material which fabricated with a specific shape and chemical composition to suit a project's applicable specifications.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Applications of Steel Sections.

Detailed content of the Lecture:

1. Find the bolt value of the connection b/w two plates of thickness 16mm which are to be joint using M20 bolts of grade 4.6 by (i) Lap joint (ii) Butt joint [using 10mm cover plates]



Given Data:-

TKS of plate = 16mm

Bolt:-

M20 $\varphi = 20\,mm, fub = 400\,N/mm^2$

Grade 4.6

Sln:-

(i) **LAP JOINT:-**

1. Strength of bolt in shear: [cls 10.3.3 IS800-2007]

$$V_{dsp} = \frac{V_{nsb}}{\gamma_{mb}}$$

$$V_{snb} = \frac{fu}{\sqrt{3}}[n_n A_{nb} + n_s A_{sb}]$$

$n_n = 1$, $n_s = 0$

$$A_{nb} = \frac{0.78 \times 20^2 \times \pi}{4}$$

A_{nb} = 245 mm^2

$$V_{nsb} = \frac{400}{\sqrt{3}}[1 \times 245]$$

V_{nsb} = 56.58 KN

$$V_{dsp} = \frac{56.58}{1.25}$$

V_{dsp} = 45.26KN

2. Strength of bolt in bearing: [cls 10.3.4 IS 800-2007]

$$V_{dsp} = \frac{V_{nsb}}{\gamma_{mb}}$$

$$V_{nbp}=2.5k_b dt.fu$$

$$K_b=\frac{e}{3d_o},\frac{p}{3d_o}-0.25,\frac{fub}{fu},1$$

Take

$K_b=1$

V_{nbp} = 2.5 x 1 x 20 x 16 x 410

V_{nbp} = 328 KN

$$V_{dbp}=\frac{328}{1.25}$$

V_{dbp} = 262.4 KN

Design strength of bolt in bearing = 262.4 KN

Design strength of bolt = 45.26 KN [Least Value]

(ii) **BUTT JOINT:-**

1. Strength of the bolt in shear: [cls 10.3.3 IS 800-2007]

$$V_{dsp}=\frac{V_{nsb}}{\gamma_{mb}}$$

$$V_{snb}=\frac{fu}{\sqrt{3}}[n_n A_{nb}+n_s A_{n_{sb}}]$$

$$A_{nb}=\frac{0.78\times\pi d^2}{4}$$

$$=\frac{0.78\times\pi\times 20^2}{4}$$

$$A_{nb}=245\,mm^2$$

$$A_{nsb}=\frac{\pi d^2}{4}$$

$$=\frac{\pi\times 20^2}{4}$$

$$A_{nsb}=314.1\,mm^2$$

$$n_n=1, n_s=1$$

$$V_{nsb}=\frac{400}{\sqrt{3}}[1\times 245+1\times 314.1]$$

$$V_{nsb}=129.1\,KN$$

$$V_{dsp}=\frac{129.1}{1.25}$$

$$\boxed{V_{dsp}=103.28\,KN}$$

2. Strength of bolt in bearing : [cls 10.3.4 IS 800-2007]

$$V_{dsp} = \frac{V_{nsb}}{\gamma_{mb}}$$

$$V_{nbp} = 2.5 k_b dt . fu$$

$$K_b = \frac{e}{3d_o}, \frac{p}{3d_o} - 0.25, \frac{fub}{fu}, 1$$

Take

$K_b = 1$ ['t' is least of 16mm (2x10mm)]

↓

$$V_{nbp} = 2.5 \times 1 \times 20 \times 16 \times 410$$

$$V_{nbp} = 328 \text{ KN}$$

$$V_{dbp} = \frac{328}{1.25}$$

$$V_{dbp} = 262.4 \text{ KN}$$

Design strength of bolt in bearing = 262.4 KN

∴ Design strength of bolt = 103.28 KN

Video Content / Details of website for further learning (if any):

1. http://fmcet.in/CIVIL/CE2352_uw.pdf

Important Books/Journals for further learning including the page nos.:

1. S.S.Bhavikatti,Design of Steel Structures. P.No: 63

Course Teacher

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LECTURE HANDOUTS

L - 11

CIVIL

III/ VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Failure of Joints

Introduction :

A failure can occur if the structural engineer underestimates the design force the connection is to withstand. Common connections in steel structures may be made with bolts or welds or a combination of both. ... Flexural members typically fail when flexural loadings cause the element to buckle.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Possibilities of failures.

Detailed content of the Lecture:

Types of failure

1.Shear failure

2. Flexural failure

3. Compression failure

4.Tensile failure

Shear Failure

- **Shear failures will typically occur in connections between members (i.e. member to column connection, member to girder connection, etc…).**
- **Designing a connection is not an easy task. Connections typically have high shearing forces that an engineer must consider when designing the connection.**
- **A failure can occur if the structural engineer underestimates the design force the connection is to withstand. Common connections in steel structures may be made with**

bolts or welds or a combination of both.

Flexural Failures

- Flexural failures occur in flexural members such as members and girders, and, in some cases, compression members such as columns that are subjected to bending stresses.
- Flexural members typically fail when flexural loadings cause the element to buckle. Because steel is strong, steel members are designed to be slim and efficient which may put them at risk of buckling.
- Heavier, stocky members are less susceptible to buckling.
- Flexural loadings create tension and compression forces in members. Lateral torsional buckling occurs when the high compression forces causes an unrestrained section of the member to buckle and laterally displace.
- Providing lateral restraint to a member helps ensure it will not buckle. However, a member may still fail should the stresses resulting from a flexural loading condition exceed the material strength of the member.

Compression Failures

- Compression failures typically occur in compression members, such as columns and braces, when the compressive axial force applied to the element caused the element to either buckle or become overstressed.
- Similar to beams, column and brace members subjected to high compressive stresses may experience buckling.
- A consideration to take into account when designing a column is its slenderness ratio (ratio of cross sectional geometry to length of member); a member with a high slenderness ratio is more susceptible to buckling than one with a lower ratio.
- Members with low slenderness ratios may still fail when the compressive stresses exceed the material strength of the member.

Tensile Failures

- Tensile failures generally occur in brace members or hangers. This type of failure occurs when the steel member is stretched to a level that exceeds the material strength

of the member.

- **This occurs in stages, the first being yielding, necking and then the material fails at the point with the least cross section area.**
- Steel is a very strong material and very reliable in structural construction of buildings.
- **Its effectiveness, however, is only guaranteed when the steel is properly designed to withstand the imposed forces. Poor design can lead to the above-mentioned failures of steel structures.**

Video Content / Details of website for further learning (if any):
https://www.youtube.com/watch?v=PkXBtE6Ylbo
https://www.youtube.com/watch?v=xBExB5tAq-U

Important Books/Journals for further learning including the page nos.:
1.Dr.B.C.Punmia, Design of Steel Structures. P.No: 57 & 58

Course Teacher

Verified by HOD

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Limit State Design Concepts

Introduction :

A limit state is a condition of a structure beyond which it no longer fulfills the relevant design criteria. The condition may refer to a degree of loading or other actions on the structure, while the criteria refer to structural integrity, fitness for use, durability or other design requirements.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Workingstress method
- ✓ Ultimate load method
- ✓ Concepts

Detailed content of the Lecture:

- ✓ Limit state design requires the structure to satisfy two principal criteria: the ultimate limit state (ULS) and the serviceability limit state (SLS).
- ✓ Any design process involves a number of assumptions. The loads to which a structure will be subjected must be estimated, sizes of members to check must be chosen and design criteria must be selected.
- ✓ All engineering design criteria have a common goal: that of ensuring a safe structure and ensuring the functionality of the structure.

Ultimate limit state (ULS)

- ✓ A clear distinction is made between the ultimate state (US) and the ultimate limit state (ULS). The US is a physical situation that involves either excessive deformations leading and approaching collapse of the component under consideration or the structure as a whole, as relevant, or deformations exceeding pre-agreed values.
- ✓ It involves, of course, considerable inelastic (plastic) behavior of the structural scheme and

residual deformations. Whereas the ULS is not a physical situation but rather an agreed computational condition that must be fulfilled, among other additional criteria, in order to comply with the engineering demands for strength and stability under design loads.

- ✓ The ULS condition is computationally checked at a certain point along the behavior function of the structural scheme, located at the upper part of its elastic zone at approximately 15% lower than the elastic limit.
- ✓ That means that the ULS is a purely elastic condition, located on the behavior function far below the real Ultimate point, which is located deep within the plastic zone.
- ✓ The rationale for choosing the ULS at the upper part of the elastic zone is that as long as the ULS design criteria are fulfilled, the structure will behave in the same way under repetitive loadings, and as long as it keeps this way, it proves that the level of safety and reliability assumed as the basis for this design is properly maintained and justified, (following the probabilistic safety approach).
- ✓ A structure is deemed to satisfy the ultimate limit state criterion if all factored bending, shear and tensile or compressive stresses are below the factored resistances calculated for the section under consideration. The factored stresses referred to are found by applying Magnification Factors to the loads on the section.
- ✓ Reduction Factors are applied to determine the various factored resistances of the section.
- ✓ The limit state criteria can also be set in terms of load rather than stress: using this approach the structural element being analysed (i.e. a beam or a column or other load bearing elements, such as walls) is shown to be safe when the "Magnified" loads are less than the relevant "Reduced" resistances.
- ✓ Complying with the design criteria of the ULS is considered as the minimum requirement (among other additional demands) to provide the proper structural safety.

Serviceability limit state (SLS)

---

1) limit state of deflection

2) limit state of cracking

3) limit state of vibration

- ✓ In addition to the ULS check mentioned above, a Service Limit State (SLS) computational check must be performed. As for the ULS, here also the SLS is not a physical situation but rather a computational check.
- ✓ The aim is to prove that under the action of Characteristic design loads (un-factored), and/or whilst applying certain (un-factored) magnitudes of imposed deformations, settlements, or vibrations, or temperature gradients etc. the structural behavior complies with, and does not

exceed, the SLS design criteria values, specified in the relevant standard in force.

- ✓ These criteria involve various stress limits, deformation limits (deflections, rotations and curvature), flexibility (or rigidity) limits, dynamic behavior limits, as well as crack control requirements (crack width) and other arrangements concerned with the durability of the structure and its level of everyday service level and human comfort achieved, and its abilities to fulfill its everyday functions.
- ✓ In view of non-structural issues it might also involve limits applied to acoustics and heat transmission that might also affect the structural design. To satisfy the serviceability limit state criterion, a structure must remain functional for its intended use subject to routine (read: everyday) loading, and as such the structure must not cause occupant discomfort under routine conditions.
- ✓ This calculation check is performed at a point located at the lower half of the elastic zone, where characteristic (un-factored) actions are applied and the structural behavior is purely elastic.

Video Content / Details of website for further learning (if any):
https://www.youtube.com/watch?v=TefLaCKB8uM
https://www.youtube.com/watch?v=olqi5zoY_DU

Important Books/Journals for further learning including the page nos.:
1.S.S.Bhavikatti, Design of Steel Structures. P.No:27 to 33

Course Teacher

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LECTURE HANDOUTS

L - 13

CIVIL

III/ VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Structural Steel Sections

Introduction :

Steel structure is a metal structure which is made of structural steel components connect with each other to carry loads and provide full rigidity.Structural steel is steel construction material which fabricated with a specific shape and chemical composition to suit a project's applicable specifications.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Applications of Steel Sections.

Detailed content of the Lecture:

- ✓ This chapter will give you a brief overview of structural steel. Structural steel is used as the framework for many steel structures such as industrial and commercial buildings, advanced base structures, and bridges.

- ✓ Many different pieces go into fabricating and erecting the framework for a steel structure, and as a Seabee Steelworker, you must have a thorough knowledge of the various structural members.

- ✓ We will discuss the most common names of the steel members as well as how to fasten and secure the members to each other and to the concrete foundation they are built upon.

- ✓ We will also discuss where and how in the structure the steel members are used. Before any structural steel is fabricated or erected, a plan of action and sequence of events, or erection, needs to be set up. The plans, sequences, and required materials are predetermined by the engineering section and drawn up as a set of plans.

- ✓ This chapter describes the basics of structural steel: the terminology, use of the members, methods of connection, and basic sequence of events during erection.

Structural steel is a category of steel used for making construction materials in a variety of shapes.

Many structural steel shapes take the form of an elongated beam having a profile of a specific cross section.

Structural steel shapes, sizes, chemical composition, mechanical properties such as strengths, storage practices, etc., are regulated by standards in most industrialized countries.

Most structural steel shapes, such as **I**-beams, have high second moments of area, which means they are very stiff in respect to their cross-sectional area and thus can support a high load without excessive sagging.

Common structural shapes

The shapes available are described in many published standards worldwide, and a number of specialist and proprietary cross sections are also available.

A steel **I**-beam, in this case used to support timber joists in a house.

- **I**-beam (**I**-shaped cross-section - in Britain these include Universal Beams (UB) and Universal Columns (UC); in Europe it includes the IPE, HE, HL, HD and other sections; in the US it includes Wide Flange (WF or W-Shape) and **H** sections)
- Z-Shape (half a flange in opposite directions)
- HSS-Shape (Hollow structural section also known as SHS (structural hollow section) and including square, rectangular, circular (pipe) and elliptical cross sections)
- Angle (**L**-shaped cross-section)
- Structural channel, or **C**-beam, or **C** cross-section
- Tee (**T**-shaped cross-section)
- Rail profile (asymmetrical **I**-beam)
    - Railway rail
    - Vignoles rail
    - Flanged **T** rail
    - Grooved rail
- Bar, a long piece with a rectangular cross section, but not so wide so as to be called a sheet.
- Rod, a round or square section long compared to its width; see also rebar and dowel.
- Plate, metal sheets thicker than 6 mm or $\frac{1}{4}$ in.
- Open web steel joist

While many sections are made by hot or cold rolling, others are made by welding together flat or bent plates (for example, the largest circular hollow sections are made from flat plate bent into a circle and seam-welded).[1]

The terms *angle iron*, *channel iron*, and *sheet iron* have been in common use since before wrought iron was replaced by steel for commercial purposes.

They have lived on after the era of commercial wrought iron and are still sometimes heard today, informally, in reference to steel angle stock, channel stock, and sheet, despite that they are misnomers (compare "tin foil", still sometimes used informally for aluminum foil).

In formal writing for metalworking contexts, accurate terms like *angle stock*, *channel stock*, and *sheet* are used.

Video Content / Details of website for further learning (if any):
https://www.youtube.com/watch?v=HYpF_xsbLLk
https://www.youtube.com/watch?v=dEJk4xptsQQ

Important Books/Journals for further learning including the page nos.:
1.Dr.B.C.Punmia, Design of Steel Structures. P.No: 1 to 8

Course Teacher

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L - 14

LECTURE HANDOUTS

CIVIL **III/ VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Failure of Joints

Introduction :

A failure can occur if the structural engineer underestimates the design force the connection is to withstand. Common connections in steel structures may be made with bolts or welds or a combination of both. ... Flexural members typically fail when flexural loadings cause the element to buckle.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Possibilities of failures.

Detailed content of the Lecture:

Types of failure

1.Shear failure

2. Flexural failure

3. Compression failure

4.Tensile failure

Shear Failure

- **Shear failures will typically occur in connections between members (i.e. member to column connection, member to girder connection, etc…).**
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Flexural Failures

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Compression Failures

- **Compression failures typically occur in compression members, such as columns and braces, when the compressive axial force applied to the element caused the element to either buckle or become overstressed.**
- **Similar to beams, column and brace members subjected to high compressive stresses may experience buckling.**
- **A consideration to take into account when designing a column is its slenderness ratio (ratio of cross sectional geometry to length of member); a member with a high slenderness ratio is more susceptible to buckling than one with a lower ratio.**
- **Members with low slenderness ratios may still fail when the compressive stresses exceed the material strength of the member.**

Tensile Failures

- **Tensile failures generally occur in brace members or hangers. This type of failure occurs when the steel member is stretched to a level that exceeds the material strength**

of the member.

- **This occurs in stages, the first being yielding, necking and then the material fails at the point with the least cross section area.**
- Steel is a very strong material and very reliable in structural construction of buildings.
- **Its effectiveness, however, is only guaranteed when the steel is properly designed to withstand the imposed forces. Poor design can lead to the above-mentioned failures of steel structures.**

Video Content / Details of website for further learning (if any):
https://www.youtube.com/watch?v=PkXBtE6Ylbo
https://www.youtube.com/watch?v=xBExB5tAq-U

Important Books/Journals for further learning including the page nos.:
1.Dr.B.C.Punmia, Design of Steel Structures. P.No: 57 & 58

Course Teacher

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L – 15

LECTURE HANDOUTS

CIVIL

III/ VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher : Mr.K.Sankar

Unit : I – Introduction **Date of Lecture:**

Topic of Lecture: Problems

Introduction :

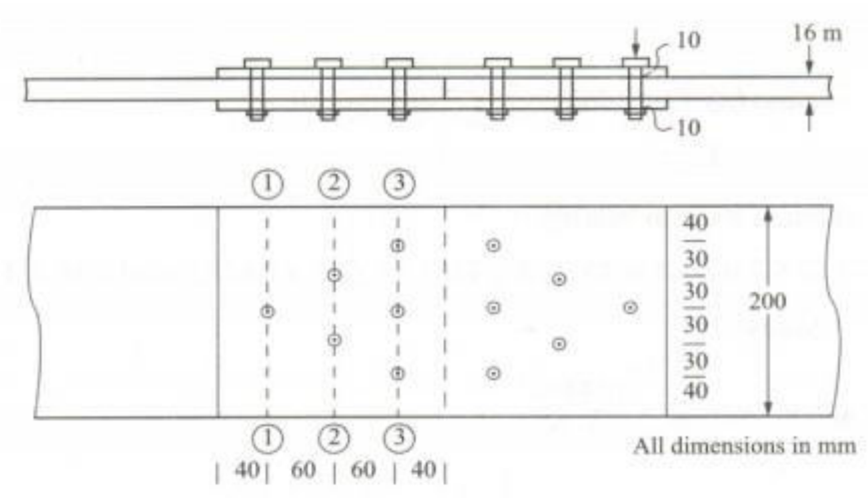
Steel structure is a **metal structure** which is made of **structural steel*** components connect with each other to carry loads and provide full rigidity. ... ***Structural steel** is **steel** construction material which fabricated with a specific shape and chemical composition to suit a project's applicable specifications.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of Steel Sections.
- ✓ Properties of Steel Sections.
- ✓ Applications of Steel Sections.

Detailed content of the Lecture:

1. Find the bolt value of the connection b/w two plates of tks 16mm which are to be joint using M20 bolts of grade 4.6 by (i) Lap joint (ii) Butt joint [using 10mm cover plates]



Given Data:-

TKS of plate = 16mm

Bolt:-

M20 $\varphi = 20\,mm, fub = 400\,N/mm^2$

Grade 4.6

Sln:-

(i) **LAP JOINT:-**

1. Strength of bolt in shear: [cls 10.3.3 IS800-2007]

$$V_{dsp} = \frac{V_{nsb}}{\gamma_{mb}}$$

$$V_{snb} = \frac{fu}{\sqrt{3}}[n_n A_{nb} + n_s A_{sb}]$$

$n_n = 1$, $n_s = 0$

$$A_{nb} = \frac{0.78 \times 20^2 \times \pi}{4}$$

A_{nb} = 245 mm^2

$$V_{nsb} = \frac{400}{\sqrt{3}}[1 \times 245]$$

V_{nsb} = 56.58 KN

$$V_{dsp} = \frac{56.58}{1.25}$$

V_{dsp} = 45.26KN

2. Strength of bolt in bearing: [cls 10.3.4 IS 800-2007]

$$V_{dsp} = \frac{V_{nsb}}{\gamma_{mb}}$$

$$V_{nbp} = 2.5 k_b dt . fu$$

$$K_b = \frac{e}{3d_o}, \frac{p}{3d_o} - 0.25, \frac{fub}{fu}, 1$$

Take

$K_b = 1$

V_{nbp} = 2.5 x 1 x 20 x 16 x 410

V_{nbp} = 328 KN

$$V_{dbp} = \frac{328}{1.25}$$

V_{dbp} = 262.4 KN

Design strength of bolt in bearing = 262.4 KN

Design strength of bolt = 45.26 KN [Least Value]

(ii) **BUTT JOINT:-**

1. Strength of the bolt in shear: [cls 10.3.3 IS 800-2007]

$$V_{dsp} = \frac{V_{nsb}}{\gamma_{mb}}$$

$$V_{snb} = \frac{fu}{\sqrt{3}} [n_n A_{nb} + n_s A_{n_{sb}}]$$

$$A_{nb} = \frac{0.78 \times \pi d^2}{4}$$

$$= \frac{0.78 \times \pi \times 20^2}{4}$$

$$A_{nb} = 245\, mm^2$$

$$A_{nsb} = \frac{\pi d^2}{4}$$

$$= \frac{\pi \times 20^2}{4}$$

$$A_{nsb} = 314.1\, mm^2$$

$$n_n = 1, n_s = 1$$

$$V_{nsb} = \frac{400}{\sqrt{3}} [1 \times 245 + 1 \times 314.1]$$

$$V_{nsb} = 129.1\, KN$$

$$V_{dsp} = \frac{129.1}{1.25}$$

$$\boxed{V_{dsp} = 103.28\, KN}$$

2. Strength of bolt in bearing : [cls 10.3.4 IS 800-2007]

$$V_{dsp} = \frac{V_{nsb}}{\gamma_{mb}}$$

$$V_{nbp} = 2.5 k_b dt . fu$$

$$K_b = \frac{e}{3d_o}, \frac{p}{3d_o} - 0.25, \frac{fub}{fu}, 1$$

Take

$K_b = 1$ ['t' is least of 16mm (2x10mm)]

↓

V_{nbp} = 2.5 x 1 x 20 x 16 x 410

V_{nbp} = 328 KN

$$V_{dbp} = \frac{328}{1.25}$$

V_{dbp} = 262.4 KN

Design strength of bolt in bearing = 262.4 KN

∴ Design strength of bolt = 103.28 KN

Video Content / Details of website for further learning (if any):

1. http://fmcet.in/CIVIL/CE2352_uw.pdf

Important Books/Journals for further learning including the page nos.:

1. S.S.Bhavikatti,Design of Steel Structures. P.No: 63

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LECTURE HANDOUTS

L-16

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II Tension Members** **Date of Lecture:**

Topic of Lecture: Types of Sections

Introduction :

- ✓ There are a number of different types of sectional views that can be drawn.
- ✓ A few of the more common ones are: full sections, half sections, broken sections, rotated or revolved sections, removed sections, offset sections, and assembly sections.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

Detailed content of the Lecture:

The tension members made of structural steel can be broadly grouped into four categories:

- ✓ Wires and Cables. The wire type tension members are used for derricks, hoists, hangers for suspension bridges, rigging slings, and guy wires.
- ✓ Bars and Rods. ...
- ✓ Single Structural Plates and Shapes. ...
- ✓ Built-up Sections.

(i) 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

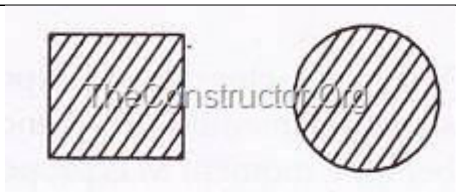
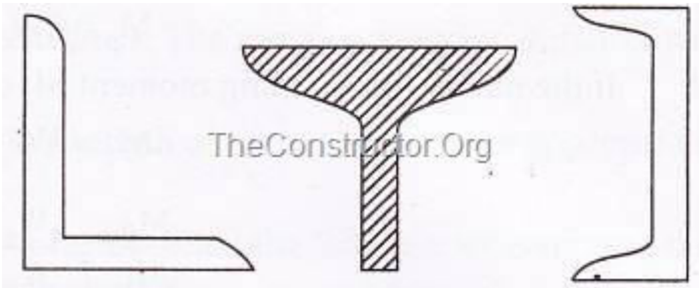


Figure: Square and circular rods and bars

(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 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 cannot furnish the required area, then built-up sections are used

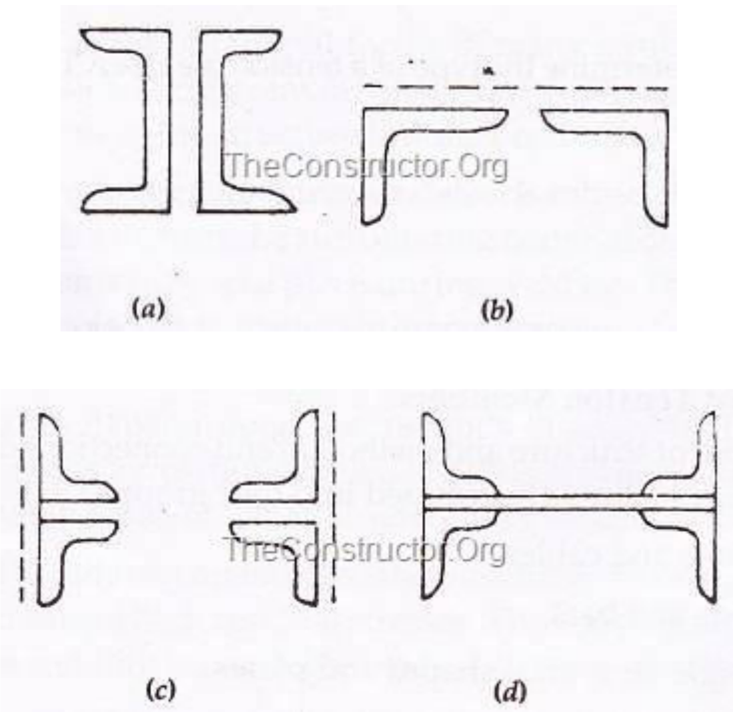


Figure: Built up steel sections

- ✓ A built-up section may be made of two channels placed back to back with a gusset in between them. Such sections are used for medium loads in a single plane-truss. In two-plane trusses, two channels are arranged at a distance with their flange turned inward. It simplifies the transverse connections and also minimizes lacing. The flanges of two channels are kept outwards, as in the case of chord members or long span girders, in order to have greater lateral rigidity.
- ✓ The heavy built-up tension members in the bridge girder trusses are made of angles and plates. Such members can resist compression in reversal of stress takes place.

Video Content / Details of website for further learning (if any):

1. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=2495
2. https://theconstructor.org/structural-engg/types-of-tension-members/4800/

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

Course Faculty

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LECTURE HANDOUTS

L-17

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II Tension Members** **Date of Lecture:**

Topic of Lecture: Net area

Introduction :

NET AREA CALCULATION FOR TENSION MEMBERS

- ✓ 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.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Connections
- ✓ Types of sections

Detailed content of the Lecture:

- ✓ The net area at any section is equal to the gross area minus the deduction for holes at that section. The deduction for the hole is the product of the hole diameter and the thickness of the material.

Net effective width,

$$b_e = b - nd + n_1\left(\frac{s^2}{4g}\right)$$

Where, s = the staggered pitch, i.e. the distance between any two consecutive rivets, in a zigzag chain measured parallel to the direction of stress in the member,

g = gauge distance

n= number of rivet holes

n_1 = number of zigzags or inclined lines

This method can be applied to the angles also in which the rows of the rivets in both legs are staggered with respect to each other. For angles, the gross width shall be the sum of the width of the legs less than the thickness. The gauge for holes in opposite legs shall be the sum of gauges from back of angles less the thickness.

Net sectional area:

- ✓ The net sectional area of the tension member is the gross sectional area of the member minus sectional area of the maximum number of holes

Video Content / Details of website for further learning (if any):

1. https://theconstructor.org/structural-engg/net-area-permissible-stresses-for-tension-members/4844/

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

Course Faculty

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LECTURE HANDOUTS | **L-18**

CIVIL | **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II -Tension Members** **Date of Lecture:**

Topic of Lecture: Net effective sections for angles and tee in tension

Introduction :

Net Effective Area

The effective area is the area that is responsible for resisting tensile load. If welded property, the gross area = net area. If we have a bolt connection, the net area is the gross area - the area removed from the holes. The area the holes remove from the member is the diameter of the whole x thickness of the plate

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of sections
- ✓ Net area

Detailed content of the Lecture:

Net Effective Section for Angles and Tees in Tension

An angle is usually connected to a gusset plate by one leg and a tee is connected through its flange only.

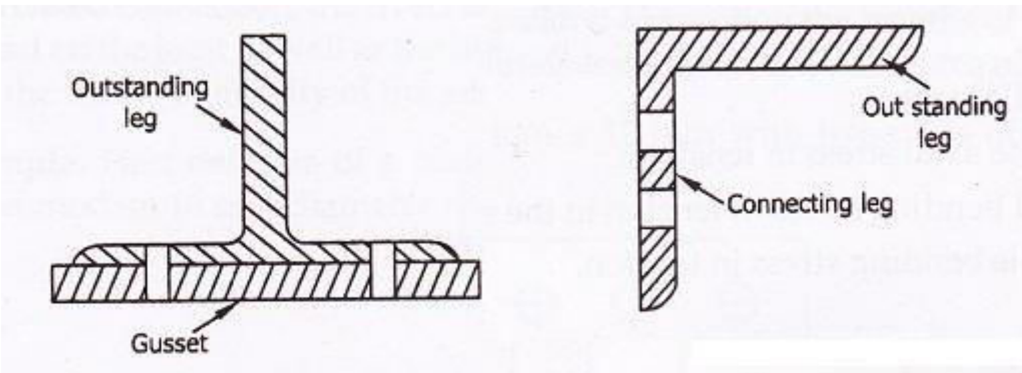
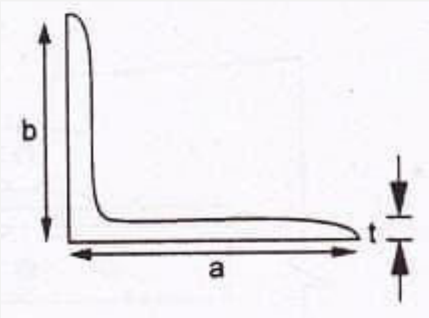


Figure: Tension Members

CASE – 1

In the case of single angles in tension, connected by one leg only,



Net effective area = $A_1 + k_1 A_2$

Where A_1 is the area of the connected leg,

A_2 = area of the outstanding leg, and

$$k_1 = \frac{3A_1}{3A_1 + A_2}$$

For angle sections, a x b x t,

$$A_1 = \left(b - d - \frac{t}{2}\right) \times t$$
$$A_2 = \left(a - \frac{t}{2}\right) \times t$$

Where lug angles are used, the net sectional area of the whole angle member could be considered.

CASE – 2

In the case of pair of angles back to back (or a single tee) in tension connected by only one leg on each angle (or by the flange of a tee) to the same side of the gusset plate,

Net effective area = $A_1 + k_2 A_2$

Where A_1 is the area of the connected legs (or flange of the tee)

A_2 = area of the outstanding leg (or web of the tee), and

$$k_2 = \frac{5A_1}{5A_1 + A_2}$$

CASE – 3

In the case of double angles or tees carrying direct tension, placed back to back and connected to both sides of the gusset,

Net effective area = gross area of section – area of holes

Video Content / Details of website for further learning (if any):

1. https://theconstructor.org/structural-engg/net-area-permissible-stresses-for-tension-members/4844/

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

Course Faculty

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Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II- Tension Members** **Date of Lecture:**

Topic of Lecture: Design of connections in tension members

Introduction :

Beams are connected to main beams or to the columns. Design of these connections is more important since failure of connection is more catastrophic than the failure of beam sections.

Types are

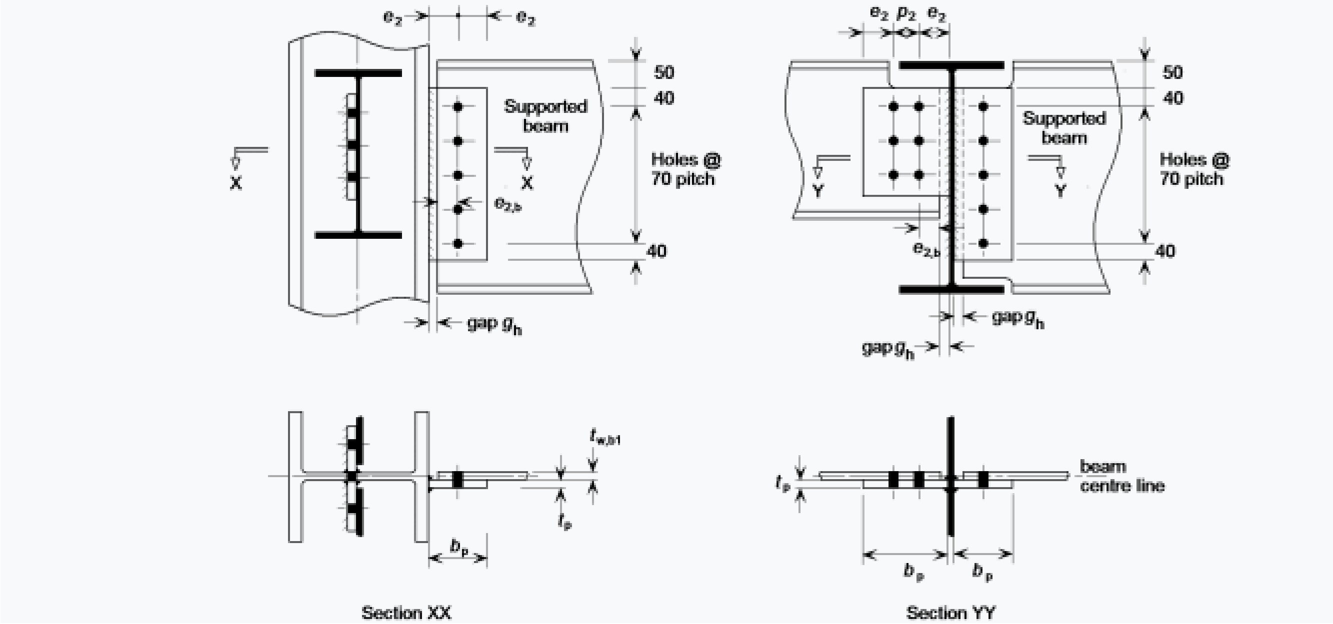
1. Simple connection or flexible connection
2. Moment resistant or rigid connection
3. Semi rigid connection

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Connections
- ✓ Sections
- ✓ Net area

Detailed content of the Lecture:

Connections: Connections must be able to transfer any axial force, shear, or moment from member to member or from beam to column. Steel construction accomplishes this with bolt and welds. Wood construction uses nails, bolts, shear plates, and split-ring connectors.



Design Of Bolted Beam Connections:

- ✓ Design of framed connections using bolts: The bolts connecting web of beam to cleat angles are in double shear. The number of bolts required to transfer end shear should be determined. They may be accommodated in a single or double row depending upon the availability of depth of web.

- ✓ Design of unstiffened seated connections: The seat angle over which beam rests is bolted to the column in shop and cleat angles are bolted in the field.

- ✓ Design of stiffened seated connections: If end reactions to be transferred is more, the thickness of seat angle required will be larger than the available thickness or the number of bolts required in the vertical leg may be too many to be accommodated in the available width.

- ✓ Design of small moment resistant connections: If the moment to be transferred is small, clip angles may be provided to transfer moment under web angles to transfer shear. Hence the design consists of (i) design of clip angle connections (ii) design of web angle connections

Design of welded beam connections:

- ✓ Framed connections: (i) Double plated framed connections (ii) Double angle framed connections

- ✓ Welded unstiffened seat connections: When the end reaction to be transferred is low, welded unstiffened seat connections may be used.

- ✓ Stiffened welded seat connections: The seat plate is not less than the thickness of flange of beam and the thickness of stiffening plate is not less than thickness of the web of beam.

- ✓ Moment resistant welded connections: If both moment and shear are to be transferred from beam to supporting structure moment resistant connections are required.

Video Content / Details of website for further learning (if any):

1. https://www.steelconstruction.info/Moment_resisting_connections

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:257**

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LECTURE HANDOUTS

L-20

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II -Tension Members** **Date of Lecture:**

Topic of Lecture: Use of lug angles

Introduction :

Lug angle: Lug Angle 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

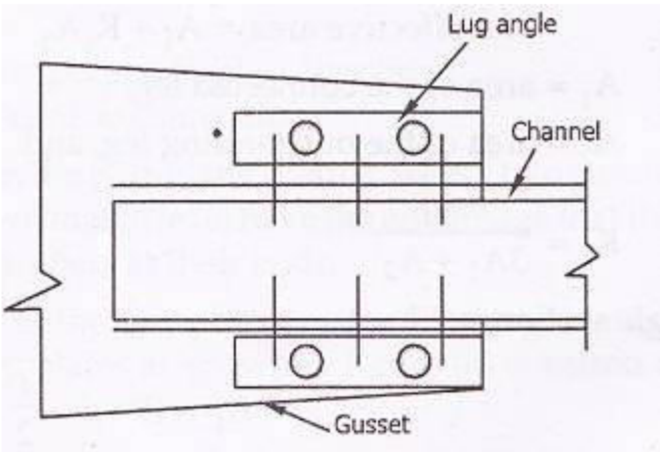
Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Connections
- ✓ Lug angle

Detailed content of the Lecture:

Uses of lug angles:

1. Length of the end connector of a heavily loaded tension member may be reduced by using lug angles
2. By using lug angles there will be saving in gusset plate
3. Lug angles are designed for 1.2 times load



The India Standard IS 800 specifies the following for the design of lug angles:

1. Lug angles connecting a channel-shaped member should as far as possible, be disposed symmetrically with respect to the section of the member.
2. In the case of angle members, the lug angles and their connections to the gusset or any other supporting member should be capable of developing a strength not less than 20% in excess of the force in the outstanding leg of the angle and the attachment of the lug angle member should be capable of developing a strength 40% in excess of that force.
3. In the case of channel sections, the lug angles and their connections to the gusset or any other supporting member should be capable of developing a strength of not less than 10% in excess of the force not accounted for by the direct connection of the member, and the attachment of the lug angles to the member should be capable of developing a strength 20% in excess of that force.
4. In no case should fewer than two bolts or rivets be used for attaching the lug angle, to the gusset or another supporting member.
5. The effective connection of the lug angle should, as far as possible, terminate at the end of the member connected and the fastening of the lug angle to the member should preferably start in advance of the direct connection of the member to the gusset or other supporting member.
6. Where lug angles are used to connect an angle member, the whole area of the member should be taken as effective, i.e.

A(net) = Gross area – deduction for holes

Video Content / Details of website for further learning (if any):

1. https://theconstructor.org/structural-engg/lug-angles/4849/

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:143**

Course Faculty

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LECTURE HANDOUTS

L-21

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II Tension Members** **Date of Lecture: 13.01.2020**

Topic of Lecture: Design of tensile splice

Introduction :

Design rules for tension splices are substantially the same as those for hanger connections. In buildings, splices should develop the strength required by the stresses at point of splice. For groove welds, however, the full strength of the smaller spliced member should be developed

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Tension sections
- ✓ Connections

Detailed content of the Lecture:

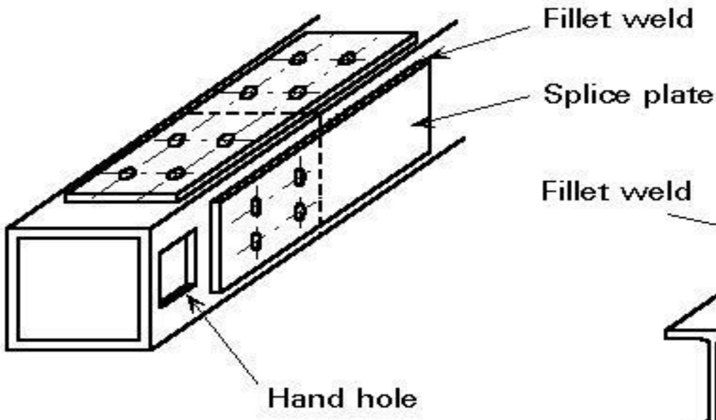
- ✓ Design rules for tension splices are substantially the same as those for hanger connections.
- ✓ **In buildings**, splices should develop the strength required by the stresses at point of splice. For groove welds, however, the full strength of the smaller spliced member should be developed
- ✓ **In highway bridges**, splices should be designed for the larger of the following: 75% of the strength of the member or the average of the calculated stress at point of splice and the strength of the member there. Where a section changes size at a splice, the strength of the smaller section may be used in sizing the splice. In tension splices, the strength of the member should be calculated for the net section.
- ✓ **In railroad bridges**, tension splices in main members should have the same strength as the members. Splices in secondary and bracing members should develop the average of the strength of the members and the calculated stresses at the splices.
  When fillers are used, the requirements should be satisfied.
- ✓ The basic allowable unit stress for such welds is the same as for the base metal joined. For fatigue, however, the allowable stress range Fsr for base metal adjacent to continuous flange-web fillet welds may be used for groove-welded splices only if

1. The parts joined are of equal thickness.

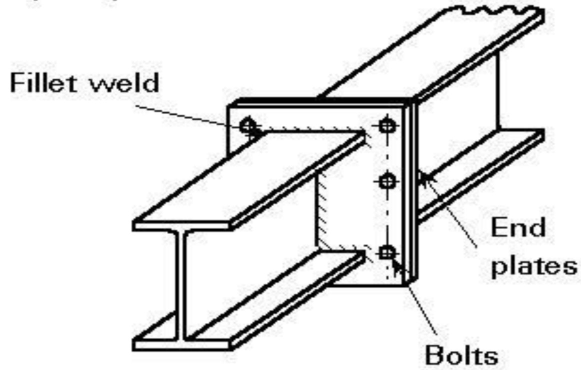
2. The parts joined are of equal widths or, if of unequal widths, the parts are tapered as indicated in Fig. 5.28, or, except for A514 and A517 steels, tapered with a uniform slope not exceeding 1:2.5.

3. Weld soundness is established by radiographic or ultrasonic testing.

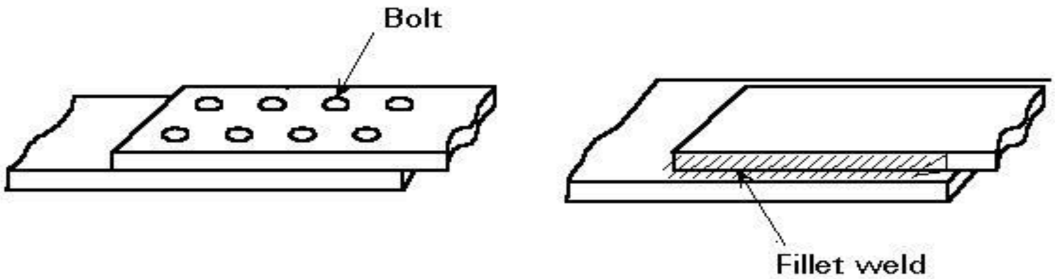
4. The weld is finished smooth and flush with the base metal on all surfaces by grinding in the direction of applied stress, leaving surfaces free from depressions. Chipping may be used if it is followed by such grinding. The grinding should not reduce the thickness of the base metal by more than 1⁄32 in or 5% of the thickness, whichever is smaller.



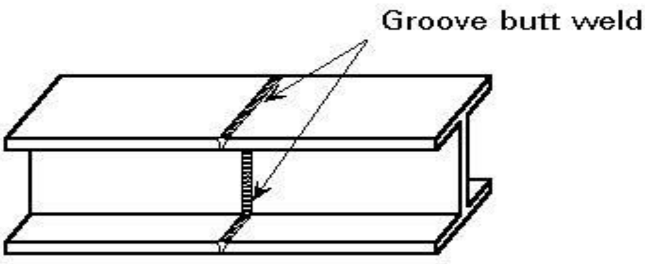
(a) Splice plated



(b) End plated



(c) Overlapped



(d) Butt welded

Video Content / Details of website for further learning (if any):

1. http://fgg-web.fgg.uni-lj.si/~/pmoze/ESDEP/master/wg11/l0800.htm

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:140**

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LECTURE HANDOUTS

L-22

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II- Tension Members** **Date of Lecture:**

Topic of Lecture: Concept of shear lag

Introduction :

- ✓ Shear lag is a concept used to account for uneven stress distribution in connected members where some but not all of their elements (flange, web, leg, etc.) are connected.
- ✓ The reduction coefficient, U, is applied to the net area, An, of bolted members and to the gross area, Ag, of welded members

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods
- ✓ Lug angles

Detailed content of the Lecture:

- ✓ The non-uniform stress distribution that occurs in a tension member adjacent to a connection, in which all elements of the cross section are not directly connected, is commonly referred to as the shear lag effect. ... Past research on the subject of shear lag has focused primarily on bolted tension members

- ✓ Shear lag occurs when the tension force is not transferred simultaneously to all elements of the cross-section. This will occur when some elements of the cross-section are not connected. For example, see Figure 4.3 below, where only one leg of an angle is bolted to the gusset plate.

- ✓ To maintain a uniform approach to both welded and bolted members, the same provisions for shear lag in bolted members were applied to welded members. Additional requirements for welded plates were added. However, the application of the shear lag requirements to welded members has raised several questions. This paper examines shear lag in steel tension members in the following context.

First, the background for the current AISC specification provisions is reviewed.

Video Content / Details of website for further learning (if any):

1. https://www.researchgate.net/publication/265225286_Shear_Lag_Effects_in_Steel_Tension_Members

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

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LECTURE HANDOUTS

L-23

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II- Tension Members** **Date of Lecture:**

Topic of Lecture: problems

Introduction :

Net 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.

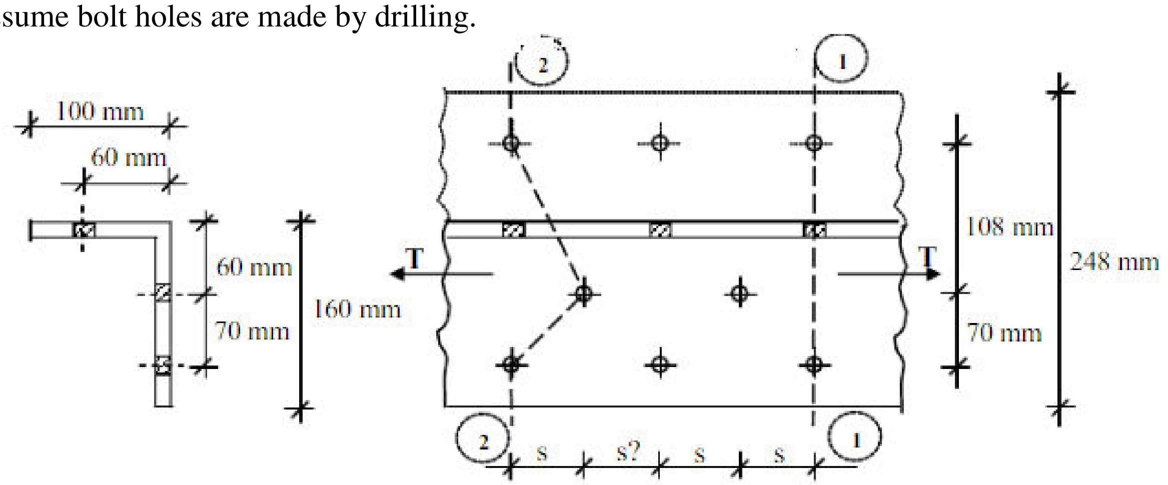
Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods
- ✓ Net area

Detailed content of the Lecture:

1. A tension member made of an angle L160x100x12mm is connected at end by two rows of12mm diameter bolts in the 160mm leg and one row of12mm diameter bolts in the100mm leg as shown below.

Assume bolt holes are made by drilling.



a) Determine the pitch distance between the adjacent bolts 's' for the same net-area of a angle section .

-diameter of bolt holes,

$$d = (\phi_b + 1.5mm) = 12 + 1.5 = 13.5mm$$

-Gross area of an angle section,

$$A_g \cong (160 + 100 - 12) \times 12 = 2976\, mm^2$$

-Net area of critical section through bolt holes is determined using

$$A_n = A_g - n.d.t + t.\sum \frac{s_i^2}{4g_i}$$

and, AISC also requires, $A_n \leq 0.85A_g = 0.85 \times 2976 = 2529.6\, mm^2$

Section 1-1: $A_{n1} = 2976 - 2 \times 13.5 \times 12 = 2652 mm^2 > 2529.6 mm^2$

$\therefore \mathbf{A_{n1} = 2529.6mm^2}$

Section 2-2: $A_{n2} = 2976 - 3 \times 13.5 \times 12 + 12 \times \frac{s^2}{4 \times 70} + 12 \times \frac{s^2}{4 \times 108} = \mathbf{2490 + 0.0706s^2}$

By equating A_{n1} with A_{n2},

$$2490 + 0.0706\, s^2 = 2529.6$$

$\leftrightarrow \quad s^2 = 560.9\, mm^2$

$\rightarrow \quad s = 23.68\, mm \qquad$ *take* $\mathbf{s = 25mm}$

Video Content / Details of website for further learning (if any):

1. https://www.scribd.com/document/365068900/Example-Problems-for-Tension-Members-stee

Important Books/Journals for further learning including the page nos.:

1. Design of steel structures by Dr.B.C.Punmia, Ashok kumar Jain, Arun Kumar Jain in page no 142

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LECTURE HANDOUTS

L-24

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II Tension Members** **Date of Lecture:**

Topic of Lecture: Workedout Problems

Introduction :

Tensile strength:

Tensile strength is often referred to as ultimate tensile strength and is calculated by dividing the peak tension force the sample withstands by its cross sectional area. A tensile tester is used to measure tensile strength. A load cell is fitted to the tensile tester to measure tensile force

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods
- ✓ Tensile strength

Detailed content of the Lecture:

1. Determine the tensile strength of the plate 130mmx12mm with the holes for 16mm diameter of holes
2. with 16mm gauge steel plate breadth 130mm. Fe415 steel is used.

Solution: strength of the plate with the least of

(a) Yielding of gross section

(b) Rupture of critical section

(c) The block shear strength

Consideration of yielding of gross section:

$$T_{dg} = A_g f_y / \gamma_{m0}$$

$A_g = 130 \times 12 = 1560 mm^2$

$f_y = 250 N/mm^2$

$\gamma_{m0} = 1.1 N/mm^2$

T_{dg}= (1560x250)/1.1 = 354.54KN

From the consideration of rupture along critical section

$\mathbf{d_0}$ = 16+2=18mm

A_n =(130-2x18)x12= 1128mm^2

T_{dn} = 0.9$A_n$fu/γml

=(0.9x1128x410)/1.25 =332.986N

Block shear strength

A_{vg}= 2x(35x60)x12 =2280mm^2

A_{tg}=60x12=720mm^2

A_{vn}=(35+60-1.5x18)x12x12= 1632mm^2

A_{tn}=(60-18)x12=504mm^2

$T_{db=}$ $A_{vg}f_y/(3)^{(1/2)}(\gamma_{m0})$ +(0.9A_{tn}fu/γml) = 447.95KN

$T_{db=}$ $A_{vg}f_y/\gamma_{m0}$ +(0.9A_{vn}fu/$(3)^{(1/2)}$γml) = 441.784KN

Strength of plate = 332.986KN

Video Content / Details of website for further learning (if any):

1. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=2496

Important Books/Journals for further learning including the page nos.:

1. Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No 125

Course Faculty

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LECTURE HANDOUTS

L-25

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II Tension Members** **Date of Lecture:**

Topic of Lecture: Net area

Introduction :

NET AREA CALCULATION FOR TENSION MEMBERS

- ✓ 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.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Connections
- ✓ Types of sections

Detailed content of the Lecture:

- ✓ The net area at any section is equal to the gross area minus the deduction for holes at that section. The deduction for the hole is the product of the hole diameter and the thickness of the material.

Net effective width,

$$b_e = b - nd + n_1\left(\frac{s^2}{4g}\right)$$

Where, s = the staggered pitch, i.e. the distance between any two consecutive rivets, in a zigzag chain measured parallel to the direction of stress in the member,

g = gauge distance

n= number of rivet holes

n_1 = number of zigzags or inclined lines

This method can be applied to the angles also in which the rows of the rivets in both legs are staggered with respect to each other. For angles, the gross width shall be the sum of the width of the legs less than the thickness. The gauge for holes in opposite legs shall be the sum of gauges from back of angles less the thickness.

Net sectional area:

- ✓ The net sectional area of the tension member is the gross sectional area of the member minus sectional area of the maximum number of holes

Video Content / Details of website for further learning (if any):

1. https://theconstructor.org/structural-engg/net-area-permissible-stresses-for-tension-members/4844/

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

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LECTURE HANDOUTS

L-26

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II -Tension Members** **Date of Lecture:**

Topic of Lecture: Use of lug angles

Introduction :

Lug angle: Lug Angle 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

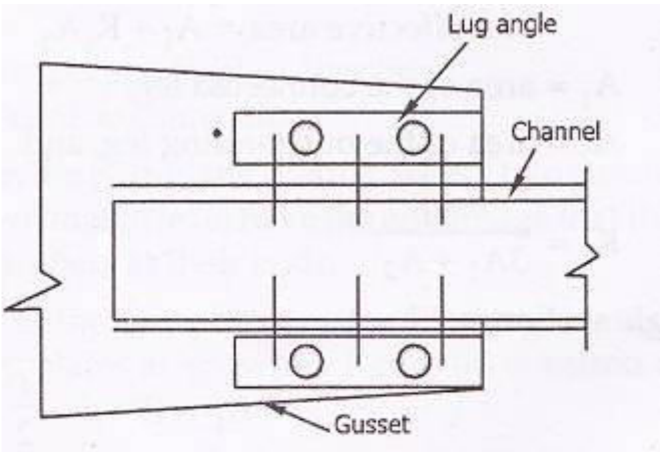
Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Connections
- ✓ Lug angle

Detailed content of the Lecture:

Uses of lug angles:

1. Length of the end connector of a heavily loaded tension member may be reduced by using lug angles
2. By using lug angles there will be saving in gusset plate
3. Lug angles are designed for 1.2 times load



The India Standard IS 800 specifies the following for the design of lug angles:

1. Lug angles connecting a channel-shaped member should as far as possible, be disposed symmetrically with respect to the section of the member.
2. In the case of angle members, the lug angles and their connections to the gusset or any other supporting member should be capable of developing a strength not less than 20% in excess of the force in the outstanding leg of the angle and the attachment of the lug angle member should be capable of developing a strength 40% in excess of that force.
3. In the case of channel sections, the lug angles and their connections to the gusset or any other supporting member should be capable of developing a strength of not less than 10% in excess of the force not accounted for by the direct connection of the member, and the attachment of the lug angles to the member should be capable of developing a strength 20% in excess of that force.
4. In no case should fewer than two bolts or rivets be used for attaching the lug angle, to the gusset or another supporting member.
5. The effective connection of the lug angle should, as far as possible, terminate at the end of the member connected and the fastening of the lug angle to the member should preferably start in advance of the direct connection of the member to the gusset or other supporting member.
6. Where lug angles are used to connect an angle member, the whole area of the member should be taken as effective, i.e.

A(net) = Gross area – deduction for holes

Video Content / Details of website for further learning (if any):

1. https://theconstructor.org/structural-engg/lug-angles/4849/

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:143**

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LECTURE HANDOUTS

L-27

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II Tension Members** **Date of Lecture:**

Topic of Lecture: Net area

Introduction :

NET AREA CALCULATION FOR TENSION MEMBERS

- ✓ 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.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Connections
- ✓ Types of sections

Detailed content of the Lecture:

- ✓ The net area at any section is equal to the gross area minus the deduction for holes at that section. The deduction for the hole is the product of the hole diameter and the thickness of the material.

Net effective width,

$$b_e = b - nd + n_1\left(\frac{s^2}{4g}\right)$$

Where, s = the staggered pitch, i.e. the distance between any two consecutive rivets, in a zigzag chain measured parallel to the direction of stress in the member,

g = gauge distance

n= number of rivet holes

n_1 = number of zigzags or inclined lines

This method can be applied to the angles also in which the rows of the rivets in both legs are staggered with respect to each other. For angles, the gross width shall be the sum of the width of the legs less than the thickness. The gauge for holes in opposite legs shall be the sum of gauges from back of angles less the thickness.

Net sectional area:

- ✓ The net sectional area of the tension member is the gross sectional area of the member minus sectional area of the maximum number of holes

Video Content / Details of website for further learning (if any):

1. https://theconstructor.org/structural-engg/net-area-permissible-stresses-for-tension-members/4844/

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

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LECTURE HANDOUTS

L-28

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II Tension Members** **Date of Lecture:**

Topic of Lecture: Types of Sections

Introduction :

- ✓ There are a number of different types of sectional views that can be drawn.
- ✓ A few of the more common ones are: full sections, half sections, broken sections, rotated or revolved sections, removed sections, offset sections, and assembly sections.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

Detailed content of the Lecture:

The tension members made of structural steel can be broadly grouped into four categories:

- ✓ Wires and Cables. The wire type tension members are used for derricks, hoists, hangers for suspension bridges, rigging slings, and guy wires.
- ✓ Bars and Rods. ...
- ✓ Single Structural Plates and Shapes. ...
- ✓ Built-up Sections.

(i) 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

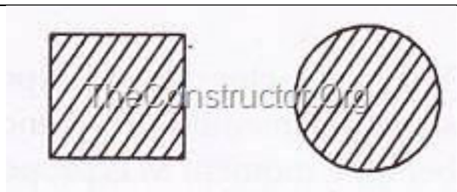
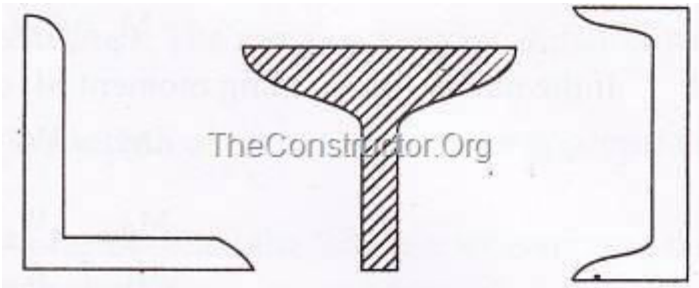


Figure: Square and circular rods and bars

(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 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 cannot furnish the required area, then built-up sections are used

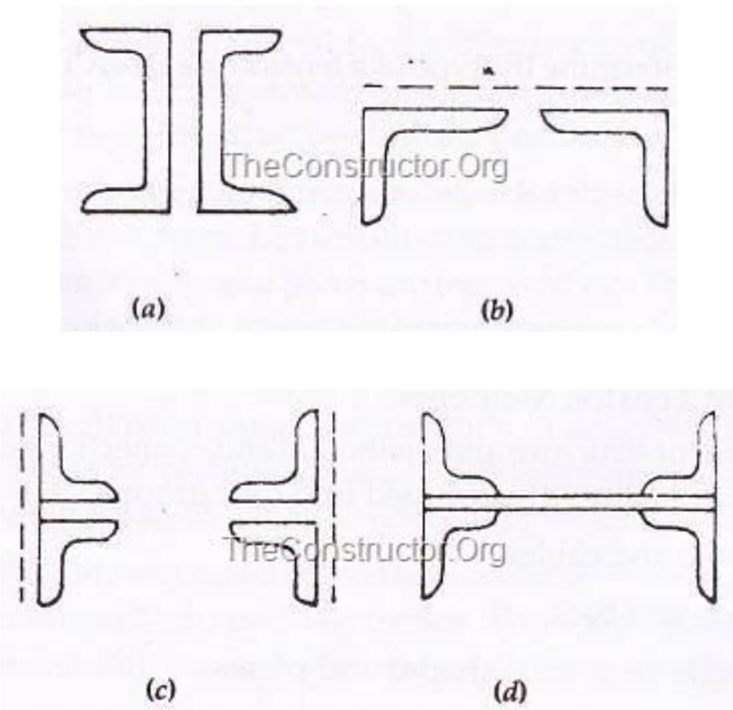


Figure: Built up steel sections

- ✓ A built-up section may be made of two channels placed back to back with a gusset in between them. Such sections are used for medium loads in a single plane-truss. In two-plane trusses, two channels are arranged at a distance with their flange turned inward. It simplifies the transverse connections and also minimizes lacing. The flanges of two channels are kept outwards, as in the case of chord members or long span girders, in order to have greater lateral rigidity.
- ✓ The heavy built-up tension members in the bridge girder trusses are made of angles and plates. Such members can resist compression in reversal of stress takes place.

Video Content / Details of website for further learning (if any):

1. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=2495
2. https://theconstructor.org/structural-engg/types-of-tension-members/4800/

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

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LECTURE HANDOUTS

L-29

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II- Tension Members** **Date of Lecture:**

Topic of Lecture: Concept of shear lag

Introduction :

- ✓ Shear lag is a concept used to account for uneven stress distribution in connected members where some but not all of their elements (flange, web, leg, etc.) are connected.
- ✓ The reduction coefficient, U, is applied to the net area, An, of bolted members and to the gross area, Ag, of welded members

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods
- ✓ Lug angles

Detailed content of the Lecture:

- ✓ The non-uniform stress distribution that occurs in a tension member adjacent to a connection, in which all elements of the cross section are not directly connected, is commonly referred to as the shear lag effect. ... Past research on the subject of shear lag has focused primarily on bolted tension members

- ✓ Shear lag occurs when the tension force is not transferred simultaneously to all elements of the cross-section. This will occur when some elements of the cross-section are not connected. For example, see Figure 4.3 below, where only one leg of an angle is bolted to the gusset plate.

- ✓ To maintain a uniform approach to both welded and bolted members, the same provisions for shear lag in bolted members were applied to welded members. Additional requirements for welded plates were added. However, the application of the shear lag requirements to welded members has raised several questions. This paper examines shear lag in steel tension members in the following context.

First, the background for the current AISC specification provisions is reviewed.

Video Content / Details of website for further learning (if any):

1. https://www.researchgate.net/publication/265225286_Shear_Lag_Effects_in_Steel_Tension_Members

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

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LECTURE HANDOUTS | **L-30**

CIVIL | **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **II -Tension Members** **Date of Lecture:**

Topic of Lecture: Net effective sections for angles and tee in tension

Introduction :

Net Effective Area

The effective area is the area that is responsible for resisting tensile load. If welded property, the gross area = net area. If we have a bolt connection, the net area is the gross area - the area removed from the holes. The area the holes remove from the member is the diameter of the whole x thickness of the plate

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of sections
- ✓ Net area

Detailed content of the Lecture:

Net Effective Section for Angles and Tees in Tension

An angle is usually connected to a gusset plate by one leg and a tee is connected through its flange only.

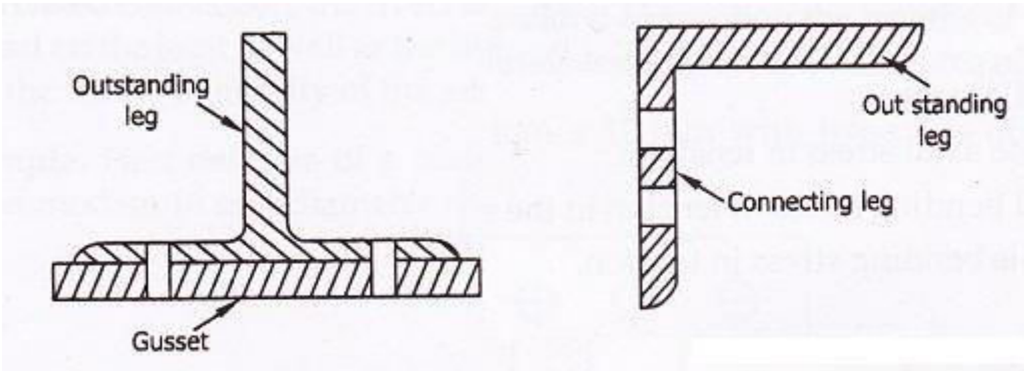
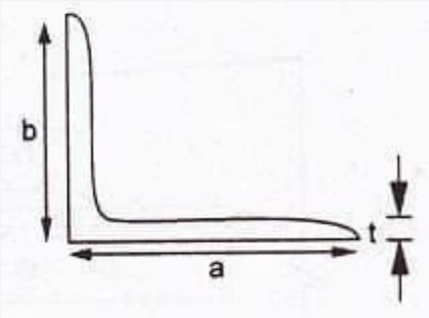


Figure: Tension Members

CASE – 1

In the case of single angles in tension, connected by one leg only,



Net effective area = $A_1 + k_1 A_2$

Where A_1 is the area of the connected leg,

A_2 = area of the outstanding leg, and

$$k_1 = \frac{3A_1}{3A_1 + A_2}$$

For angle sections, a x b x t,

$$A_1 = \left(b - d - \frac{t}{2}\right) \times t$$

$$A_2 = \left(a - \frac{t}{2}\right) \times t$$

Where lug angles are used, the net sectional area of the whole angle member could be considered.

CASE – 2

In the case of pair of angles back to back (or a single tee) in tension connected by only one leg on each angle (or by the flange of a tee) to the same side of the gusset plate,

Net effective area = $A_1 + k_2 A_2$

Where A_1 is the area of the connected legs (or flange of the tee)

A_2 = area of the outstanding leg (or web of the tee), and

$$k_2 = \frac{5A_1}{5A_1 + A_2}$$

CASE – 3

In the case of double angles or tees carrying direct tension, placed back to back and connected to both sides of the gusset,

Net effective area = gross area of section – area of holes

Video Content / Details of website for further learning (if any):

1. https://theconstructor.org/structural-engg/net-area-permissible-stresses-for-tension-members/4844/

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

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LECTURE HANDOUTS

L-31

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III -Compression Members** **Date of Lecture:**

Topic of Lecture: Effective Length about major and minor principal axis

Introduction :

- ✓ Effective length of compression member. Column or strut is a compression member, the effective length of which exceeds three times the least lateral dimension.
- ✓ Column or strut is a compression member, the effective length of which exceeds three times the least lateral dimension.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of columns
- ✓ Types of connections
- ✓ Types of joints

Detailed content of the Lecture:

Length of the column:

- ➢ Length of column is the distance between two points where a column gets its fixidty of support so its movement is restrained in all directions. Structurally effective length of column is defined as height between the points of contraflexure of the buckled column i.e. between two floors basically.

- ➢ Clause 25.2 of IS 456 stipulates the effective lengths of compression members (vide Annex E of IS 456). ... (c) Column: Column is a vertical compression member whose unsupported length l shall not exceed sixty times of b (least lateral dimension), if restrained at the two ends.

- ➢ Minimum size of an RCC column should not be less than 9” x 12” (225mm x 300mm) with 4 bars of 12 MM Fe415 Steel. These days the minimum I use in my projects is 9″ x 12″ (225 mm x 300mm) with 6 bars of 12 MM Fe500 steel. You can never go wrong with strong columns.

- ➢ The equivalent or effective length is defined as the distance between two adjacent points of contra flexure on the column.

- The equivalent length of a column is usually given in terms of the actual length and depends upon the end conditions of the column

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=wJWt0dcgafs
2. https://www.youtube.com/watch?v=p6aDP4ycISM

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

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LECTURE HANDOUTS

L32

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III- Compression Members** **Date of Lecture:**

Topic of Lecture: IS code provisions permissible stresses

Introduction :

- ✓ Permissible stresses are obtained by dividing the ultimate strength of concrete or yield strength of steel (0.2% proof stress) by appropriate factors of safety.
- ✓ The factors of safety used in working stress method are:
  - (i) For concrete
    - (a) in bending compression – 3.0
    - (b) in direct compression – 4.0.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ About codal provisions
- ✓ About IS 800:2007

Detailed content of the Lecture:

Permissible stress:

- ➢ Permissible stress design is a design philosophy used by civil engineers. The designer ensures that the stresses developed in a structure due to service loads do not exceed the elastic limit.
- ➢ This limit is usually determined by ensuring that stresses remain within the limits through the use of factors of safety

Maximum allowable stress:

- ➢ The allowable stress or allowable strength is the maximum stress (tensile, compressive or bending) that is allowed to be applied on a structural material.
- ➢ The allowable stresses are generally defined by building codes, and for steel, and aluminum is a fraction of their yield stress.

Permissible stress in steel:

- ➢ The working stress method is based upon the concept of permissible stresses.
- ➢ Permissible stresses are obtained by dividing the ultimate strength of concrete or yield strength of steel (0.2% proof stress) by appropriate factors of safety.

Factor of safety:

- Buildings commonly use a factor of safety of 2.0 for each structural member. The value for buildings is relatively low because the loads are well understood and most structures are redundant.

Video Content / Details of website for further learning (if any):

1. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=2495
2. https://theconstructor.org/structural-engg/types-of-tension-members/4800/

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

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LECTURE HANDOUTS

L33

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III Compression Members** **Date of Lecture:**

Topic of Lecture: design rules design of one component

Introduction :

- ✓ Identify your audience and design for them.
- ✓ Cover first.
- ✓ Take the right cover approach
- ✓ Keep it gridded (but not too gridded)
- ✓ Typographic hierarchy
- ✓ Don't be afraid of white space
- ✓ Pacing
- ✓ Hierarchy of elements and entry points.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Effective length
- ✓ Permissible stress
- ✓ Design of rules

Detailed content of the Lecture:

- ✓ Structuring components to handle states, themes, and variations
- ✓ As you're thinking of UI components, you're most likely also considering how to handle related components—these could be additional states, themes like light or dark, or other variations.
- ✓ What's the best way to handle them? How will designers interact with them?

- ✓ Nesting states and variations in a single component
- ✓ When you place an instance of a component into your design, Figma gives you access to its layers in the layers panel.
- ✓ This enables you to view and expand each instance in the layers panel.
- ✓ You may consider nesting elements in your component which users can turn on (by toggling the layer visibility) when needed; you could even nest every state within a single component.
- ✓ This method does have some benefits, but also a few drawbacks.

Benefits:

- ✓ This means one component to maintain, one component for designers to use, and only one to find in the components panel and instance menus.

Drawbacks:

- ✓ This method can make it more difficult for designers for discover the different states within the layer stack of each component.
- ✓ Switching between them can be more cumbersome since designers must know to toggle the appropriate layers within the component.
- ✓ These states are not always immediately apparent unless designers expand the component in the layers panel.
- ✓ This method can also result in a lot of repeated layers within your component.
- ✓ For example, a button comprised of a text box and a rectangle may need to repeat those layers for every state—when users override the text, and later want to show a different variation/state, the designer will need to re-input the override.
- ✓ This use case is handled much smoother with the following approaches.

Video Content / Details of website for further learning (if any):

1.https://unacademy.com › lesson › design-of-compression-members-part-3
2.https://www.steelconstruction.info/Design_codes_and_standards

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:165**

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LECTURE HANDOUTS

L34

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III- Compression Members** **Date of Lecture:**

Topic of Lecture: Two components and built up compression member under axial load.

Introduction :

- ✓ Built-up members are used in many structures, such as compression members of trusses or supporting columns. They are composed from two rolled U-sections or four rolled angles. They are used in the present study, the aim of which is to elaborate the optimum design of such structural parts.

Prerequisite knowledge for Complete understanding and learning of Topic:

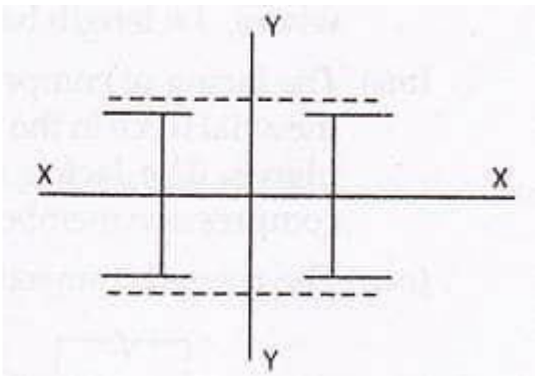
- ✓ Effective length
- ✓ Permissible stress
- ✓ Design of rules

- ✓ **Detailed content of the Lecture:**
- ✓ **DESIGN OF STEEL COMPRESSION MEMBERS**
- ✓ A structural member loaded axially in compression is generally called a compression member. Vertical compression members in buildings are called columns, posts or stanchions.
- ✓ A compression member in roof trusses is called struts and in a crane is called a boom.

- ✓ Columns which are long tend to buckle out of the plane of the load axis.

- ✓ *LACINGS AND BATTENS FOR BUILT-UP COMPRESSION MEMBERS*

- ✓ As per Indian Standard, IS 800-1984, the following specifications are used for the design of lacing and batten plates.
- ✓ In a built-up section, the different components are connected together so that they act as a single column. Lacing is generally preferred in case of eccentric loads.
- ✓ Battening is normally used for axially loaded columns and in sections where the components are not far apart. Flat bars are generally used for lacing.
- ✓ Angles, channels and tubular sections are also used for lacing of very heavily columns. Plates are used for battens.
- ✓ **Lacings**



- ✓ **A lacing system should generally conform to the following requirements:**

- ✓ The compression member 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 at right angles to that axis.
- ✓ The lacing system should not be varied throughout the length of the strut as far as practicable.
- ✓ Cross (except tie plates) should not be provided along the length of the column with lacing system, unless all forces resulting from deformation of column members are calculated and provided for in the lacing and its fastening.
- ✓ The single-laced systems on opposite sides of the main components should preferably be in the same direction so that one system is the shadow of the other.
- ✓ Laced compression members should be provided with tie plates at the ends of the lacing system and at points where the lacing system are interrupted.
- ✓ The tie plates should be designed by the same method as followed for battens.

DESIGN OF BATTENS

Battens should be designed to carry bending moment and shear arising from a transverse shear,

$$V = \frac{2.5}{100} P$$

Where P = total axial load in the compression member.

Transverse shear V is divided equally between the parallel planes of battens. Battens and their connections to main components resist simultaneously a longitudinal shear.

$$V_1 = \frac{V \times C}{N \times S}$$

and , moment $M = \frac{V \times C}{2N}$

due to transverse shear V.

where, C = spacing of battens

N= number of parallel planes of battens

S= minimum transverse distance between centroid of rivet group or welding.

The end connections should also be designed to resist the longitudinal shear force V_1 and the moment M.

For welded connection

1. Lap < 4t
2. Total length of weld at edge of batten < D/2

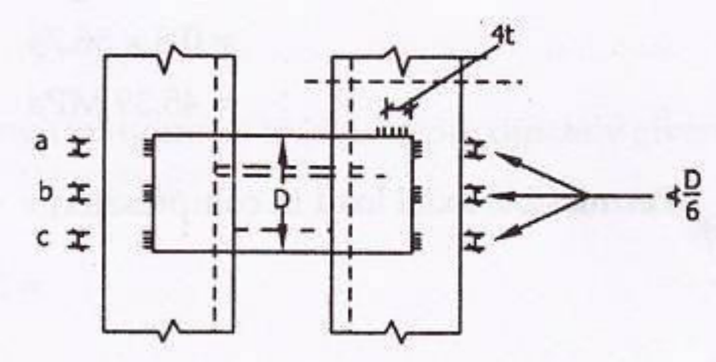
a + b+ c < D/2

let t = thickness of batten

Length of continuous weld at each edge of batten < 1/3 of total length required.

Return weld along transverse axis of the column < 4t

Where, t and D are the thickness and overall depth of battens, respectively.



Video Content / Details of website for further learning (if any):

1.Built-up Compression Members - ppt video online download

2.Design codes and standards - SteelConstruction.info

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:160**

Course Faculty

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Estd. 2000

LECTURE HANDOUTS

L35

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III- Compression Members** **Date of Lecture:**

Topic of Lecture: design of lacing and battens

Introduction :

- ✓ The main difference is in the purpose for which they are provided-**Lacing** flats carry no force but their sole purpose is to prevent buckling of column while **Battens** along with to check buckling plays a role in force transfer.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Design of rules of one component
- ✓ Built up compression member

Detailed content of the Lecture:

Laced Columns:

- ✓ In this case the components of the composite section are connected by lacing.
- ✓ Lacing consists of connecting the components of the column by a system of generally flat plates. (In some cases angles and channels are also used as lacings).
- ✓ Lacing plates may be 50 mm to 75 mm wide and 8 mm to 10 mm thick.

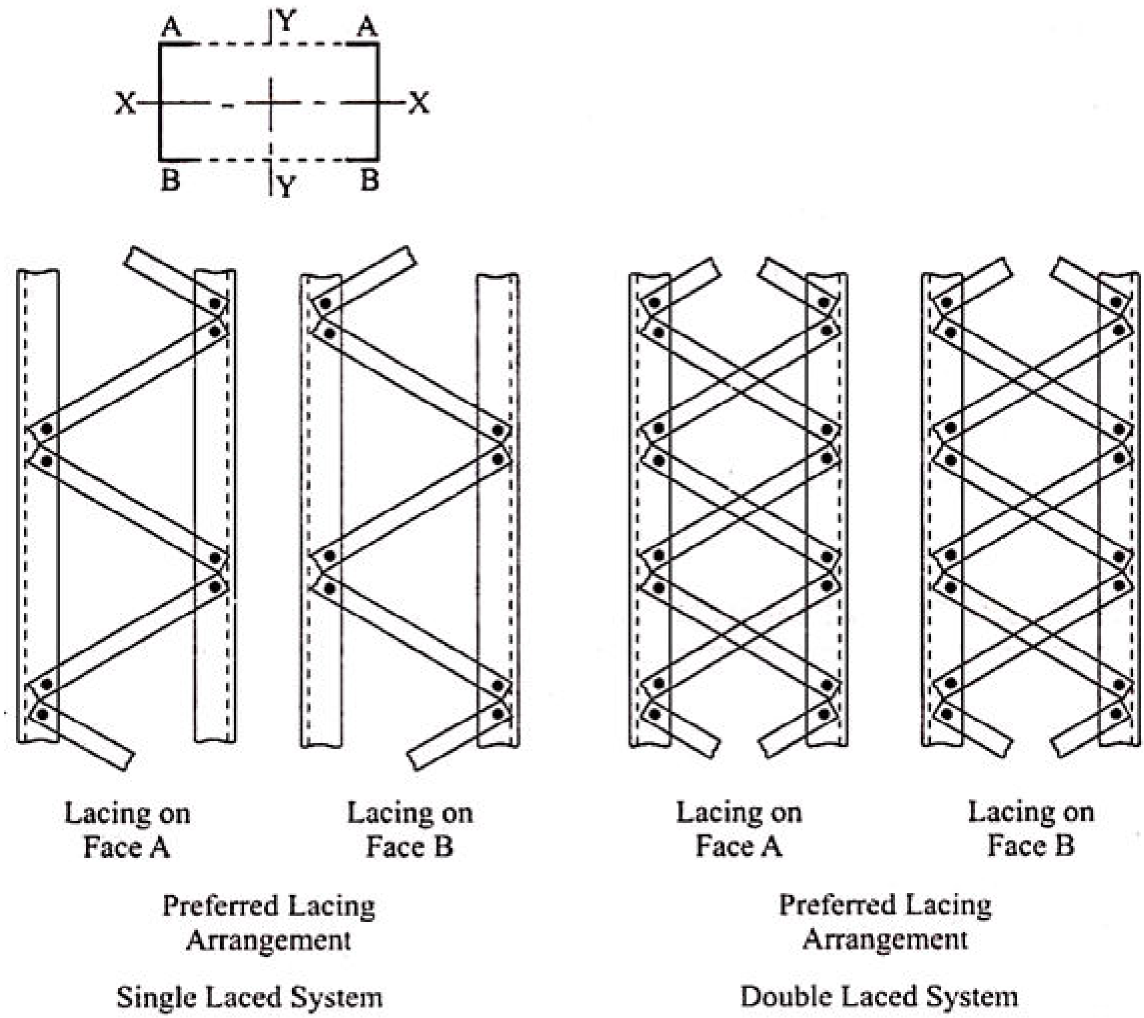

Fig. 7.37

- ✓ **General Requirements for Lacing (IS 800):**
- ✓ **ADVERTISEMENTS:**

- ✓ Compression 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.

- ✓ As far as possible the lacing system shall be uniform throughout the length of the column.

- ✓ 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.

- ✓ **ADVERTISEMENTS:**

- ✓ 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.
- ✓ 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.

- ✓ Thickness of lacing bars – The thickness of flat lacing bars shall not be less than one-fortieth of its effective length for single lacing and one-sixtieth of the effective length for double lacings.

- ✓ Rolled sections or tubes of equivalent strength may be permitted instead of flats for lacings.

- ✓ **ADVERTISEMENTS:**

- ✓ Angles of inclination – Lacing bars, whether in double or single or double system shall be inclined at an angle not less than 40° nor more than 70° to the axis of the built-up member.

- ✓ Spacing – The maximum spacing of lacing bars, whether connected by bolting, riveting or welding, shall also be such that the maximum slenderness ratio of the components of the main member (a_1/r_1) between consecutive lacing connections is not greater than 50 or 0.7 times the most unfavourable slenderness ratio of the member as a whole, whichever is less, where a_1 is the unsupported length of the individual member between lacing points, and r_1 is the minimum radius of gyration of the individual member being laced together.
- ✓ **Design of Lacings:**
- ✓ The lacing shall be proportioned to resist a total transverse shear V_t, at any point in the member, equal to at least 2.5 per cent of the axial force in the member and shall be divided equally among all transverse lacing systems in parallel planes.
- ✓ ADVERTISEMENTS:

- ✓ 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 in addition to that specified above.

- ✓ The slenderness ratio KL/r, of the lacing bars shall not exceed 145. In bolted/riveted constructions, 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 lacing effectively connected at inter sections. 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.

- ✓ **Attachments to Main Members:**
- ✓ The bolting riveting or welding of lacing bars to the main members shall be sufficient to transmit the force calculated in the bars.

- ✓ Where welded lacing bars overlap the main members, the amount of lap measured along either edge of the lacing bar shall be not less than four times the thickness of the bar or the thickness of the element of the members to which it is connected, whichever is less.

- ✓ The welding should be sufficient to transmit the load in the bar and shall in any case, be provided along each side of the bar for the full length of lap.

- ✓ **End Tie Plates:**
- ✓ Laced compression members shall be provided with tie plates at the ends of the lacing systems and at intersections with other members/stays and at point, where the lacing systems are interrupted.

- ✓ ***Battened Columns:***
- ✓ Compression members composed of two main components battened should preferably have the individual members of the same cross-section and symmetrically disposed about their major axis. Where practicable, the compression members should have a radius of gyration about the axis perpendicular to the plane of the batten not less than the radius of gyration about the axis parallel to the plane of the batten.

- ✓ The battens should be placed opposite to each end of the member and at points where the member is stayed in its length and as far as practicable, be spaced and proportioned uniformly throughout. The number of battens shall be such that the member is divided into not less than three bays within its actual length from centre to centre of end connections.

- ✓ The effective slenderness ratio $(KL/r)_c$ of battened columns, shall be taken as 1.1 time $(KL/r)_o$, the maximum actual slenderness ratio of the column, to account for shear deformation effects.
- ✓ **Design of Battens:**
- ✓ Battens shall be designed to carry the bending moments and shear forces arising from transverse shear force V_t equal to 2.5 per cent of the total axial force in the whole compression member, at any point in the length of the member divided equally between parallel planes of the battens. Battened member divided equally between parallel planes of the battens.
- ✓ Battened member carrying calculated bending moment due to eccentricity of axial loading, calculated end moments or lateral loads parallel to the plane of battens, shall be designed to carry actual shear in addition to the above shear. The main members shall also be checked for the same shear force and bending moments as for the battens.

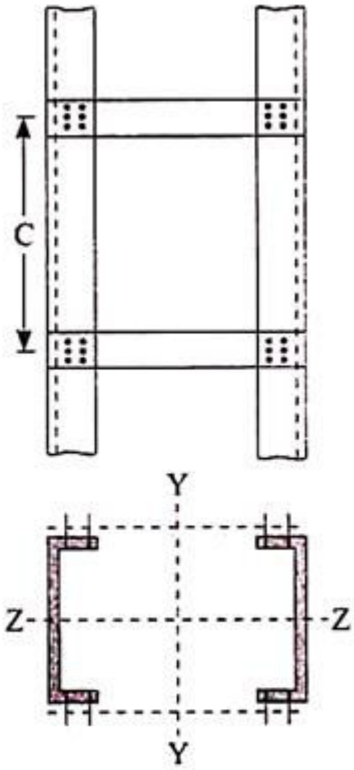

Fig. 7.39

- Battens shall be of plates, angles, channels or I-sections and at their ends shall be riveted, bolted or welded to the main components so as to resist simultaneously a shear $V_b = (V_1C)/N5$ along the column axis and a moment $M = (V_1C)/2N$ at each connection.
- where,
- V_1 = Transverse shear force as defined above
- C = Distance between centre to centre of battens, longitudinally
- N = Number of parallel planes of battens, and
- S = Minimum transverse distance between the centroid of the rivet/bolt group/welding connecting the batten to the main member.
- **Tie Plates:**
- Tie plates are members provided at the end of battened and laced members, and shall be designed by the same method as battens. In no case shall a tie plate and its fastening be incapable of carrying the forces for which the lacing or batten has been designed.
- **Size:**
- When plates are used for battens, the end battens and those at points where the member is stayed in its length shall have an effective depth, longitudinally, not less than the perpendicular distance between the centroids of the main members.
- The intermediate battens shall have an effective depth of not less than three quarters of this distance, but in no case shall the effective depth of any batten be less than twice the width of one member in the plane of the battens.

- ✓ The effective depth of a batten shall be taken as the longitudinal distance between outermost bolts, rivets or welds at the ends. The thickness of batten or the tie plates shall be not less than one-fiftieth of the distance between the innermost connecting lines of rivets, bolts or welds, perpendicular to the main member.

- ✓ The requirement of bolt size and thickness of batten specified above does not apply when angles, channels or I-sections are used for battens with their legs or flanges perpendicular to the main member. However it should be ensured that the ends of the compression members are tied to achieve rigidity.

- ✓ **Spacing of Battens:**
- ✓ In battened compression members where the individual members are not specifically checked for shear stress and bending moments, the spacing of battens, centre to centre of its end fastenings shall be such that the slenderness ratio (KL/r) of any component over that distance shall be neither greater than 50 nor greater than 0.7 times the slenderness ratio of the member as a whole about its Z-Z (axis parallel to the battens).

- ✓ **Attachment to Main Members:**
- ✓ **Welded Connections:**
- ✓ Where tie or batten plates overlap the main members, the amount of lap shall be not less than four times the thickness of the plate. The length of weld connecting each edge of the batten plate to the member shall in aggregate be not less than half the depth of the batten plate. At least one-third of the weld shall be placed at each end of this edge. The length of weld and the depth of batten plate shall be measured along the longitudinal axis of the main member.

Video Content / Details of website for further learning (if any):

1.Design of Lacings - YouTube

2.laced column single lacing system - YouTube

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:169 to174**

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LECTURE HANDOUTS

L36

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III Compression Members** **Date of Lecture:**

Topic of lecture: Different types of column bases

Introduction :

- ✓ Slab base, and.
- ✓ Gusseted bases.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Lacings and battens
- ✓ Types of column bsaes.

Detailed content of the Lecture:

- ✓ Column bases are structural elements used in the design of steel structures to transfer the column load to the footings.
- ✓ *Types of Column bases*

- ✓ Slab base
- ✓ Gusseted base

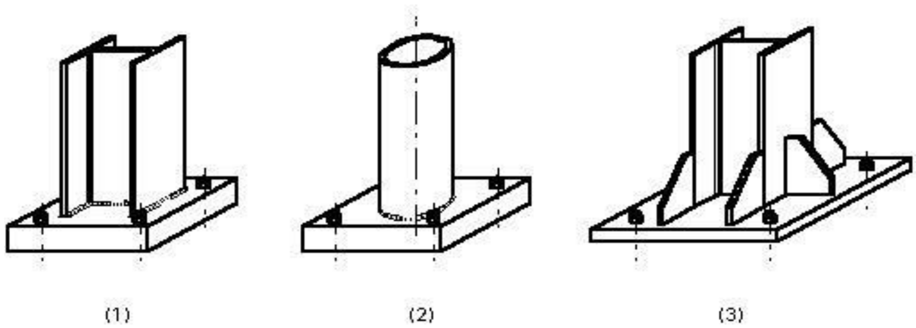
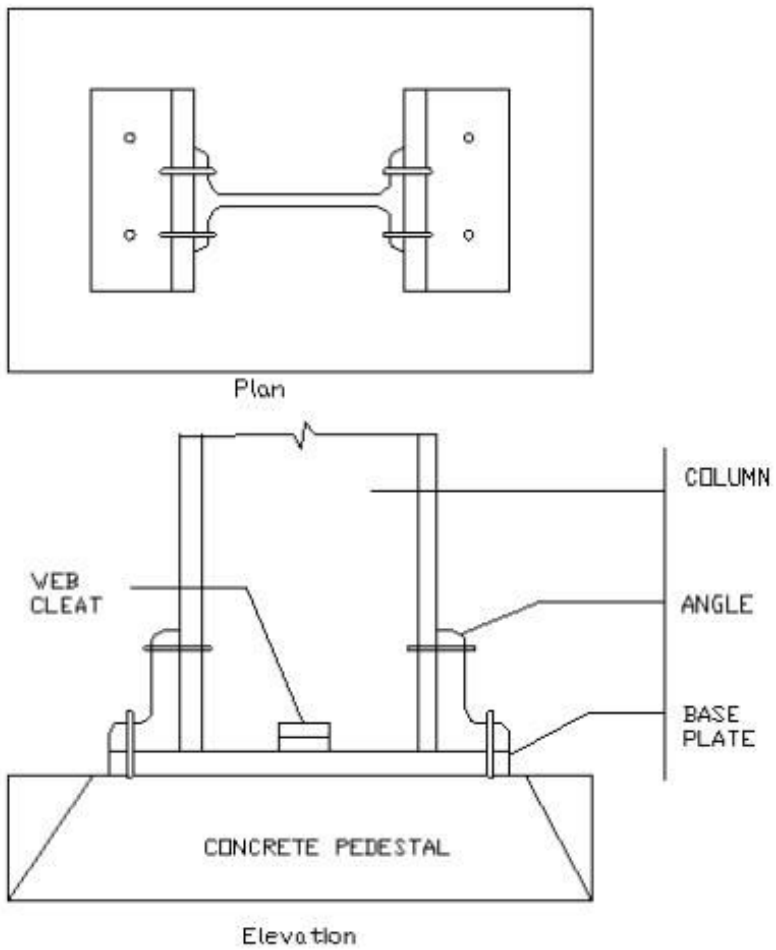


Figure 9 Column bases



- ✓ Slab bases are used where the columns have independent concrete pedestals.
- ✓ A thick steel base plate and two cleat angles connecting the flanges of the column to the base plate.
- ✓ In addition to these, web cleats are provided to connect the web of the column to the base plate.
- ✓ These web cleats guard against the possible dislocation of the column during erection.
- ✓ The ends of the column and also the base plate should be mechanized so that the column load is wholly transferred to the base plate.
- ✓ Area of base plate= (load of column)/(permissible bearing stress in concrete)

Gusseted base

- ✓ Gussetted bases are provided for columns carrying heavier loads requiring large base plates.
- ✓ A gusseted base consists of a base of reduced thickness and two gusseted plates are attached one to each flange of the column.
- ✓ The traditional approach for the design of pinned bases results in a base plate thickness of sufficient stiffness to ensure a uniform stress under the base plate and therefore the base plate can be modelled as a rigid plate [DeWolf, 1978].
- ✓ The traditional design of moment-resisting column bases involves an elastic analysis based on the assumption that the sections remain plane.
- ✓ By solving equilibrium equations, the maximum stress in the concrete foundation (based on linear stress distribution) and the tension in the holding down assembly may be determined.

- ✓ Whilst this procedure has proved satisfactory in service over many years, the approach ignores the flexibility of the base plate in bending (even when it is strengthened by stiffeners), the holding down assemblies and the concrete [DeWolf, Ricker, 1990].
- ✓ The concept, which was adopted in 1993-1-8: transfers the flexible base plate into an effective rigid plate and allows stress in the concrete foundation equal to the resistance in concentrated compression [Murray, 1983].
- ✓ A plastic distribution of the internal forces is used for calculations at the ultimate limit state.
- ✓ The component method similar to method for beam-to-column joints is used for the calculation of stiffness [Wald, 1995].
- ✓ The component approach involves identifying the important parts of the connection, see Figure 7.1 [Wald et al, 1998], called components, and determining the strength and stiffness of each component. The components are assembled to produce a model of the complete arrangement.
- ✓ The rules for resistance calculation of column bases are included in prEN 1993-1-8: 2003 Chapter 6.2.6 and rules for stiffness calculation are given in Chapter 6.3.4.
- ✓ Methods for transferring the horizontal shear forces are given in Chapter 6.2.1.2. Classification boundaries,

Video Content / Details of website for further learning (if any):

1. **https://www.youtube.com/watch?v=O8EiN-Eam48**
2. https://www.youtube.com › watch

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:184**

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LECTURE HANDOUTS

L37

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III- Compression Members** **Date of Lecture:**

Topic of Lecture: slab base and gusseted base

Introduction :

- ✓ Slab base is a type of the column base. Slab bases are used where the columns have independent concrete pedestals. A thick steel base plate and two cleat angles connecting the flanges of the column to the base plate. In addition to these, web cleats are provided to connect
- ✓ A gusseted base consists of a base of reduced thickness and two gusseted plates are attached one to each flange of the column. Gusseted Column Base. The gusseted plates, cleat angles and fastenings (bolts, rivets) in combination with bearing area of shaft shall be sufficient to take all loadseb of the column to the base plate.

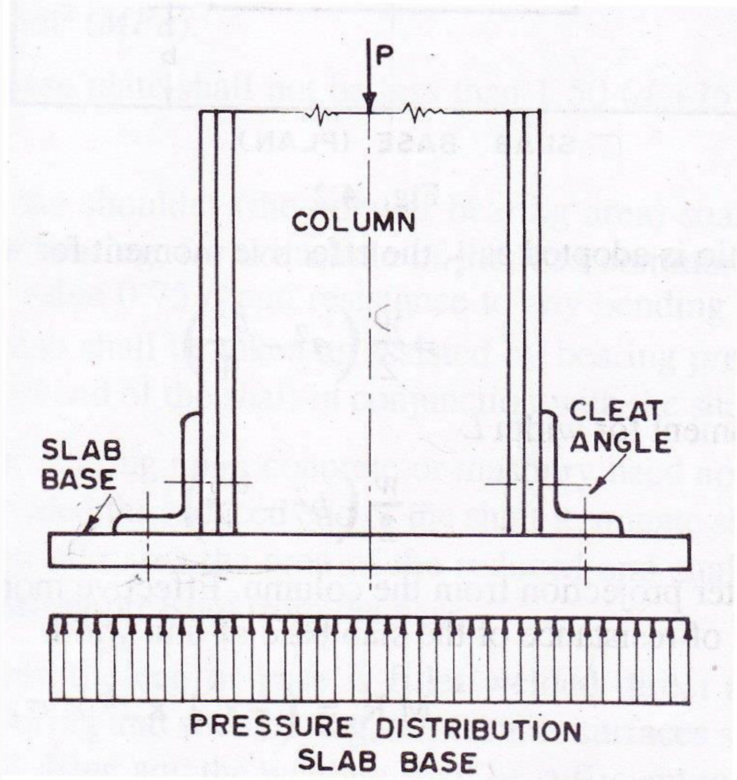
Prerequisite knowledge for Complete understanding and learning of Topic:

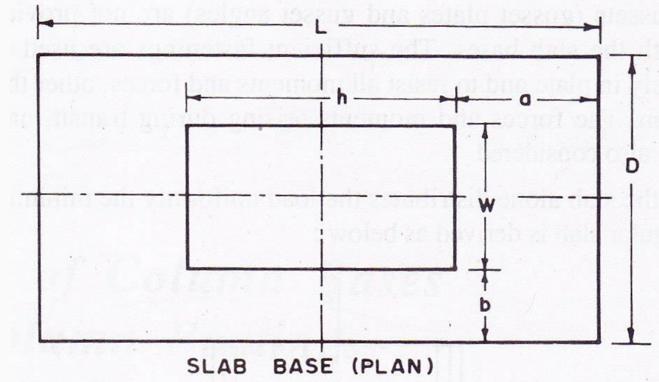
- ✓ Lacings and battens
- ✓ Types of column bases

Detailed content of the Lecture:

SLAB BASE

- ✓ The gussets (gusset plates and gusset angles) are not provided with the column with slab bases. The sufficient fastenings are used to retain the parts securely in plate and to resist all moments and forces, other than the direct compression.
- ✓ The forces and moments arising during transit, unloading and erection are also considered. When the slab alone distributes the load uniformly the minimum thickness of a rectangular slab is derived as below;

✓ 



- ✓ The column is carrying an axial load P. Consider the load distributed over area h x w and under the slab over the area L x D as shown in Fig. 12.2.
- ✓ Let t=Thickness of the slab
- ✓ W=Pressure or loading on the underside of the base
- ✓ a=Greater projection beyond column
- ✓ b=Lesser projection beyond column
- ✓ σ_{bs}= Allowable bending stress in the slab bases for all steels, it shall be assumed as 185 N/mm^2
- ✓ Consider a strip of unit width.
- ✓ Along the xx-axis $M_{xx} = \left(\frac{wa^2}{2}\right)$
- ✓ Along the yy-axis $M_{yy} = \left(\frac{wb^2}{2}\right)$
- ✓ If Poison ratio is adopted as ¼ the effective moment for width D $= \frac{w}{2}\left(a^2 - \frac{b^2}{4}\right)$

- ✓ Effective moment for width L $= \frac{w}{2}\left(b^2 - \frac{a^2}{4}\right)$
- ✓ Since a is greater projection from the column, the effective moment for width D is more. Moment of resistance of the slab base of unit width

$$M.R = \left(\frac{1}{6} \times 1 \times t^2 \times \sigma_{bs}\right)$$

Where t= Thickness of plate in mm

W=Total axial load in kN

B=Length of the side of base of cap in mm

d_0=Diameter of the reduced end (if any) of the column in mm

σ_{bs}= Allowable bending stress in steel (is adopted as 185 N/mm^2)

- ✓ The allowable intensity of pressure on concrete may be assumed as 4 N/mm^2. When the slab does not distribute the load uniformly or where the slab is not rectangular, separate calculation shall be made to show that stresses are within the specified limits.
- ✓ When the load on the cap or under the base is not uniformly distributed or where end of the column shaft is not machined with the cap or base, or where the cap or base is not square in plan, the calculations are made on the allowable stress of 185 N/mm^2 (MPa). The cap or base plate shall not be less than 1.50 (d_o+75) mm in length or diameter.
- ✓ The area of the shoulder (the annular bearing area) shall be sufficient to limit the stress in bearing, for the whole of the load communicated to the slab to the maximum value 0.75 f_y and resistance to any bending communicated to the shaft by the slab shall be taken as assisted by bearing pressures developed against the reduced and of the shaft in conjunction with the shoulder.
- ✓ The bases foe bearing upon concrete or masonry need not be machined on the underside provided the reduced end of the shaft terminate short of the surface of the slab and in all cases the area of the reduced end shall be neglected in calculating the bearing pressure from the base.

Video Content / Details of website for further learning (if any):

1.https://www.youtube.com › watch
2.design of column base. - YouTube

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:185 to 189**

Course Faculty

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LECTURE HANDOUTS

L38

CIVIL **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III- Compression Members** **Date of Lecture:**

Topic of Lecture: connection details

Introduction :

- ✓ There are several types of **compression members**: column, strut, post, stanchion, and top chords of trusses. very short **members** can reach their yield capacity under **compressive** loading. Usually, buckling due to instability occurs before the material reaches its full strength.

Prerequisite knowledge for Complete understanding and learning of Topic:

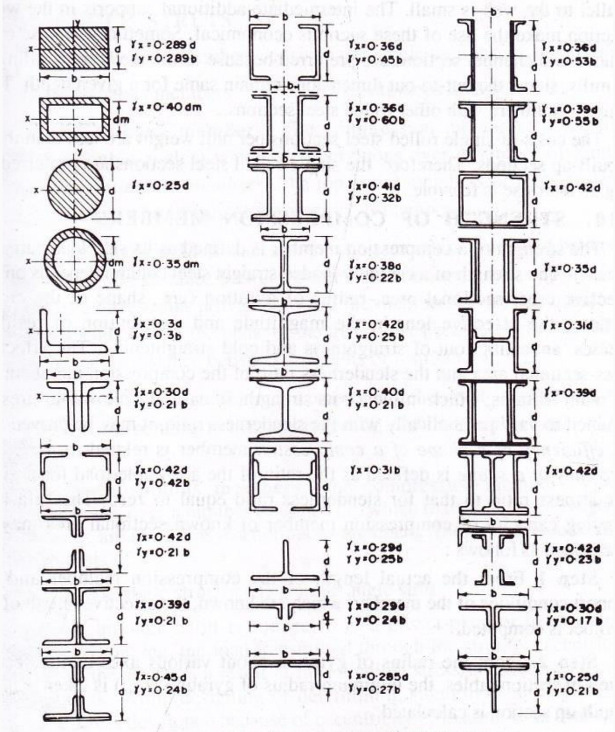
- ✓ Lacings and battens
- ✓ Column bases
- ✓ Slab base and gusted base

Detailed content of the Lecture:

- ✓ A strut is defined as a structural member subjected to compression in a direction parallel to its longitudinal axis.
- ✓ The term strut is commonly used for compression members in roof trusses. A strut may be used in a vertical position or in an inclined position in roof trusses.
- ✓ The compression members may be subjected to both axial compression and bending.
- ✓ When compression members are overloaded then their failure may take place because of one of the following:
- ✓ Direct compression
- ✓ Excessive bending
- ✓ Bending combined with twisting
- ✓ The failure of column depends upon its slenderness ratio. The load required to cause above mentioned failures decreases as the length of compression member increases, the cross-sectional area of the member being constant.

COMMON SECTIONS OF COMPRESSION MEMBERS

- ✓ The common sections used for compression members are shown in Fig. 11.1 with their approximate radii of gyration. A column or a compression member may be made



APPROXIMATE RADIUS OF GYRATION FOR COMMON SECTIONS FOR COMPRESSION MEMBERS

- ✓ Few sections satisfy practical requirement in a given case. A tubular section is most efficient and economical for the column free to buckle in any direction.
- ✓ The radius of gyration r for the tubular section in all the directions remains same. The tubular section has high local buckling strength.
- ✓ The tubular sections are suitable for medium loads. However, it is difficult to have their end connections. A solid round bar having a cross-sectional area equal to that of a tubular section has radius of gyration, r much smaller than that of tube. The solid round bar is less economical than the tubular section.
- ✓ The solid round bar is better than the thin rectangular section or a flat strip. The radius of gyration of flat strip about its narrow direction is very small. Theoretically, the rods and bars do resist some compression.
- ✓ When the length of structural member is about 3 m, then the compressive strengths of the rods and bars are very small.
- ✓ Single angle sections are rarely used except in light roof trusses, because of eccentricity at the end connections.
- ✓ Tee-sections are often used in roof trusses. The single rolled steel I-section and single rolled steel channel section are seldom used as column.
- ✓ The value of radius of gyration r, about the axis parallel to the web is small. The intermediate additional supports in the weak direction make the use of these sections economical.
- ✓ Sometimes the use of I-sections and channel sections are preferred because of the method of rolling at the mills, since, the out-to-out dimensions remain same for a given depth.
- ✓ This failure is not there with other rolled steel sections. The costs of single rolled steel sections per unit weight are less than those of built-up sections. Therefore the single rolled steel sections are preferred so long as their use is feasible.

3. STRENGTH OF COMPRESSION MEMBERS

- ✓ The strength of a compression member is defined as its safe load carrying capacity.
- ✓ The strength of a centrally loaded straight steel column depends on the effective cross-sectional area, radius of gyration (viz., shape of the cross-section), the effective length, the magnitude and distribution of residual stresses, annealing, out of straightness and cold straightening.
- ✓ The effective cross-sectional area and the slenderness ratio of the compression members are the main features, which influence its strength.
- ✓ In case, the allowable stress is assumed to vary parabolically with the slenderness ratio, it may be proved that the efficiency of a shape of a compression member is related to A/r^2.
- ✓ The efficiency of a shape is defined as the ratio of the allowable load for a given slenderness ratio to that for slenderness ratio equal to zero. The safe load carrying capacity of compression member of known sectional area may be determined as follows:
- ✓ **Step 1**. From the actual length of the compression member and the support conditions of the member, which are known, the effective length of the member is computed.
- ✓ **Step 2.** From the radius of gyration about various axes of the section given in section tables, the minimum radius of gyration (r_{min}) is taken. r_{min} for a built up section is calculated.
- ✓ **Step 3**. The maximum slenderness ratio (l/ r_{min}) is determined for the compression member.
- ✓ **Step 4**. The allowable working stress (σ_{ac}) in the direction of compression is found corresponding to the maximum slenderness ratio of the column from IS:800-1984.
- ✓ **Step 5**. The effective sectional area (A) of the member is noted from structural steel section tables. For the built up members it can be calculated.
- ✓ Step 6. The safe load carrying capacity of the member is determined as $P=(\sigma_{ac}.A)$, where P=safe load

ANGLE STRUTS

- ✓ The compression members consisting of single sections are of two types:
- ✓ Discontinuous members
- ✓ Continuous members

Continuous members

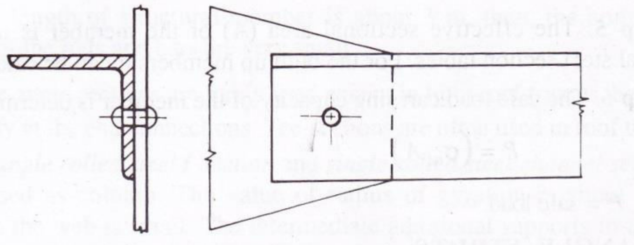
- ✓ The compression members (consisting of single or double angles) which are continuous over a number of joints are known as continuous members.
- ✓ The top chord members of truss girders and principal rafters of roof trusses are continuous members.
- ✓ The effective length of such compression members is adopted between 0.7 and 1.0 times the distance between the centres of intersections, depending upon degree of restraint provided.
- ✓ When the members of trusses buckle in the plane perpendicular to the plane of the truss, the effective length shall be taken as 1.0 times the distance between the points of restraint.
- ✓ The working stresses for such compression members is adopted from IS:800-1984

corresponding to the slenderness ratio of the member and yield stress for steel.

Discontinuous members

✓ The compression members which are not continuous over a number of joints, i.e., which extend between two adjacent joints only are known as discontinuous members. The discontinuous members may consist of single angle strut or double angle strut. When an angle strut is connected to a gusset plate or to any structural member by one leg, the load transmitted through the strut, is eccentric on the section of the strut. As a result of this, bending stress is developed along with direct stress. While designing or determining strength of an angle strut, the bending stress developed because of eccentricity of loading is accounted for as follows:

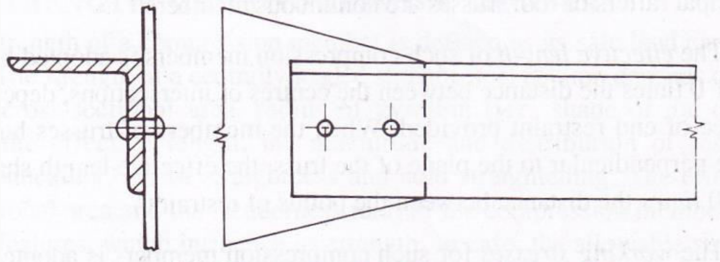
i.Single angle strut



✓ (A) SINGLE ANGLE STRUT CONNECTED WITH ONE RIVET.

- When single angle discontinuous strut is connected to a gusset plate with one rivet as shown in Fig. 11.2.A, its effective length is adopted as centre to centre of intersection at each end and the allowable working stress corresponding to the slenderness ratio of the member is reduced to 80 per cent. However, the slenderness ratio of such single angle strut should not exceed 180.

- When a single angle discontinuous strut is connected with two or more number of rivets or welding as shown in Fig. 11.2.B, its effective length is adopted as 0.85 times the length of strut centre to centre of intersection of each end and allowable working stress corresponding to the slenderness ratio of the member is not reduced.



✓ (B) SINGLE ANGLE STRUT CONNECTED TWO OR MORE RIVETS.

ii.Double angle strut

- A double angle discontinuous strut with angles placed back to back and connected to both sides of a gusset or any rolled steel section by not less than two rivets or bolts or in line along the angles at each end or by equivalent in welding as shown in Fig. 11.3.A, can be regarded as an axially loaded strut. Its effective length is adopted as 0.85 times the distance between intersections, depending on the degree of restraint provided and in the plane perpendicular to that of the gusset, the effective length 'l' shall be taken as equal to the distance between centres of the intersections. The tacking rivets should be provided at appropriate pitch.

- The double angles, back to back connected to one side of a gusset plate or a section by one or more rivets or bolts or welds as show in Fig. 11.3.B, these are designed as single angle discontinuous strut connected by single rivet or bolt.

- ✓ If the struts carry in addition to axial loads, loads which cause transverse bending, the combined bending and axial stress shall be checked as described for the columns subjected to eccentric loading. The tacking rivets should be provided at appropriate pitch.
- ✓ The tacking rivets are also termed as stitching rivets. In case of compression members, when the maximum distance between centres of two adjacent rivets exceeds 12 t to 200 mm whichever is less, then tacking rivets are used.
- ✓ The tacking rivets are not subjected to calculated stress. The tacking rivets are provided throughout the length of a compression member composed of two components back to back. The two components of a member act together as one piece by providing tacking rivets at a pitch in line not exceeding 600 mm and such that minimum slenderness ratio of each member between the connections is not greater than 40 or 0.6 times the maximum slenderness ratio of the strut as a whole, whichever is less.
- ✓ The minimum radius of gyration of the single angle section is much less than the other sections of same cross-sectional area.
- ✓ Therefore, the single angle sections are not suitable for the compression member of long lengths. The single angle sections are commonly used in the single plane trusses (i.e., the trusses having gusset plates in one plane). The angle sections simplify the end connections.
- ✓ The tee-sections are suitable for the compression members for small trusses. The tee-sections are more suitable for welding.

Video Content / Details of website for further learning (if any):

1.https://www.youtube.com › watch

2.https://www.frontiersin.org › articles

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:257**

Course Faculty

Verified by HOD

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III- Compression Members** **Date of Lecture:**

Topic of Lecture: problem

Introduction :

- ✓ **Slab base** is a type of the column **base**. **Slab bases** are used where the columns have independent concrete pedestals. A thick steel **base** plate and two cleat angles connecting the flanges of the column to the **base** plate.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Column bases
- ✓ slab base
- ✓ connection details

Detailed content of the Lecture:

Example .1 A column section HB 250,@ 0.510 kN/m carries an axial load of 600 kN. Design a slab for the column. The allowable bearing pressure on concrete is 4 N/mm^2. The allowable bending stress in the slab base is 185 N/mm^2(MPa).

Design:

Step 1: Area of slab base required

Axial load of column = 600 kN

It is assumed uniformly distributed under the slab

Area of the slab base required $= \left(\frac{600\times1000}{4}\right) = 15\times10^4 mm^2$

The length and width of slab base are proportioned so that projections on either side beyond the column are approximately equal.

Size of column section HB 250,@ 0.510 kN/mm is 250 mm x 25 mm

Area of slab base =(250+2a)(250+2b) mm^2

Step 2: Projections of base plate

Let projections a and b are equal

Area of slab $(250+2a)^2 = 15 \times 10^4$. Therefore a=68.45 mm

Provide projections a=b=70 mm

Provide slab base (250 + 2 x 70) (250 + 2 x 70) = 390 mm x 390 mm

Area of slab provided = 390 x 390 = 1,52,100 mm^2

Intensity of pressure from concrete under slab $w = \left(\frac{600 \times 1000}{152100}\right) = 3.945\ N/mm^2$

Step 3: Thickness of slab base:

Thickness of slab $= \left[\frac{3 \times 3.945}{185}\left(70^2 - \frac{70^2}{4}\right)\right]^{1/2} = 15.33\ mm$

Provide 16 mm thick slab base. The fastenings are provided to keep the column in position.

Example 12.2 A column section SC 250,@ 85.6 carries an axial load of 600 kN. Design a slab base for the column. The allowable bearing pressure on concrete is 4 N/mm^2. The allowable bending stress in the slab base is 185 N/mm^2(MPa).

Design:

Step 1: Area of slab base required

Axial load of column is 600 kN. It is assumed uniformly distributed under the slab.

Area of slab base required $= \left(\frac{600 \times 1000}{4}\right) = 15 \times 10^4 mm^2$

The length and width of slab base are proportioned so that the projections on either side beyond the column are approximately equal.

Size of column section SC 250,@ 85.6 kg/m = 250 mm x 250 mm

Area of slab base = (250 + 2a)(250+2b) mm^2

Step 2: Projections of base plate

Let the projections a and b be equal.

Area of slab $(250+2a)^2 = 15 \times 10^4$. Therefore a=68.45 mm

Provide projections a=b=70 mm

Provide slab base (250 + 2 x 70) (250 + 2 x 70) = 390 mm x 390 mm

Area of slab provided = 390 x 390 = 1,52,100 mm^2

Intensity of pressure from concrete under slab

Step 3: Thickness of slab base:

Thickness of slab $= \left[\frac{3\times 3.945}{185}\left(70^2 - \frac{70^2}{4}\right)\right]^{1/2} = 15.33\ mm$

Provide 16 mm thick slab base. The fastenings are provided to keep the column in position.

Video Content / Details of website for further learning (if any):

1.https://www.youtube.com › watch

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:185**

Course Faculty

Verified by HOD

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III -Compression Members** **Date of Lecture:**

Topic of Lecture: Effective Length about major and minor principal axis

Introduction :

- ✓ Effective length of compression member. Column or strut is a compression member, the effective length of which exceeds three times the least lateral dimension.
- ✓ Column or strut is a compression member, the effective length of which exceeds three times the least lateral dimension.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Types of columns
- ✓ Types of connections
- ✓ Types of joints

Detailed content of the Lecture:

Length of the column:

- ➢ Length of column is the distance between two points where a column gets its fixidty of support so its movement is restrained in all directions. Structurally effective length of column is defined as height between the points of contraflexure of the buckled column i.e. between two floors basically.

- ➢ Clause 25.2 of IS 456 stipulates the effective lengths of compression members (vide Annex E of IS 456). ... (c) Column: Column is a vertical compression member whose unsupported length l shall not exceed sixty times of b (least lateral dimension), if restrained at the two ends.

- ➢ Minimum size of an RCC column should not be less than 9" x 12" (225mm x 300mm) with 4 bars of 12 MM Fe415 Steel. These days the minimum I use in my projects is 9″ x 12″ (225 mm x 300mm) with 6 bars of 12 MM Fe500 steel. You can never go wrong with strong columns.

- ➢ The equivalent or effective length is defined as the distance between two adjacent points of contra flexure on the column.

- The equivalent length of a column is usually given in terms of the actual length and depends upon the end conditions of the column

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=wJWt0dcgafs
2. https://www.youtube.com/watch?v=p6aDP4ycISM

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

Course Faculty

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LECTURE HANDOUTS

L41

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III Compression Members** **Date of Lecture:**

Topic of Lecture: design rules design of one component

Introduction :

- ✓ Identify your audience and design for them.
- ✓ Cover first.
- ✓ Take the right cover approach
- ✓ Keep it gridded (but not too gridded)
- ✓ Typographic hierarchy
- ✓ Don't be afraid of white space
- ✓ Pacing
- ✓ Hierarchy of elements and entry points.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Effective length
- ✓ Permissible stress
- ✓ Design of rules

Detailed content of the Lecture:

- ✓ Structuring components to handle states, themes, and variations
- ✓ As you're thinking of UI components, you're most likely also considering how to handle related components—these could be additional states, themes like light or dark, or other variations.
- ✓ What's the best way to handle them? How will designers interact with them?

- ✓ Nesting states and variations in a single component
- ✓ When you place an instance of a component into your design, Figma gives you access to its layers in the layers panel.
- ✓ This enables you to view and expand each instance in the layers panel.
- ✓ You may consider nesting elements in your component which users can turn on (by toggling the layer visibility) when needed; you could even nest every state within a single component.
- ✓ This method does have some benefits, but also a few drawbacks.

Benefits:

- ✓ This means one component to maintain, one component for designers to use, and only one to find in the components panel and instance menus.

Drawbacks:

- ✓ This method can make it more difficult for designers for discover the different states within the layer stack of each component.
- ✓ Switching between them can be more cumbersome since designers must know to toggle the appropriate layers within the component.
- ✓ These states are not always immediately apparent unless designers expand the component in the layers panel.
- ✓ This method can also result in a lot of repeated layers within your component.
- ✓ For example, a button comprised of a text box and a rectangle may need to repeat those layers for every state—when users override the text, and later want to show a different variation/state, the designer will need to re-input the override.
- ✓ This use case is handled much smoother with the following approaches.

Video Content / Details of website for further learning (if any):

1.https://unacademy.com › lesson › design-of-compression-members-part-3
2.https://www.steelconstruction.info/Design_codes_and_standards

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:165**

Course Faculty

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MUTHAYAMMAL ENGINEERING COLLEGE
(An Autonomous Institution)

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Rasipuram - 637 408, Namakkal Dist., Tamil Nadu

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LECTURE HANDOUTS

L42

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III- Compression Members** **Date of Lecture:**

Topic of Lecture: Two components and built up compression member under axial load.

Introduction :

- ✓ Built-up members are used in many structures, such as compression members of trusses or supporting columns. They are composed from two rolled U-sections or four rolled angles. They are used in the present study, the aim of which is to elaborate the optimum design of such structural parts.

Prerequisite knowledge for Complete understanding and learning of Topic:

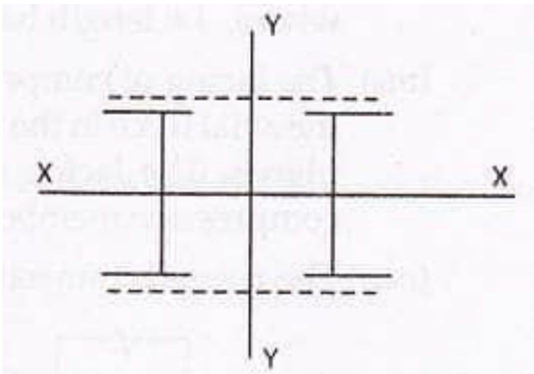
- ✓ Effective length
- ✓ Permissible stress
- ✓ Design of rules

- ✓ **Detailed content of the Lecture:**
- ✓ **DESIGN OF STEEL COMPRESSION MEMBERS**
- ✓ A structural member loaded axially in compression is generally called a compression member. Vertical compression members in buildings are called columns, posts or stanchions.
- ✓ A compression member in roof trusses is called struts and in a crane is called a boom.

- ✓ Columns which are long tend to buckle out of the plane of the load axis.

- ✓ ***LACINGS AND BATTENS FOR BUILT-UP COMPRESSION MEMBERS***

- ✓ As per Indian Standard, IS 800-1984, the following specifications are used for the design of lacing and batten plates.
- ✓ In a built-up section, the different components are connected together so that they act as a single column. Lacing is generally preferred in case of eccentric loads.
- ✓ Battening is normally used for axially loaded columns and in sections where the components are not far apart. Flat bars are generally used for lacing.
- ✓ Angles, channels and tubular sections are also used for lacing of very heavily columns. Plates are used for battens.
- ✓ **Lacings**



- ✓ **A lacing system should generally conform to the following requirements:**

- ✓ The compression member 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 at right angles to that axis.
- ✓ The lacing system should not be varied throughout the length of the strut as far as practicable.
- ✓ Cross (except tie plates) should not be provided along the length of the column with lacing system, unless all forces resulting from deformation of column members are calculated and provided for in the lacing and its fastening.
- ✓ The single-laced systems on opposite sides of the main components should preferably be in the same direction so that one system is the shadow of the other.
- ✓ Laced compression members should be provided with tie plates at the ends of the lacing system and at points where the lacing system are interrupted.
- ✓ The tie plates should be designed by the same method as followed for battens.

DESIGN OF BATTENS

Battens should be designed to carry bending moment and shear arising from a transverse shear,

$$V = \frac{2.5}{100} P$$

Where P = total axial load in the compression member.

Transverse shear V is divided equally between the parallel planes of battens. Battens and their connections to main components resist simultaneously a longitudinal shear.

$$V_1 = \frac{V \times C}{N \times S}$$

and , moment $M = \dfrac{V \times C}{2N}$

due to transverse shear V.

where, C = spacing of battens

N= number of parallel planes of battens

S= minimum transverse distance between centroid of rivet group or welding.

The end connections should also be designed to resist the longitudinal shear force V_1 and the moment M.

For welded connection

1. Lap < 4t
2. Total length of weld at edge of batten < D/2

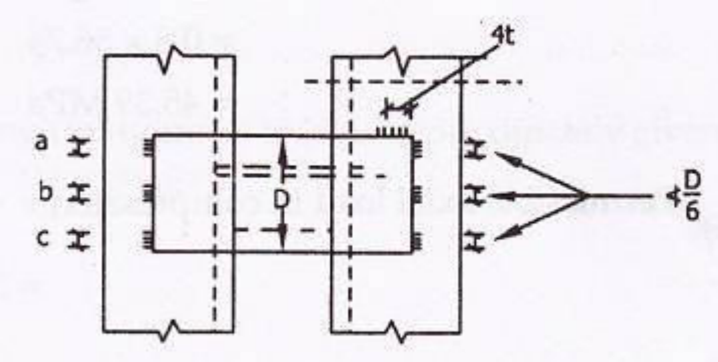
a + b+ c < D/2

let t = thickness of batten

Length of continuous weld at each edge of batten < 1/3 of total length required.

Return weld along transverse axis of the column < 4t

Where, t and D are the thickness and overall depth of battens, respectively.



Video Content / Details of website for further learning (if any):

1.Built-up Compression Members - ppt video online download

2.Design codes and standards - SteelConstruction.info

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:160**

Course Faculty

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LECTURE HANDOUTS

L43

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III- Compression Members** **Date of Lecture:**

Topic of Lecture: Two components and built up compression member under axial load.

Introduction :

- ✓ Built-up members are used in many structures, such as compression members of trusses or supporting columns. They are composed from two rolled U-sections or four rolled angles. They are used in the present study, the aim of which is to elaborate the optimum design of such structural parts.

Prerequisite knowledge for Complete understanding and learning of Topic:

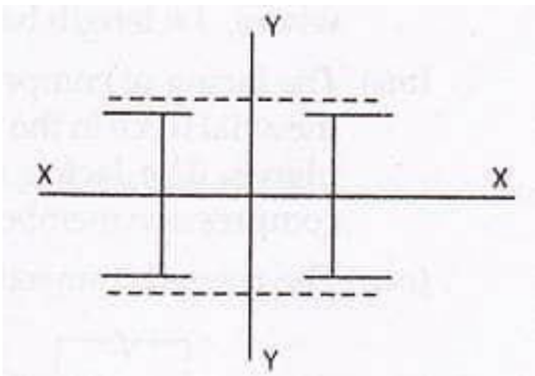
- ✓ Effective length
- ✓ Permissible stress
- ✓ Design of rules

- ✓ **Detailed content of the Lecture:**
- ✓ **DESIGN OF STEEL COMPRESSION MEMBERS**
- ✓ A structural member loaded axially in compression is generally called a compression member. Vertical compression members in buildings are called columns, posts or stanchions.
- ✓ A compression member in roof trusses is called struts and in a crane is called a boom.

- ✓ Columns which are long tend to buckle out of the plane of the load axis.

- ✓ *LACINGS AND BATTENS FOR BUILT-UP COMPRESSION MEMBERS*

- ✓ As per Indian Standard, IS 800-1984, the following specifications are used for the design of lacing and batten plates.
- ✓ In a built-up section, the different components are connected together so that they act as a single column. Lacing is generally preferred in case of eccentric loads.
- ✓ Battening is normally used for axially loaded columns and in sections where the components are not far apart. Flat bars are generally used for lacing.
- ✓ Angles, channels and tubular sections are also used for lacing of very heavily columns. Plates are used for battens.
- ✓ **Lacings**



- ✓ **A lacing system should generally conform to the following requirements:**

- ✓ The compression member 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 at right angles to that axis.
- ✓ The lacing system should not be varied throughout the length of the strut as far as practicable.
- ✓ Cross (except tie plates) should not be provided along the length of the column with lacing system, unless all forces resulting from deformation of column members are calculated and provided for in the lacing and its fastening.
- ✓ The single-laced systems on opposite sides of the main components should preferably be in the same direction so that one system is the shadow of the other.
- ✓ Laced compression members should be provided with tie plates at the ends of the lacing system and at points where the lacing system are interrupted.
- ✓ The tie plates should be designed by the same method as followed for battens.

DESIGN OF BATTENS

Battens should be designed to carry bending moment and shear arising from a transverse shear,

$$V = \frac{2.5}{100} P$$

Where P = total axial load in the compression member.

Transverse shear V is divided equally between the parallel planes of battens. Battens and their connections to main components resist simultaneously a longitudinal shear.

$$V_1 = \frac{V \times C}{N \times S}$$

and , moment $M = \frac{V \times C}{2N}$

due to transverse shear V.

where, C = spacing of battens

N= number of parallel planes of battens

S= minimum transverse distance between centroid of rivet group or welding.

The end connections should also be designed to resist the longitudinal shear force V_1 and the moment M.

For welded connection

1. Lap < 4t
2. Total length of weld at edge of batten < D/2

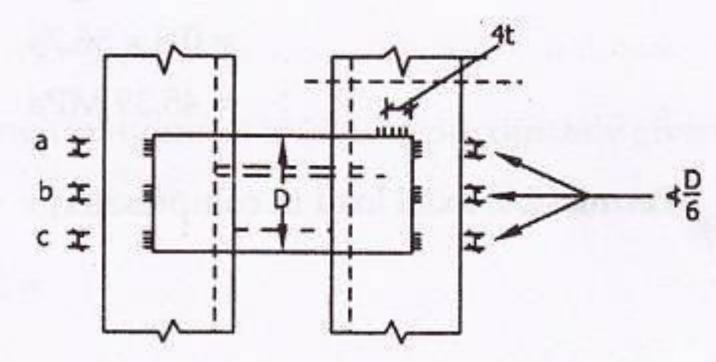
a + b+ c < D/2

let t = thickness of batten

Length of continuous weld at each edge of batten < 1/3 of total length required.

Return weld along transverse axis of the column < 4t

Where, t and D are the thickness and overall depth of battens, respectively.



Video Content / Details of website for further learning (if any):

1.Built-up Compression Members - ppt video online download

2.Design codes and standards - SteelConstruction.info

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:160**

Course Faculty

Verified by HOD

LECTURE HANDOUTS | **L44**

CIVIL | **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III- Compression Members** **Date of Lecture:**

Topic of Lecture: design of lacing and battens

Introduction :

- ✓ The main difference is in the purpose for which they are provided-**Lacing** flats carry no force but their sole purpose is to prevent buckling of column while **Battens** along with to check buckling plays a role in force transfer.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Design of rules of one component
- ✓ Built up compression member

Detailed content of the Lecture:

Laced Columns:

- ✓ In this case the components of the composite section are connected by lacing.
- ✓ Lacing consists of connecting the components of the column by a system of generally flat plates. (In some cases angles and channels are also used as lacings).
- ✓ Lacing plates may be 50 mm to 75 mm wide and 8 mm to 10 mm thick.

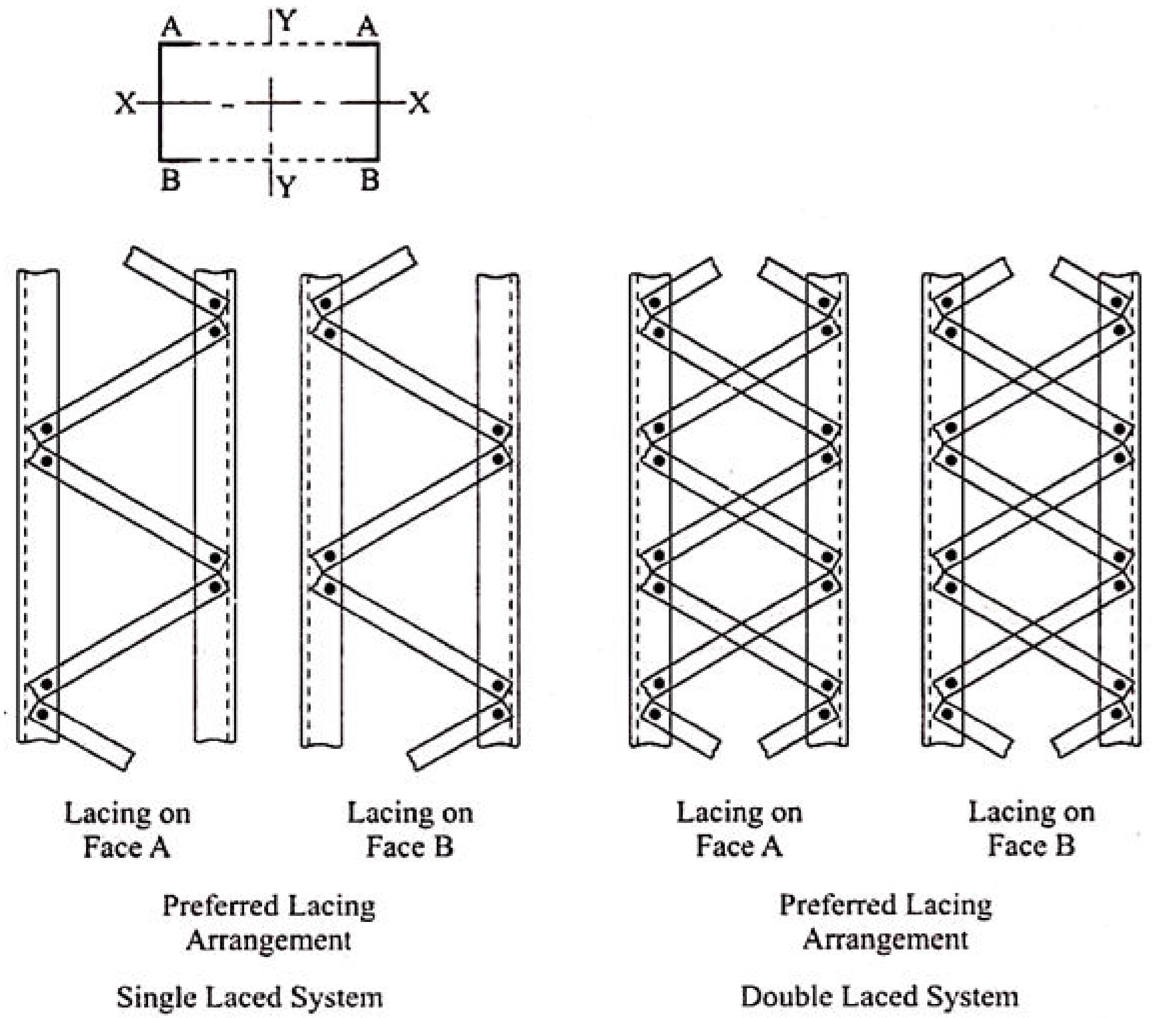


Fig. 7.37

- ✓ **General Requirements for Lacing (IS 800):**
- ✓ **ADVERTISEMENTS:**

- ✓ Compression 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.

- ✓ As far as possible the lacing system shall be uniform throughout the length of the column.

- ✓ 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.

- ✓ **ADVERTISEMENTS:**

- ✓ 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.
- ✓ 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.

- ✓ Thickness of lacing bars – The thickness of flat lacing bars shall not be less than one-fortieth of its effective length for single lacing and one-sixtieth of the effective length for double lacings.

- ✓ Rolled sections or tubes of equivalent strength may be permitted instead of flats for lacings.

- ✓ **ADVERTISEMENTS:**

- ✓ Angles of inclination – Lacing bars, whether in double or single or double system shall be inclined at an angle not less than 40° nor more than 70° to the axis of the built-up member.

- ✓ Spacing – The maximum spacing of lacing bars, whether connected by bolting, riveting or welding, shall also be such that the maximum slenderness ratio of the components of the main member (a_1/r_1) between consecutive lacing connections is not greater than 50 or 0.7 times the most unfavourable slenderness ratio of the member as a whole, whichever is less, where a_1 is the unsupported length of the individual member between lacing points, and r_1 is the minimum radius of gyration of the individual member being laced together.
- ✓ **Design of Lacings:**
- ✓ The lacing shall be proportioned to resist a total transverse shear V_t, at any point in the member, equal to at least 2.5 per cent of the axial force in the member and shall be divided equally among all transverse lacing systems in parallel planes.
- ✓ ADVERTISEMENTS:

- ✓ 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 in addition to that specified above.

- ✓ The slenderness ratio KL/r, of the lacing bars shall not exceed 145. In bolted/riveted constructions, 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 lacing effectively connected at inter sections. 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.

- ✓ **Attachments to Main Members:**
- ✓ The bolting riveting or welding of lacing bars to the main members shall be sufficient to transmit the force calculated in the bars.

- ✓ Where welded lacing bars overlap the main members, the amount of lap measured along either edge of the lacing bar shall be not less than four times the thickness of the bar or the thickness of the element of the members to which it is connected, whichever is less.

- ✓ The welding should be sufficient to transmit the load in the bar and shall in any case, be provided along each side of the bar for the full length of lap.

- ✓ **End Tie Plates:**
- ✓ Laced compression members shall be provided with tie plates at the ends of the lacing systems and at intersections with other members/stays and at point, where the lacing systems are interrupted.

- ✓ ***Battened Columns:***
- ✓ Compression members composed of two main components battened should preferably have the individual members of the same cross-section and symmetrically disposed about their major axis. Where practicable, the compression members should have a radius of gyration about the axis perpendicular to the plane of the batten not less than the radius of gyration about the axis parallel to the plane of the batten.

- ✓ The battens should be placed opposite to each end of the member and at points where the member is stayed in its length and as far as practicable, be spaced and proportioned uniformly throughout. The number of battens shall be such that the member is divided into not less than three bays within its actual length from centre to centre of end connections.

- ✓ The effective slenderness ratio $(KL/r)_c$ of battened columns, shall be taken as 1.1 time $(KL/r)_o$, the maximum actual slenderness ratio of the column, to account for shear deformation effects.
- ✓ **Design of Battens:**
- ✓ Battens shall be designed to carry the bending moments and shear forces arising from transverse shear force V_t equal to 2.5 per cent of the total axial force in the whole compression member, at any point in the length of the member divided equally between parallel planes of the battens. Battened member divided equally between parallel planes of the battens.
- ✓ Battened member carrying calculated bending moment due to eccentricity of axial loading, calculated end moments or lateral loads parallel to the plane of battens, shall be designed to carry actual shear in addition to the above shear. The main members shall also be checked for the same shear force and bending moments as for the battens.

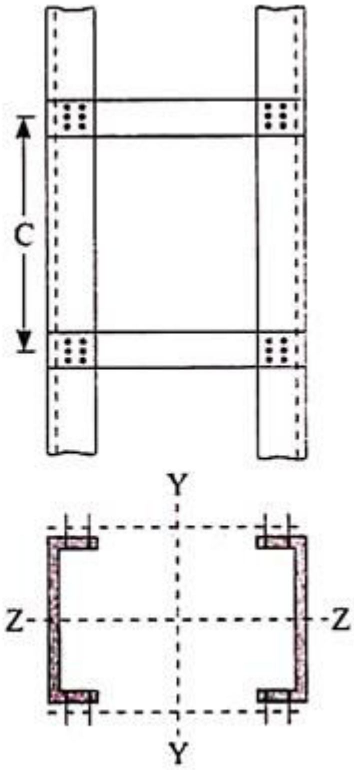


Fig. 7.39

- ✓ Battens shall be of plates, angles, channels or I-sections and at their ends shall be riveted, bolted or welded to the main components so as to resist simultaneously a shear $V_b = (V_1C)/N5$ along the column axis and a moment $M = (V_1C)/2N$ at each connection.
- ✓ where,
- ✓ V_1 = Transverse shear force as defined above
- ✓ C = Distance between centre to centre of battens, longitudinally
- ✓ N = Number of parallel planes of battens, and
- ✓ S = Minimum transverse distance between the centroid of the rivet/bolt group/welding connecting the batten to the main member.
- ✓ **Tie Plates:**
- ✓ Tie plates are members provided at the end of battened and laced members, and shall be designed by the same method as battens. In no case shall a tie plate and its fastening be incapable of carrying the forces for which the lacing or batten has been designed.
- ✓ **Size:**
- ✓ When plates are used for battens, the end battens and those at points where the member is stayed in its length shall have an effective depth, longitudinally, not less than the perpendicular distance between the centroids of the main members.
- ✓ The intermediate battens shall have an effective depth of not less than three quarters of this distance, but in no case shall the effective depth of any batten be less than twice the width of one member in the plane of the battens.

- ✓ The effective depth of a batten shall be taken as the longitudinal distance between outermost bolts, rivets or welds at the ends. The thickness of batten or the tie plates shall be not less than one-fiftieth of the distance between the innermost connecting lines of rivets, bolts or welds, perpendicular to the main member.

- ✓ The requirement of bolt size and thickness of batten specified above does not apply when angles, channels or I-sections are used for battens with their legs or flanges perpendicular to the main member. However it should be ensured that the ends of the compression members are tied to achieve rigidity.

- ✓ **Spacing of Battens:**
- ✓ In battened compression members where the individual members are not specifically checked for shear stress and bending moments, the spacing of battens, centre to centre of its end fastenings shall be such that the slenderness ratio (KL/r) of any component over that distance shall be neither greater than 50 nor greater than 0.7 times the slenderness ratio of the member as a whole about its Z-Z (axis parallel to the battens).

- ✓ **Attachment to Main Members:**
- ✓ **Welded Connections:**
- ✓ Where tie or batten plates overlap the main members, the amount of lap shall be not less than four times the thickness of the plate. The length of weld connecting each edge of the batten plate to the member shall in aggregate be not less than half the depth of the batten plate. At least one-third of the weld shall be placed at each end of this edge. The length of weld and the depth of batten plate shall be measured along the longitudinal axis of the main member.

Video Content / Details of website for further learning (if any):

1.Design of Lacings - YouTube

2.laced column single lacing system - YouTube

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:169 to174**

Course Faculty

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LECTURE HANDOUTS

L45

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **III- Compression Members** **Date of Lecture:**

Topic of Lecture: slab base and gusseted base

Introduction :

- ✓ Slab base is a type of the column base. Slab bases are used where the columns have independent concrete pedestals. A thick steel base plate and two cleat angles connecting the flanges of the column to the base plate. In addition to these, web cleats are provided to connect
- ✓ A gusseted base consists of a base of reduced thickness and two gusseted plates are attached one to each flange of the column. Gusseted Column Base. The gusseted plates, cleat angles and fastenings (bolts, rivets) in combination with bearing area of shaft shall be sufficient to take all loadseb of the column to the base plate.

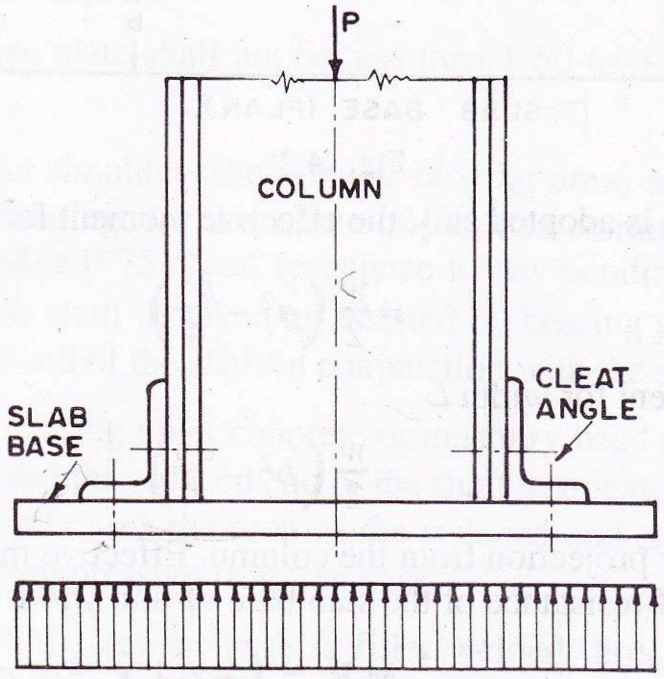
Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Lacings and battens
- ✓ Types of column bases

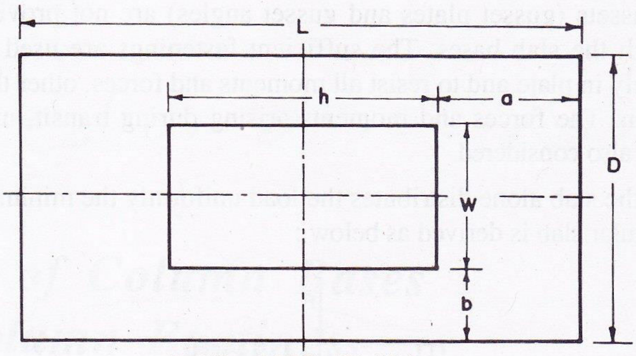
Detailed content of the Lecture:

SLAB BASE

- ✓ The gussets (gusset plates and gusset angles) are not provided with the column with slab bases. The sufficient fastenings are used to retain the parts securely in plate and to resist all moments and forces, other than the direct compression.
- ✓ The forces and moments arising during transit, unloading and erection are also considered. When the slab alone distributes the load uniformly the minimum thickness of a rectangular slab is derived as below;

✓ 

SLAB BASE



SLAB BASE (PLAN)

- ✓ The column is carrying an axial load P. Consider the load distributed over area h x w and under the slab over the area L x D as shown in Fig. 12.2.
- ✓ Let t=Thickness of the slab
- ✓ W=Pressure or loading on the underside of the base
- ✓ a=Greater projection beyond column
- ✓ b=Lesser projection beyond column
- ✓ σ_{bs}= Allowable bending stress in the slab bases for all steels, it shall be assumed as 185 N/mm^2
- ✓ Consider a strip of unit width.
- ✓ Along the xx-axis $M_{xx} = \left(\frac{wa^2}{2}\right)$
- ✓ Along the yy-axis $M_{yy} = \left(\frac{wb^2}{2}\right)$
- ✓ If Poison ratio is adopted as ¼ the effective moment for width D $= \frac{w}{2}\left(a^2 - \frac{b^2}{4}\right)$

- ✓ Effective moment for width L $= \frac{w}{2}\left(b^2 - \frac{a^2}{4}\right)$

- ✓ Since a is greater projection from the column, the effective moment for width D is more. Moment of resistance of the slab base of unit width

$$M.R = \left(\frac{1}{6} \times 1 \times t^2 \times \sigma_{bs}\right)$$

Where t= Thickness of plate in mm

W=Total axial load in kN

B=Length of the side of base of cap in mm

d_0=Diameter of the reduced end (if any) of the column in mm

σ_{bs}= Allowable bending stress in steel (is adopted as 185 N/mm^2)

- ✓ The allowable intensity of pressure on concrete may be assumed as 4 N/mm^2. When the slab does not distribute the load uniformly or where the slab is not rectangular, separate calculation shall be made to show that stresses are within the specified limits.

- ✓ When the load on the cap or under the base is not uniformly distributed or where end of the column shaft is not machined with the cap or base, or where the cap or base is not square in plan, the calculations are made on the allowable stress of 185 N/mm^2 (MPa). The cap or base plate shall not be less than 1.50 (d_o+75) mm in length or diameter.

- ✓ The area of the shoulder (the annular bearing area) shall be sufficient to limit the stress in bearing, for the whole of the load communicated to the slab to the maximum value 0.75 f_y and resistance to any bending communicated to the shaft by the slab shall be taken as assisted by bearing pressures developed against the reduced and of the shaft in conjunction with the shoulder.

- ✓ The bases foe bearing upon concrete or masonry need not be machined on the underside provided the reduced end of the shaft terminate short of the surface of the slab and in all cases the area of the reduced end shall be neglected in calculating the bearing pressure from the base.

Video Content / Details of website for further learning (if any):

1.https://www.youtube.com › watch
2.design of column base. - YouTube

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:185 to 189**

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LECTURE HANDOUTS

L46

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV- Beams** **Date of Lecture:**

Topic of Lecture: Design of laterally supported and unsupported beams

Introduction :

- ✓ All these will prevent or inhibit the top flange of the **beam** from buckling, and such **beams** have much more load-bearing capacity than **beams** of the same size and of the same span, with no such **lateral supports**, which are called **laterally unsupported beams**

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

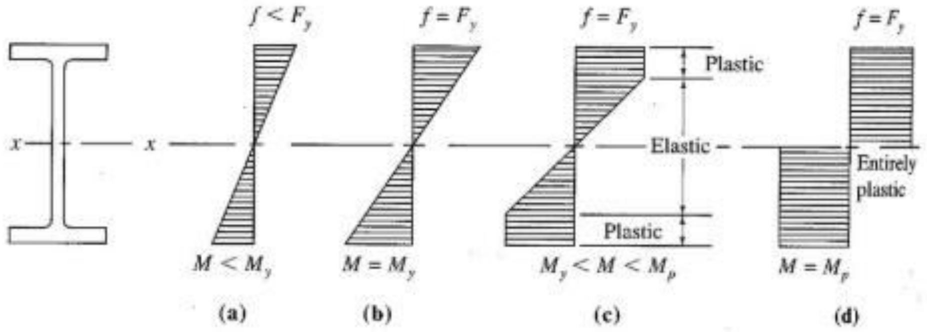
Detailed content of the Lecture:

- ✓ Design of laterally unsupported steel I-section beams according to ASD (Allowable Stress Design) and LRFD (Load and Resistance Factor Design) techniques requires the use of multiple equations
- ✓ These equations depend on the section compactness, the laterally unsupported length of the beam, the geometric properties of the cross section and the yield strength of the steel.
- ✓ Furthermore, local buckling and lateral torsion-flexure buckling significantly affect the behaviour of steel I-section beams.
- ✓ Flange outstand-to-thickness and web height-to-thickness ratios define the I-section compactness and hence control the local buckling behavior. The laterally unsupported length of the beam on the other hand, affects the critical moment initiating lateral flexure-torsion buckling.
- ✓ According to most codes of practice, three distinct zones are established for the behaviour of laterally unsupported steel beams; the moment resistance or the allowable bending stress is defined by a different equation in each zone.
- ✓ The first zone defines the elastic lateral torsion-flexure buckling behaviour while the second

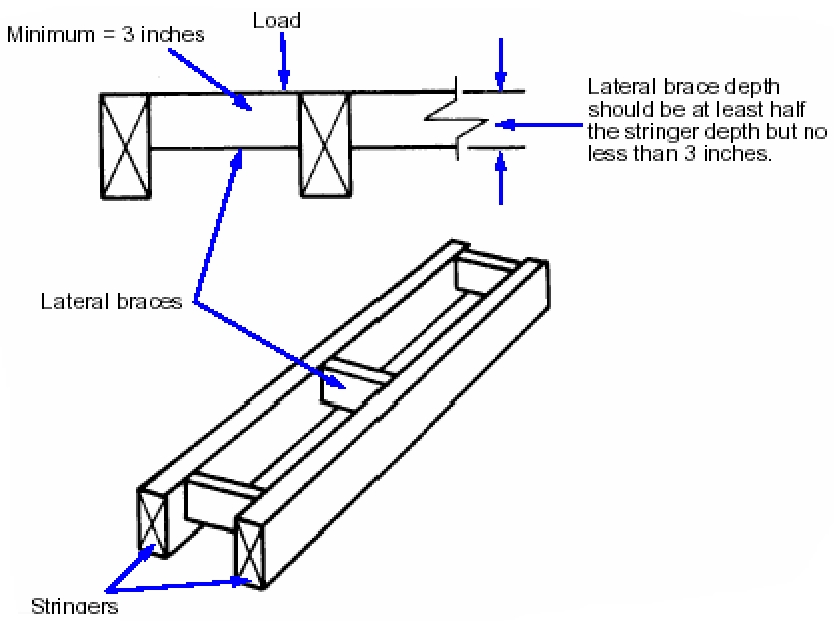
defines the DESIGN OF LATERALLY UNSUPPORTED STEEL I-BEAMS ACCORDING TO THE EGYPTIAN CODE OF PRACTICE: A PROPOSED SIMPLE EQUATION AUEJ, 7, 5,2004 1044 elasto-plastic lateral torsion-flexure buckling behaviour.

- ✓ The third zone is not affected by lateral buckling and failure is controlled by steel yielding. The ECPSCB-ASD (Egyptian Code of Practice for Steel Construction and Bridges – Allowable Stress Design) even treats the warping and the torsion resistances of the beam's cross section separately
- ✓ In this paper, a single equation which defines the allowable bending stress for laterally unsupported steel I-section beams is proposed to cover all these zones.
- ✓ The proposed equation results are compared to those obtained using the design provisions of the ECPSCB (ASD).
- ✓ The equation is proposed to replace the discontinuous definitions currently adopted by the ECPSCB (ASD) defining the allowable bending stress for laterally unsupported steel I-section beams.

LATERALLY SUPPORTED BEAM



LATERALLY UNSUPPORTED BEAM



Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=-f1CckABkx0
2. https://www.youtube.com/watch?v=kRSKLXoaN54

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures , by Dr.B.C. Punmia, Ashok kumar jain, Arun kumar jain in the page No:241**

Course Faculty

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LECTURE HANDOUTS | **L47**

CIVIL | **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV - Beams** **Date of Lecture:**

Topic of Lecture: Built Up Beams

Introduction :

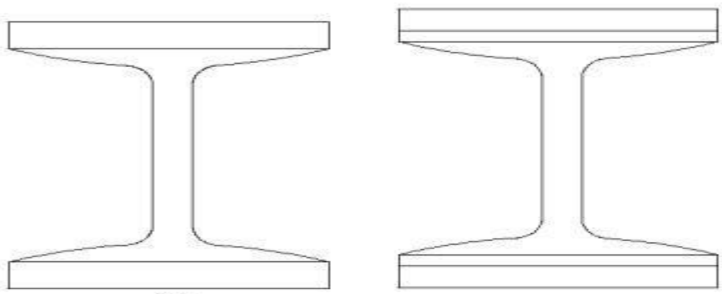
- ✓ A beam made of structural metal units (such as plates and angles) which are riveted, bolted,
- ✓ or welded together.
- ✓ A beam of precast concrete units which are joined by shear connectors.
- ✓ A flitch beam.
- ✓ A timber made up of several pieces fastened together, forming one of larger dimensions.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

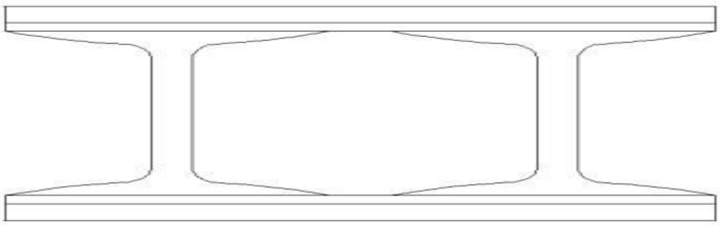
Detailed content of the Lecture:

- ✓ A built-up beam is also known as compound beam.
- ✓ The built-up beams are used when the span, load and corresponding bending moment are of such magnitudes that rolled steel beam section becomes inadequate to provide required section modulus.
- ✓ Built-up beams are also used when rolled steel beams are inadequate for limited depth.
- ✓ In building construction, the depth of beam is limited by a space provided by the architect.
- ✓ Drawing beam of small depth do not provide required section modulus. Therefore, plates are attached to the beams.
- ✓ The strength of rolled steel beams is increased by adding plates to its flange which is one of the method forming built-in section.
- ✓ The other method is to compound a number of rolled steel sections themselves.



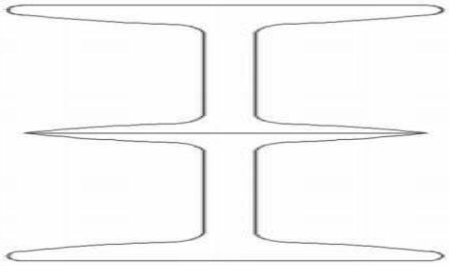
(A) (B)

The built-up sections shown in figure' A' and 'B' are used for heavy loads and small spans



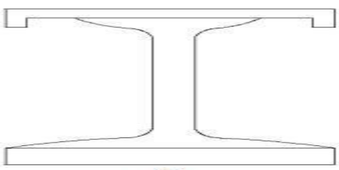
(C)

The built-up section 'C' is also used for heavy loads and small span

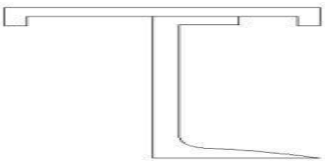


(D)

The built-up section 'D' is used for light loads and large spans



(E)



(F)

The built-up sections 'E' & 'F' are provided for Gantry girders

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=wjEQ6F4HCaU
2. https://www.youtube.com/watch?v=GBh8dMMyU30

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by Dr.B.C.Punmia, Ashok kumar jain, Arun kumar jain in the page No:270**

Course Faculty

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LECTURE HANDOUTS | **L48**

CIVIL | **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV - Beams** **Date of Lecture:**

Topic of Lecture: Built Up Beams

Introduction :

- ✓ All these will prevent or inhibit the top flange of the **beam** from buckling, and such **beams** have much more load-bearing capacity than **beams** of the same size and of the same span, with no such **lateral supports**, which are called **laterally unsupported beams**

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

Detailed content of the Lecture:

- ✓ A built-up beam is also known as compound beam.
- ✓ The built-up beams are used when the span, load and corresponding bending moment are of such magnitudes that rolled steel beam section becomes inadequate to provide required section modulus.
- ✓ Built-up beams are also used when rolled steel beams are inadequate for limited depth.
- ✓ In building construction, the depth of beam is limited by a space provided by the architect.
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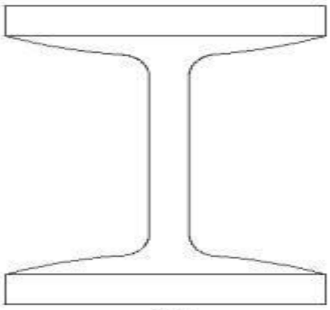
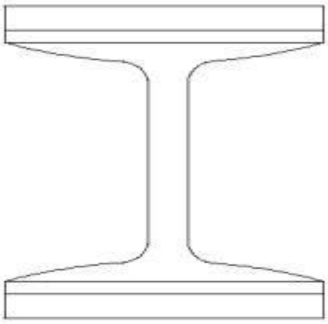
- ✓ The strength of rolled steel beams is increased by adding plates to its flange which is one of the method forming built-in section.
- ✓ The other method is to compound a number of rolled steel sections themselves.

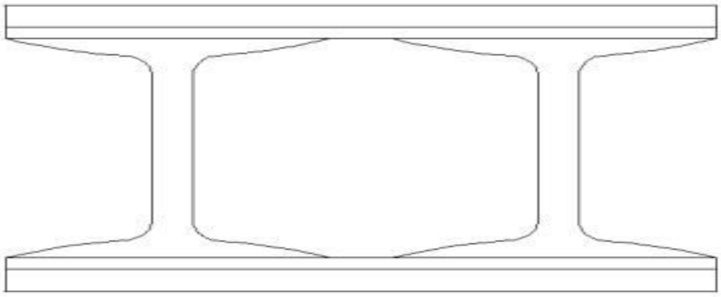


(A)



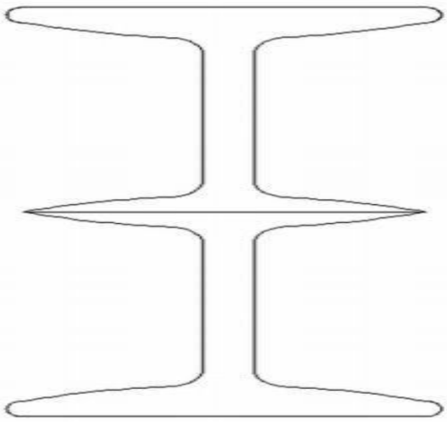
(B)

The built-up sections shown in figure' A' and 'B' are used for heavy loads and small spans



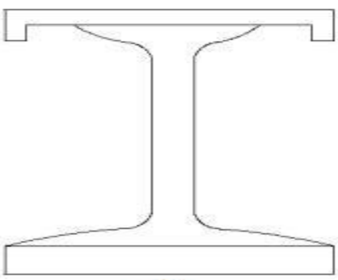
(C)

The built-up section 'C' is also used for heavy loads and small span

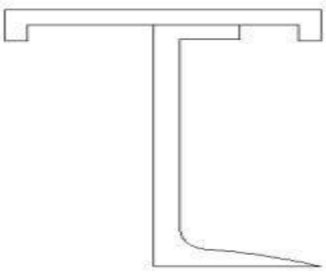


(D)

The built-up section 'D' is used for light loads and large spans



(E)



(F)

The built-up sections 'E' & 'F' are provided for Gantry girders

Video Content / Details of website for further learning (if any): 1. https://www.youtube.com/watch?v=wjEQ6F4HCaU 2. https://www.youtube.com/watch?v=GBh8dMMyU30
Important Books/Journals for further learning including the page nos.: **1. Design of steel structures by by Dr.B.C.Punmia, Ashok kumar jain, Arun kumar jain in the page No:270**

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LECTURE HANDOUTS

CIVIL **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV-Beams** **Date of Lecture:**

Topic of Lecture: Design of plate girders

Introduction :

- ✓ The plate girders are essentially built-up beams to carry heavier loads over large spans.
- ✓ They are deep structural members subjected to transverse loads.
- ✓ The plate girders consist of plates and angles riveted together. Plates and angles form an I-Section.

Prerequisite knowledge for Complete understanding and learning of Topic:

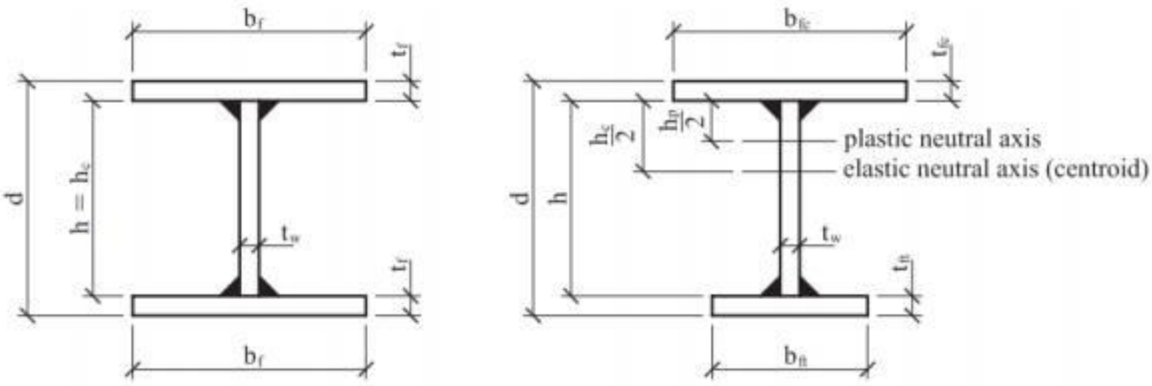
- ✓ Joints
- ✓ Connections
- ✓ Design methods

Detailed content of the Lecture:

- ✓ Welded plate girders, which are the most common form of plate girders, are built-up structural steel members that consists of flange plates welded to a web plate with fillet welds.
- ✓ They are used to support loads over long spans (60 ft. to 200 ft.) and to support structural loads that are too large to be supported by the rolled steel shapes shown in the AISCM.
- ✓ Plate girders are rarely used in building structures, but are commonly used in bridge structures.
- ✓ They are used as transfer girders in building structures to support columns above large column-free areas.
- ✓ Plate girders may also be used in the retrofitting of existing building structures where column-free areas are needed and existing columns have to be cut off or removed below a certain floor level.
- ✓ Plate girders are also used as crane support girders in heavy industrial structures with long

spans.

- ✓ All the standard hot-rolled shapes in the Manual, the webs are compact. Some have noncompact flanges, but none have slender flanges.
- ✓ With shapes built up from plates, however, both flanges and webs can be compact, noncompact, or slender.
- ✓ These built-up shapes usually are used when the bending moments are larger than standard hot-rolled shapes can resist, usually because of a large span.
- ✓ These girders are invariably very deep, resulting in noncompact or slender webs. A plate girder cross section can take several forms.
- ✓ The usual configuration is a single web with two equal flanges, with all parts connected by welding.
- ✓ The box section, which has two webs as well as two flanges, is a torsionally superior shape and can be used when large unbraced lengths are necessary.
- ✓ Hybrid girders, in which the steel in the flanges is of a higher strength than that in the web or webs, are sometimes used.



a. doubly symmetric plate girder section *b. singly symmetric plate girder section*

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=rxFP-cYpbLw
2. https://www.youtube.com/watch?v=45sp65he2BA

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:305**

Course Faculty

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LECTURE HANDOUTS **L50**

CIVIL **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV- Beams** **Date of Lecture:**

Topic of Lecture: Design of plate girders

Introduction :

- ✓ The plate girders are essentially built-up beams to carry heavier loads over large spans.
- ✓ They are deep structural members subjected to transverse loads.
- ✓ The plate girders consist of plates and angles riveted together. Plates and angles form an I-Section.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

Detailed content of the Lecture:

- ✓ Welded plate girders, which are the most common form of plate girders, are built-up structural steel members that consists of flange plates welded to a web plate with fillet welds.
- ✓ They are used to support loads over long spans (60 ft. to 200 ft.) and to support structural loads that are too large to be supported by the rolled steel shapes shown in the AISCM.
- ✓ Plate girders are rarely used in building structures, but are commonly used in bridge structures.
- ✓ They are used as transfer girders in building structures to support columns above large column-free areas.
- ✓ Plate girders may also be used in the retrofitting of existing building structures where column-free areas are needed and existing columns have to be cut off or removed below a certain floor level.
- ✓ Plate girders are also used as crane support girders in heavy industrial structures with long spans.
- ✓ All the standard hot-rolled shapes in the Manual, the webs are compact. Some have noncompact flanges, but none have slender flanges.

- ✓ With shapes built up from plates, however, both flanges and webs can be compact, noncompact, or slender.
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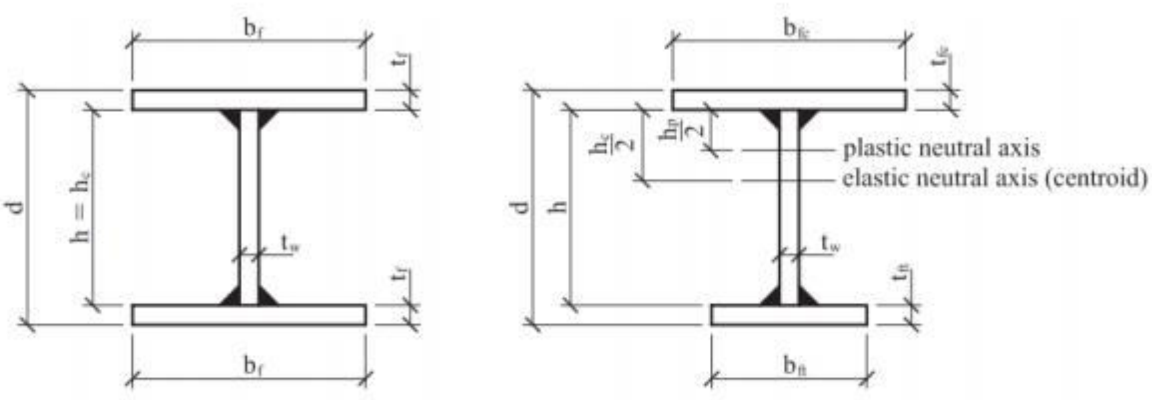
- ✓ These girders are invariably very deep, resulting in noncompact or slender webs. A plate girder cross section can take several forms.
- ✓ The usual configuration is a single web with two equal flanges, with all parts connected by welding.
- ✓ The box section, which has two webs as well as two flanges, is a torsionally superior shape and can be used when large unbraced lengths are necessary.
- ✓ Hybrid girders, in which the steel in the flanges is of a higher strength than that in the web or webs, are sometimes used.



a. doubly symmetric plate girder section

b. singly symmetric plate girder section

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=rxFP-cYpbLw
2. https://www.youtube.com/watch?v=45sp65he2BA

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:305**

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L51

LECTURE HANDOUTS

CIVIL **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV-Beams** **Date of Lecture:**

Topic of Lecture: Intermediate and bearing stiffeners

Introduction :

- ✓ End stiffeners are also called as bearing stiffeners.
- ✓ Intermediate stiffeners are required when there are concentrated loads acting on the plate girder.
- ✓ When the thickness of the web is very less (less than 1/85th of the depth of the web), then the web may buckle due to shear.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

Detailed content of the Lecture:

- ✓ End stiffeners are also called as bearing stiffeners.
- ✓ Intermediate stiffeners are required when there are concentrated loads acting on the plate girder.

When the thickness of the web is very less (less than 1/85th of the depth of the web), then the web may buckle due to shear.

Intermediate stiffeners

- ✓ Intermediate stiffeners are also called as non-bearing or stability stiffeners. These are placed at various intervals along the web to counteract against the buckling due to diagonal compression.
- ✓ These are provided in pairs on both sides of the web or as a single unit alternatively on each

side of the web.

Bearing stiffeners

- ✓ Bearing stiffeners are provided just above the reactions or just below the heavy concentrated loads.
- ✓ These transfer heavy reactions or concentrated loads to the full depth of the web providing a uniform shear transfer.
- ✓ Bearing stiffeners are always provided in pairs, i.e., on both sides of the web.

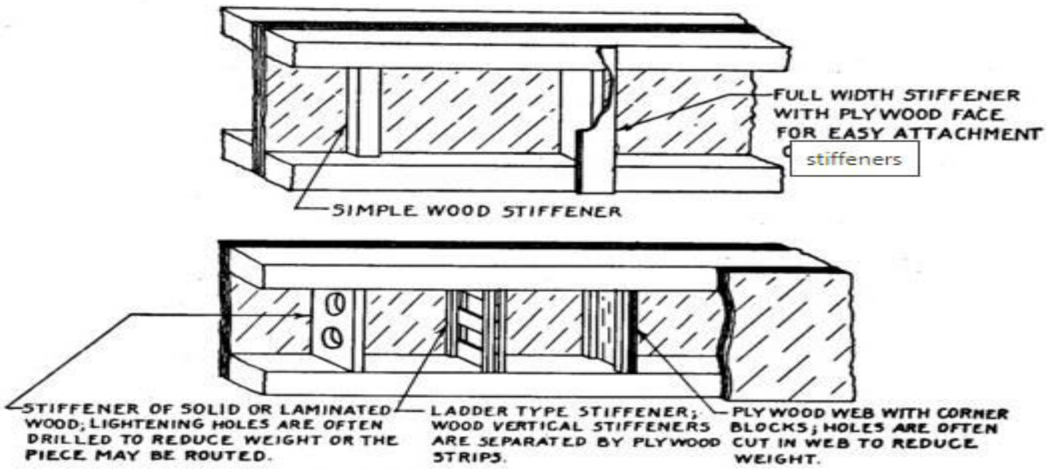

Figure 4 15. Typical stiffeners for I- and box-beams.

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=kup5iBXaGT8
2. https://slideplayer.com/slide/4713235/

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:316,319**

Course Faculty

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Rasipuram - 637 408, Namakkal Dist., Tamil Nadu

L52

LECTURE HANDOUTS

CIVIL **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV-Beams** **Date of Lecture:**

Topic of Lecture: Web splicing

Introduction :

Web splice :

- ✓ A joint in the web plate provide to increase the length is known as web splice.
- ✓ Web splice become essential, when the maximum manufactured length of plate is insufficient for full length of plate girder.
- ✓ The plate is manufactured up to a limited length

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

Detailed content of the Lecture:

- ✓ Bolted web splices will be designed for number of vertical and horizontal lines of bolts, splice plate thickness, vertical and horizontal gage distances, vertical edge distance, and horizontal plate and web edge distance.
- ✓ The method of LRFD Specification article 6.13.6.1.4b is employed, but with the appropriate load factors of the specification being used.
- ✓ If this condition is given in girder design generation input and the girder design is generated the resulting bolted web splice dimensions will be placed in the girder definition input for review and modification by the user.
- ✓ Modifications by the user, if any, will be evaluated upon re-analysis and the results will be

shown in the girder rating output.

- ✓ this condition is only given in girder definition input the resulting web splice dimensions will be shown just in the girder rating output.
- ✓ Splices in beams and girders are often required when the lengths of members are limited by fabrication, transportation, or handling facilities available, or by the construction process.
- ✓ Splice plates are lapped across the joint and bolted to the webs and the flanges of the beam in order to transfer the load.
- ✓ This type of splice is usually referred to as a web-flange splice.
- ✓ Current design methods for the connectors in web-flange splices vary.
- ✓ For example, Fisher and Struik 1 recommend that the web splice be assumed to transfer all of the shear and that the flange splice be assumed to transfer all of the moment at the section.
- ✓ The bolt group on one side of the web splice is designed on the assumption that the shear force acts at the centroid of the bolt group on the opposite side of the splice.
- ✓ For the web splice, the first approach considers the shear force to act at the centroid of the opposite bolt group.
- ✓ This is similar to the recommendation of Fisher and Struik. In the second approach, the bolt group on one side of the web splice is designed assuming that the shear force acts at the centerline of the splice.
- ✓ Bresler, Lin and Scalzi, Salmon and Johnson, and Nethercot also use this second approach, and they further recommend that the web splice be designed to transmit both the eccentric shear force and the portion of the moment that the web was designed to carry.
- ✓ However, Salmon and Johnson suggest that the effect of the eccentricity can be neglected except in cases where the shear and moment are high, and Bresler, et al. recommend neglecting the effect of the eccentricity when the eccentricity is much less than the depth of the web.

Video Content / Details of website for further learning (if any):

1. **https://www.youtube.com/watch?v=fC174baDyZw**
2. **https://www.youtube.com/watch?v=K_p_pfyowAM**

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures, Dr.B.C.Punmia,Ashok kumar jain, Arun kumar jain in the page No:454**

Course Faculty

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LECTURE HANDOUTS

L53

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV-Beams** **Date of Lecture:**

Topic of Lecture: Web splicing

Introduction :

- ✓ A joint in the web plate provide to increase the length is known as web splice.
- ✓ Web splice become essential, when the maximum manufactured length of plate is insufficient for full length of plate girder.
- ✓ The plate is manufactured up to a limited length

Prerequisite knowledge for Complete understanding and learning of Topic:

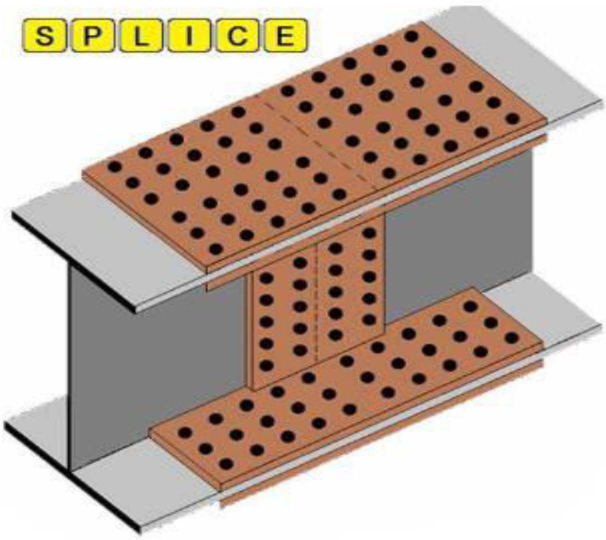
- ✓ Joints
- ✓ Connections
- ✓ Design methods

Detailed content of the Lecture:

- ✓ Bolted web splices will be designed for number of vertical and horizontal lines of bolts, splice plate thickness, vertical and horizontal gage distances, vertical edge distance, and horizontal plate and web edge distance.
- ✓ The method of LRFD Specification article 6.13.6.1.4b is employed, but with the appropriate load factors of the specification being used.
- ✓ If this condition is given in girder design generation input and the girder design is generated the resulting bolted web splice dimensions will be placed in the girder definition input for review and modification by the user.
- ✓ Modifications by the user, if any, will be evaluated upon re-analysis and the results will be shown in the girder rating output.
- ✓ this condition is only given in girder definition input the resulting web splice dimensions will be shown just in the girder rating output.
- ✓ Splices in beams and girders are often required when the lengths of members are limited by

fabrication, transportation, or handling facilities available, or by the construction process.

- ✓ Splice plates are lapped across the joint and bolted to the webs and the flanges of the beam in order to transfer the load.
- ✓ This type of splice is usually referred to as a web-flange splice.
- ✓ Current design methods for the connectors in web-flange splices vary.
- ✓ For example, Fisher and Struik 1 recommend that the web splice be assumed to transfer all of the shear and that the flange splice be assumed to transfer all of the moment at the section.
- ✓ The bolt group on one side of the web splice is designed on the assumption that the shear force acts at the centroid of the bolt group on the opposite side of the splice.
- ✓ In a commonly used British design manual, the same approach is recommended. Ballio and Mazzolani 3 present two alternative approaches for design of web-flange splices.
- ✓ In both approaches, the moment at the location of the splice is proportioned between the web splice and the flange splice.
- ✓ For the web splice, the first approach considers the shear force to act at the centroid of the opposite bolt group.
- ✓ This is similar to the recommendation of Fisher and Struik. In the second approach, the bolt group on one side of the web splice is designed assuming that the shear force acts at the centerline of the splice.
- ✓ Bresler, Lin and Scalzi, Salmon and Johnson, and Nethercot also use this second approach, and they further recommend that the web splice be designed to transmit both the eccentric shear force and the portion of the moment that the web was designed to carry.
- ✓ However, Salmon and Johnson suggest that the effect of the eccentricity can be neglected except in cases where the shear and moment are high, and Bresler, et al. recommend neglecting the effect of the eccentricity when the eccentricity is much less than the depth of the web.



✓

Video Content / Details of website for further learning (if any): 1. https://www.youtube.com/watch?v=fC174baDyZw 2. https://www.youtube.com/watch?v=K_p_pfyowAM
Important Books/Journals for further learning including the page nos.: 1. Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121

Course Faculty

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L54

LECTURE HANDOUTS

CIVIL **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Teacher **:K.Sankar**

Unit **: IV-Beams** **Date of Lecture:**

Topic of Lecture: Problem

Introduction : A beam is a structural element that primarily resists loads applied laterally to the beam's axis. Its mode of deflection is primarily by bending. The loads applied to the beam result in reaction forces at the beam's support points.

Prerequisite knowledge for Complete understanding and learning of Topic:
- ✓ Beams
- ✓ Griders

Detailed content of the Lecture:

Example 7.1

Design a welded plate girder to carry a superimposed load of 10 tonnes per metre on an effective span of 24 metres.

Solution

Total superimposed load $= 10 \times 1000 \times 24$

$= 240{,}000$ kg

Assuming self weight $= \dfrac{wl}{400}$

$= \dfrac{240{,}000 \times 24}{400}$

Total load $= 240{,}000 + 14{,}400 = 254{,}400$ kg

Maximum B.M. $= \dfrac{25{,}400 \times 2400}{8}$ kg. cm.

$= 76{,}320{,}000$ kg. cm.

Assuming girders to be laterally supported throughout so that maximum allowable stresses both in tension and compression are 1575 kg/cm^2

$$D = 5\sqrt[3]{\frac{M}{f}}$$

$$= 5\sqrt[3]{\frac{76{,}320{,}000}{1575}}$$

$$= 182.3 \text{ cm}$$

Use overall depth of 180 cm.

Taking flange plate thickness as 5 cm, depth of web will be 170 cm

Maximum shear $= \dfrac{254{,}400}{2} = 127{,}200$ kg

A_w = web plate area

$$\therefore \quad 1575 \times 175\left(A + \frac{170 \times 1}{6}\right) = 76{,}320{,}000$$

$$A = \frac{76{,}320{,}000}{1575 \times 175} - \frac{170}{6}$$

$$= 276.9 - 28.33 = 248.57 \text{ cm}^2$$

Wi... ange plate $= \dfrac{248.57}{5} = 49.71$

Width provided is 52 cm.

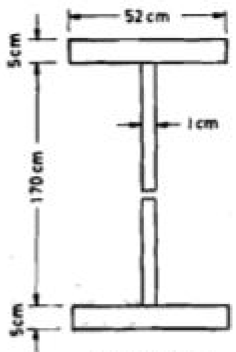

Figure 7.9(a)

Check by Moment of Inertia Method

$$I = 52\left(\frac{180^3 - 170^3}{12}\right) + \frac{1 \times 170^3}{12}$$

$$= 3{,}995{,}100 + 409{,}300$$

$$= 4{,}404{,}300 \text{ cm}^4$$

$$Z = \frac{I}{y_{max}} = \frac{4{,}404{,}300}{90}$$

Moment of inertia with 4 cm flange thickness

$$I = \frac{52\,(178^3 - 170^3)}{12} + \frac{1 \times 170^3}{12}$$

$$= 3{,}154{,}000 + 409{,}300$$

$$= 3{,}563{,}300\,\text{cm}^4$$

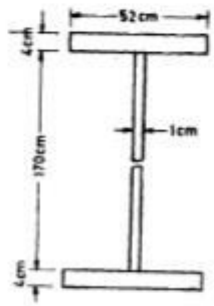

Figure 7.9(b)

Moment of resistance

$$= \frac{f}{y_{max}} \times I$$

$$= \frac{1575}{89} \times 356{,}300$$

$$= 63{,}050{,}000\,\text{kg.cm}$$

Let x metres be the distance from end where 5cm. Flange will be terminated. B.M. at this section will be equal to moment of resistance of section with 4cm flange thickness.

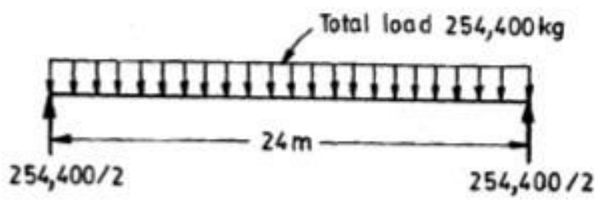

Figure 7.9(c)

$$100\left(\frac{254{,}400\,x}{2} - \frac{254{,}400}{24} \times \frac{x^2}{2}\right) = 63{,}050{,}000$$

$$24x - x^2 = \frac{63{,}050{,}000}{100 \times 254{,}400} \times 48$$

$$= 119$$

$$(x - 12)^2 = -119 + 144$$

$$x = \pm 5 + 12$$

Distance x from left support, where BM is equal to moment of resistance is given by

$$100\left[\frac{254{,}400}{2}x - \frac{254{,}400}{24}\times\frac{x^2}{2}\right] = 42{,}210{,}000$$

$$24x - x^2 = \frac{42{,}210{,}000\times 48}{100\times 254{,}400}$$

$$= 79.64$$

$$(x-12)^2 = -79.64 + 144 = 64.36$$

$$x = -\pm 8.02 + 12$$

$$= 3.98 \text{ m} \quad \text{and} \quad 20.02 \text{ m}$$

The variation of flange thickness is shown in Figure 7.9(e).

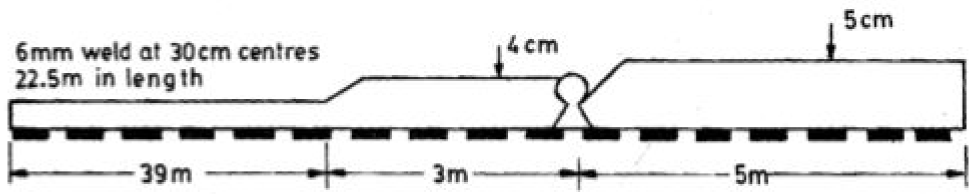

Figure 7.9(e)

Connection of Flange with Web

Horizontal shear for 1 cm length

$$F_A = \frac{F}{I}(A\,\bar{y})$$

$$F = \frac{254{,}400}{2} = 127{,}200 \text{ kg}$$

$$I = 2{,}345{,}300 \text{ cm}^4$$

$$A\,\bar{y} = 52\times 2.5\times(85+1.25)$$

$$= 130\times 86.25 = 11{,}212.5$$

h = outstand of stiffener in cm

$\therefore$ Shear per cm $= \dfrac{1^2}{2\times 12}\times 1000 \quad = 41.67$ kg

Use 5 mm intermediate weld on both sides of stiffener

$$= \frac{\text{Effective length}}{\text{Centre to centre of weld}}$$

$$= \frac{41.67}{2\times 1025\times 0.7\times 0.5}$$

$$= \frac{41.67}{718} = 0.058$$

Use 5 cm weld with effective length 4 cm and centre to centre of welds 20 cm. This gives clear distance of 16 cm between effective length of welds which is permissible.

Video Content / Details of website for further learning (if any): **1.https://www.youtube.com/watch?v=817zxuiMGJY** **2.https://www.youtube.com/watch?v=rxFP-cYpbLw**
Important Books/Journals for further learning including the page nos.: DESIGN OF STEEL STRUCTURE,S.S.BHAVIKATTI,Page no:305

Course Teacher

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LECTURE HANDOUTS

L55

CIVIL **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV- Beams** **Date of Lecture:**

Topic of Lecture: Design of laterally supported and unsupported beams

Introduction :

- ✓ All these will prevent or inhibit the top flange of the **beam** from buckling, and such **beams** have much more load-bearing capacity than **beams** of the same size and of the same span, with no such **lateral supports**, which are called **laterally unsupported beams**

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

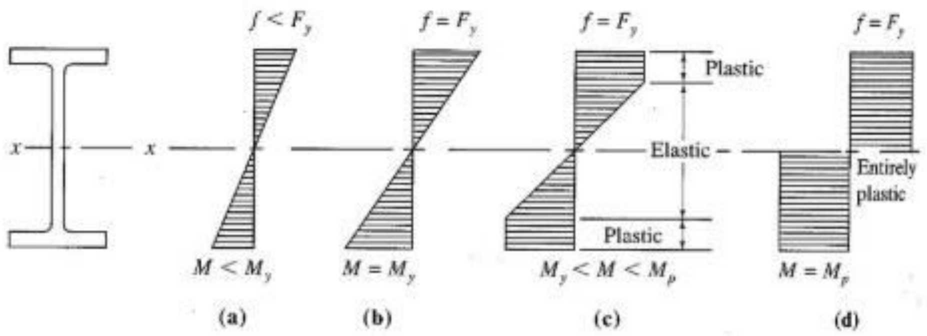
Detailed content of the Lecture:

- ✓ Design of laterally unsupported steel I-section beams according to ASD (Allowable Stress Design) and LRFD (Load and Resistance Factor Design) techniques requires the use of multiple equations
- ✓ These equations depend on the section compactness, the laterally unsupported length of the beam, the geometric properties of the cross section and the yield strength of the steel.
- ✓ Furthermore, local buckling and lateral torsion-flexure buckling significantly affect the behaviour of steel I-section beams.
- ✓ Flange outstand-to-thickness and web height-to-thickness ratios define the I-section compactness and hence control the local buckling behavior. The laterally unsupported length of the beam on the other hand, affects the critical moment initiating lateral flexure-torsion buckling.
- ✓ According to most codes of practice, three distinct zones are established for the behaviour of laterally unsupported steel beams; the moment resistance or the allowable bending stress is defined by a different equation in each zone.
- ✓ The first zone defines the elastic lateral torsion-flexure buckling behaviour while the second

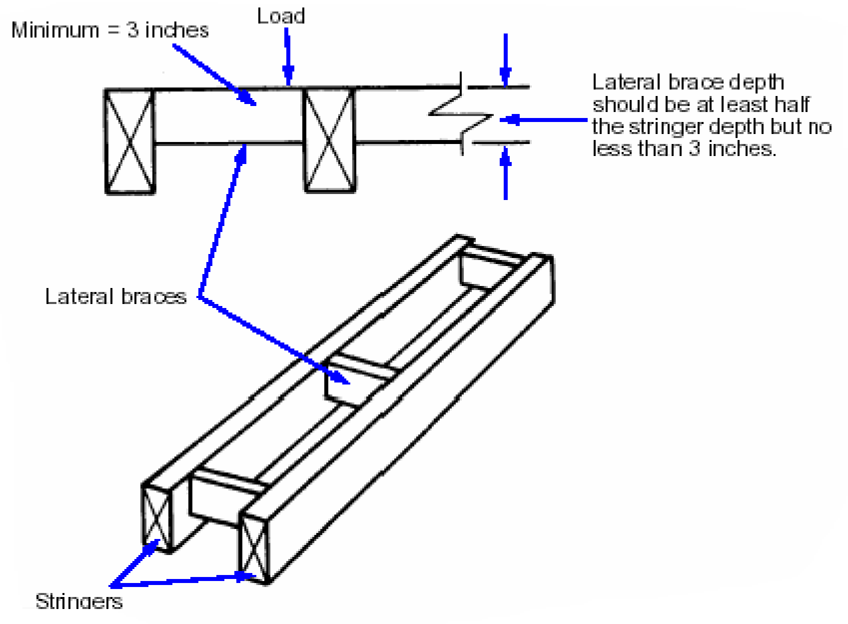
defines the DESIGN OF LATERALLY UNSUPPORTED STEEL I-BEAMS ACCORDING TO THE EGYPTIAN CODE OF PRACTICE: A PROPOSED SIMPLE EQUATION AUEJ, 7, 5,2004 1044 elasto-plastic lateral torsion-flexure buckling behaviour.

- ✓ The third zone is not affected by lateral buckling and failure is controlled by steel yielding. The ECPSCB-ASD (Egyptian Code of Practice for Steel Construction and Bridges – Allowable Stress Design) even treats the warping and the torsion resistances of the beam's cross section separately
- ✓ In this paper, a single equation which defines the allowable bending stress for laterally unsupported steel I-section beams is proposed to cover all these zones.
- ✓ The proposed equation results are compared to those obtained using the design provisions of the ECPSCB (ASD).
- ✓ The equation is proposed to replace the discontinuous definitions currently adopted by the ECPSCB (ASD) defining the allowable bending stress for laterally unsupported steel I-section beams.

LATERALLY SUPPORTED BEAM



LATERALLY UNSUPPORTED BEAM



Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=-f1CckABkx0
2. https://www.youtube.com/watch?v=kRSKLXoaN54

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures , by Dr.B.C. Punmia, Ashok kumar jain, Arun kumar jain in the page No:241**

Course Faculty

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LECTURE HANDOUTS

L56

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV - Beams** **Date of Lecture:**

Topic of Lecture: Built Up Beams

Introduction :

- ✓ All these will prevent or inhibit the top flange of the **beam** from buckling, and such **beams** have much more load-bearing capacity than **beams** of the same size and of the same span, with no such **lateral supports**, which are called **laterally unsupported beams**

Prerequisite knowledge for Complete understanding and learning of Topic:

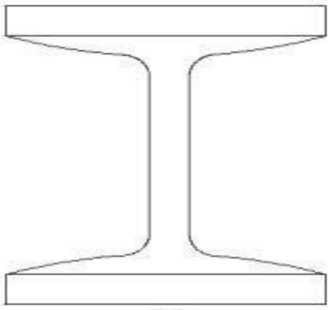
- ✓ Joints
- ✓ Connections
- ✓ Design methods

Prerequisite knowledge for Complete understanding and learning of Topic:

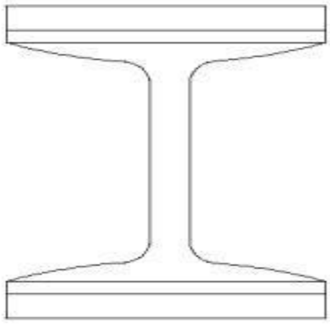
- ✓ Joints
- ✓ Connections
- ✓ Design methods

Detailed content of the Lecture:

- ✓ A built-up beam is also known as compound beam.
- ✓ The built-up beams are used when the span, load and corresponding bending moment are of such magnitudes that rolled steel beam section becomes inadequate to provide required section modulus.
- ✓ Built-up beams are also used when rolled steel beams are inadequate for limited depth.
- ✓ In building construction, the depth of beam is limited by a space provided by the architect.
- ✓ Drawing beam of small depth do not provide required section modulus. Therefore, plates are attached to the beams.
- ✓ The strength of rolled steel beams is increased by adding plates to its flange which is one of the method forming built-in section.
- ✓ The other method is to compound a number of rolled steel sections themselves.

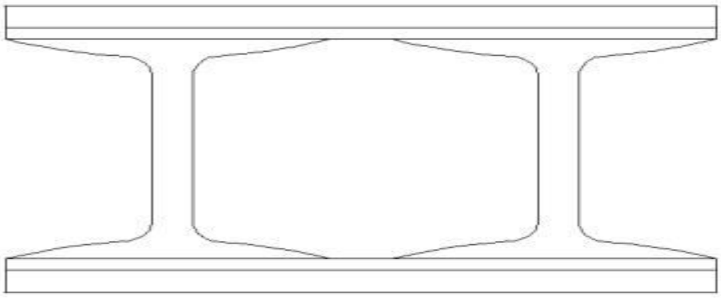


(A)



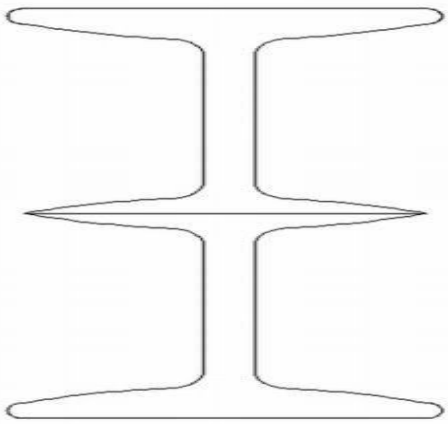
(B)

The built-up sections shown in figure' A' and 'B' are used for heavy loads and small spans



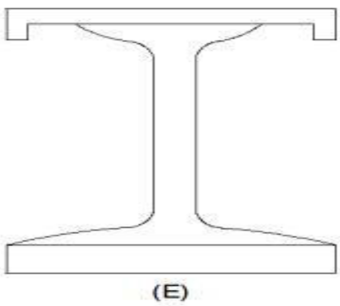
(C)

The built-up section 'C' is also used for heavy loads and small span

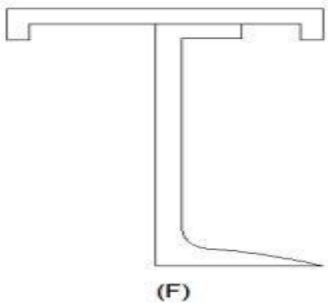


(D)

The built-up section 'D' is used for light loads and large spans



(E)



(F)

The built-up sections 'E' & 'F' are provided for Gantry girders

Video Content / Details of website for further learning (if any): 1. https://www.youtube.com/watch?v=wjEQ6F4HCaU 2. https://www.youtube.com/watch?v=GBh8dMMyU30
Important Books/Journals for further learning including the page nos.: 1. **Design of steel structures by by Dr.B.C.Punmia, Ashok kumar jain, Arun kumar jain in the page No:270**

Course Faculty

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LECTURE HANDOUTS

L57

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV- Beams** **Date of Lecture:**

Topic of Lecture: Design of plate girders

Introduction :

- ✓ The plate girders are essentially built-up beams to carry heavier loads over large spans.
- ✓ They are deep structural members subjected to transverse loads.
- ✓ The plate girders consist of plates and angles riveted together. Plates and angles form an I-Section.

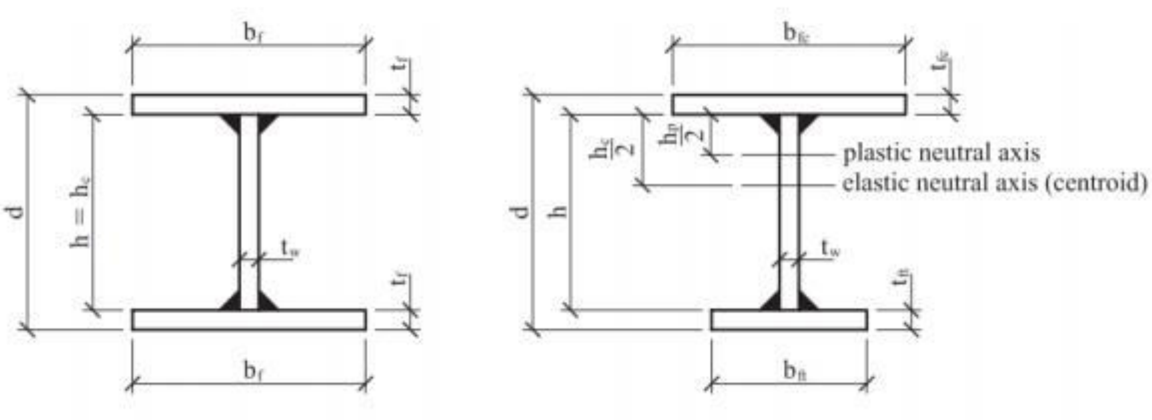
Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

Detailed content of the Lecture:

- ✓ Welded plate girders, which are the most common form of plate girders, are built-up structural steel members that consists of flange plates welded to a web plate with fillet welds.
- ✓ They are used to support loads over long spans (60 ft. to 200 ft.) and to support structural loads that are too large to be supported by the rolled steel shapes shown in the AISCM.
- ✓ Plate girders are rarely used in building structures, but are commonly used in bridge structures.
- ✓ They are used as transfer girders in building structures to support columns above large column-free areas.
- ✓ Plate girders may also be used in the retrofitting of existing building structures where column-free areas are needed and existing columns have to be cut off or removed below a certain floor level.
- ✓ Plate girders are also used as crane support girders in heavy industrial structures with long spans.
- ✓ All the standard hot-rolled shapes in the Manual, the webs are compact. Some have noncompact flanges, but none have slender flanges.

- ✓ With shapes built up from plates, however, both flanges and webs can be compact, noncompact, or slender.
- ✓ These built-up shapes usually are used when the bending moments are larger than standard hot-rolled shapes can resist, usually because of a large span.
- ✓ These girders are invariably very deep, resulting in noncompact or slender webs. A plate girder cross section can take several forms.
- ✓ The usual configuration is a single web with two equal flanges, with all parts connected by welding.
- ✓ The box section, which has two webs as well as two flanges, is a torsionally superior shape and can be used when large unbraced lengths are necessary.
- ✓ Hybrid girders, in which the steel in the flanges is of a higher strength than that in the web or webs, are sometimes used.



a. doubly symmetric plate girder section *b. singly symmetric plate girder section*

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=rxFP-cYpbLw

2.https://www.youtube.com/watch?v=45sp65he2BA

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:305**

Course Faculty

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LECTURE HANDOUTS

L58

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV-Beams** **Date of Lecture:**

Topic of Lecture: Web splicing

Introduction :

- ✓ A joint in the web plate provide to increase the length is known as web splice.
- ✓ Web splice become essential, when the maximum manufactured length of plate is insufficient for full length of plate girder.
- ✓ The plate is manufactured up to a limited length

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

Detailed content of the Lecture:

- ✓ Bolted web splices will be designed for number of vertical and horizontal lines of bolts, splice plate thickness, vertical and horizontal gage distances, vertical edge distance, and horizontal plate and web edge distance.
- ✓ The method of LRFD Specification article 6.13.6.1.4b is employed, but with the appropriate load factors of the specification being used.
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- ✓ Current design methods for the connectors in web-flange splices vary.
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- ✓ The bolt group on one side of the web splice is designed on the assumption that the shear force acts at the centroid of the bolt group on the opposite side of the splice.
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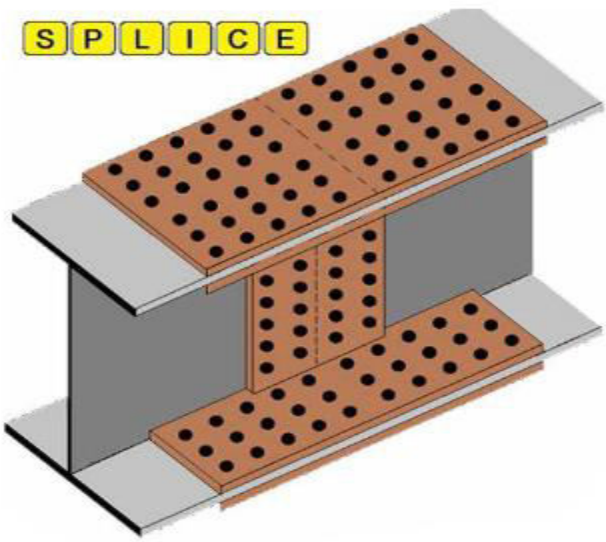

✓

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=fC174baDyZw
2. https://www.youtube.com/watch?v=K_p_pfyowAM

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures by limit state method as per IS:800-2007 , by S.S.Bhavikatti in the page No:121**

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LECTURE HANDOUTS

L59

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV- Beams** **Date of Lecture:**

Topic of Lecture: Design of laterally supported and unsupported beams

Introduction :

- ✓ All these will prevent or inhibit the top flange of the **beam** from buckling, and such **beams** have much more load-bearing capacity than **beams** of the same size and of the same span, with no such **lateral supports**, which are called **laterally unsupported beams**

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

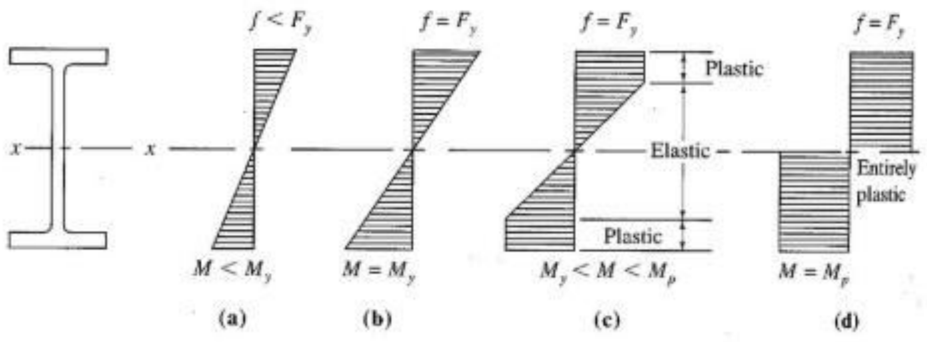
Detailed content of the Lecture:

- ✓ Design of laterally unsupported steel I-section beams according to ASD (Allowable Stress Design) and LRFD (Load and Resistance Factor Design) techniques requires the use of multiple equations
- ✓ These equations depend on the section compactness, the laterally unsupported length of the beam, the geometric properties of the cross section and the yield strength of the steel.
- ✓ Furthermore, local buckling and lateral torsion-flexure buckling significantly affect the behaviour of steel I-section beams.
- ✓ Flange outstand-to-thickness and web height-to-thickness ratios define the I-section compactness and hence control the local buckling behavior. The laterally unsupported length of the beam on the other hand, affects the critical moment initiating lateral flexure-torsion buckling.
- ✓ According to most codes of practice, three distinct zones are established for the behaviour of laterally unsupported steel beams; the moment resistance or the allowable bending stress is defined by a different equation in each zone.
- ✓ The first zone defines the elastic lateral torsion-flexure buckling behaviour while the second

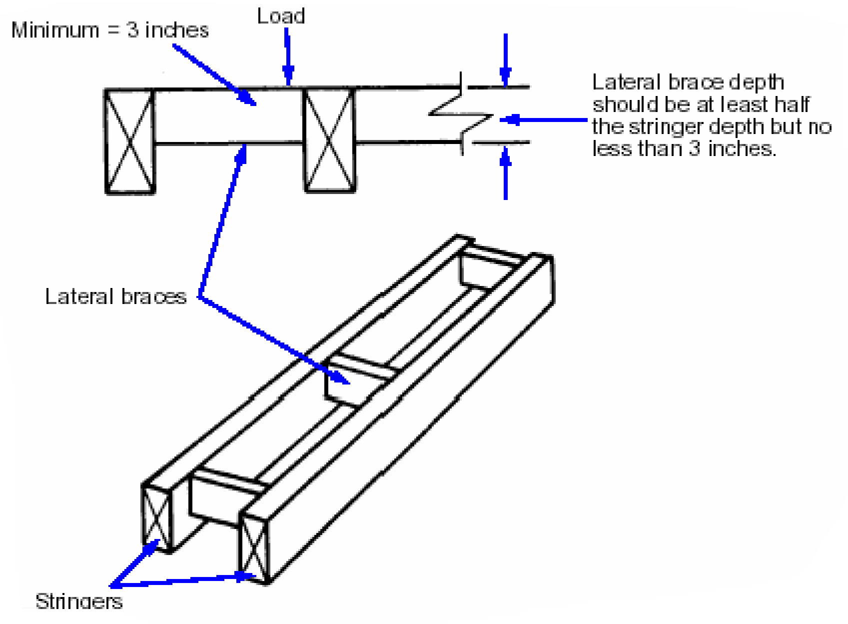
defines the DESIGN OF LATERALLY UNSUPPORTED STEEL I-BEAMS ACCORDING TO THE EGYPTIAN CODE OF PRACTICE: A PROPOSED SIMPLE EQUATION AUEJ, 7, 5,2004 1044 elasto-plastic lateral torsion-flexure buckling behaviour.

- ✓ The third zone is not affected by lateral buckling and failure is controlled by steel yielding. The ECPSCB-ASD (Egyptian Code of Practice for Steel Construction and Bridges – Allowable Stress Design) even treats the warping and the torsion resistances of the beam's cross section separately
- ✓ In this paper, a single equation which defines the allowable bending stress for laterally unsupported steel I-section beams is proposed to cover all these zones.
- ✓ The proposed equation results are compared to those obtained using the design provisions of the ECPSCB (ASD).
- ✓ The equation is proposed to replace the discontinuous definitions currently adopted by the ECPSCB (ASD) defining the allowable bending stress for laterally unsupported steel I-section beams.

LATERALLY SUPPORTED BEAM



LATERALLY UNSUPPORTED BEAM



Video Content / Details of website for further learning (if any): 1. https://www.youtube.com/watch?v=-f1CckABkx0 2. https://www.youtube.com/watch?v=kRSKLXoaN54
Important Books/Journals for further learning including the page nos.: **1. Design of steel structures , by Dr.B.C. Punmia, Ashok kumar jain, Arun kumar jain in the page No:241**

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L60

LECTURE HANDOUTS

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **IV-Beams** **Date of Lecture:**

Topic of Lecture: Web splicing

Introduction :

Web splice :

- ✓ A joint in the web plate provide to increase the length is known as web splice.
- ✓ Web splice become essential, when the maximum manufactured length of plate is insufficient for full length of plate girder.
- ✓ The plate is manufactured up to a limited length

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Joints
- ✓ Connections
- ✓ Design methods

Detailed content of the Lecture:

- ✓ Bolted web splices will be designed for number of vertical and horizontal lines of bolts, splice plate thickness, vertical and horizontal gage distances, vertical edge distance, and horizontal plate and web edge distance.
- ✓ The method of LRFD Specification article 6.13.6.1.4b is employed, but with the appropriate load factors of the specification being used.
- ✓ If this condition is given in girder design generation input and the girder design is generated the resulting bolted web splice dimensions will be placed in the girder definition input for review and modification by the user.
- ✓ Modifications by the user, if any, will be evaluated upon re-analysis and the results will be

shown in the girder rating output.

- ✓ this condition is only given in girder definition input the resulting web splice dimensions will be shown just in the girder rating output.
- ✓ Splices in beams and girders are often required when the lengths of members are limited by fabrication, transportation, or handling facilities available, or by the construction process.
- ✓ Splice plates are lapped across the joint and bolted to the webs and the flanges of the beam in order to transfer the load.
- ✓ This type of splice is usually referred to as a web-flange splice.
- ✓ Current design methods for the connectors in web-flange splices vary.
- ✓ For example, Fisher and Struik 1 recommend that the web splice be assumed to transfer all of the shear and that the flange splice be assumed to transfer all of the moment at the section.
- ✓ The bolt group on one side of the web splice is designed on the assumption that the shear force acts at the centroid of the bolt group on the opposite side of the splice.
- ✓ For the web splice, the first approach considers the shear force to act at the centroid of the opposite bolt group.
- ✓ This is similar to the recommendation of Fisher and Struik. In the second approach, the bolt group on one side of the web splice is designed assuming that the shear force acts at the centerline of the splice.
- ✓ Bresler, Lin and Scalzi, Salmon and Johnson, and Nethercot also use this second approach, and they further recommend that the web splice be designed to transmit both the eccentric shear force and the portion of the moment that the web was designed to carry.
- ✓ However, Salmon and Johnson suggest that the effect of the eccentricity can be neglected except in cases where the shear and moment are high, and Bresler, et al. recommend neglecting the effect of the eccentricity when the eccentricity is much less than the depth of the web.

Video Content / Details of website for further learning (if any):

1. **https://www.youtube.com/watch?v=fC174baDyZw**
2. **https://www.youtube.com/watch?v=K_p_pfyowAM**

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures, Dr.B.C.Punmia,Ashok kumar jain, Arun kumar jain in the page No:454**

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LECTURE HANDOUTS

L61

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Design of roof trusses

Introduction :

- ✓ In architecture or structural engineering or building, a purlin (or purlin) is a horizontal structural member in a roof. Purlins support the loads from the roof deck or sheathing and are supported by the principal rafters and/or the building walls, steel beams etc.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Roof trusses
- ✓ Elements of roof truss

Detailed content of the Lecture:

- ➢ Material for the roof should be selected after determining the purpose of the structure. The stress value of any structure should not exceed the permissible limit, as it can lead to collapse of the whole structure
- ➢ This is because the pitch of a roof depends solely on the roof truss. With the ever increasing demand to optimize the land, the builders are looking towards such type of roof trusses which provide a solution to every requirement.
- ➢ The traditional way to build the roof was on site where the carpenter used to fix the wall plates and ridge plates to make the structure and then cut the rafters to the required length.
- ➢ It all happened on the site and though it was the acceptable way, yet it was quite complex as it included human measurements.
- ➢ Currently, prefabricated roof trusses have replaced the skill of roof carpentry. Now the trusses are just lifted and craned quite easily and quickly.
- ➢ Trusses can be customized according to the requirement and thus serve as a simplified way of roofing. Steel roof truss design example is evident in the major structures built across the globe.
- ➢ Steel trusses are mainly used to build the strong base. They are being used for both buildings and bridges. Design of roof truss should follow the general layout that is prepared first. After that, the external load is to be estimated including the self-load of the truss.
- ➢ Different steel roof truss designs are prepared depending upon the shape of the structure. There are parallel and triangular, and trapezoidal trusses. Parallel trusses are used for deep roofs,

whereas triangular are usually employed in the trusses with steep pitches.

- Purlins are light and therefore easily fit between the steel structures and are quite economic. Gravity load also plays a very important role in determining the strength of the structure.
- the desired shape. The number of trusses required for shed roof truss depends upon the length of the roof. Generally, the roofs that are wide and longer require more trusses to cover up.
- The trusses are simple to construct and install. It is easy to make this roof truss with the help of wood. The number of rafters required to build the trusses are generally double the number of roof trusses required depending upon the length of the roof.

They are prepared in triangular form so as to cover all the joints between the rafters and the other parts at the surface. The trusses can be set in place using glue and nails

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=-f1CckABkx0
2. https://www.youtube.com/watch?v=kRSKLXoaN54

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures , by Dr.B.C. Punmia, Ashok kumar jain, Arun kumar jain in the page No:365**

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LECTURE HANDOUTS

L62

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Elements of roof trusses

Introduction :

In architecture or structural engineering or building, a purlin (or purlin) is a horizontal structural member in a roof. Purlins support the loads from the roof deck or sheathing and are supported by the principal rafters and/or the building walls, steel beams etc.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Roof trusses
- ✓ Elements of roof truss

Detailed content of the Lecture:

Apex – Highest point where the sloping top chords meet.

Bearing – Structural support of trusses (usually walls) normally with a timber wall plate.

Bottom Chords (BC) – the lowest longitudinal member of a truss.

Cantilever – part of structural member that extends beyond its support.

Components of a Steel Roof Truss:

A roof truss consists essentially of the following components:

(i) Upper chord members.

(ii) Bottom chord members.

(iii) Web members.

The upper most line of members which extend from one support to the other through the apex is called the upper chord, where as the bottom chord consists of the lowermost line of members extending from one support to the other.

In trusses simply supported at the ends, the members in the top chord are subjected to compression and the members of the bottom chord are subjected to tension. But in cantilever trusses, the top chord members will be in tension and the bottom chord members will be in compression. Usually in simply supported trusses, for the normal loadings, the top and bottom chord members near the support carry greater forces.

The top and the bottom chord members are connected by vertical or diagonal members called web members. The joints at which the web members are connected to the chords are called panel points. The joint at the support is called the heel joint while the joint at the ridge is called the peak joint. Tension members are called ties while compression members are called struts.

The truss provides an easy means to transmit the loads through the reactions to the walls or supporting columns.

The distance between the supporting end joints of a truss is called its span. When supported on walls, the distance between the centres of bearings is considered as the span. When framed into columns the distance between the column faces is regarded as the span.

The rise of the truss is the vertical distance between the apex and the line joining the supports.

The ratio of the rise to the span is called the pitch.

When the rise is not more than 1 vertical to 6 horizontal the roof is called a flat roof. If the rise exceeds the above limit the roof is called a pitched roof. As far as possible steep pitches are to be avoided since they will have to resist greater wind pressure. Moreover truss members become longer, particularly the compression members, if made longer can carry only low stresses depending on their slenderness ratio. Thus compression members will have to be of heavy sections.

The portion of the truss lying between two consecutive joints is called a panel. The portion of the roof contained between successive trusses is called a bay. The member spanning from truss to truss which is meant to carry the load of the roofing material and to transfer it on the panel points is called a purlin. Hence the length of the purlin is equal to the width of the bay, i.e., the spacing of the trusses.

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=-f1CckABkx0
2. https://www.youtube.com/watch?v=kRSKLXoaN54

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures , by Dr.B.C. Punmia, Ashok kumar jain, Arun kumar jain in the page No:365**

Course Faculty

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LECTURE HANDOUTS

L63

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Design of purlins

Introduction :

In architecture or structural engineering or building, a purlin (or purlin) is a horizontal structural member in a roof. Purlins support the loads from the roof deck or sheathing and are supported by the principal rafters and/or the building walls, steel beams etc.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Roof trusses
- ✓ Elements of roof truss

Detailed content of the Lecture:

1 Basic function

The principal function of roofing purlins is to transfer the forces on the roof of a building to its **1**main structure.

- ✓ The wall rails perform the same role on the facades. Purlins and wall rails are important components in the secondary structure of a building.
- ✓ It should be noted that, in a large number of steel-frame buildings, with a single ground floor, the weight of the purlins and wall rails constitutes an important element in terms of the overall weight of the structure (15 to 20%); failure to optimize on this could lead to a deal being lost in a highly competitive situation.
- ✓ The purlin structure of a building is designed in accordance with the type of roofing to be used. The nature of the roofing, in particular, directly influences the spacing between purlins; it also determines what purlin-roofing interaction we can expect for dimensioning the purlins (see Section 3). A purlin structure includes not just the purlins themselves (see different types in Section 2), but also any splice connections that make the purlins continuous (see Section 4), the cleats that join the purlins to the main structure (see Section 5), and any sag bars and batten plates responsible for holding the purlins laterally (see Section 6). The loads to be considered

(see further information on these in Section 7) are primarily:

- ✓ The actual weight of the roofing, the purlins and their accessories
- ✓ The actual weight of any equipment carried by the roofing
- ✓ The imposed loads suspended inside (e.g. a sprinkler system, lighting, etc.)
- ✓ The maintenance load of the roofing
- ✓ Snow

2. Different types of purlins

- ✓ rule, the choice is made between hot-rolled beam purlins, most often IPEs, and thin coldformed purlins, with lattice-purlins only very rarely being used.
- ✓ This choice, if left to the constructor of the steel structure, is based more on organizing the
- ✓ production rather than a choice associated with the performance of either product. IPE purlins
- ✓ and thin cold-formed purlins may, in effect, fulfil the same functions.
- ✓ Thin cold-formed purlins and their accessories are more often designed and manufactured by
- ✓ a specialized manufacturer possessing roll-forming machines: the constructor responsible for
- ✓ making the steel structure of a building purchases the purlins from one of these
- ✓ manufacturers. However, IPE purlins are more often designed and manufactured by the
- ✓ constructor of the main structure. One of the criteria for choosing between the two options
- ✓ depends on the constructor's workload in the workshop: if very busy, he will prefer to
- ✓ purchase the cold-formed purlin; if less busy, he will prefer to manufacture it itself.
- ✓ Whatever the type of purlin to be used, the type of roofing determines a maximum spacing

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=-f1CckABkx0

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures , by Dr.B.C. Punmia, Ashok kumar jain, Arun kumar jain in the page No:365**

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LECTURE HANDOUTS

L64

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Estimation of wind loads

Introduction :

Extreme wind load is estimated based on the true annual r-order maximum wind speed by considering the autocorrelation function of the wind speed. Results obtained by the modified method show a big discrepancy from those of the existing methods, which indicates a significant improvement to the classical method

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Bracings
- ✓ Types of roof trusses
- ✓ Purlins

Detailed content of the Lecture:

Depends upon wind load

- ✓ velocity and density of the air
- ✓ height above ground level
- ✓ shape and aspect ratio of the building
- ✓ topography of the surrounding ground surface
- ✓ angle of wind attack
- ✓ solidity ratio or openings in the buildings

Basic wind speed

- ✓ IS 875 (Part 3) gives the basic wind speeds
- ✓ having a return period of 50 years and at a
- ✓ height of 10 m above ground level.
- ✓ Entire country is divided into six wind
- ✓ zones

- ✓ To calculate wind load using the generic formula, use F = A × P × Cd, where F is the force or wind load, A is the projected area of the object, P is the wind pressure, and Cd is the drag coefficient. First find A, the area of the 2-dimensional face the wind is hitting, using A = length × height for a flat wall.

Estimation of Extreme Wind Load on Structures and Claddings

Abstract

- ✓ A modified Cook-Mayne method is proposed for extreme wind load estimation.
- ✓ A technique that can simulate true r-order extreme values of a correlated random process is

adopted in this method to estimate the annual multiorder maximum 10-min mean wind speeds.

- ✓ These estimated extreme wind speeds are then used for extreme wind load estimation on structures.
- ✓ Results show that the autocorrelation of the macrometeorological fluctuating wind can have significant effects on the estimated extreme wind load.
- ✓ A big difference is found when comparing the design fractile of the extreme wind load coefficients obtained from the modified method by considering the autocorrelation of wind speeds and the existing full-order method in which only independent wind speeds are adopted.
- ✓ Wind Loads on Tall Building Structures / Building Motion Studie The order of annual maximum wind speeds required for wind load estimation is also examined. The number of orders that is needed for 50-year return period wind load design varies greatly—from 2 to 50—and depends on the application conditions.
- ✓ The design fractile of extreme wind load coefficient distribution for a 50-year return period can be increased to 93% from the 79% recommended in the existing method.

Wind Loads on Tall Building Structures / Building Motion Studies

Introduction

- ✓ Recent trends towards tall, slender, flexible and light-weight buildings have resulted in a large number of buildings being susceptible to wind induced motion and human perception of building motion has become a critical consideration in modern building design.

- ✓ The Australian and New Zealand Wind Loading Standard, AS/NZS 1170.2:2011 stipulates that structures having a height to breadth ratio of 5 or more should be designed using dynamic analysis. The dynamic wind loads can be accurately estimated by means of a wind tunnel study. This can result in a rationalisation of the structure and has the potential to effect considerable savings in the cost of the structure.

- ✓ The Australian and New Zealand Wind Loading Standard, AS/NZS 1170.2:2011 also stipulates that the wind loads of structures taller than 200m or with a natural frequency less than 0.2Hz must be analysed using the wind tunnel modelling technique.

- ✓ The high- frequency base balance technique is applicable to the large majority of tall buildings and has the advantage of allowing the structural engineer to easily update the results in the case of a change in the building's stiffness, mass or natural

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=-f1CckABkx0

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures , by Dr.B.C. Punmia, Ashok kumar jain, Arun kumar jain in the page No:365**

Course Faculty

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LECTURE HANDOUTS

L65

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Design of gantry

Introduction :

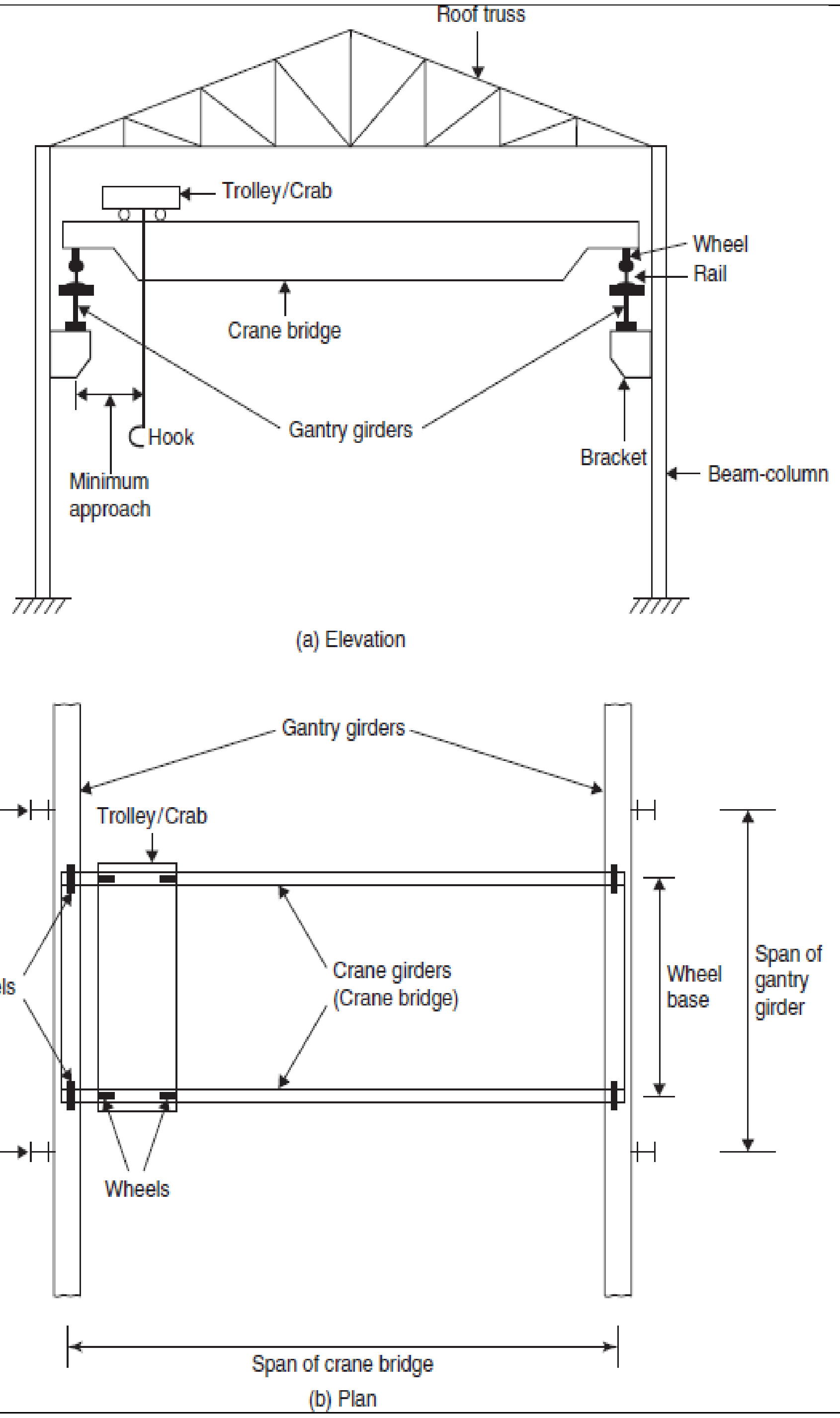
The gantry girder is designed on the assumption that either of the horizontal forces, transverse to the rails or along the rails, act the same time as the vertical loads including the impact load. ... The bending of the crane gantry girder occurs about the vertical axis as well as about the horizontal axis of the member

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Trusses
- ✓ Purlins
- ✓ Estimation of wind load

Detailed content of the Lecture:

- ✓ Usually, most of the industrial buildings have built-in overhead cranes for handling heavy equipment or goods.
- ✓ With the help of the overhead cranes, heavy equipment or goods can be lifted and moved from one point of work place to another.
- ✓ The cranes may be hand operated (generally they have a capacity of up to 5 tonnes) and electrically operated (EOT) The gantry girder is designed on the assumption that either of the horizontal forces, transverse to the rails or along the rails, act the same time as the vertical loads including the impact load.
- ✓ The horizontal forces act at the rail level. ... The flange of channel section resists the bending in the horizontal plane.
- ✓ 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



Video Content / Details of website for further learning (if any):

1.https://www.youtube.com/watch?v=JPeN7xV0-2.fkhttps://www.youtube.com/watch?v=ycF8EoRoJXc

Important Books/Journals for further learning including the page nos.:

Design of steel structures , by Dr.B.C. Punmia, Ashok kumar jain, Arun kumar jain in the page No:346

Course Faculty

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Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Design of gantry griders

Introduction :

The gantry girder is designed on the assumption that either of the horizontal forces,transverse to the rails or along the rails, act the same time as the vertical loads including the impact load. The horizontal forces act at the rail level. ... The flange of channel section resists the bending in the horizontal plane.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Purlins
- ✓ Estimation of wind load
- ✓ Gantry

Detailed content of the Lecture:

Design of wind girders

- ✓ Transverse wind girder
- ✓ In general, the form of a transverse wind girder is as follows:

- ✓ The wind girder is arranged as a Warren or Pratt truss, parallel to the roof plane
- ✓ The chords of the wind girder are the upper chords of two adjacent vertical trusses. This means that the axial forces in these members due to loading on the vertical truss and those due to loads on the wind girder loading must be added together (for an appropriate combination of actions)

DESIGN OF GANTRY GRIDERS:

Assumption: The lateral load is resisted entirely by the compression flange.

- ➢ **Step I:** Calculate the Maximum Wheel had

This occurs when the crab is closest to the gantry girder. The maximum wheel load will be half the reaction as there two wheels to the crab. Add the impact load.

- ➢ **Step 2**: Calculate the Maximum Bending Moment Due to Vertical Forces (M,):

This is the sum of the bending moments due to wheel load, impact load and dead load. The dead load bending moment [MI =$I is calculated by 1 assuming the dead load which is to be checked later on. The bending moment (M2) due to wheel load is absolutely maximum, when the resultant and the load. under which the bending moment is maximum, are equidistant from the mid-span (see Figure 10.6(a) & (b)).

- ➢ **Step 3:** Calculate the Maximum Shear Force (V,):

This is the sum of the shear forces due to wheel load, impact load and dead load. The shear force due to wheel load is maximum, when one of the wheel loads is at the support (see Figure 10.6(c)).

(a) M,,, af D 1%<0,586)

a-g kG ~/2 --I-.- -I

: Maximum Bending Moment Due to Vertical Loads

- **Step 4:** Calculate Required:

where, (Jbc = 0.66 fy

fy is the yield strength of the steel. For trial section the value of (Jbc is kept 1 2 between - and - of this value i.e. between 0.33 fy and 0.44 4.. 2 3

- **Step 5**: Calculate Ixx and Iyy

Calculate I, and Iyy for trial section and I for compression flange Z,, Z2 for r y trial section and I,, for trial and compression flange (Icy)

- **Step 6**: Calculate ~(hcx.cao and (J(br.r.cao

where, ZI and Z2 are the section moduli as calculated in step 5 above.

Note: u,,~,,,, 1.1 x 0.664. The permissible bending stress otherwise redesign the section.

- **Step 7:** Lateral Forces Analysis

Calculate the lateral forces on the girder.

Gantry Girders

Calculate the maximum bending moment (My) and maximum shear force (V,,)

This is proportional to M, and Vx as the wheel load positions for maximum is same as in steps 2 and 3.

- **Step 8**: Calculate

-- MY

(T(bcy.cal) - zYy of cornp. flange x [n]

where, b = width of compression flange

- **Step 9:** Calculate from Tables in Unit 6 (IS: 800 Table 6.1)
- **Step 10:** As the bending is biaxial check for stresses by adding bending stresses calculated in steps 6 and 8.
- **Step 11**: If the above condition is not satisfied redesign the section.
- **Step 12**: Calculate the longitudinal force and check the stresses
- **Step 13..** Check for Shear
- **Step 14**: Check for Diagonal buckling
- **Step 15**: Check for Deflection
- **Step 16:** Design the Connections.

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=-f1CckABkx0
2. https://www.youtube.com/watch?v=kRSKLXoaN54

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures , by Dr.B.C. Punmia, Ashok kumar jain, Arun kumar jain in the page No:346**

Course Faculty

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Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Problem

Introduction :

In architecture or structural engineering or building, a purlin (or purlin) is a horizontal structural member in a roof. Purlins support the loads from the roof deck or sheathing and are supported by the principal rafters and/or the building walls, steel beams etc.

Prerequisite knowledge for Complete understanding and learning of Topic:

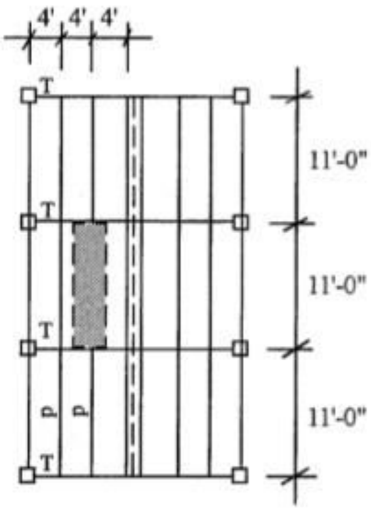
- ✓ Roof trusses
- ✓ Elements of roof truss

Detailed content of the Lecture:

Chapter 3
DESIGN OF PURLINS AND TRUSSES

3.1. DESIGN OF PURLIN

Design of purlin sizes are based on an analysis of bending members as a simple beam. The length of the purlin from truss to truss is taken as the span length needed for the single span, simply supported beam formula. This is a conservative approach as it provides for a larger bending moment than that obtained by true engineering analysis.



Illustrative Example

Let purlin spacing = 4' - 0" C/C
Truss spacing = 11' - 0" C/C
Truss span = 50' - 0"
L. L = 16 psf
Sheathing = 2 psf
Roofing material = 4.5 psf
Use PyinKado. Unit wt. = 60 pcf.

Assume 5" x 2" purlins are used.

L.L	=	16 x 4 x 11	=	704	Lb
Roofing	=	4.5 x 4 x 11	=	198	Lb
Sheathing	=	2 x 4 x 11	=	88	Lb
Own wt.	=	$\frac{5 \times 2}{144} \times 60 \times 11$	=	45.83	Lb
		W	=	**1035.83**	**Lb**

$$\theta = \tan^{-1} \frac{18}{25} = 35.754$$

$$W_N = W \cos\theta = 1035.83 \times \cos 35.754 = 840.61 \text{ Lb}$$

$$W_T = W \sin\theta = 1035.83 \times \sin 35.754 = 605.24 \text{ Lb}$$

$$M_X = \frac{W_N L}{8} = \frac{840.61 x (11 x 12)}{8} = 13870.07 \text{ in-lb}$$

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=-f1CckABkx0
2. https://www.youtube.com/watch?v=kRSKLXoaN54

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures , by Dr.B.C. Punmia, Ashok kumar jain, Arun kumar jain in the page No:365**

Course Faculty

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LECTURE HANDOUTS

L68

CIVIL **III/VI**

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Problem

Introduction :

Wind load is the "load" placed by the wind speed and its air density onto a building. With high velocity winds, low pressure areas are created on the building which creates suction pressure. Some are so strong that they can pull of the corner of a home's roof. Wind load has 3 components: Uplift Load.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Roof trusses
- ✓ Elements of roof truss

Detailed content of the Lecture:

- ➢ Material for the roof should be selected after determining the purpose of the structure. The stress value of any structure should not exceed the permissible limit, as it can lead to collapse of the whole structure
- ➢ This is because the pitch of a roof depends solely on the roof truss. With the ever increasing demand to optimize the land, the builders are looking towards such type of roof trusses which provide a solution to every requirement.
- ➢ The traditional way to build the roof was on site where the carpenter used to fix the wall plates and ridge plates to make the structure and then cut the rafters to the required length.
- ➢ It all happened on the site and though it was the acceptable way, yet it was quite complex as it included human measurements.
- ➢ Currently, prefabricated roof trusses have replaced the skill of roof carpentry. Now the trusses are just lifted and craned quite easily and quickly.
- ➢ Trusses can be customized according to the requirement and thus serve as a simplified way of roofing. Steel roof truss design example is evident in the major structures built across the globe.
- ➢ Steel trusses are mainly used to build the strong base. They are being used for both buildings and bridges. Design of roof truss should follow the general layout that is prepared first. After that, the external load is to be estimated including the self-load of the truss.
- ➢ Different steel roof truss designs are prepared depending upon the shape of the structure. There

are parallel and triangular, and trapezoidal trusses. Parallel trusses are used for deep roofs, whereas triangular are usually employed in the trusses with steep pitches.

- Purlins are light and therefore easily fit between the steel structures and are quite economic. Gravity load also plays a very important role in determining the strength of the structure.

- the desired shape. The number of trusses required for shed roof truss depends upon the length of the roof. Generally, the roofs that are wide and longer require more trusses to cover up.

- The trusses are simple to construct and install. It is easy to make this roof truss with the help of wood. The number of rafters required to build the trusses are generally double the number of roof trusses required depending upon the length of the roof.

They are prepared in triangular form so as to cover all the joints between the rafters and the other parts at the surface. The trusses can be set in place using glue and nails

Video Content / Details of website for further learning (if any):

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LECTURE HANDOUTS

L69

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Problem

Introduction :

In architecture or structural engineering or building, a purlin (or purlin) is a horizontal structural member in a roof. Purlins support the loads from the roof deck or sheathing and are supported by the principal rafters and/or the building walls, steel beams etc.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Roof trusses
- ✓ Elements of roof truss

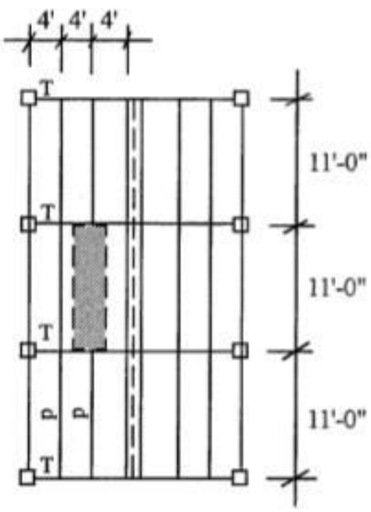
Detailed content of the Lecture:

Chapter 3
DESIGN OF PURLINS AND TRUSSES

3.1. DESIGN OF PURLIN

Design of purlin sizes are based on an analysis of bending members as a simple beam. The length of the purlin from truss to truss is taken as the span length needed for the single span, simply supported beam formula. This is a conservative approach as it provides for a larger bending moment than that obtained by true engineering analysis.

Illustrative Example



Let	purlin spacing	=	4' - 0" C/C
	Truss spacing	=	11' - 0" C/C
	Truss span	=	50' - 0"
	L. L	=	16 psf
	Sheathing	=	2 psf
	Roofing material	=	4.5 psf
	Use PyinKado.Unit wt. = 60 pcf.		

Assume 5" x 2" purlins are used.

L.L	=	16 x 4 x 11	=	704	Lb
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LECTURE HANDOUTS

L70

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Design of roof trusses

Introduction :

- ✓ In architecture or structural engineering or building, a purlin (or purlin) is a horizontal structural member in a roof. Purlins support the loads from the roof deck or sheathing and are supported by the principal rafters and/or the building walls, steel beams etc.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Roof trusses
- ✓ Elements of roof truss

Detailed content of the Lecture:

- ➢ Material for the roof should be selected after determining the purpose of the structure. The stress value of any structure should not exceed the permissible limit, as it can lead to collapse of the whole structure
- ➢ This is because the pitch of a roof depends solely on the roof truss. With the ever increasing demand to optimize the land, the builders are looking towards such type of roof trusses which provide a solution to every requirement.
- ➢ The traditional way to build the roof was on site where the carpenter used to fix the wall plates and ridge plates to make the structure and then cut the rafters to the required length.
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whereas triangular are usually employed in the trusses with steep pitches.

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- the desired shape. The number of trusses required for shed roof truss depends upon the length of the roof. Generally, the roofs that are wide and longer require more trusses to cover up.
- The trusses are simple to construct and install. It is easy to make this roof truss with the help of wood. The number of rafters required to build the trusses are generally double the number of roof trusses required depending upon the length of the roof.

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Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Elements of roof trusses

Introduction :

In architecture or structural engineering or building, a purlin (or purlin) is a horizontal structural member in a roof. Purlins support the loads from the roof deck or sheathing and are supported by the principal rafters and/or the building walls, steel beams etc.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Roof trusses
- ✓ Elements of roof truss

Detailed content of the Lecture:

Apex – Highest point where the sloping top chords meet.

Bearing – Structural support of trusses (usually walls) normally with a timber wall plate.

Bottom Chords (BC) – the lowest longitudinal member of a truss.

Cantilever – part of structural member that extends beyond its support.

Components of a Steel Roof Truss:

A roof truss consists essentially of the following components:

(i) Upper chord members.

(ii) Bottom chord members.

(iii) Web members.

The upper most line of members which extend from one support to the other through the apex is called the upper chord, where as the bottom chord consists of the lowermost line of members extending from one support to the other.

In trusses simply supported at the ends, the members in the top chord are subjected to compression and the members of the bottom chord are subjected to tension. But in cantilever trusses, the top chord members will be in tension and the bottom chord members will be in compression. Usually in simply supported trusses, for the normal loadings, the top and bottom chord members near the support carry greater forces.

The top and the bottom chord members are connected by vertical or diagonal members called web members. The joints at which the web members are connected to the chords are called panel points.

The joint at the support is called the heel joint while the joint at the ridge is called the peak joint.

Tension members are called ties while compression members are called struts.

The truss provides an easy means to transmit the loads through the reactions to the walls or supporting columns.

The distance between the supporting end joints of a truss is called its span. When supported on walls, the distance between the centres of bearings is considered as the span. When framed into columns the distance between the column faces is regarded as the span.

The rise of the truss is the vertical distance between the apex and the line joining the supports.

The ratio of the rise to the span is called the pitch.

When the rise is not more than 1 vertical to 6 horizontal the roof is called a flat roof. If the rise exceeds the above limit the roof is called a pitched roof. As far as possible steep pitches are to be avoided since they will have to resist greater wind pressure. Moreover truss members become longer, particularly the compression members, if made longer can carry only low stresses depending on their slenderness ratio. Thus compression members will have to be of heavy sections.

The portion of the truss lying between two consecutive joints is called a panel. The portion of the roof contained between successive trusses is called a bay. The member spanning from truss to truss which is meant to carry the load of the roofing material and to transfer it on the panel points is called a purlin. Hence the length of the purlin is equal to the width of the bay, i.e., the spacing of the trusses.

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=-f1CckABkx0
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LECTURE HANDOUTS

L72

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Design of purlins

Introduction :

In architecture or structural engineering or building, a purlin (or purlin) is a horizontal structural member in a roof. Purlins support the loads from the roof deck or sheathing and are supported by the principal rafters and/or the building walls, steel beams etc.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Roof trusses
- ✓ Elements of roof truss

Detailed content of the Lecture:

1 Basic function

The principal function of roofing purlins is to transfer the forces on the roof of a building to its **1**main structure.

- ✓ The wall rails perform the same role on the facades. Purlins and wall rails are important components in the secondary structure of a building.
- ✓ It should be noted that, in a large number of steel-frame buildings, with a single ground floor, the weight of the purlins and wall rails constitutes an important element in terms of the overall weight of the structure (15 to 20%); failure to optimize on this could lead to a deal being lost in a highly competitive situation.
- ✓ The purlin structure of a building is designed in accordance with the type of roofing to be used. The nature of the roofing, in particular, directly influences the spacing between purlins; it also determines what purlin-roofing interaction we can expect for dimensioning the purlins (see Section 3). A purlin structure includes not just the purlins themselves (see different types in Section 2), but also any splice connections that make the purlins continuous (see Section 4), the cleats that join the purlins to the main structure (see Section 5), and any sag bars and batten plates responsible for holding the purlins laterally (see Section 6). The loads to be considered

(see further information on these in Section 7) are primarily:

- ✓ The actual weight of the roofing, the purlins and their accessories
- ✓ The actual weight of any equipment carried by the roofing
- ✓ The imposed loads suspended inside (e.g. a sprinkler system, lighting, etc.)
- ✓ The maintenance load of the roofing
- ✓ Snow

2. Different types of purlins

- ✓ rule, the choice is made between hot-rolled beam purlins, most often IPEs, and thin coldformed purlins, with lattice-purlins only very rarely being used.
- ✓ This choice, if left to the constructor of the steel structure, is based more on organizing the
- ✓ production rather than a choice associated with the performance of either product. IPE purlins
- ✓ and thin cold-formed purlins may, in effect, fulfil the same functions.
- ✓ Thin cold-formed purlins and their accessories are more often designed and manufactured by
- ✓ a specialized manufacturer possessing roll-forming machines: the constructor responsible for
- ✓ making the steel structure of a building purchases the purlins from one of these
- ✓ manufacturers. However, IPE purlins are more often designed and manufactured by the
- ✓ constructor of the main structure. One of the criteria for choosing between the two options
- ✓ depends on the constructor's workload in the workshop: if very busy, he will prefer to
- ✓ purchase the cold-formed purlin; if less busy, he will prefer to manufacture it itself.
- ✓ Whatever the type of purlin to be used, the type of roofing determines a maximum spacing

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=-f1CckABkx0

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LECTURE HANDOUTS

L73

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Estimation of wind loads

Introduction :

Extreme wind load is estimated based on the true annual r-order maximum wind speed by considering the autocorrelation function of the wind speed. Results obtained by the modified method show a big discrepancy from those of the existing methods, which indicates a significant improvement to the classical method

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Bracings
- ✓ Types of roof trusses
- ✓ Purlins

Detailed content of the Lecture:

Depends upon wind load

- ✓ velocity and density of the air
- ✓ height above ground level
- ✓ shape and aspect ratio of the building
- ✓ topography of the surrounding ground surface
- ✓ angle of wind attack
- ✓ solidity ratio or openings in the buildings

Basic wind speed

- ✓ IS 875 (Part 3) gives the basic wind speeds
- ✓ having a return period of 50 years and at a
- ✓ height of 10 m above ground level.
- ✓ Entire country is divided into six wind
- ✓ zones

- ✓ To calculate wind load using the generic formula, use F = A × P × Cd, where F is the force or wind load, A is the projected area of the object, P is the wind pressure, and Cd is the drag coefficient. First find A, the area of the 2-dimensional face the wind is hitting, using A = length × height for a flat wall.

Estimation of Extreme Wind Load on Structures and Claddings

Abstract

- ✓ A modified Cook-Mayne method is proposed for extreme wind load estimation.
- ✓ A technique that can simulate true r-order extreme values of a correlated random process is

adopted in this method to estimate the annual multiorder maximum 10-min mean wind speeds.

- ✓ These estimated extreme wind speeds are then used for extreme wind load estimation on structures.
- ✓ Results show that the autocorrelation of the macrometeorological fluctuating wind can have significant effects on the estimated extreme wind load.
- ✓ A big difference is found when comparing the design fractile of the extreme wind load coefficients obtained from the modified method by considering the autocorrelation of wind speeds and the existing full-order method in which only independent wind speeds are adopted.
- ✓ Wind Loads on Tall Building Structures / Building Motion Studie The order of annual maximum wind speeds required for wind load estimation is also examined. The number of orders that is needed for 50-year return period wind load design varies greatly—from 2 to 50—and depends on the application conditions.
- ✓ The design fractile of extreme wind load coefficient distribution for a 50-year return period can be increased to 93% from the 79% recommended in the existing method.

Wind Loads on Tall Building Structures / Building Motion Studies

Introduction

- ✓ Recent trends towards tall, slender, flexible and light-weight buildings have resulted in a large number of buildings being susceptible to wind induced motion and human perception of building motion has become a critical consideration in modern building design.

- ✓ The Australian and New Zealand Wind Loading Standard, AS/NZS 1170.2:2011 stipulates that structures having a height to breadth ratio of 5 or more should be designed using dynamic analysis. The dynamic wind loads can be accurately estimated by means of a wind tunnel study. This can result in a rationalisation of the structure and has the potential to effect considerable savings in the cost of the structure.

- ✓ The Australian and New Zealand Wind Loading Standard, AS/NZS 1170.2:2011 also stipulates that the wind loads of structures taller than 200m or with a natural frequency less than 0.2Hz must be analysed using the wind tunnel modelling technique.

- ✓ The high- frequency base balance technique is applicable to the large majority of tall buildings and has the advantage of allowing the structural engineer to easily update the results in the case of a change in the building's stiffness, mass or natural

Video Content / Details of website for further learning (if any):

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Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Design of gantry griders

Introduction :

The gantry girder is designed on the assumption that either of the horizontal forces,transverse to the rails or along the rails, act the same time as the vertical loads including the impact load. The horizontal forces act at the rail level. ... The flange of channel section resists the bending in the horizontal plane.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Purlins
- ✓ Estimation of wind load
- ✓ Gantry

Detailed content of the Lecture:

Design of wind girders

- ✓ Transverse wind girder
- ✓ In general, the form of a transverse wind girder is as follows:

- ✓ The wind girder is arranged as a Warren or Pratt truss, parallel to the roof plane
- ✓ The chords of the wind girder are the upper chords of two adjacent vertical trusses. This means that the axial forces in these members due to loading on the vertical truss and those due to loads on the wind girder loading must be added together (for an appropriate combination of actions)

DESIGN OF GANTRY GRIDERS:

Assumption: The lateral load is resisted entirely by the compression flange.

- ➢ **Step I:** Calculate the Maximum Wheel had

This occurs when the crab is closest to the gantry girder. The maximum wheel load will be half the reaction as there two wheels to the crab. Add the impact load.

- ➢ **Step 2**: Calculate the Maximum Bending Moment Due to Vertical Forces (M,):

This is the sum of the bending moments due to wheel load, impact load and dead load. The dead load bending moment [MI =$I is calculated by 1 assuming the dead load which is to be checked later on. The bending moment (M2) due to wheel load is absolutely maximum, when the resultant and the load. under which the bending moment is maximum, are equidistant from the mid-span (see Figure 10.6(a) & (b)).

- ➢ **Step 3:** Calculate the Maximum Shear Force (V,):

This is the sum of the shear forces due to wheel load, impact load and dead load. The shear force due to wheel load is maximum, when one of the wheel loads is at the support (see Figure 10.6(c)).

(a) M,,, af D 1%<0,586)

a-g kG ~/2 --I-.- -I

: Maximum Bending Moment Due to Vertical Loads

- **Step 4:** Calculate Required:

where, (Jbc = 0.66 fy

fy is the yield strength of the steel. For trial section the value of (Jbc is kept 1 2 between - and - of this value i.e. between 0.33 fy and 0.44 4.. 2 3

- **Step 5**: Calculate Ixx and Iyy

Calculate I, and Iyy for trial section and I for compression flange Z,, Z2 for r y trial section and I,, for trial and compression flange (Icy)

- **Step 6**: Calculate ~(hcx.cao and (J(br.r.cao

where, ZI and Z2 are the section moduli as calculated in step 5 above.

Note: u,,~,,,, 1.1 x 0.664. The permissible bending stress otherwise redesign the section.

- **Step 7:** Lateral Forces Analysis

Calculate the lateral forces on the girder.

Gantry Girders

Calculate the maximum bending moment (My) and maximum shear force (V,,)

This is proportional to M, and Vx as the wheel load positions for maximum is same as in steps 2 and 3.

- **Step 8**: Calculate

-- MY

(T(bcy.cal) - zYy of cornp. flange x [n]

where, b = width of compression flange

- **Step 9:** Calculate from Tables in Unit 6 (IS: 800 Table 6.1)
- **Step 10:** As the bending is biaxial check for stresses by adding bending stresses calculated in steps 6 and 8.
- **Step 11**: If the above condition is not satisfied redesign the section.
- **Step 12**: Calculate the longitudinal force and check the stresses
- **Step 13..** Check for Shear
- **Step 14**: Check for Diagonal buckling
- **Step 15**: Check for Deflection
- **Step 16:** Design the Connections.

Video Content / Details of website for further learning (if any):

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2. https://www.youtube.com/watch?v=kRSKLXoaN54

Important Books/Journals for further learning including the page nos.:

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LECTURE HANDOUTS

L75

CIVIL

III/VI

Course Name with Code : 19CEC04/Design of Steel Structures

Course Faculty : **Mr.K.Sankar**

Unit : **V- Roof Truss and Industrial Structures** **Date of Lecture:**

Topic of Lecture: Problem

Introduction :

Wind load is the "load" placed by the wind speed and its air density onto a building. With high velocity winds, low pressure areas are created on the building which creates suction pressure. Some are so strong that they can pull of the corner of a home's roof. Wind load has 3 components: Uplift Load.

Prerequisite knowledge for Complete understanding and learning of Topic:

- ✓ Roof trusses
- ✓ Elements of roof truss

Detailed content of the Lecture:

- ➢ Material for the roof should be selected after determining the purpose of the structure. The stress value of any structure should not exceed the permissible limit, as it can lead to collapse of the whole structure
- ➢ This is because the pitch of a roof depends solely on the roof truss. With the ever increasing demand to optimize the land, the builders are looking towards such type of roof trusses which provide a solution to every requirement.
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- ➢ Currently, prefabricated roof trusses have replaced the skill of roof carpentry. Now the trusses are just lifted and craned quite easily and quickly.
- ➢ Trusses can be customized according to the requirement and thus serve as a simplified way of roofing. Steel roof truss design example is evident in the major structures built across the globe.
- ➢ Steel trusses are mainly used to build the strong base. They are being used for both buildings and bridges. Design of roof truss should follow the general layout that is prepared first. After that, the external load is to be estimated including the self-load of the truss.
- ➢ Different steel roof truss designs are prepared depending upon the shape of the structure. There

are parallel and triangular, and trapezoidal trusses. Parallel trusses are used for deep roofs, whereas triangular are usually employed in the trusses with steep pitches.

- Purlins are light and therefore easily fit between the steel structures and are quite economic. Gravity load also plays a very important role in determining the strength of the structure.

- the desired shape. The number of trusses required for shed roof truss depends upon the length of the roof. Generally, the roofs that are wide and longer require more trusses to cover up.

- The trusses are simple to construct and install. It is easy to make this roof truss with the help of wood. The number of rafters required to build the trusses are generally double the number of roof trusses required depending upon the length of the roof.

They are prepared in triangular form so as to cover all the joints between the rafters and the other parts at the surface. The trusses can be set in place using glue and nails

Video Content / Details of website for further learning (if any):

1. https://www.youtube.com/watch?v=-f1CckABkx0
2. https://www.youtube.com/watch?v=kRSKLXoaN54

Important Books/Journals for further learning including the page nos.:

1. **Design of steel structures , by Dr.B.C. Punmia, Ashok kumar jain, Arun kumar jain in the page No:365**

Course Faculty

Verified by HOD