SUBJECT:

DESIGN OF STEEL STRUCTURES

- Course No. CE 313
- Teachers:
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  - Dr. Rashid Hameed (Assistant Professor)
  - Engr. Rizwan Riaz (Lecturer)

Introduction…….

- Introduction of students.
- Introduction of subject.
- Introduction of instructors.
- Introduction of books and specifications.
- Introduction of structural steel.
- Introduction of steel shapes.
- Introduction of design.

Evaluation

Theory Part

Quiz - I:	10 %
Quiz - II:	10 %
Class Participation: (Assignments, Presentations and Attendance)	10 %
Mid-Semester Exam:	30 %
Final Exam:	40 %

Final grades are assigned according to the approved policy

Evaluation…….

Practical Part

Quiz - I
Quiz - II
Class Design Calculations
Home Design Calculations
Drawing Sheets

Final grades are assigned according to the approved policy

Reference Books

- AISC 2005 Specifications
  (Free on web site www. AISC.org).
- *Steel Structures, 2nd Ed. by Zahid and Ashraf.*
- *LRFD Steel Design Aids, 3rd Ed. by Zahid (Always bring in the practical classes).*
- Steel Structures by John. E. Lothers.
- Any other book on Steel Structures, like Bowles, McCormac, Salmon & Johnson, Gaylord & Gaylord.

Assignment No.1

- Write and explain your objectives of taking this course.
- Search remarkable steel structures from internet, attach photographs and brief description of each, like longest bridge, tallest steel building, etc.
- Should be 3 to 5 pages long.

Introduction to Steel Structures

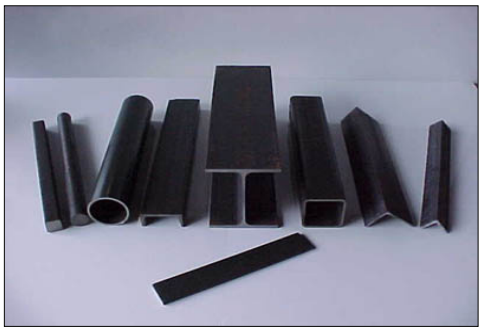
- Steel structures are assembly of structural steel shapes joined together by means of riveted / bolted or welded connections.

Bolted Connection

Welded Connection

Introduction to Steel Structures

- Selection of a section out of those available in the market.



Hot Rolled Sections

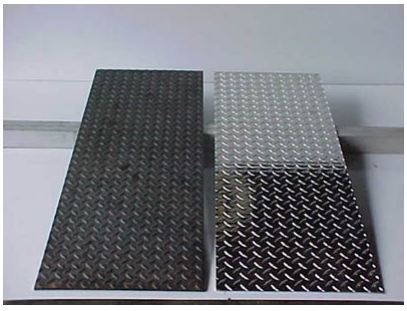
Introduction to Steel Structures

- Selection of a section out of those available in the market.


Cold Formed Sections

Introduction to Steel Structures

- Selection of a section out of those available in the market.

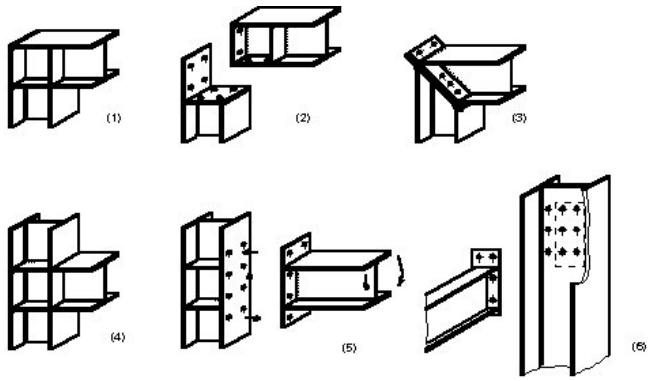


Steel Diamond Plate

Introduction to Steel Structures

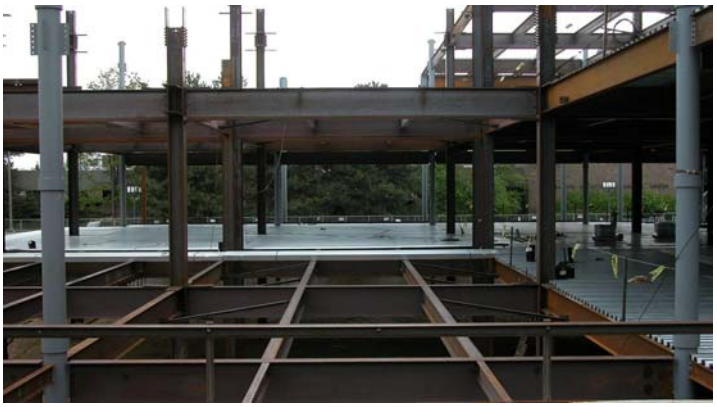
- Concrete structures are easily joined together by monolithic construction. But special methods are required to join individual members for steel structures.

Introduction to Steel Structures



Beam Column Connections

Introduction to Steel Structures



Typical Steel Structure (Building)

Structural System

- Steel construction is being used for almost every type of structure including multi-storey buildings, bridges, industrial buildings, towers, etc.
- There are two main categories of steel structures:-

1. Framework or Skeletal System

2. Shell System

Framework or Skeletal System

- The main load carrying elements in this type are one-dimensional or line elements (such as beams, columns, etc.) forming two-dimensional or three-dimensional frames.
  - Examples are:-
    - **The frameworks of industrial buildings with their internal members such as crane girders, platforms, etc.**
    - **Highway and railways large span bridges.**
    - **Multi-storey buildings, large halls, domes etc.**
    - **Towers, poles, structural components of hydraulic works**
    - **All other trusses and rigidly connected frame structures.**

Shell System

- The main load carrying elements in this category of structures are plates and sheets besides some skeletal members.
  - Examples are:-
    - **Gas tanks for the storage and distribution of gases.**
    - **Tanks and reservoirs for the storage of liquids.**
    - **Bins and bunkers for the storage of loose material.**
    - **Special structures such as blast furnaces, air heaters, etc.**
    - **Large diameter pipes.**
    - **All other plate and shell structures.**

Prominent Features of Steel Construction

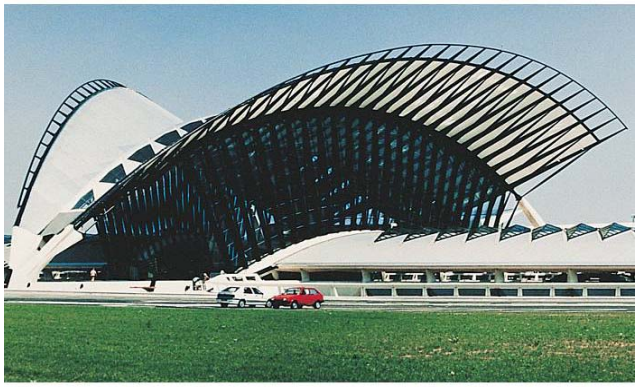
Freedom of Expression

Prominent Features of Steel Construction

Creativity

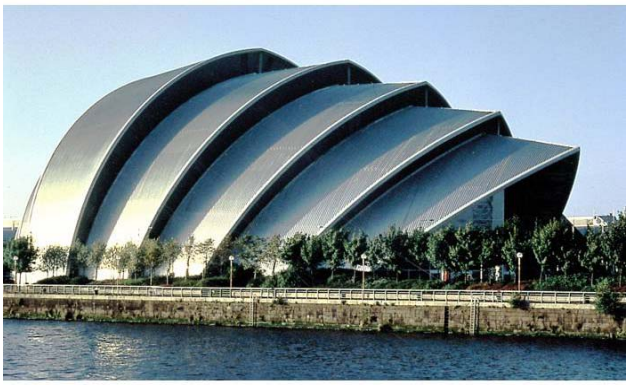
Prominent Features of Steel Construction

Creativity



Prominent Features of Steel Construction

Creativity



Prominent Features of Steel Construction

Easy Extension

Prominent Features of Steel Construction

Easy Fixing of Facade

Prominent Features of Steel Construction

Easy and Efficient Fabrication

Prominent Features of Steel Construction

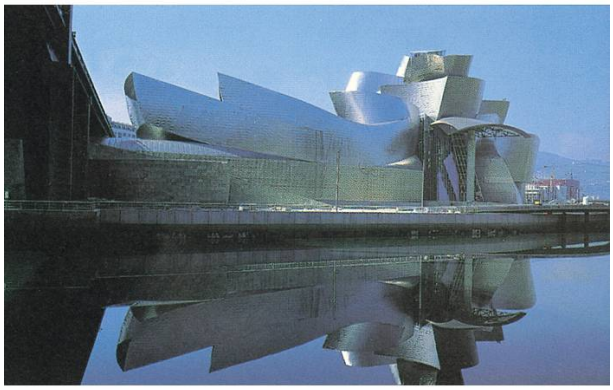
Long Span

Prominent Features of Steel Construction

Long Span

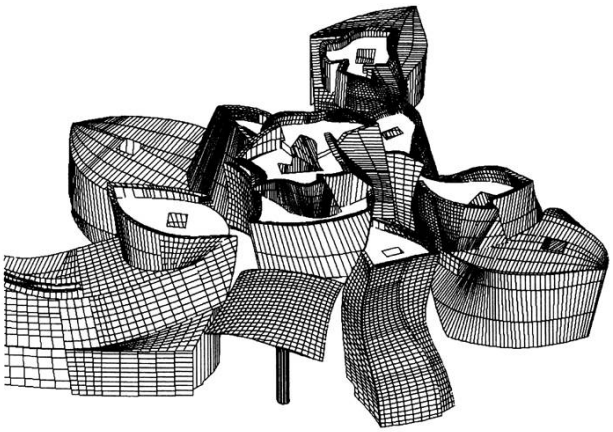
Prominent Features of Steel Construction

No Limit of Architectural Design



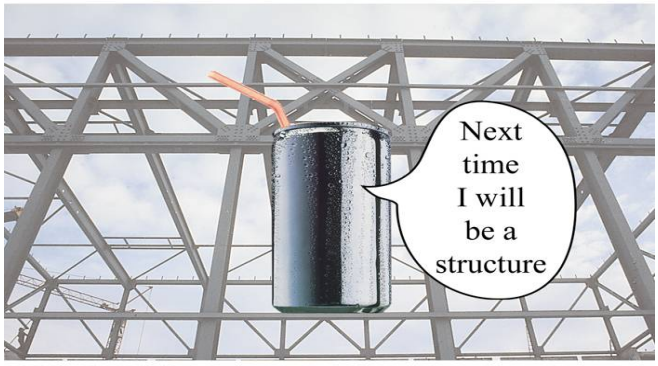
Prominent Features of Steel Construction

No Limit of Architectural Design



Prominent Features of Steel Construction

Recycling is Possible



Prominent Features of Steel Construction

Slender Columns, More Space

Prominent Features of Steel Construction

Transparency (use of natural light)

Prominent Features of Steel Construction

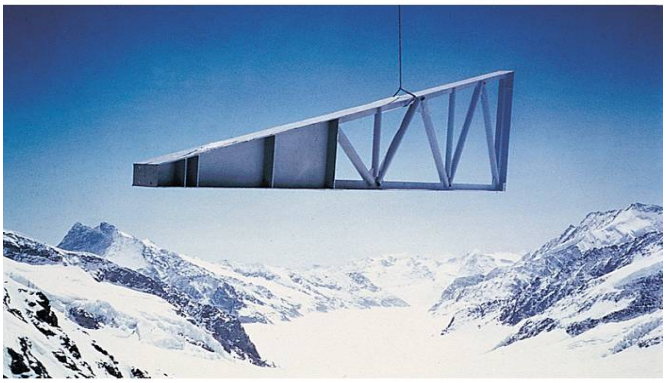
Visible Connections

Prominent Features of Steel Construction

Visible Connections

Prominent Features of Steel Construction

Weather Independent Construction



Merits of Steel Construction

Merits of Steel Construction

1. Reliability

- Consistency and uniformity in properties.
- Better quality control because of factory manufacture.
- Large elasticity.
- Ductility.
- Because of truly homogeneous and elastic material, steel satisfies most of the assumptions involved in the derivation of the analysis and design formulas and hence the results obtained are reliable.

Merits of Steel Construction

2. Industrial Behaviour

- Rolled steel sections are manufactured in factories.
- Also, the members may be cut and prepared for assembly in factories.
- Only joining of these components is carried out at the site by installing rivets or bolts and by welding different components.
- Sometimes parts of the structure are also assembled in the factories, that is, there is a great adaptation to prefabrication.
- Manual errors reduce greatly in such cases, the speed of construction increases and the total cost reduces.

Merits of Steel Construction

3. Lesser Construction Time

- Because of the industrial nature of steel construction, progress of the work is very fast making the structures economical.
- The reason is that these structures can be put to use earlier.
- The reduction in labour cost and overhead charges and the benefits obtained from the early use of the building contribute to the economy.

Merits of Steel Construction

4. High Strength and Light Weight Nature

- Steel provides high strength per unit weight.
- Dead loads become lesser.
- Dead loads are a bigger part of the total loads on a structure.
- When dead load reduces, the underneath members become still smaller due to less weight acting on them.
- More important for long-span bridges, tall buildings, and for structures having poor foundation conditions.

Merits of Steel Construction

5. Uniformity, Durability and Performance

- Durability means long life of a structure.
- Steel is a very homogeneous and uniform material.
- It satisfies the basic assumptions of most of the analysis and design formulas.
- If properly maintained by painting, etc., the properties of steel do not change appreciably with time.
- Hence, steel structures are more durable.

Merits of Steel Construction

6. Elasticity

- Steel behaves closer to design assumptions than most of the other materials because it follows Hooke's law up to fairly high stresses.
- The stress produced remains proportional to the strain applied or the stress-strain diagram remains a straight line.
- The steel sections do not crack or tear before ultimate load and hence the moments of inertia of a steel structure can be definitely calculated.

Merits of Steel Construction

7. Ductility and Warning before Failure

- The property of a material by which it can withstand extensive deformation without failure under high tensile stresses is said to be its ductility.
- Mild steel is a very ductile material. The percentage elongation of a standard tension test specimen after fracture can be as high as 25 to 30%.
- This gives visible deflections or evidence of impending failure in case of overloads.
- The extra loads may be removed from the structure to prevent collapse.

Merits of Steel Construction

7. Ductility and Warning before Failure (cont....)

- Even if collapse does occur, time is available for occupants to vacate the building.
- In structural members under normal loads, high stress concentrations develop at various points.

Merits of Steel Construction

8. Addition to Existing Structures

- Additions to existing steel structures are very easy to be made.
- Connections between new and existing structures can be employed very effectively.
- New bays or even entire new wings of buildings can be added to existing steel frame buildings, and steel bridges may often be widened.

Merits of Steel Construction

9. Possible Reuse

- Steel sections can be reused after a structure is disassembled.

10. Scrap Value

- Steel has a scrap value even though it is not reusable in its existing form.

11. Water Tight and Air Tight Construction

- Steel structures provide completely impervious construction.
- Structures like reservoirs, oil pipes, gas pipes, etc., are preferably made from structural steel.

Merits of Steel Construction

12. Long Span Construction

- High-rise buildings, long span bridges and tall transmission towers are made up of structural steel.
- Industrial buildings up to a span of 90 m can be designed by plate girders or trusses.
- Bridge spans up to 260 m are made with plate girders.
- For through truss bridges, spans of 300 m have been used.

Merits of Steel Construction

13. Temporary Construction

- For temporary structures, steel construction is always preferred.
- Army constructions during war are mostly made out of structural steel.
- The structures may be disassembled by opening few bolts, component parts are carried to new places and the structure is easily reassembled.

Demerits of Steel Construction

Demerits of Steel Construction

1. High Maintenance Costs and Corrosion

- Most steels are susceptible to corrosion when freely exposed to air and water and must therefore be periodically painted.
- This requires extra cost and special care.
- The use of weathering steels, in suitable design applications, tends to eliminate this cost.
- If not properly maintained, steel members can loose 1 to 1.5 mm of their thickness each year.
- Accordingly such constructions can loose weight up to 35% during their specified life and can fail under the external loads.

Demerits of Steel Construction

2. High Fireproofing Cost

- Although steel members are incombustible, their strength is tremendously reduced at temperatures prevailing in fires.
- At about 400°C, creep becomes much more pronounced.
- Creep is defined as plastic deformation under a constant load for a long period of time.
- This produces excessively large deflections / deformations of main members forcing the other members to higher stresses or even to collapse.

Demerits of Steel Construction

2. High Fireproofing Cost (cont....)

- Steel is an excellent conductor of heat and may transmit enough heat from a burning compartment of a building to start fire in other parts of the building.
- Extra cost is required to properly fire proof the building.

Demerits of Steel Construction

3. Susceptibility to Buckling

- *Buckling* is a type of collapse of the members due to sudden large bending caused by a critical compressive load.
- The steel sections usually consist of a combination of thin plates.
- Further, the overall steel member dimensions are also smaller than reinforced concrete members.
- If these slender members are subjected to compression, there are greater chances of buckling.
- Sometimes steel, when used for columns, is not very economical because considerable material has to be used merely to stiffen the columns against buckling.

Demerits of Steel Construction

3. Susceptibility to Buckling

Demerits of Steel Construction

4. High initial Costs / Less Availability

- In few countries, Pakistan is one such example, steel is not available in abundance.
- Hence, its initial cost is very high compared with the other structural materials.
- This is the most significant factor that has resulted in the decline of steel structures in these countries.

Demerits of Steel Construction

5. Aesthetics

- For certain types of buildings, the steel form is architecturally preferred.
- However, for majority of residential and office buildings, steel structures without the use of false ceiling and cladding are considered to have poor aesthetic appearance.
- A considerable cost is to be spent on such structures to improve their appearance.
- *Cladding* is a covering of metal, concrete, plastic or timber put on the surface of a structural member to completely encase it. The cladding not only protects the member but also improves its appearance.

Steel Structure

Steel Structure

Steel Structure

Steel Structure

Steel Structure (Column-Beam Joint)

Steel Structure (Column-Beam Joint)

Steel Structure (Column-Beam Joint)

Specifications

- The adequacy of a structural member is determined by a set of design rules, called specifications.
- These include formulas that guide the designer in checking strength, stiffness, proportions and other criteria that may govern the acceptability of the member.
- There are a variety of specifications that have been developed for both materials and structures.
- Each is based on years of research and experience gained through actual structural usage.

Following specifications will be used in this class quite often

1-	AISC:	American Institute of Steel Construction.
2-	AISI:	American Iron and Steel Institute
3-	AWS:	American Welding Society.
4-	AASHTO:	American Association of State Highway and Transportation Officials.
5-	AREA:	American Railway Engineering Association.
6-	ASTM:	American Society for Testing and Materials.
7-	ASCE:	American Society of Civil Engineers

Types of Loads

1. Dead Load

- It almost retains its magnitude and point of application throughout the life of the structure and is denoted by D.
- This load is usually the self weight of the structure (not only this member but all other members resting on it).
- This is estimated by multiplying volume of a member with the standard density of the material of construction.
- This load constitutes a bigger part of the total load on a structure.

Types of Loads

2. Live Load

- The load due to persons occupying the structure and their belongings, denoted by L.
- Its magnitude and point of application changes with time.
- In case of bridges, live load consists of weight of vehicles moving over the bridge.
- Typical values for common occupancy types are given in next slide.

Types of Loads

2. Live Load

Occupancy or Use	Live Load (kg/m^2)
Private apartments, school class rooms	200
Offices	250
Fixed-seats, assembly halls, library reading rooms	300
Corridors	400
Movable seats assembly hall	500
Wholesale stores, light storage warehouses	600
Library stack rooms	750
Heavy manufacturing, heavy storage warehouses, sidewalks and driveways subject to trucking	1200

Types of Loads

3. Self Load

- This is type of dead load, which is due to self weight of the member to be designed.
- For design, a reasonable value of self load depending on past experience is assumed in the start which is then compared with the actual self weight at the end.
- Corrections in design are made if necessary.
- Other types of loads are wind load, earthquake loads, water ad earth retaining loads and temperature loads, etc.

Types of Loads

4. Superimposed Load

- This term is used for all external loads, leaving the self weight, acting on the member to be designed.
- This includes live load, wind load, earthquake load, etc. Part of dead load may also act as imposed load.

5. Service Load

- The maximum intensity of load expected during the life of the structure depending upon a certain probability of occurrence is called service load.
- No additional factor of safety or overload factor is included in the service loads.

Types of Loads

6. Factored Loads

- Service loads increased by some factor of safety or overload factor are called factored loads.

Mechanism of Load Transfer

- The gravity load passes from top to bottom through all the members of the structure until it reaches the underneath soil.
- The load acts at the floor finish, goes to the underneath slab and transfers to the beams and walls.
- This is then accumulated in the columns, moves to the foundations and then finally dissipates in the soil.
- For the roof slab, beams and walls are supports.
- For the beams, columns are acting like supports, and for the columns, foundations are acting as supports.

Mechanism of Load Transfer (cont.....)

- Similarly, the underneath soil acts as support for the foundations.
- This load path is only in one direction.
- The load of roof slab may act on the beams, columns and foundations, but the load of column is not acting on the beams.
- Similarly, the load of foundation can not act on the columns.