

# Design of Steel Structures



**Module # 1**  
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## 1.1 Introduction to Steel Structures

- Steel structures are assembly of structural steel shapes joined together by means of riveted / bolted or welded connections.
- Majority of concrete structures are cast in-situ but in steel structures, we have to select out of those available in the market.
- Joints are monolithic in concrete structures whereas in steel structures special methods are required to join individual members.

## Steel Shapes



## Connections

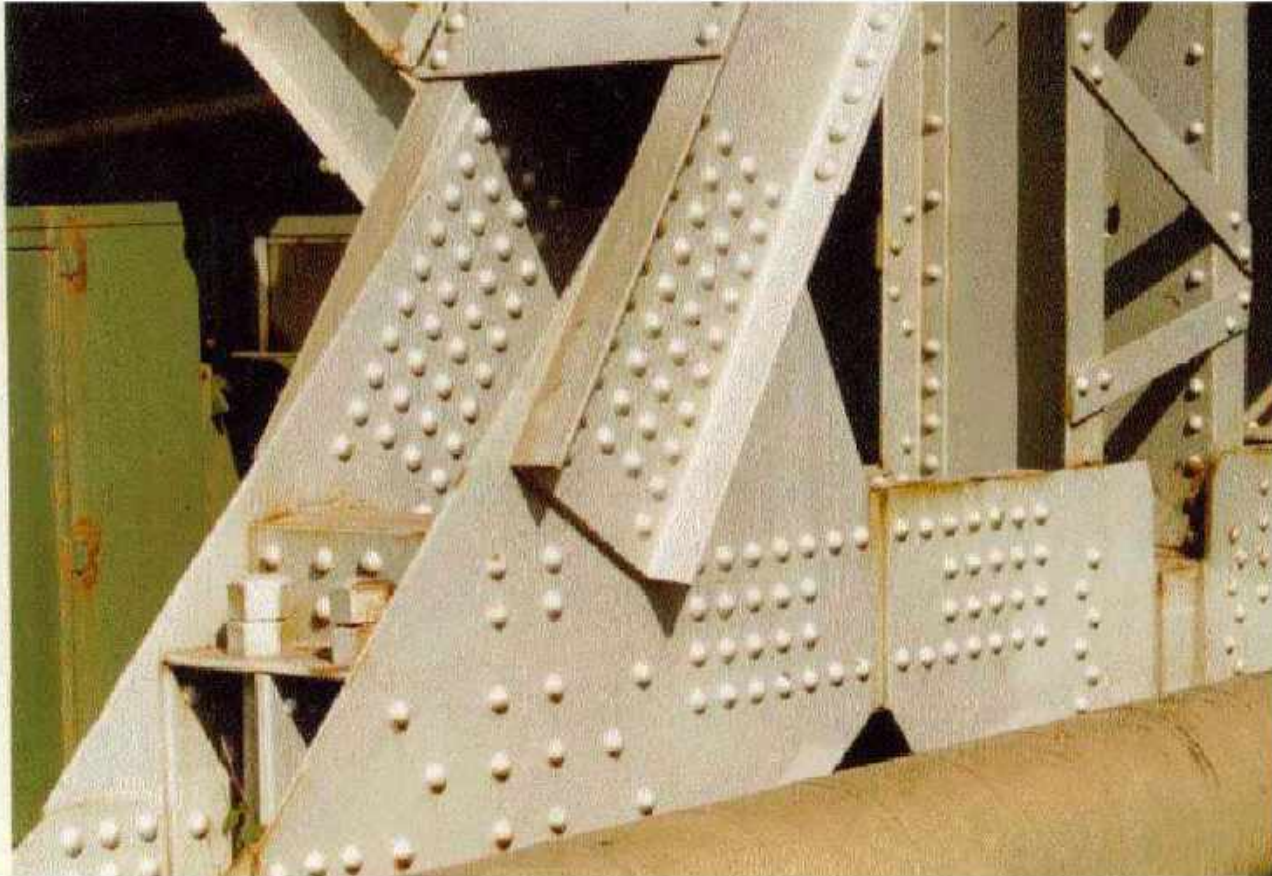




## Bolted Connections



## Riveted Connections



## Simple & Moment Resisting Joints





- In steel structures, connections including the details are to be designed for expected forces.
- Steel construction is being used for almost every type of structure including high-rise buildings, bridges, industrial building, towers etc.
- There are main two categories of steel structures:-
  - Framework or Skeletal Systems
  - Shell Systems



## Industrial Building



- Multi-storey buildings, large halls, domes etc.
- Towers, poles, structural components of hydraulic works.
- All other trusses and rigidly connected frame structures.

# Merits of Steel Construction

## 1. Reliability

- Consistency and uniformity in properties.
- Better quality control due to factory manufacture.
- Large elasticity and ductility.
- Truly homogeneous.
- Satisfies most of the analysis & design assumptions.

## 2. Industrial Behavior

- Rolled steel sections are manufactured in factories.
- Also, the members may be cut & prepared for assembly in factories while only joining is carried out at site.
- Sometimes parts are also assembled in the factories, that is, there is great adaptation to prefabrication.



## Erection



## Hot Rolled Steel



## Hot Rolled Steel





## Hot Rolled Steel





## Assembling in factory



### 3. Lesser Construction Time

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

## 4. High Strength & Light Weight Nature

- It means that the dead load will be smaller.
- Dead loads are bigger part of the total structure load.
- If dead load reduces, the resulting member will be smaller.
- This fact is important for long span bridges, tall buildings & for structures having poor foundations.



## 5. Uniformity, Durability & Performance

- Durability means long life of structures.
- Steel is a homogeneous & uniform material.
- Satisfies the basic assumptions of analysis & design.
- If properly maintained with painting, etc., the properties of steel do not change appreciably with time.



## 6. Elasticity

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

## 7. Ductility & 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 to prevent collapse.
- Even if collapse occurs, time is available for occupants to vacate the building.
- In structural members under normal loads, high stress concentrations develop at various points.
- The ductile nature of the structural steels enable them to yield locally at those points, thus redistributing the stresses and preventing premature failure.



## 8. Additions 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.



## 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 re-useable in its existing form.

## Steel Scrap



## 11. Water-Tight & Air-Tight

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

## 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 truss bridges, spans of 300 m have been used.



## Long Span



## Long Span





## Long Span



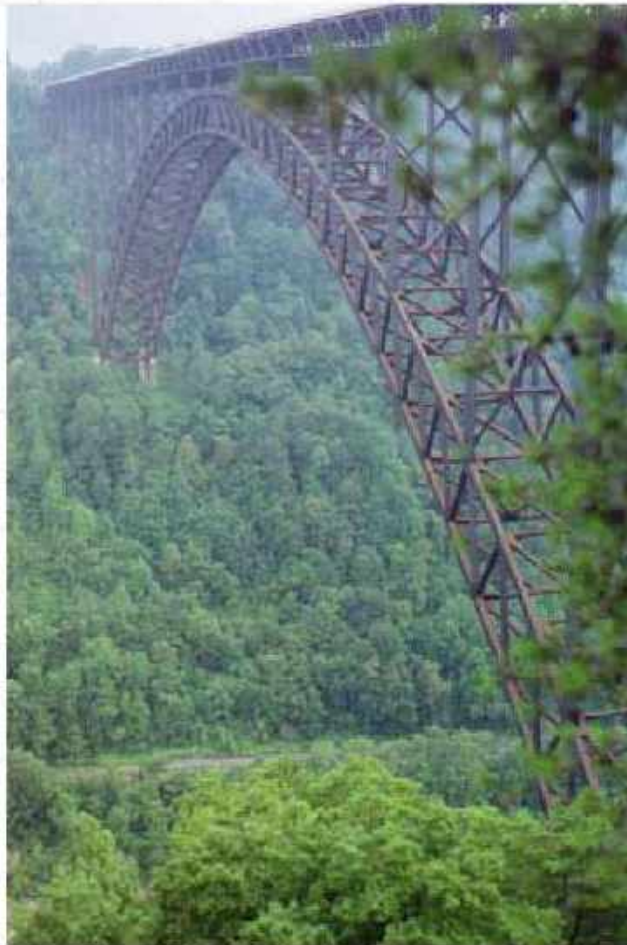
## Long Span





## Long Span





Long Span

## Long Span





## 13. Temporary Construction

- Steel structure is always preferred for temporary construction.
- 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

### 1. High Maintenance Costs & More Corrosion

- Most steels are susceptible to corrosion when freely exposed to air and water.
- They must be periodically painted.
- This requires extra cost and special care.
- The use of weathering steels, in suitable design applications, tends to eliminate this cost.

## Corrosion





# Corrosion



## 2. Fireproofing Costs

- Although steel members are incombustible, their strength is tremendously reduced at temperatures prevailing in fire.
- 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 large deflections/deformations of main members forcing the other members to higher stresses or even to collapse.
- 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.





## Steel in Fire

### 3. Susceptibility to Buckling

- Steel sections usually consists of a combination of thin plates.
- 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.

- Buckling is a type of collapse of the members due to sudden large bending caused by a critical compressive load.
- Steel when used for columns is sometimes not very economical because considerable material has to be used to stiffen the column against buckling.





Buckling in a  
Composite column

## 4. Higher Initial Cost / Less Availability

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

## 5. Aesthetics

- For certain types of buildings, the steel form is architecturally preferred.
- However, for majority of residential & 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.

## False Ceiling



## Cladding

