

MODULE 1 - INTRODUCTION

Structural Design

Definition: Determination of overall proportions and dimensions of the supporting framework and the selection of individual members.

Responsibility: The structural engineer, within the constraints imposed by the architect (number of stories, floor plan,...) is responsible for structural design

Safety (the structure doesn't fall down)

Serviceability (how well the structure performs in term of appearance and deflection)

Economy (an efficient use of materials and labor)

Alternatives

Several alternative designs should be prepared and their costs compared

Types of Load

Dead Loads (permanent; including self-weight, floor covering, suspended ceiling, partitions,..)

Live Loads (not permanent; the location is not fixed; including furniture, equipment, and occupants of buildings)

Wind Load (exerts a pressure or suction on the exterior of a building)

Types of Load Continued

Earthquake Loads (the effects of ground motion are simulated by a system of horizontal forces)

Snow Load (varies with geographical location and drift)

Other Loads (hydrostatic pressure, soil pressure)

Types of Load Continued

If the load is applied suddenly, the effects of IMPACT must be accounted for.

If the load is applied and removed many times over the life of the structure, FATIGUE stress must be accounted for

Design Specifications

Provide guidance for the design of structural members and their connections.

They have no legal standing on their own, but they can easily be adopted, by reference, as part of a building code.

American Concrete Institute (ACI 318-99) Building Code Requirements for Structural Concrete

National Design Specifications for Wood Construction by American Forest and Paper Association.

Structural **Steel**

Steel is an alloy of primarily iron, carbon (1 to 2%) and small amount of other components (manganese, nickel, ...)

Carbon contributes to strength but reduces ductility.

Steel Properties

The important characteristics of **steel** for **design** purposes

- are:
- yield stress (F^y)
 - ultimate stress (F^u)
 - modulus of elasticity (E)
 - percent elongation (ϵ)
 - coefficient of thermal expansion (α)

Standard Cross-Sectional Shapes

Refer steel table

Design Philosophies

Allowable Stress **Design** Method (ASD)

Load and Resistance Factor **Design** (LRFD)

A member is selected such that the max stress due to working loads does not exceed an allowable stress.

It is also called elastic **design** or working stress **design**.

- allowable stress = yield stress / factor of safety
- actual stress \leq allowable stress

LRFD –Load and Resistance Factor Design

A member is selected such that its factored strength is more than the factored loads.

- $\Sigma(\text{loads} \times L \text{ factors}) \leq \text{resistance} \times R \text{ factor}$

Each load effect (DL, LL, ..) has a different load factor which its value depends on the combination of loads under consideration.

Load Factors

The values are based on extensive statistical studies

- DL only 1.4D
- DL+LL+SL (LL domin.) 1.2D+1.6L+0.5S
- DL+LL+SL (SL domin.) 1.2D+0.5L+1.6S
- In each combination, one of the effects is considered to be at its “lifetime” max value and the others at their “arbitrary point in time” values.

Resistance Factor

The resistance factors range in value from 0.75 to 1.0 depending on the type of resistance (tension, bending, compression, ..)

These factors account for uncertainties in material properties, **design** theory, and fabrication and construction practices.

History

ASD has been the primary method used for **steel design** since the first AISC specifications was issued in 1923.

In 1986, AISC issued the first specification for LRFD.

The trend today is toward LRFD method, but ASD is still in use.

Advantages of LRFD

It provides a more uniform reliability in all structures subjected to many types of loading conditions. It does not treat DL and LL as equivalent, thereby leading to a more rational approach.

It provides better economy as the DL make up a greater percentage on a given structure. Because DLs are less variable by nature than live loads, a lower load factor is used.

This may lead to a reduction in member size and therefore better economy

STEEL AS A STRUCTURAL MATERIAL

1.1 General

Structural steel is a material used for steel construction, which is formed with a specific shape following certain standards of chemical composition and strength. They can also be defined as hot rolled products, with a cross section of special form like angles, channels and beams/joints. There has been an increasing demand for structural steel for construction purposes in the United States and India.



Measures are been taken by the structural steel authority for ready availability of structural steel on time for the various projects. The people at every level are working hard to realize the purpose of producing steel on time, like, service centers, producers, fabricators and erectors along with the general contractors, engineers and architects are all working hand in hand. Steel has always been more preferred to concrete because steel offers better tension and compression thus resulting in lighter construction. Usually structural steel uses three dimensional trusses hence making it larger than its concrete counterpart. There are different new techniques which

enable the production of a wide range of structures and shapes, the procedures being the following:

High-precision stress analysis

Computerized stress analysis

Innovative jointing

The structural steel all over the world pre-dominates the construction scenario. This material has been exhaustively used in various constructions all over the world because of its various specific characteristics that are very much ideally suited for construction. Structural steel is durable and can be well molded to give the desired shape to give an ultimate look to the structure that has been constructed. There is a mention of The Super dome situated in the United States and The Fukuoka Dome of Japan; both speak the unique language of the unique capabilities of the structural steel.



1.2 Types of structural steel:

Various types of structural steel sections and their technical specifications are as follows:

Beams

Channels

Angles

Flats

1.2.1 Steel Beams

Steel Beams is considered to be a structural element which mainly carries load in flexure meaning bending. Usually beams carry vertical gravitational force but are also capable of carrying horizontal loads generally in the case of an earthquake. The mechanism of carrying load in a beam is very unique, like; the load carried by a beam is transferred to walls, columns or girders which in turn transfer the force to the adjacent structural compression members. The joists rest on the beam in light frame constructions.



The beams are known by their profile meaning:

- The length of the beam
- The shape of the cross section
- The material used

The most commonly found steel beam is the I beam or the wide flanged beam also known by the name of universal beam or stouter sections as the universal column. Such beams are commonly used in the construction of bridges and steel frame buildings. The most commonly found types of steel beams are varied and they are mentioned below:

- I beams
- Wide flange beams
- HP shape beams

Typical characteristics of beams

Beams experience tensile, shear and compressive stresses internally due to the loads applied to them. Generally under gravity loads there is a slight reduction in the original length of the beam. This results in a smaller radius arc enclosure at the top of the beam thus showing compression. While the same beam at the bottom is slightly stretched enclosing a larger radius arc due to tension. The length of the beam midway and at the bends is the same as it is not under tension or compression and is defined as the neutral axis. The beam is completely exposed to shear stress above the support. There are some reinforced concrete beams that are completely under compression, these beams are called pre-stressed concrete beams and are built in such a manner to produce a compression more than the expected tension under loading conditions. The pre-stressed concrete steel beams have the manufacturing process like, first the high strength steel tendons are stretched and then the beam is cast over them. Then as the concrete begins to cure the tendons are released thus the beam is immediately under eccentric axial loads. An internal moment is created due to the eccentric axial load which in turn increases the moment carrying capacity of the beam. Such beams are generally used in highway and bridges.

Materials Used

In today's modern construction the beams are generally made up of materials like:

Steel

Wood

Reinforced concrete

1.2.2 Steel Channels:

Steel channels are used ideally as supports and guide rails. These are roll-formed products. The main metal used for making channels is steel along with aluminum. There are certain variations that are available in the channels category, the categorization is mainly on the shape of the channel, the varieties are mentioned below:



J channels: This kind of channel has two legs and a web. One leg is longer. This channel resembles the letter-J.

Hat channels: This channel has legs that are folded in the outward direction resembling an old fashioned man's hat.

U channels: This most common and basic channel variety. It has a base known as a web and two equal length legs.

C channels: In this channel the legs are folded back in the channel and resemble the letter-C. C channels are known as rests.

Hemmed channels: In this kind of channel the top of the leg is folded hence forming double thickness.

There are other variations of channels that are available, which are customized according to the customer's needs.

Application

Steel channels are subjected to a wide array of applications. The application fields are:

Construction

Appliances

Transportation

Used in making Signposts

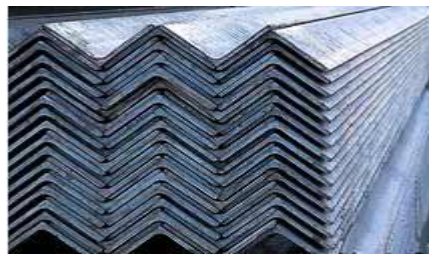
Used in wood flooring for athletic purposes

Used in installing and making windows and doors

A major variant of the channel is the mild steel channel. Such channels are generally used in heavy industries. They are used in the heavy machinery industry and automotive industry too.

1.2.3 Steel Angle:

A steel angle is long steel with mutually vertical sides. The steel angles are the most basic type of roll-formed steel. The most commonly found steel angles are formed at a 90 degree angle and has two legs of equal length. The sides are either equal or of different sizes.



There are certain variations in the steel angles depending on it's basic construction. The variations are like; if one leg is longer than the other then it is known as L angle. If the steel angle is something different from 90 degrees then it is known as V angle. In some steel angles, double thickness is achieved by folding the legs inward. If the steel angle has same sides then it means that it has identical width. The steel angles are made according to the strength that is required for the different structures for construction purposes.

Applications

the steel angle finds an application in a number of things, they are mentioned below:

Used in framing

Used in trims

For reinforcement

In brackets

Used in transmission towers

Bridges

Lifting and transporting machinery

Reactors

Vessels

Warehouses

Industrial boilers

Structural steel angles are used in rolling shutters for fabricating guides for strength and durability.

1.2.4 Steel Flats:

Flats are actually thin strips of mild steel having the thickness of the strip commonly varying from 12mm to 10mm but thicker flats than this are also available. Steel flats are produced by the utilization of relatively smooth, cylindrical rolls on rolling mills. Generally the width to thickness ratio of flat rolled products is fairly large. The steel flat bars are manufactured using advanced thickness control technology for controlled thicknesses. The hi-tech machineries enable the production of top grade steel flat bars with superlative flatness and controlled thickness. This product is highly customized and the specific sizes according to the client's requirement are produced. After production the flat steels are subjected to a variety of finishes like, painting and galvanizing. The flat carbon steel is a hot or cold rolled strip product also known as a plate product. These plate products have a size variation between 10mm to 200mm and the thin flat rolled flat rolled product's size varies from 1 mm to 10 mm.



Applications

The steel flats are used in a wide array of applications. The varied applications are listed below:

Railway parts
Ordinance factories
Hand tools
Engineering industries
Auto components- two-wheeler, four-wheeler, commercial vehicles
Domestic white goods products
Office furniture's
Heart pacemakers
Tin cans
Press working

1.3 Advantages of steel as a structural material:

Structural steel sections are usually used for construction of buildings, buildings, and transmission line towers (TLT), industrial sheds and structures etc. They also find in manufacturing of automotive vehicles, ships etc.

Steel exhibits desirable physical properties that make it one of the most versatile structural materials in use.

Its great strength, uniformity, light weight, easy of use, and many other desirable properties makes it the material of choice for numerous structures such as steel bridges, high rise buildings, towers, and other structure.

Elasticity: steel follows hooks law very accurately.

Ductility: A very desirable of property of steel, in which steel can withstand extensive deformation without failure under high tensile stresses, i.e., it gives warning before failure takes place.

Toughness: Steel has both strength and ductility.

Additions to existing structures: Example: new bays or even entire new wings can be added to existing frame buildings, and steel bridges may easily be widened.

1.4 Disadvantages of steel as a structural material:

Although steel has all these advantages as structural material, it also has many disadvantages that make reinforced concrete as a replacement for construction purposes.

For example steel columns sometimes cannot provide the necessary strength because of buckling, whereas RCC columns are generally sturdy and massive, i.e., no buckling problem occurs.

Many disadvantages of steel can be summarized below:

Maintenance cost: Steel structures are susceptible to corrosion when exposed to air.

Fire proofing cost: steel is an incombustible material; however, its strength is reduced tremendously at high temperature due to common fires.

Fatigue: The strength of structural steel member can be reduced if this member is subjected to cyclic loading.

Brittle fracture: under certain conditions steel loses its ductility, and brittle fracture may occur at places of stress concentration. Fatigue type loadings and very low temperature trigger the situation.

Limit state design:

Refer IS:800-2009 in detail and other text bookd
