Steel Structures

M.Sc. Structural Engineering

SE-505

Lecture #1

Introduction

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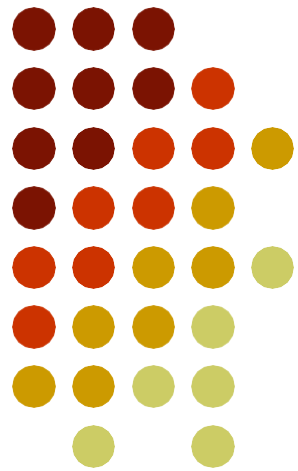

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Course Outline

Plastic Design

- Analysis and design of trusses, beams, portal frames
- Second order effect
- Design of connections
- Column bases
- Minimum weight design
- Moment distribution

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Books

1. AISC, LRFD Specifications for Structural Steel Buildings, 2005. www.aisc.org
2. Steel Structural Design and Behavior By Salmon and Johnson, 3rd edition or latest.
3. Ductile Design of Steel Structures by Bruneau, Chia Ming Vong and Whittaker (1998)
4. Plastic Design of Steel Frames by Lynn S. Beedle.
5. LRFD Steel Design Aids in SI units by Zahid Ahmed Siddiqui
6. Steel Structures by Zahid Ahmed Siddiqui

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Design Methods

1. LRFD Method

Strength design method is based on the philosophy of dividing F.O.S. in such a way that **Bigger part** is applied on **loads** and **smaller part** is applied on **material strength.**

 Strength Load Factor Service Loads

 $M_n \geq M_u$ $V_n \geq V_u$ $P_n \geq P_u$

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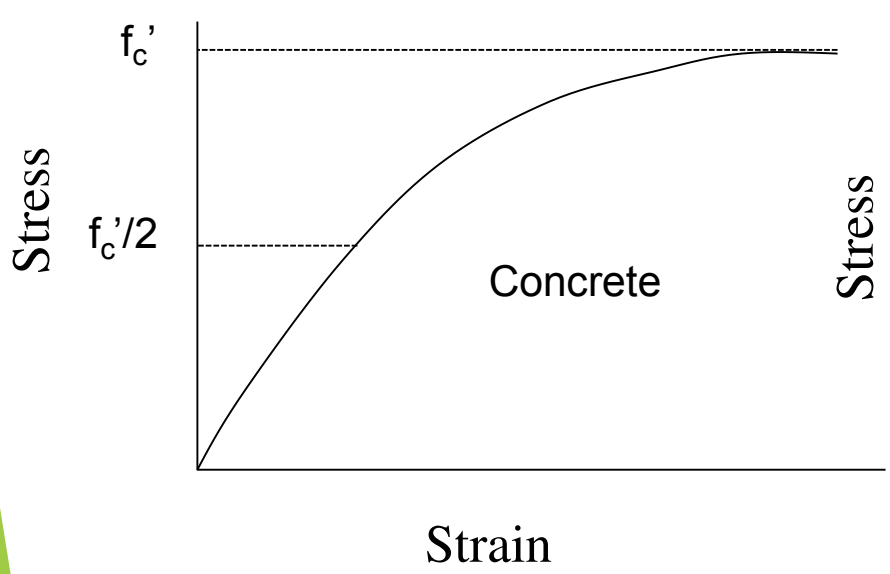
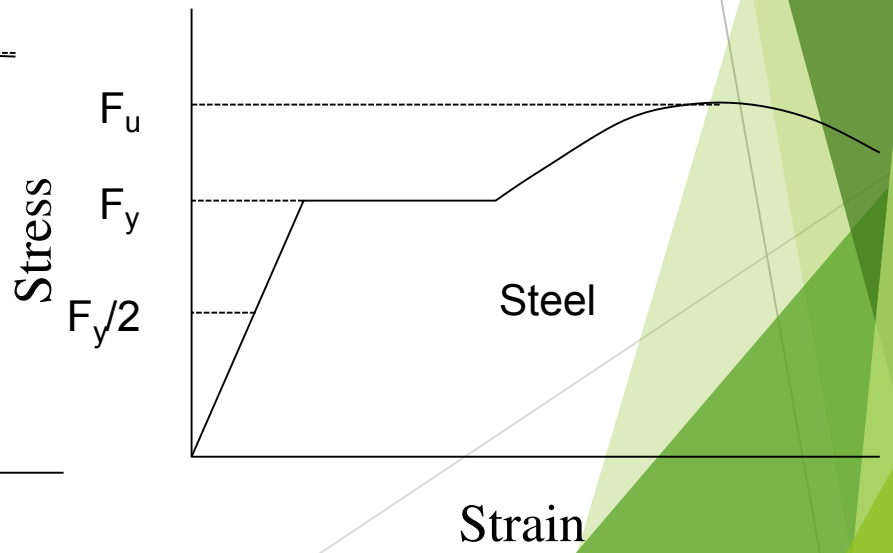
2. Allowable Stress Design (ASD)

In allowable strength design the whole F.O.S. is applied on **material strength** and service loads (un-factored) are taken as it is.

Material Strength / F.O.S. ≥ Service Loads

In both Allowable stress design and LRFD, analysis is carried out in **elastic range**.





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Factor of Safety

- Value is always greater than one
- Brings the structure from state of collapse to a usable service state to avoid excessive deformations, cracking, and buckling, etc.
- Covers uncertainties in loads within limits.
- Covers uncertainties in material strengths up to certain extent.

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Factor of Safety

- Covers, in part, poor workmanship
- Covers unexpected behavior in theory due to simplifying assumptions or limited knowledge.
- Reduces the effect of natural disasters.
- Incorporates the fabrication and erection stresses.
- Presence of residual stresses and local stress concentrations are safely considered.

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Limit State

- Stage in loading after which the structure cannot fulfill its intended function
- Limit state may be related with strength or serviceability considerations
- Actual collapse is not necessary
- Strength limit states corresponds to maximum strengths, such as ultimate compressive strength, flexural strength, ultimate shear strength, buckling failure, fatigue, plastic mechanism, overturning and sliding, etc.

Limit States

- Serviceability limit states are concerned with occupancy such as excessive deflections, undesirable vibrations, permanent deformations, excessive cracking and

- For a perfect design, structure should not cross any strength or serviceability limit states.

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Strength and Ductility

In general, structures are designed for strength against loads. Strength of a material means that maximum stresses should be below the strength.

- Ductility means how much deformations are produced before final collapse

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Types of Design

- Allowable Stress Design (ASD)
- Strength Design, Load and Resistance Factor Design (LRFD), or Limit State Design
- Plastic Design

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Advantages of ASD

- Elastic analysis for loads and elastic material behavior are compatible for design
- Senior engineers are used to this method.
- Old famous books are according to this method.
- Was the only method of design in past
- Is included as alternate method of design in AISC-05 Specifications.

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Disadvantages of ASD

- Latest research and literature is very much limited.
- Same factor of safety is used for different loads.
- The failure mode is not directly predicted.
- The ductility and warning before failure cannot be precisely predicted.
- Results cannot be compared with experimental tests up to collapse.

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Advantages of Using LRFD

- Behavior at collapse including ductility, warning before failure and strain-hardening, etc. may be considered directly
- Every type of load may be given a different FOS depending upon its probability of overload, number of severe occurrences and changes in point of application.

Advantages of Using LRFD

- More safe structures result due to better awareness of structural behaviour near collapse.
- Results can be compared with experiments up to collapse and with structural failures in the past.
- Latest research and literature is available in this method

Advantages of Using LRFD

- The convenient elastic analysis for loads is generally used in this method
- The design procedure is similar to ASD with only slight modifications.
- Using LRFD, steel and concrete design become consistent with each other.

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Disadvantages of LRFD

Elastic behaviour considered for load analysis and ultimate plastic behaviour for material strengths are not compatible.

Engineers experienced in ASD have to become familiar with this technique

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Plastic Design

- Same as LRFD with the difference that plastic analysis is used for load analysis.
- Best available method.
- Incompatibility in load analysis and material behavior is removed.
- Very lengthy even for computer application due to plastic analysis.

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Plastic Design

In plastic design, plastic analysis is carried out in order to find the behavior of structure near **collapse state**.

In this type of design material strength is taken from **inelastic range**.

It is observed that whether the failure is sudden or ductile. Ductile failure is most favorable because it gives a **warning** before the failure of structures