LECTURE NOTE ON
CVE 417 (STRUCTURAL DESIGN II)
Course Unit 2

Course Lecturer: Engr. Akinyele J.O

Duration for lecture: 2 hours per week
(15 weeks)

Design philosophies

(Week1)

- Allowable stress design
- working stress design (for concrete)
- ultimate stress design

Limit state design (Week2)

- A condition beyond which a structural system or a structural component ceases to fulfill the function for which it is designed.
- **Examples of limit states**
- Deflection
- Fatigue
- Shear
- Buckling
- Bearing
- Cracking
- Flexure
- Torsion
- Settlement
- Stability
- **Strength limit states**
- Flexure
- Shear
- Torsion
- **Serviceability limit states**
- Cracking
- Excessive deflection

Material properties (Week2)

- **Ductility:**
  Ability of a structure to go through in-elastic deformation without rupture.
- **Redundancy:**
  it is the ability to redistribute the load. Simple beam is determinate. Fixed beam is indeterminate by 2 degrees so it has two redundant actions. fixed supported beam is more better as indeterminate structure can redistribute the load. When load increases support becomes plastic and it turns into a simply supported beam. But simply supported does not go through the stage of plastic hinge rather they fail directly.
- **Hardness:**
  It is the ability to resist abrasion.
- **Steel Strength:**
  Maximum load which an object can resist. OR it is the maximum load that the steel can resist before failure. Steel is said to be failed when it has yielded. It is thus called yield strength
- **Toughness:**
  Ability of a structure or structural component to absorb energy.
- **Fatigue:**
  It is a progressive, localized permanent damage under fluctuating stress.

Design process (Week 3)

- Preliminary member sizing of beams
- Structural analysis - modeling, analysis
- Design review - member modifications
- Cost of estimation
- Preparation of structural drawings and specifications
- Loads for structural analysis and design
  - Dead load
  - Live load
  - Live loads for various occupancies
  - Reduction in basic design live load
  - Impact Load
  - Wind load

Factor of safety (Week4)

- The development of design specifications to provide suitable values of the margin of safety, reliability and probability of failure must take into consideration the following factors.
- Variability of the material with respect to strength and other physical properties
- Uncertainty in the expected loads
- Precision with which internal forces are calculated
- Possibility of corrosion
- Extent of damage, loss of life
- Operational importance
- Quality of workmanship

Steel sections (Week4)

- Hot-rolled sections are produced in steel mills from steel billets by passing them through a series of rolls. The main sections are:
- Universal beam, Universal columns, Channels, Equal and unequal angles, Structural tees and Circular, square, rectangular hollow sections.

Connections (Week5)

- Connections are needed to join: Members together in trusses and lattice girders, Plates together to form built-up members, Beams to beams, trusses, bracing, columns, frames etc. Columns to foundation.
- Type of connections : Ordinary bolts, Friction grip bolts and Welding.

Beam design (Week 6)

- Beams span between supports to carry lateral loads which are resisted by bending and shear. However, deflections and local stress are also important.
- Beams may be : cantilevered, simply supported, fixed ended or continuous.
- Classification of beam cross sections:

The projecting flange of an I beam will buckle prematurely if it too thin, web will also buckle under stress from bending and from shear. To prevent such from occurring, beam sections are classified as follows in accordance with their behavior in bending.

Class 1. Plastic cross section.

Class 2. Compact cross section

Class3. Semi-compact cross section

Class4.Slender cross section.

Design procedure for steel beam (Week 7-8)

- The general procedure for checking the lateral torsional buckling resistance according to BS 5950 part 1. are:

1. If the member or part being checked carries no loads between adjacent lateral restraints the equivalent uniform moment factor ***m*** is evaluated.
2. Calculate the equivalent uniform moment so that $M = \boldsymbol{m}M_A$, M_A is maximum moment in the beam considered.
3. Estimate the effective length L_E of the unrestrained compression flange. Minor axis slenderness $\lambda = L_E/r_y$
4. Calculate the equivalent slenderness: $\lambda LT = uv\lambda$.
5. Read the bending strength Pb from Table 11 in the code.
6. Calculate the buckling resistance moment: Mb = SxPb. For safe design, Mb>M
7. Check for local capacity at point of maximum combined moment. So that Mx/Mcx + My/Mcy <1.
8. Overall buckling check at the centre of the beam: so that, mMx/Mb + mMy/PyZy <1.
9. Check for deflection of beam.

Design procedure for steel beam (Plastic theory) (Week 9)

- Calculate factored and unfactored load
- Check for design strength of section: Py = 275N/mm^2 for grade 43 steel, 355N/mm^2 for grade 50 steel and 450N/mm^2 for grade 55 steel.
- Check for plastic modulus: S=M/Py
- The moment capacity is : PyS<1.2PyZ
- Check for deflection due to unfactored imposed load.
- Check the effect of shear at the support.

Design of compression members (Column) (Week 11-12)

- Consider the loads on the column, both vertical and lateral loads and chose a suitable section
- Chose a steel grade to determine it design strength. Py
- Check the plastic and elastic modulus in other to determine the section classification.
- Determine slenderness ratio, λ and compressive strength, Pc.
- Check local capacity
- Check overall buckling
- Determine Pb from table 11 of code
- Determine the equivalent uniform moment on both axis
- Determine the buckling resistance Mb.

Design of tension members (13)

- Tension members may consist of standard rolled sections, or combinations such as back to back angles and channels.
- Design procedures are :
- Determine section classification
- Moment capacity
- Effective area of section
- Tension capacity = Pt = AePy.
- And unity check : F/Pt + Mx/Mcx + My/Mcy <1.

References

- Structural steel work: Design to Limit state theory 3rd edition: D.Lam, T.C. Ang, S.P. Chiew.
- Structural steel work design to BS 5950, 2nd edition. L.J. Morris, D.R. Plum. Longman books London.

Assessments

- Week 10 Quiz

Week 14 Class project

Week 15 Class revision

- Grading
- Assignments =15%
- Quiz = 15%
- Examination =70%
- Total =100%