Course Name:
Ductile Behaviour of Steel Structures

Course Number:
20002

Credit:
3

Course Content (outline):

1. Materials Behaviour
   1.1. Mechanical properties of various metallic materials and comparison between those of Ductile and Brittle materials including: Stress-Strain Curves, Hardness, Energy absorption versus temperature curve obtained from Charpy Impact test, Stress-Strain curves at different temperatures and under various rates of strain.
   1.2. Welding and flame cutting of steel components and their adverse effects on mechanical properties of steel.
   1.3. Low-Cycle and High-Cycle Fatigue.
   1.4. Plasticity, Hysteresis and Bauschinger Effect.
   1.5. Materials Models including: Rigid-Plastic, Elastic-Perfectly Plastic, Elastic-Piecewise Linear Plastic, Power Models, Ramberg-Osgood Model, etc.
2. Ductility
   2.1. Ductility at Material Level.
   2.2. Ductility at Structural Level.
3. Production Processes
   3.1. Rolling including Hot and Cold Rolling.
   3.2. Extrusion and Pultrusion.
   3.3. Deep Drawing.
   3.4. Sheet Metal Forming.
4. Load-Bearing Capacity of Sections
   4.1. Load-bearing capacity of sections under axial loading, solving indeterminate systems under axial loading, discussion on “Redistribution of Internal Forces”.
   4.2. Elastic-Plastic bending of various sections and their Moment-Curvature curves. Shape factor.
   4.3. Effects of various factors on the bending capacity of sections including residual stresses, variation of yield stress with thickness of the sections, strain-hardening, local buckling, lateral buckling, and encasement,
   4.4. Effect of axial force on the bending capacity of various sections and their moment-curvature curves, yield surface, and bending moment-axial force interaction curves in the presence and absence of buckling.
   4.5. Effect of shear force on the bending capacity of sections and their moment-curvature curves (Optional).
5. Load-Bearing Capacity of Systems

5.1. Inelastic behavior of Indeterminate flexural systems, step-by-step method of solving such systems, Redistribution of Moments.
5.2. Direct method of calculating ultimate load-bearing capacity of indeterminate flexural systems using either of the two following methods: Equilibrium Method (Statical Method) and Mechanism Method (Virtual Work Method).
5.3. Upper Bound, Lower Bound and Uniqueness Theorems.
5.4. Comparing the design of Determinate Systems based on elastic and ultimate load approaches to work out the Load Factor and its application in designing indeterminate systems. Eventually, comparing the outcomes of designs based on the two methods, namely the elastic and plastic methods to show the economic gains of the plastic approach.
5.5. Ultimate capacity of 2D frames, their various mechanisms including their Independent and Combined (Composite) Mechanisms. Number of Independent Mechanisms, and using Instantaneous Centre of Rotation in solving pitched-roof (gable) frames.
5.6. Using Matrix Methods in working out the ultimate load of frames, the PushOver Analysis.
5.7. Energy absorption of Moment-Resisting Frames and Braced Frames under cyclic loading, Hysteresis Loops.
5.8. Mathematical Methods of calculating ultimate loads of flexural systems, Linear Programming Methods.
5.9. Ultimate loads of regular rectangular grids under nodal point loads.
5.10. Plastic bending of Plates, Yield Line Theory.

6. Physical-Mathematical Models for Representing Materials Behavior, Rheology
6.1. Elastic Behavior, Rigid-Plastic Behavior, Elastic-Bilinear Plastic Behavior, Visco-Elastic Behavior, Voigt-Kelvin Model, Maxwell Model, Creep, (Strain) Recovery, Residual Strains, Stress Relaxation, Standard Linear Solids, Visco-Elastic Models in 3D, Visco-Plasticity, with and without Strain-Hardening, Rate-Sensitive Plasticity.

References:

- Beedle, L.S. Plastic design of steel frames, Wiley, N.Y., 1958.
- Baker, J. and Heyman, J. Plastic Design of Frames, Cambridge University Press, London, 1969.
- Bruneau, M., Uang, C.M., and Whittaker, A. Ductile Design of Steel Structures, McGraw-Hill, Boston. 1998.
- Beedle, L.S. and Galambos, T.V., Plastic Design of Steel Structures, in Gaylord, Jr., E.H. and Gaylord, C.N. (Editors), Structural Engineering Handbook (Section 7), McGraw-Hill, N.Y., 1968
- Galambos, T.V., Combined Bending and Compression, in Tall, L., Beedle, L.S. and Galambos, T.V. (Editors), Structural Steel Design (Chapter 11), Ronald Press, N.Y., 1964.
- Naeim, F. (Editor), The Seismic Design Handbook, Van Nostrand Reinhold, N.Y. 1989.
- ANSI/AISC 341-16, Seismic Provision for Structural Steel Buildings, American Institute of Steel Construction, Chicago, Illinois, 2016.

- Fung, Y.C., A First Course in Continuum Mechanics, 2nd Edition, Prentice-Hall, N.J., 1977
- Fung, Y.C., Foundations of Solid Mechanics, Prentice-Hall, N.J., 1965.
- Malvern, L., Introduction to the Mechanics of a Continuous Medium (Chapter 6), Prentice-Hall, N.J., 1969.
- Blodgett, O.W., Design of Welded Structures, The James F. Lincoln Arc Welding Foundation, 1966.