Chapter 1: Introduction to Engineering Structures

1.1 Overview

This chapter introduces the fundamental concepts of structural engineering, focusing on the analysis and design of structures under various loads.

1.2 Basic Principles

- Load and resistance factor design (LRFD)
- Serviceability and ultimate limit states

1.3 Common Materials

- Steel
- Concrete
- Timber

1.4 Structural Systems

- Framed structures
- Plate and shell structures

1.5 Design Codes

- American Institute of Steel Construction (AISC)
- American Concrete Institute (ACI)

1.6 Case Studies

- Bridge design and construction
- Skyscraper engineering

1.7 Future Trends

- Sustainable and green engineering
- Advanced materials and technologies

References


Appendix A: Glossary of Terms

- Load factor
- Resistance factor
- Ultimate limit state

Appendix B: Useful Tables

- Material properties
- Design load factors

Appendix C: Sample Problems

- Bridge design problem
- Skyscraper analysis problem

Appendix D: Further Reading

- Construction Engineering: Design and Practice by W. H. Weiss
- Structural Engineering: Materials and Behavior by J. M. Kelly and R. A. Mowery
paradox, and how this was resolved by Shanley's analysis, thereby presenting further difficulties for a general theory of structures.

- Understand the importance of lateral-torsional buckling of beams.
- Understand how of the above ideas combine in the context of column design.

Content

There are two themes in this module: elastic analysis & stability and buckling of structures. Each section leads on from and extends a corresponding section of the first or second year courses in Structures.

In the first course the aims are to extend the elastic analysis of beam elements as given in Part I to cover asymmetric sections in bending, to revise the determination of shearing stresses in beams, to consider the torsion of open section beams, including effects due to restraint of warping and to introduce the concept of shear centre. The course will cover the analysis of beams via differential equations, and their efficient solution using Macaulay's method. This will be applied to beams on elastic foundations, as well as to normal beams. The reciprocal theorem will be introduced which will lead to the study of influence lines. The course will also cover some new applications of virtual work, grillages and other beams curved in plan, and the cable catenary.

In the second course the aims are to understand the fundamental principles of structural stability, to become familiar with common types of bifurcation and buckling phenomena and to formulate methods capable of dealing with geometrically non-linear structural behaviour. Once the general concept of stiffness degradation and the various post-buckling possibilities are understood, the course addresses the specific problem of column and beam design, taking account of initial imperfections, coexistent end-moments, residual stresses and material inelasticity.

Elastic Theory (8L) (Dr C Stanier)

- Asymmetric beams; principal axes;
- Shear centre; torsion and warping of open-sections;
- Virtual work;
- Grillages;
- Differential equation of beam (Macaulay);
- Reciprocal theorem and influence lines;
- Beams on elastic foundations;
- Catenary.

Stability and Buckling (8L) (Dr A McRobie)

- Fundamentals of buckling and stability: total potential energy approach and direct equilibrium approach;
- Classification of instabilities into snap-through type and bifurcation type;
- Eigenvalues and eigenvectors of stiffness matrix;
- Buckling of elastic structures; approximate estimates of buckling load; Rayleigh quotient;
- Lateral buckling of columns: Euler strut, imperfections, Southwell plot, beam-columns, stability coefficients, buckling of frames;
- Elasto-plastic buckling: tangent-modulus, double-modulus, Shanley's analysis;
- Design of columns;
- Lateral-torsional buckling of beams.

Coursework

Buckling Elastic and Inelastic

Learning objectives:

- Understand the difference between stable and unstable buckling.
- Appreciate the circumstances in which a "classical" buckling calculation gives a useful estimate of the buckling strength of a structure, and those in which it does not.
- Be able to cite examples of structures for which the buckling load is both significantly less than the
prediction of "classical" theory, and the postbuckling behaviour is highly unstable.

- Be aware of the "classical" buckling formulae for bars (including the "tangent-modulus" formula), simple plates and cylindrical shells.

Practical information:


Full Technical Report:

Students will have the option to submit a Full Technical Report.

Booklists

Please see the Booklist for Part IIA Courses [4] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [5].

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