GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2016-2017

Finite Element Analysis for Solids (E900524)

Course size *(nominal values; actual values may depend on programme)*

Credits 6.0 **Study time 180 h** **Contact hrs** 41.0 h

Course offerings in academic year 2017-2018

A (semester 1)

Lecturers in academic year 2017-2018

Pankaj, Pankaj	EDINBU lecturer-in-charge
Karamanos, Spyros	LUND01 co-lecturer

Offered in the following programmes in 2017-2018	crdts	offering
International Master of Science in Fire Safety Engineering	6	A

Teaching languages

English

Keywords

Numerical methods, solid mechanics, elasticity

Position of the course

The finite element method (FEM) (also called finite element analysis or FEA) originated from the need to solve complex problems in solid mechanics. FEM is used to obtain approximate numerical solutions to a variety of equations of calculus. Today it is used in a wide range of disciplines. This course is an introduction to FEA as applied to elasticity problems in solid and structural mechanics. The mathematical equations are developed using the virtual work basis of FEM and this is used to develop equations for one, two and three dimensional elements. As FEA is a computational tool this course includes practical exercises using the commercial package ABAQUS. A number of tutorials involving hand calculations are provided to aid understanding of the technique.

Contents

1. Introduction
Course outline; areas of application of the finite element (FE) method; examples of some problems for which FE analysis has been used.
2. FE terminology and steps
Introduction to FE terminology; steps of the analysis using an assumed displacement field approach for linear elastic analysis of structures.
3. Input to and Output from a FE program 1
Feeding a finite element program (ABAQUS) with geometric, physical and loading information.
4. Input to and Output from a FE program 2
Understanding and interpreting results from a FE program.
5. FE Modelling
Introduction to plane stress, plane strain, axisymmetric, and plate bending problems; degrees of freedom; stress-strain and strain-displacement relations.
6. Virtual Work Basis of Finite Element Method: 1
Definition of generic displacements, body forces, nodal displacements, and nodal actions; displacement shape functions with simple examples; relating generic displacements, strains, and stresses to nodal displacements.
7. Virtual Work Basis of Finite Element Method: 2
Derivation of FE equilibrium equations using the virtual work principle; examples of derivation of stiffness and equivalent load vector for a two node truss element.
8. Quadrilateral Elements 1
Normalised coordinates; shape functions for the bi-linear and quadratic elements; Isoparametric concept; examples
9. Quadrilateral Elements 2

Evaluation of element matrices; the Jacobian matrix; examples of specific cases.
10. Quadrilateral Elements 3
Numerical integration; examples of numerical evaluation of element matrices
11. Quadrilateral Elements 4
Examples of numerical and closed form evaluation of stiffness and load matrix terms
12. Triangular elements 1
Natural coordinates; shape functions of constant and linear strain triangular elements; isoparametric mapping; examples
13. Triangular elements 2
Evaluation of element matrices; the Jacobian matrix; examples of specific cases.
14. Triangular elements 3
Numerical integration; examples of numerical evaluation of element matrices
15. Beam elements 1
FE basis of Euler Bernoulli beam elements; FE matrices and shape functions
16. Beam elements 2
Strain-displacement and stress-strain relations for Euler Bernoulli beams; evaluation FE matrices; limitations; examples
17. Beam elements 3
FE basis of thick (Timoshenko) beam elements; shape functions
18. Beam elements 4
Generalised strain-displacement and generalised stress-strain relations; evaluation of FE matrices; reduced integration

Initial competences

None are assumed.

Final competences

1 Describe the analytical methods and procedures which the finite element programs use to analyse elastic solid structures.
2 Be able to use the computer based finite element methods to solve simple problems by hand calculations.
3 Identify and understand all the various matrix operations involved in the process.
4 Use computer programs to analyse elastic structures.
5 Present results in appropriate graphical formats, carry out checks to assess the correctness of the output, and interpret results properly.

Conditions for credit contract

This course unit cannot be taken via a credit contract

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Lecture

Extra information on the teaching methods

20 hours of lectures; 11 hours of seminars/tutorials; 10 hours of supervised practicals/workshops/studios; 2 hours of summative assessment; 2 hours of programme level learning and teaching; 55 hours of directed and independent learning.
Feedback will be available throughout the course by discussion with tutors and lecture staff.
Tutorials will also offer a route for formal, formative feedback.
Students will be given the opportunity to provide Stop, Start and Continue feedback and comments on this will be provided back by the course lecturer.
Exam Post-Mortem comments will be provided.

Learning materials and price

References

1 Cook, RD; Malkus, DS; Plesha, ME; Witt, RJ. Concepts and Applications of Finite Element Analysis, Wiley, 2002.
2 Zienkiewicz, OC; Taylor, RL. The Finite Element Method for Solid and Structural Mechanics, Butterworth-Heinemann, 2005.
3 Bathe, KJ. Finite Element Procedures, Prentice Hall, 1996.
4 Smith, IM; Griffiths, DV. Programming the Finite Element Method, Wiley, 2004.

Course content-related study coaching

Evaluation methods

end-of-term evaluation and continuous assessment

Examination methods in case of periodic evaluation during the first examination period

Written examination

Examination methods in case of periodic evaluation during the second examination period

Examination methods in case of permanent evaluation

Assignment, report

Possibilities of retake in case of permanent evaluation

examination during the second examination period is not possible

Extra information on the examination methods

The assessment will be made on the basis of:
Intermittent Assessment (40%)
Finite element project (ABAQUS)
Written Examination (60%)
The written examination will be 2 hours long with 2 compulsory questions.

Calculation of the examination mark

Written Exam 60 %, Coursework 40 %