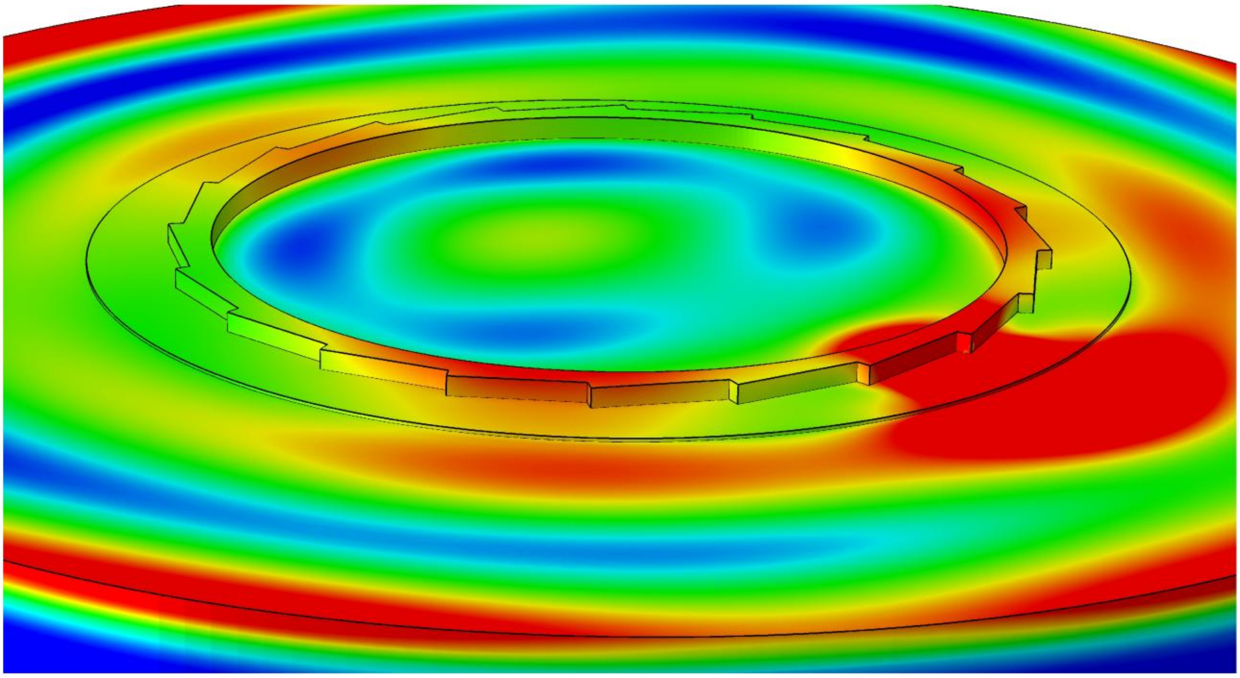
STRUCTURAL DYNAMIC COMPUTING

VSMN10



Course program 2020

Structural dynamic computing - VSMN10 - 7.5hp

General

In the course various structural dynamic models are formulated. Analytical and numerical methods to analyze structures affected by dynamic loads are treated, especially using the finite element method.

Two conceptual project tasks are included in the course based on real designs. Physical properties and dynamic behavior are determined, and shall then be verified by calculations. The basis for a synthesis between real structures, structural dynamics models and mathematical descriptions is created by the acquired experimental data. It is also required that the differences between the real behavior and the computed solution can be explained. The project problems yield more than one solution and in fact more than one answer. The aim is to strengthen the capacity to make decisions based on different assumption.

Grading in the course is based on project reports and oral presentation of the solution procedure as compared with fellow course attendants. In this way you learn to evaluate different decisions in relation to the project tasks. Some homework problems and a theory exam also affect the grade given.

Overview

The course includes

- theory lectures
- 5 homework assignments submitted for marking
- a lecture on measurement techniques
- lectures and exercises on Abaqus
- a theory exam with short math problems and also descriptive questions
- a guest lecture on PhD projects and/or from industry/companies
- two project tasks, the first presented only in writing and the second with both written and oral presentation

Theory contents

The theoretical content is mainly defined by the literature (Chopra “Reading instructions” see below) which contains about 400 pages (3:d ed.). The lectures deal with the central parts of the material that broadly covers

- One degree of freedom models.
- Multi degree of freedom models, finite elements, direct integration, modal synthesis, eigenvalue analysis.
- Generalized one degree of freedom models and reduction methods
- Time Integration; implicit method, explicit method, and Newmark family methods.
- Earthquake load and analysis, vibration dampers, and shock absorbers.

Theory Lectures

A series of lectures dealing with the items above define the focus of the theoretical content. See also under "Preliminary content of theory lectures" below.

Lectures on measurements and on a commercial FE-program

A lecture provides an introduction to measurement techniques for sound and vibration. And as an introduction to Project 2 there is also some lectures on a general commercial FE program - Abaqus. These lectures also include hands-on exercises.

Guest Lecture

A guest lecture is planned to be given by an invited speaker from industry / company. Alternatively a PhD-project will be presented.

Homework

Five homework assignments are handed out during the first course weeks. They are handed out in connection to the lectures and should be submitted for correction and shall be carried out individually.

Project tasks

Two project tasks involving experimental data comparison are a major part of the course. The project assignments are carried out in groups of three (alternatively two) students. New groups can be formed after the first project.

Project 1 addresses a multi storey frame studied with analytical methods and the FE software CALFEM. Project 1 is reported only in writing in a report that describes the experiments and the comparative analysis. The report is scored.

Project 2 concerns a bridge like structure and is connected to analysis in Abaqus. It should be presented both orally and in writing. The report describes test results and computations. Both the report and the oral presentation are scored. Project 2 is assessed during the presentation by another group and evaluated in relation to other reports and presentations.

Time and place for the activities concerning the projects is communicated during the course. See also "Assessment" below.

Theory exam

The Theory exam consists of short math problems and also descriptive questions giving 20 points. It is given after the lecture series in the last course week. The requirement to pass the exam and the course is 7p. An extra Theory exam on nominally 20 points will be given if you do not pass and you also need 7 points in order to pass this extra exam. But you may only count a maximum of 10 points on the extra exam to add to the points you have collected throughout the course.

Assessment

Rating is based on:

- Submitted homework max 5 points
- Report on Project 1 max 15 points
- Theory exam max 20 points
- Report and oral presentation of Project 2 max 20 points

The final grade is calculated as:

- 30-39 points: grade 3
- 40-49 points: grade 4
- 50-60 points: grade 5

Completion of assignments, theory exam, and project reports/presentations are required to pass the course. Unapproved submissions shall be presented at a time determined in consultation with the teachers.

Activities, deadlines, and submissions:

- Homework assignments will be distributed at the theory lectures, with submission as described above to Peter Persson by mail as *one* PDF document.
- Laboratory work/demo for Project 1 and 2 shall be booked in advance on booking lists.
- Project 1 is introduced 31/1 and ends with report submission 17/2 at 12.00 by mail to Per-Erik Austrell as *one* PDF document.
- Project 2 is introduced 18/2 and the report should be submitted 12/3 at 12.00 by mail to Per-Erik Austrell as *one* PDF document. Oral presentations will be booked in the exam week. One or two reports from other groups will be sent out to each group for comments and ranking. The evaluations should be submitted 16/3 at 12.00.

Teachers and responsibility:

Per-Erik Austrell	046-222 4798	pea@byggmek.lth.se
Jens Malmborg		jens.malmborg@construction.lth.se
Kent Persson	046-222 8152	kent.persson@construction.lth.se
Peter Persson	046-222 8353	peter.persson@construction.lth.se

Responsibilities; different teachers:

- Per-Erik Austrell - Course coordinator, theory lectures, and examination
- Jens Malmborg - Laboratory and consulting on Abaqus Project 1 & 2
- Kent Persson - Abaqus finite element task and examination Project 2
- Peter Persson – Homework and examination Project 1 & 2

Website:

www.byggmek.lth.se/utbildning/kurser/valfria

Activities day by day:

Cal. week	Date	Day	Time	Place	Activity
4	21/1	Tuesd.	10-12	V: S2	Introductory/Theory Lecture 1
	23/1	Thursd.	13-15	V: S1	Theory Lecture 2-3
	24/1	Friday	10-12	V: R2	Theory Lecture 4-5
5	27/1	Monday	12.00		Submission of Homework 1
	28/1	Tuesd.	10-12	V:S2	Theory lecture 6-7
	30/1	Thursd.	13-15	V: P2	Theory lecture 8-9
	31/1	Friday	10-12	V:Q1	Lecture Exp. techn. and Intro Project 1
6	3/2	Monday	12.00		Submission of Homework 2
	4/2	Tuesd.	10-12	V: S2	Theory lecture 10-11
	6/2	Thursd..	13-15	V: S2	Theory lecture 12-13
	7/2	Friday	10.00		Submission of Homework 3 (at 10.00)
			10-12	V: R2	Theory lecture 14-15
7	10/2	Mond.	12.00		Submission of Homework 4
	12/2	Wedn.	08-10	V: S2	Theory lecture 16-17 *)
			12.00		Submission of Homework 5
	13/2	Thursd.	13-15	V: S2	Theory lecture 18-19
	14/2	Friday	10-12	V: R2	Theory lecture 20-21
8	17/2	Monday	12.00		Submission of Project 1 report
	18/2	Tuesd.	10-12	V: S2	Lecture on Abaqus and Intro Project 2
	20/2	Thursd.	13-15	V: Dalab 11 o 12	Exercise on Abaqus
	21/2	Friday	10-12	V: Dalab 11 o 12	Project 2 start exercise Abaqus
9	25/2	Tuesd.	10-12	V: S2	Project 1 seminar
	27/2	Thursd.	13-15	V: S2	Guest Lecture
	28/2	Friday	10-12	V: N1	Theory lecture 22-23
10	3/3	Tuesd.	10-12	V:S2	Theory lecture 24-25
	5/3	Thursd.	13-15	V:S2	Exam preparation; solutions to exam questions
	6/3	Friday	10-12	V: R1 o R2	Theory exam
11	10/3	Tuesd.	10-12	V: S2	Theory exam discussion & booking of oral pres.
	12/3	Thursd.	12.00		Submission of Project 2 report
Exam-Week	16/3	Mond.	12.00		Submission of Project 2 evaluations
	17/3	Tuesd.	10-12, 14-16	V: BM konf. 5:e	Oral presentation of Project 2
	18/3	Wedn.	10-12, 14-16	V: BM konf. 5:e	Oral presentation of Project 2

*) “Branschdag V” on Tuesday 11/2

Preliminary contents theory lectures

The basic theory on linear dynamics is presented at the beginning of the course in a series of lectures. The home work hand in exercises are strongly linked to the first lectures. Following lectures are more specialized according to the contents below. The approximate end of lectures according to the time schedule are also marked.

A. SDOF systems no damping

- SDOF systems - equation of motion
- Free vibrations *- \ end TL1*
- Forced harmonic vibration
- Dynamic response factor *- \ end TL2*

B. SDOF systems damping included

- Various damping and hysteresis in harmonic loading
- Equation of motion – standard form *- \ end TL3*
- Free vibrations - damped systems *- \ end TL4*
- Forced harmonic vibration with damping
- Complex representation - damped systems
- Dynamic response factor
- Introduction to time stepping methods *- \ end TL5*

C. MDOF systems and solutions

- MDOF- systems - equations of motion *~ \ end TL6*
- Free vibrations; frequencies and mode vectors
- Harmonic force excitation, direct steady state solution *~ \ end TL7*
- Time stepping methods a simple procedure *~ \ end TL8*
- CALFEM functions for dynamic analysis *~ \ end TL9*

D. MDOF systems: Modal decomposition

- Natural frequencies and mode vectors *- \ end TL10*
- Modal expansion in natural modes and modal coordinates
- Free vibration response
- Transformation to uncoupled equations *- \ end TL11*
- Free vibrations in damped systems *- \ end TL12*
- Forced harmonic vibrations and modal analysis
- Construction of damping matrices *~ \ end TL13*

E. Continuous systems and FEM

- Distributed mass and elasticity - analytical solutions *- \ end TL14*
- FE formulation of linear dynamics
- Example; use of CALFEM in dynamic analysis
- Dynamics of beams *- \ end TL15*

F. Reduction methods for dynamic systems

- Static condensation *- \ end TL16*
- Modal truncation
- Generalized SDOF systems *- \ end TL17*
- Use of Ritz vectors *~ \ end TL18*

G. Solution procedures for SDOF and MDOF systems

- Fourier series solutions
- Duhamel's integral *- \ end TL19*
- Numerical solution with time stepping- SDOF
- Time stepping - MDOF systems *- \ end TL21*

H. Special applications

- Vibration isolation, damping, and transmissibility *~ \ end TL22*
- Earthquake load and response *- \ end TL23*
- Pulse load and response *- \ end TL24*
- Shock absorbers
- Dynamic properties of rubber materials *- \ end TL25*

Literature:

- Chopra, A. K.: Dynamics of Structures, Prentice Hall, 1995
- CALFEM version 3.4 – A finite element toolbox to MATLAB. Lund, 1999.

Other interesting literature:

- Mechanical Vibrations, Prentice Hall (2005) by Rao S.S.
- Dynamics of structures, McGraw-Hill, by Clough R. W. & Penzien J.

Reading instructions:

Theory in the course is defined by the Lecture notes and by chapters and sections from Chopra A. K., *Dynamics of Structures* as given below. Major parts are covered by the theory lectures. However, not all can be covered by the lectures.

Moreover, the FE-formulation and parts of the "Special applications" section (see "Preliminary contents theory lectures" below) are only given in the Lecture notes.

Chapters and sections included in the course referring to the third and fourth edition are listed below. The chapter numbers given in parentheses refers to the fourth edition.

Chapter	Section	
		Single-degree-of-freedom systems, SDOF-systems
1	1-11	Introduction
2	1-3	Free vibrations
3	1-8, 12-13	Response to harmonic and periodic excitation
4	1-12	Response to different step- and pulse loads
5	1-5	Overview of time integration procedures in structural dynamics
6	1-9	Various aspects of earthquake analysis
8	1-6	Generalized SDOF-systems, assumed deflection
		Multi-degree-of-freedom systems, MDOF-systems
9	1-4, 11	Formulation of MDOF-system
10	1-10	Free vibrations of MDOF-systems
11	1-4	Notes on the formulation of damping
12	1-11	Dynamic analysis and response of linear MDOF-systems
14(15)	1-5	Reduction of degrees-of freedom
15(16)	1-2	Overview of time integration procedures
16(17)	1-5	Analysis of systems with distributed flexibility and mass - continuous systems