Project 1 – Identifying natural frequencies and modal behaviour

Structural Dynamic Computing 2017

This assignment is divided into two parts. The first part concerns a three degree of freedom mass-spring system under forced vibration. The second part concerns a six-storey frame and its low frequency structural vibrations. You are to take measurements and establish models of the two systems that can be compared to the experimental data. Each group will be able to book a two-hour session for conducting the measurements.

Part 1:

Figure 1a shows a set of three small carts with weights connected via four springs. The left cart is attached with a spring to a large mass and the cart to the right is connected to an electro-mechanical shaker with spring in between. An idealization of the system can be seen in Figure 1b.

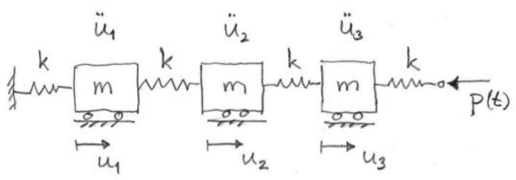

Figure 1.a: *Mass-spring system.* ***b:*** *idealization of the mass-spring system.*

Missing in Figure 1a are the accelerometers used to measure the acceleration of the individual carts and the force transducer between the rightmost spring and the actuating rod (stinger) transferring the force from the shaker to the system of springs and masses.

Your task is to measure the accelerations in the carts during a frequency sweep. Apart from accelerations you will also measure the force input. You are then expected to create a model of the system and simulate the behaviour you measured.

Part 2:

This part of the assignment concerns a six-storey frame (shown in the photo below) and its low frequency structural vibrations. It is an idealized scaled model of a so called Shear-building. It consists of seven wooden plates connected by four steel strips.

The project concerns natural frequencies and mode shapes. The modal properties are investigated using harmonic base excitation. You are supposed to take measurements and establish a model that can be compared to the experimental data.

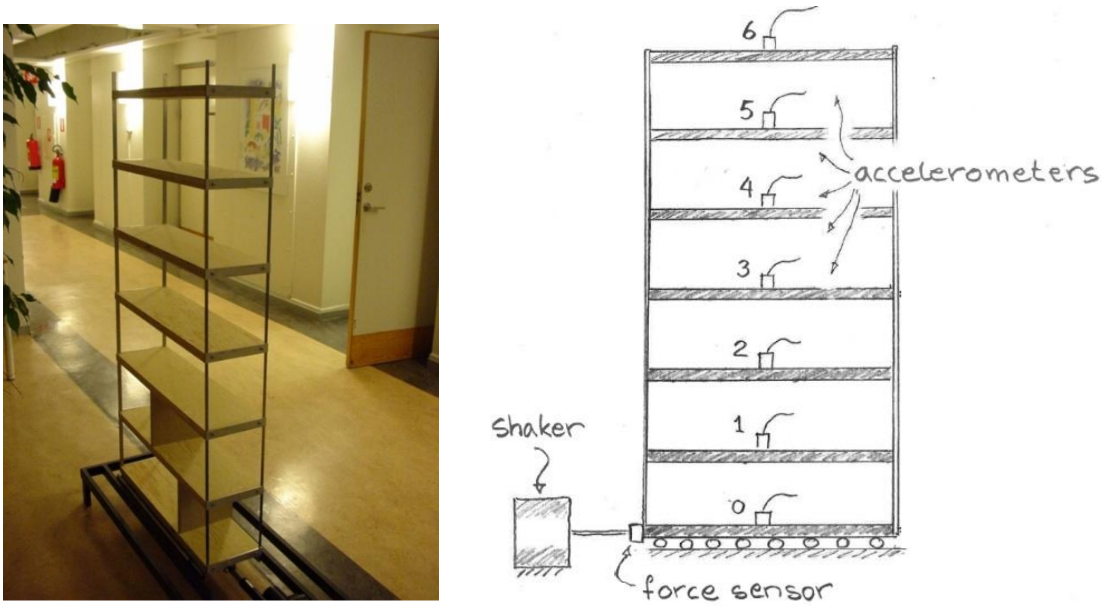

Figure 2. A shear building and its idealized representation.

The experimental set up is according to the schematic figure above. A shaker puts the base into horizontal harmonic motion. Accelerometers are put on all seven wooden plates. You can vary the frequency of the base excitation and you can also change the amplitude.

The model used is the idealized Shear-building model discussed in the theory lectures.

Laboratory tasks:

You need to store some data for comparison with the models. Bring your own USB-stick for this purpose. Data from all accelerometers and the force sensor can be logged as functions of time and stored in an ordinary text-file. Data from the force sensor (f), and the accelerometers (a) are organized in columns with time values:

	f	a_0	a_1	
t_1				….
t_2				….
etc				….

Before making the measurements, try to think through what data you will need for establishing the models and for comparing them with the test results.

Part 1

- Determine the mass of the weights and carts. Each mass has its weight written on it.
- Determine the natural frequencies of the system that are visible. The experimental mode shapes need not be determined.
- The stiffness of the springs are determined by the resonance frequencies.
- Measure the horizontal accelerations of the carts and the force input when the system is subjected to a frequency sweep around a resonance.

Part 2

- Determine mass and stiffness properties of the frame. Measure the dimensions accurately. The weight of the wooden pieces need not be determined. The mass of each plate is 2.24 kg.
- Let the frame be subjected to a transient. From a FFT-analysis of the time signals from the accelerometers it is possible to approximately locate the resonance frequencies. This is useful in the next task.
- Measure horizontal accelerations on the "floors" when the frame is subjected to harmonic ground excitation. Find and determine the resonance frequencies and the corresponding mode shapes. Plot the mode shapes from the experimental data. Determine as many resonances you can experimentally for steady state behaviour of the frame.

Modelling tasks

In this part you will create models of the systems you have been measuring. You will simulate the systems and compare the simulations with the measured data.

Part1:

- Establish an analytic model of the mass-spring system.
- Calculate the natural frequencies of the system using measured stiffness and mass. If required, change the stiffness to tune the model to the measured data.
- Use the Calfem function **`step2`** to simulate the movement of the system, with the measured force as input to the function for the sweep around a resonance (as messured above). You need to add a damping matrix to the system.
- Compare your model behaviour with measurements around the peak chosen in the experimental frequency sweep. Adjust the damping to get as close to the measured values as possible.

Part2:

- Establish a shear-building model (with the wooden plates considered as rigid masses) and find the resonance frequencies and the mode shapes by an eigenvalue analysis.
- Compare the model with your experimental data and identify as many resonances and mode shapes you can.

Report

Document your findings in a written report that clearly shows your assumptions, measurements, model features and results. Try to keep it short and concise without leaving out essential information. Make sure that a qualified reader (i.e. with basic knowledge in structural dynamics) can understand. Don't spend too much text on basic theory. It is assumed knowledge. Focus on your results and how you obtained them.

The report should have:

- Cover page with the names of the group members
- Table of contents
- Introduction/problem description
- Measurements description
- Short paragraph about modelling and analysis
- Results discussion
- Appendix with code measured data etc.

It should not exceed 12 pages (Appendix excluded). Text references are (at least) the Lecture notes and the CALFEM manual.

To be handed in according to the course programme.