TECHNICAL UNIVERSITY OF CLUJ-NAPOCA ROMANIA

Experimental Modal Analysis

Author: Dr. Mihai Nedelcu, Lecturer

Laboratory

„ Actions in Buildings and Structures", Department of Structural Mechanics

Faculty of Civil Engineering

Address: Str. C. Daicoviciu Nr. 15, Cluj-Napoca

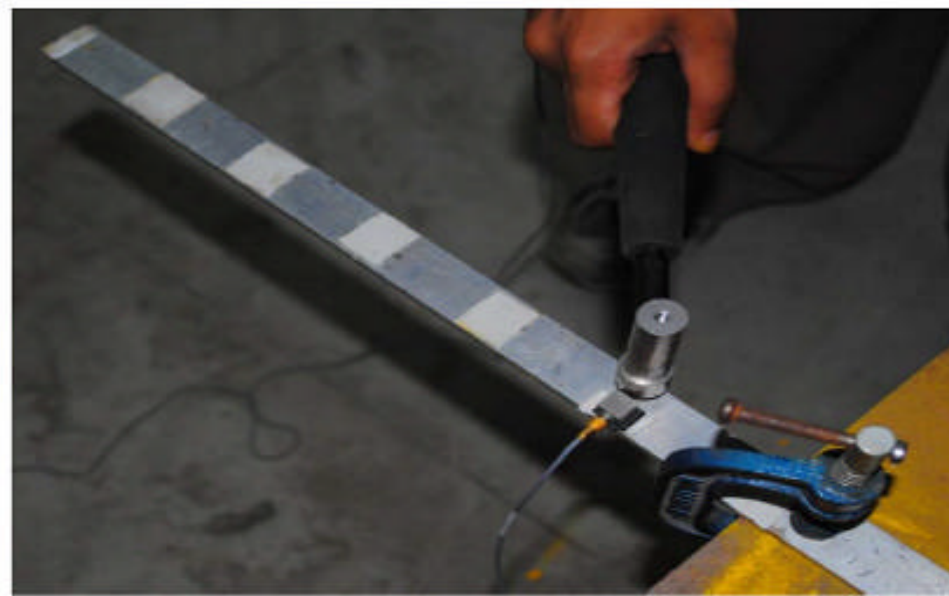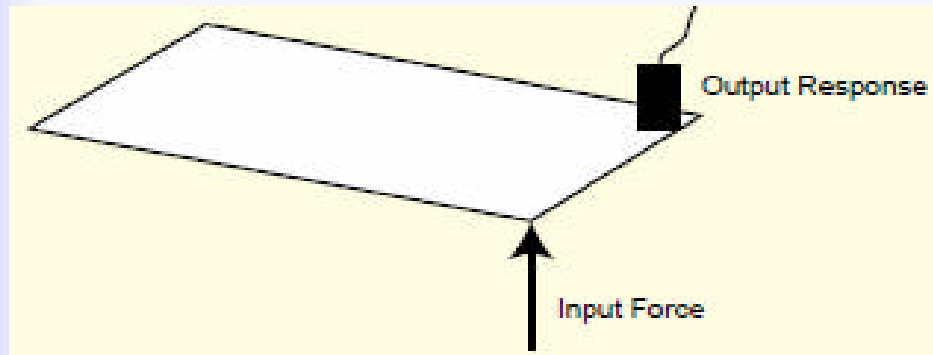# Experimental Modal Analysis

- describes the structure in terms of its *dynamic properties* :

➢ natural frequencies

➢ modal shapes

➢ damping coefficients

Applications

✓ Optimisation of structure's dynamic characteristics (mass, stiffness, damping)

✓ Risk assessment of having the resonance phenomenon

✓ Prediction of dynamic behaviour

✓ Evaluating the damping for inclusion in FE models

✓ Correlation of FE models with real structures

✓ Damage detection and assessment

✓ Long term building monitoring

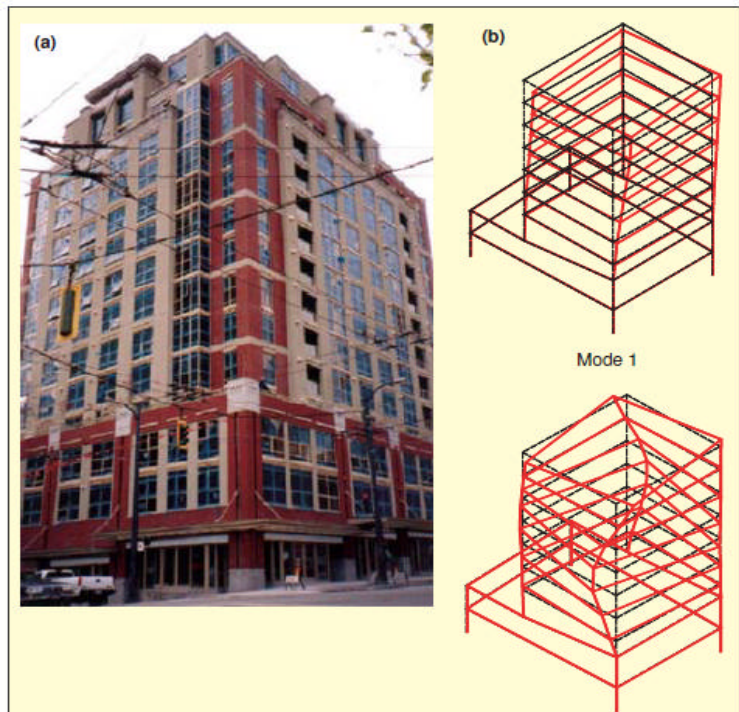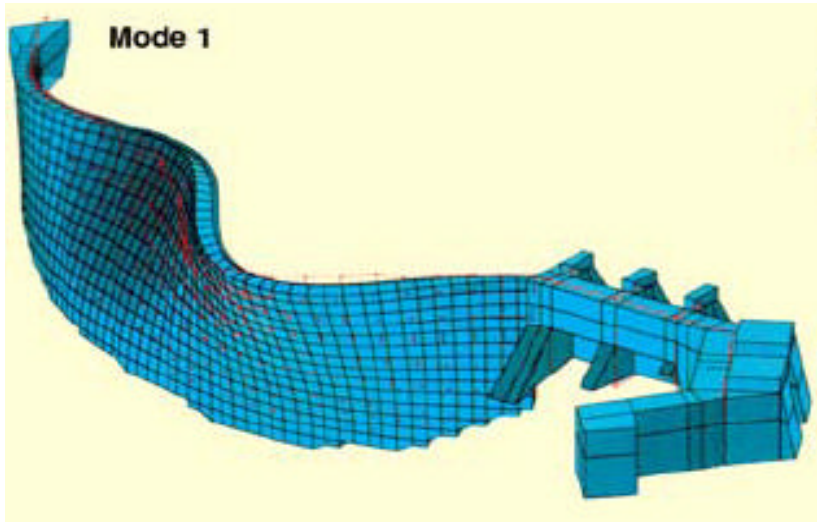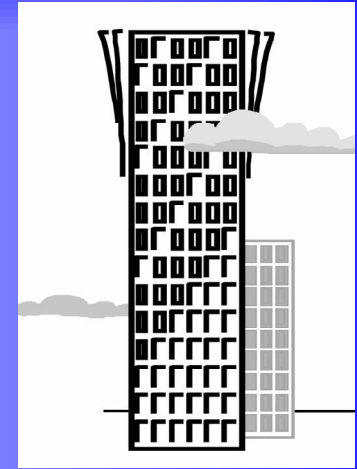# Experimental Modal Analysis

- ## Classical (Input - Output)

a) Impulse hammer; b) eccentric mass vibrator;
c) electrodynamic shaker over three load cells;
d) impulse excitation device for bridges
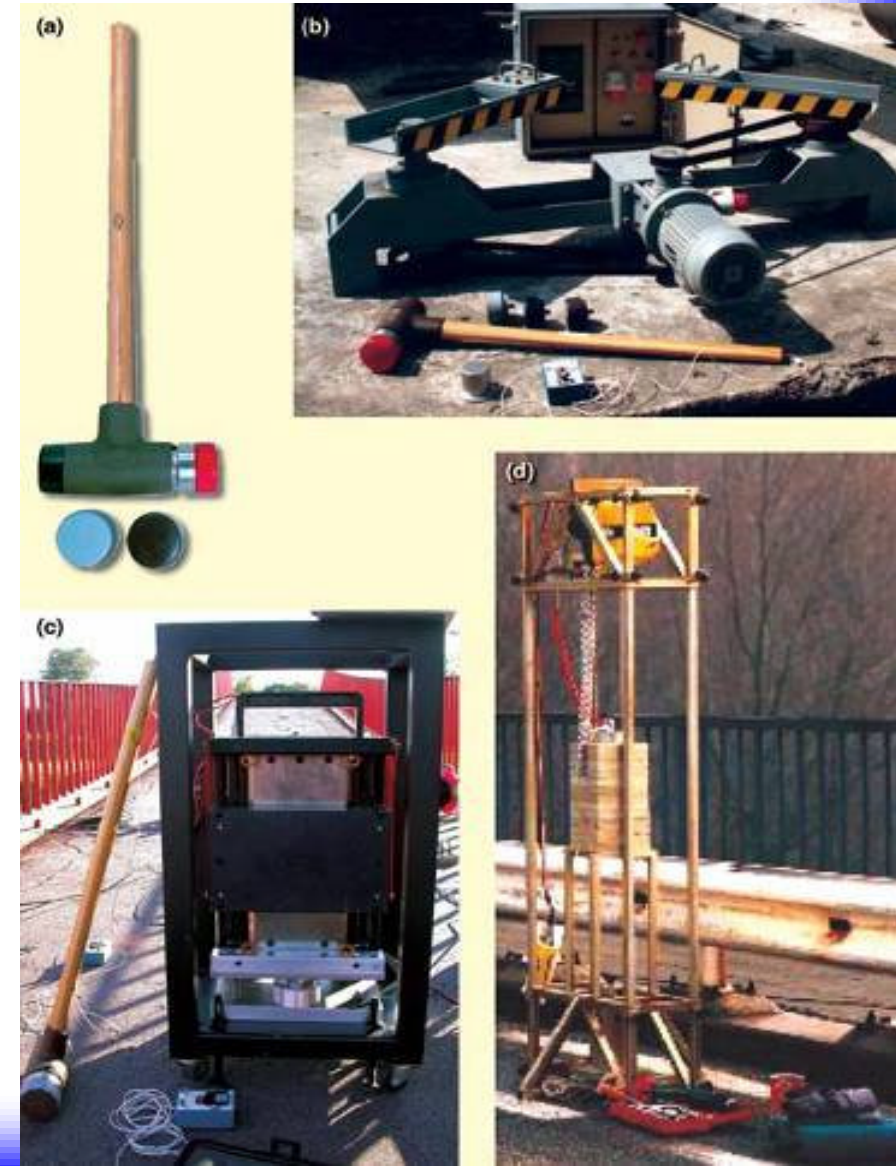
Experimental Modal Analysis

- ## Operational (Output - only)

Laboratory equipment - Bruel&Kjaer

- **Portable Vibration Data Acquisition System**

- **Calibration system**

- **Piezoelectric and seismic accelerometers**
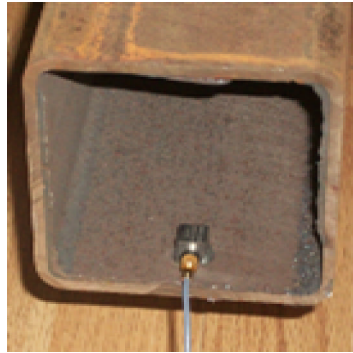

- **Cables**
- **Accessories**
- **Software Pulse v.12**

   Me'scope v.5

- **Impact hammer**

Classical Modal Analysis (Input - output)

Analysed element

- steel square pipe 100x5, L=2.2m, S235

- fixed accelerometer at one end

- 2 elastic supports

Classical Modal Analysis (Input - output)
Project definition

Classical Modal Analysis (Input-output)
Measurements
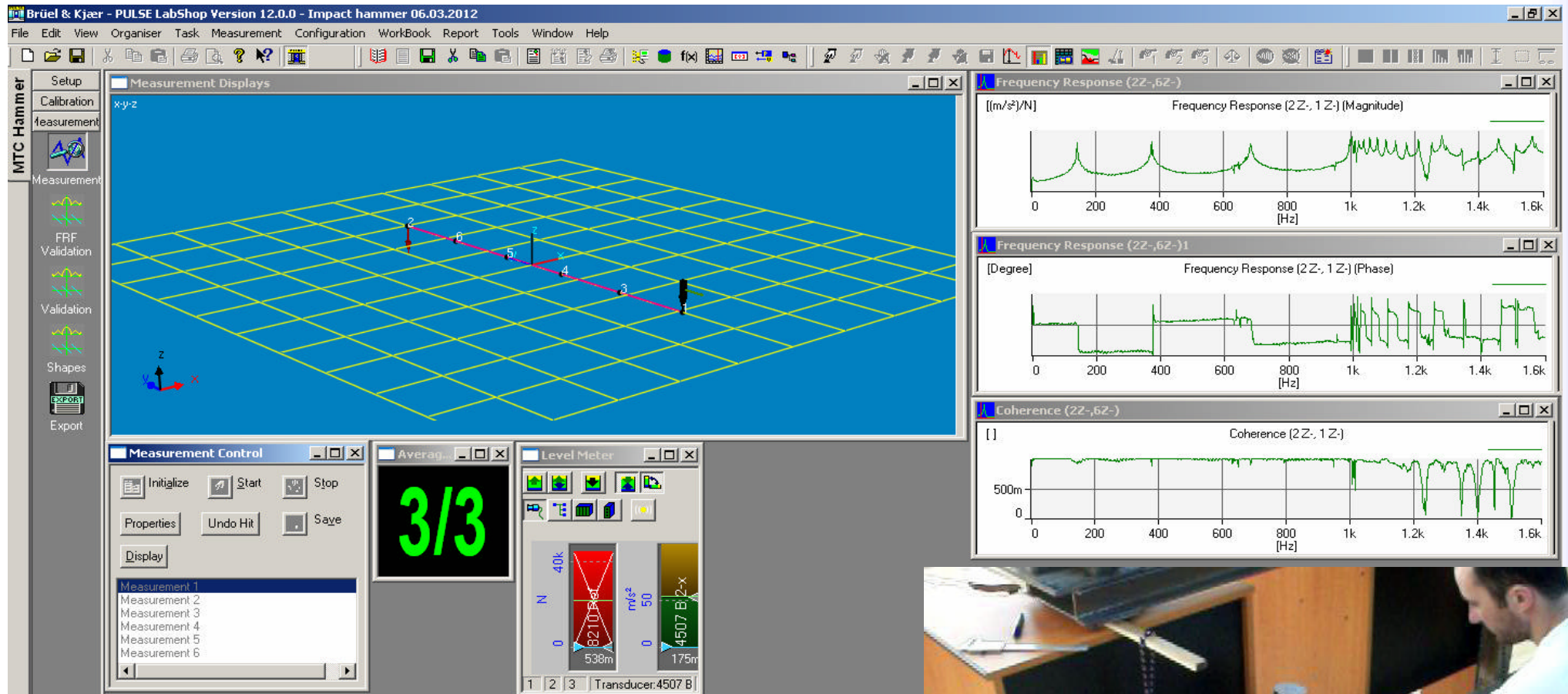
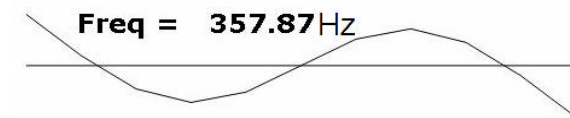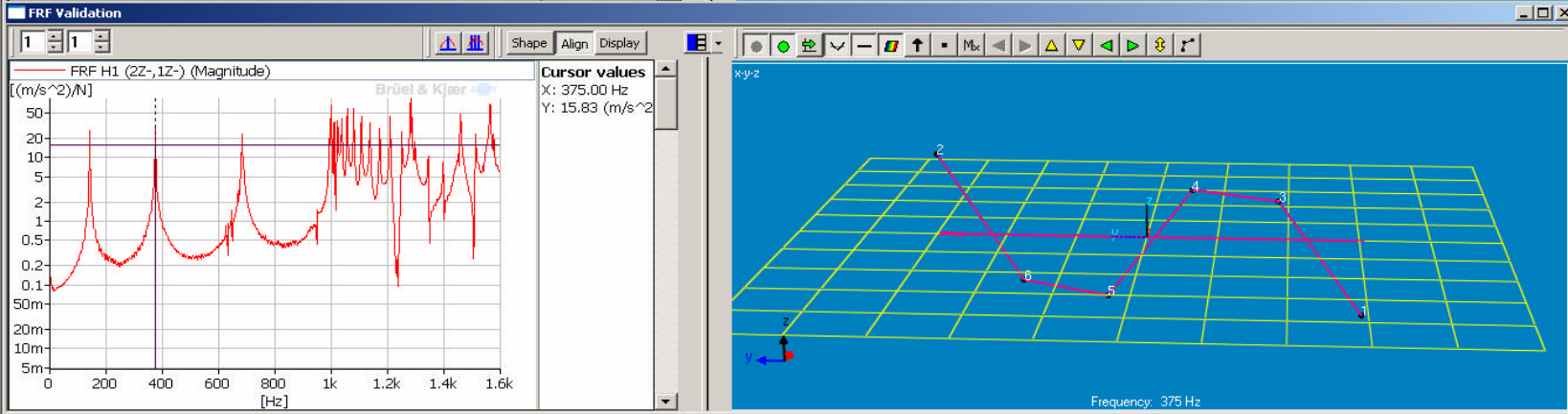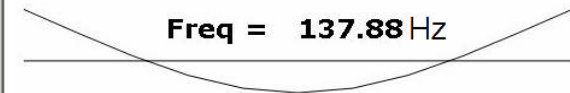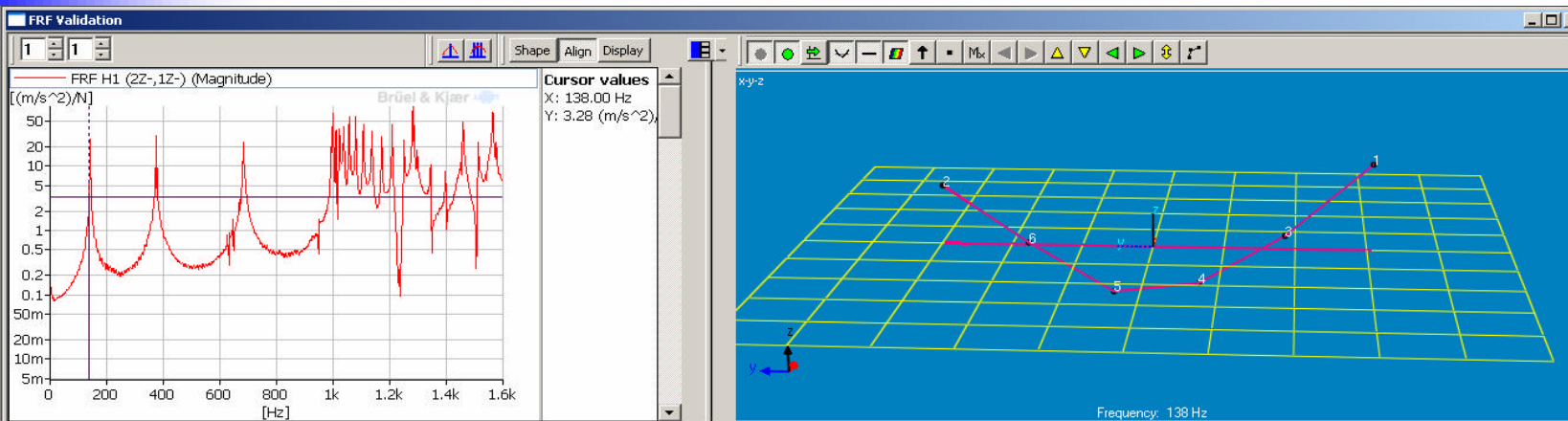**The excitation was introduced on a mesh of 6 points along the bar length. Three measurements were made for each point.**

Classical Modal Analysis (Input - output)
Comparing Results (Experiment vs. FEA)

Freq = 137.88 Hz

Freq = 357.87 Hz

Freq = 650.98 Hz
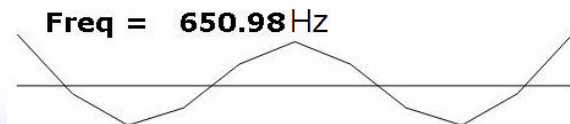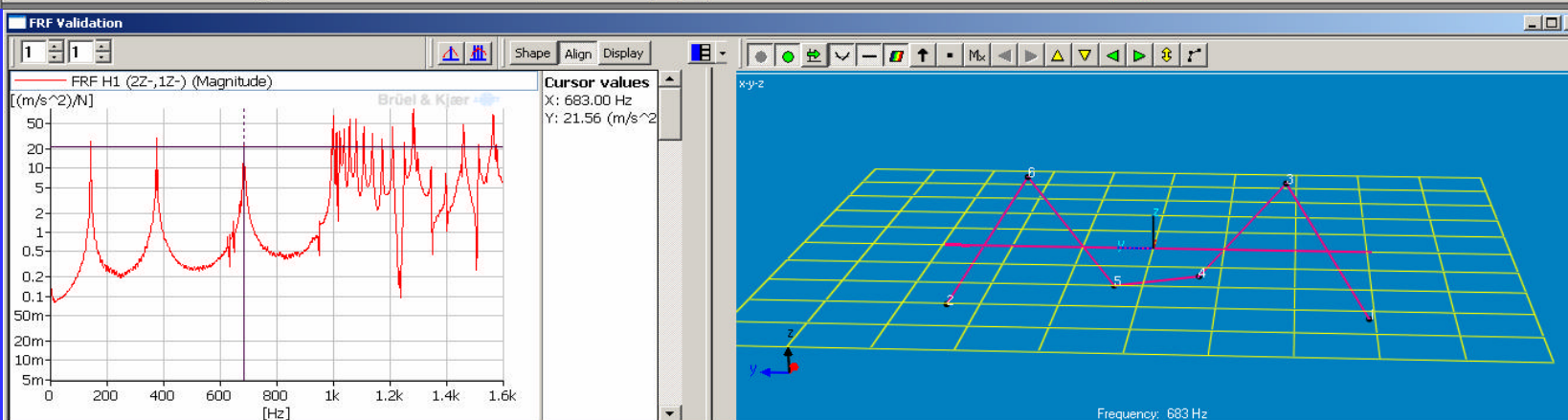
Conclusions

- good agreement between the results of the two analyses experimental and FE) in the frequency range 0-1kHz

- over 1kHz – poor identification of the vibration modes, the measurements displayed poor coherence, probably because of the too large impact hammer

Future research directions

- Analysis of hollow core slabs

- Analysis of any flexible structure small enough to be excited with our impact hammer

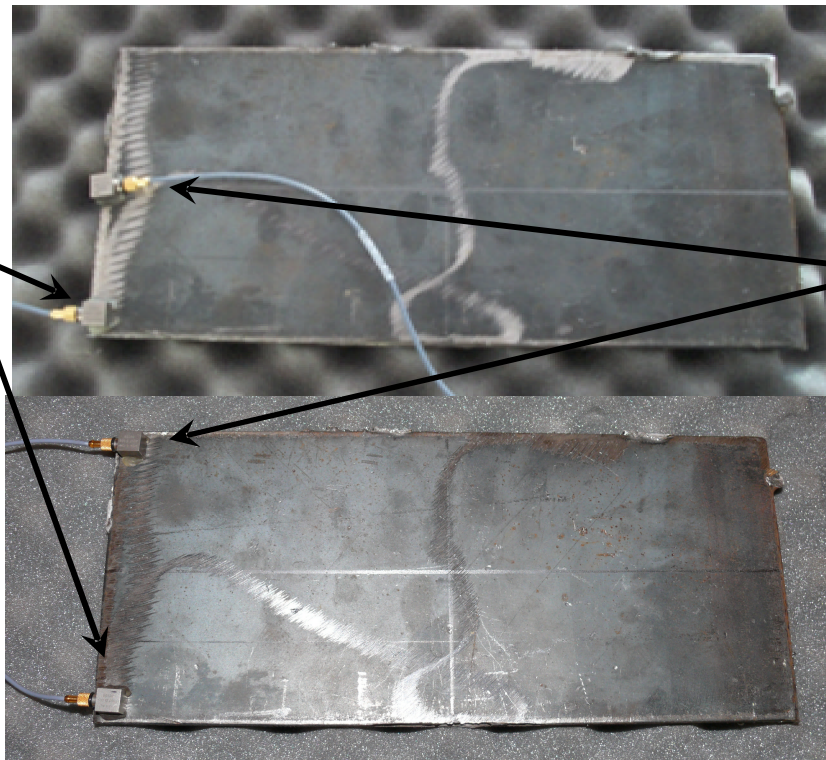# Operational Modal Analysis (Output - only)

Analysed element

- steel plate 300x180x10, S235

- two accelerometers:

  1) reference - fixed

  2) roving

- elastic supports

Measurements were made on a rectangular grid of 9 points.

Operational Modal Analysis (Output - only)
Project definition

Operational Modal Analysis (Output - only)
Measurements
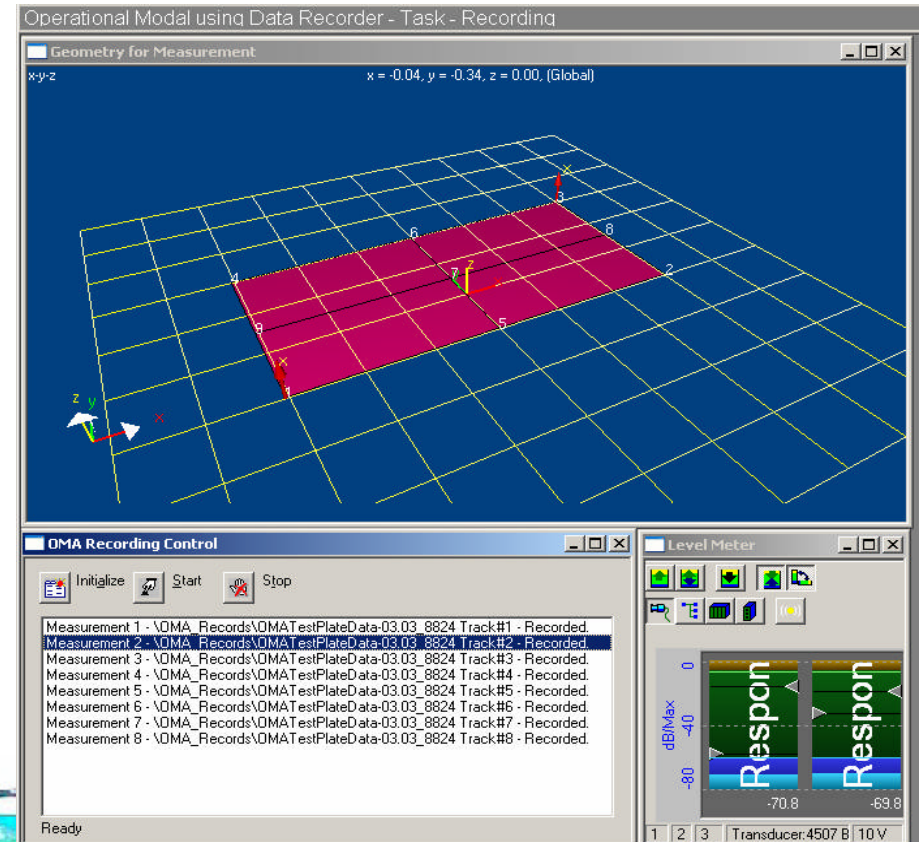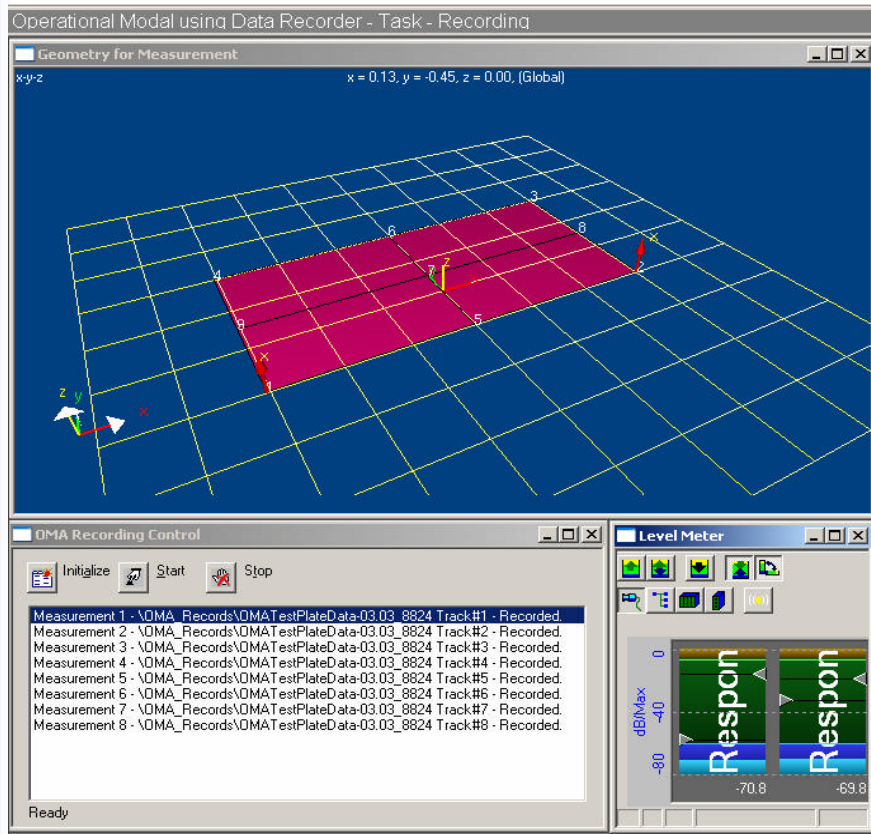
The plate was excited only by random tapping.
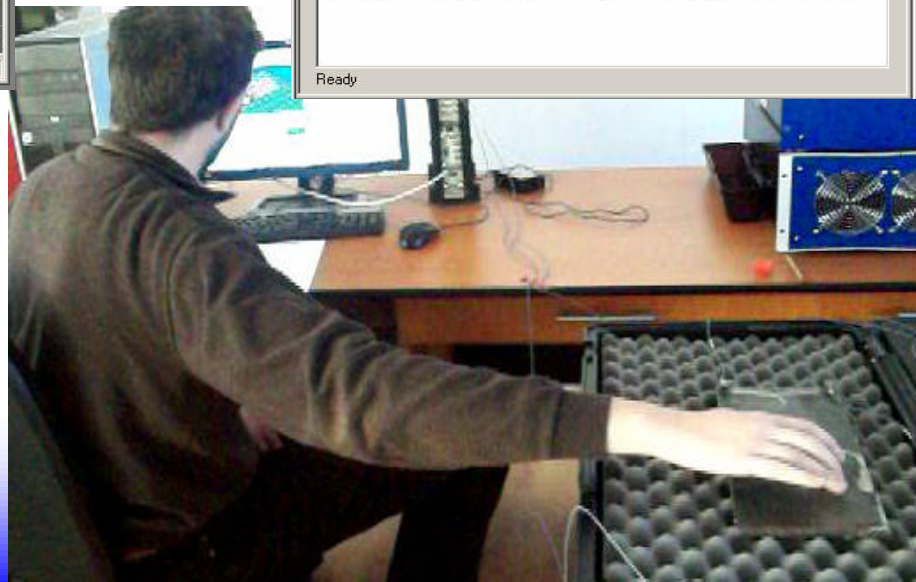
Operational Modal Analysis (Output - only)
Comparing Results (Experiment vs. FEA)

Frequency=594Hz

Freq =   679.69Hz

Frequency=784Hz

Freq =   840.29Hz

Frequency=1692Hz

Freq =   1836.3Hz
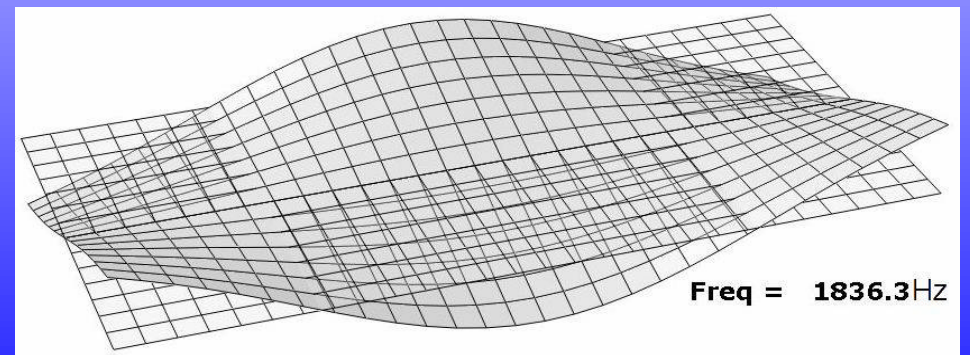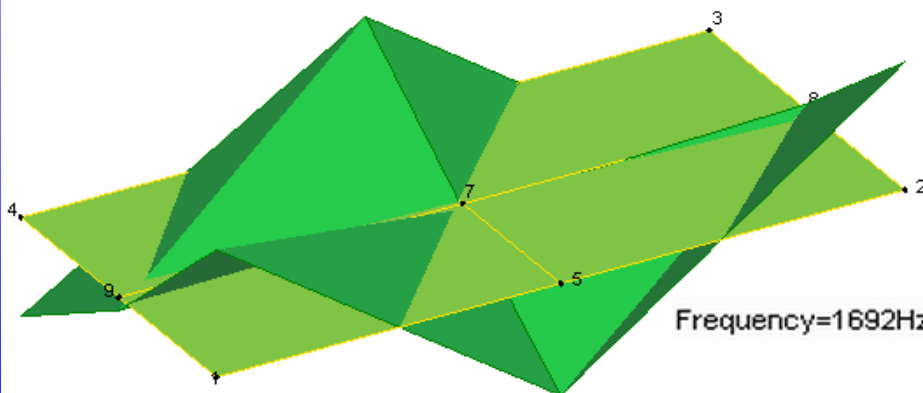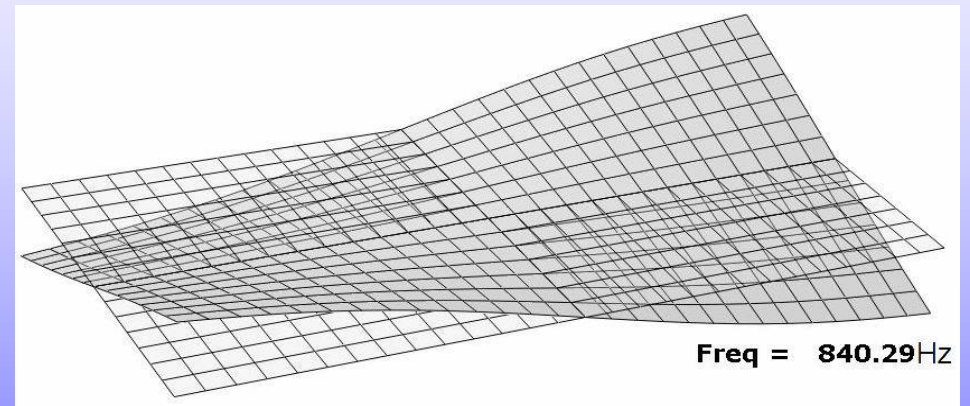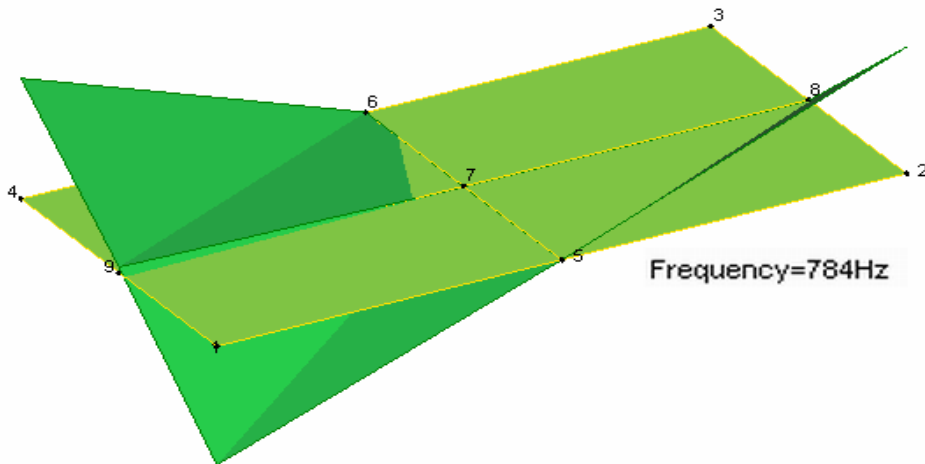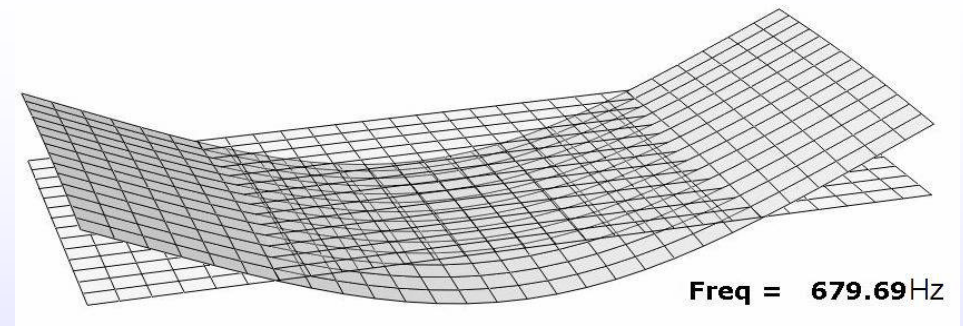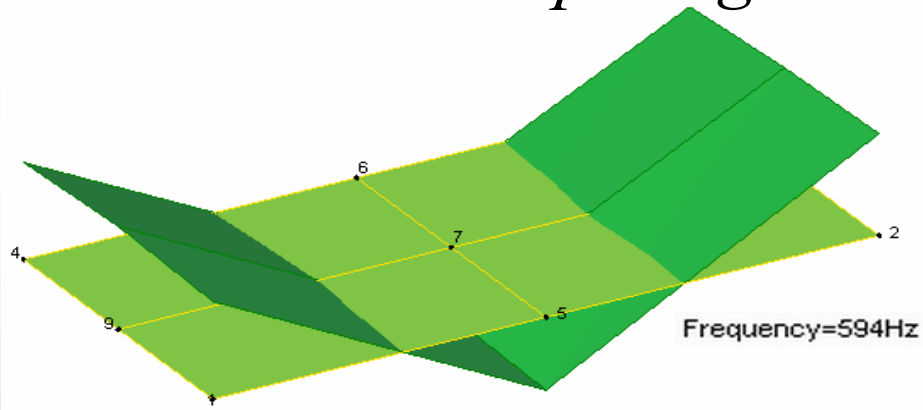
Conclusions

- Generally, good agreement between the results of the two analyses (experimental and FE). The differences are explained by the significant imperfections of the steel plate (weldings, cuts etc).

- ***Experimental Analysis provides the real results!***

Future research directions

- Analysis of any flexible structure (buildings, bridges, railways, etc.)

Experimental Modal Analysis

Teaching/Research activity

• Experiments presentation on internet and at teaching courses

• Students can model and test small-scale structures

• Research activity for Ph.D. students

• Research activity for M.S. students

Experimental Modal Analysis

Technical studies and valuations

- analysis of dynamic properties of structural systems

- experimental support for structural consolidation projects

- experimental assessment of traffic induced vibrations

- long term monitoring of dynamic structural behaviour

References:
1. Cunha, A. & Caetano, E. (2006) "Experimental Modal Analysis of Civil Engineering Structures", Sound and Vibration, Vol. 6, No. 40, pp.12-20
2. Bruel&Kjaer - http://www.bksv.com
3. Shibabrat Naik, Wrik Mallik "Experimental modal testing for estimating the dynamic properties of a cantilever beam" - http://fosetonline.org/Thought/CA-77.pdf