

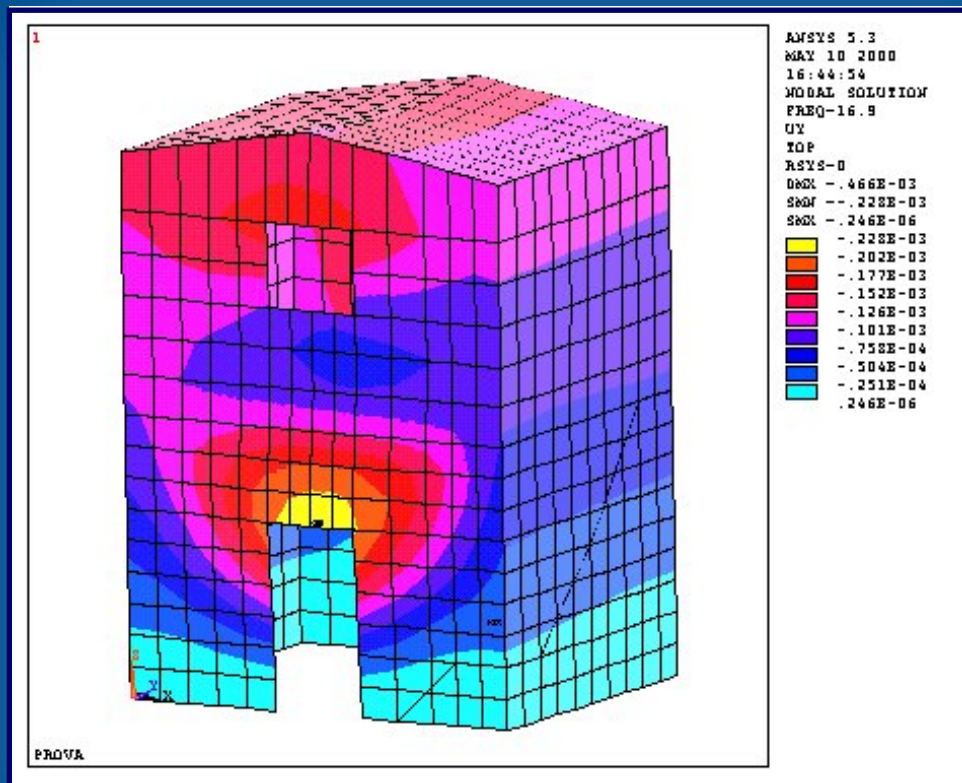
M2

EMMEDUE

Advanced
Building
System

Supplementary numerical report of the experimental tests

Emmedue building system



RITAM

ISRIM-UNIVERSITY OF PERUGIA CSM

RITAM

ISRIM – UNIVERSITY OF PERUGIA – CSM

*Research and Technology Laboratory
For Aseismic systems, structures and Materials*

**SUPPLEMENTARY NUMERICAL REPORT
OF THE EXPERIMENTAL TESTS
ON THE EMMEDUE
CONSTRUCTION SYSTEM**

Perugia, 13th of July 2000

The experimenters

Professor Engineer Antonio Borri

Professor Engineer Andrea Vignoli

Doctor Engineer Emanuela Speranzini

TABLE OF CONTENTS

1.	INTERPRETATION OF PROTOTYPE TESTS RESULTS	3
2.	PROTOTYPE NUMERICAL MODELLING AND CALIBRATION OF THE MECHANICAL CHARACTERISTICS OF THE STRUCTURAL ELEMENTS	21
3.	EXAMPLES OF ASSEMBLING	83

1. Interpretation of prototype tests results

This is to continue the considerations of the final part of the “Dynamic tests on the EMTWO construction system” report dated 04.02.2000, supplemented by further documents allowing to identify natural frequencies of the prototype.

1.1 Data structure and tools position

The test data are stored in ASCII files and, after seven introductory describing the data general characteristics, organized in eight columns the first of which contains the axis of times and the other seven contain the accelerometer reading.

Data have been sampled at the same time at a frequency of 500 Hz.

Data concerning four different forced tests have been examined; as for the first two tests, the mechanical exciter supplied sinusoidal excitation in north-south direction, while, as for the other two tests, the mechanical exciter excited the structure in East-West direction.

As already known, two structure levels have been instrumented: the first floor level (level 1) and the roofing level (level 2) which turns out to be instrumented at slightly different heights according to the positioning of the elevations, and more precisely at the ridge as for the North/South elevations and at the roof projecting edge line as for the East/West elevations.

The positions of accelerometers change from test to test according to the diagrams shown both in the test description report and here below to allow relevant reading.

Data have undergone neither filtering nor pre-processing and come from accelerometers of the PCB type equipped with self-balancing device.

1.2 Data analysis for dynamic identification

The data obtained have been filtered by a digital low-pass filter with cut-off frequency at 50 Hz.

Afterwards the spectrum tensor of the recording – suitably detrended by means of a FFT algorithm applied to consecutive time windows – has been calculated; the length of these windows has been fixed in the minimal power of 2 necessary to obtain a resolution in frequency equal to $r_f = 0.05$ Hz, therefore, since $f_c = 500$ Hz is the frequency of signal sampling, the following is obtained:

$$n = 2^{\lfloor \log_2(f_c/r_f) \rfloor + 1} = 2^{14} = 16384 \quad \text{data for each window}$$

The number of windows averaged in order to obtain the signal spectrum changes according to the length of the signals themselves; anyway, we have tried to obtain a time superimposition between two consecutive windows equal to 10-15% of the length of each window, that is to say about 2000 data. Finally, the spectra have been divided by f^4 so as to balance the rise in the force intensity which is proportional to f^2 .

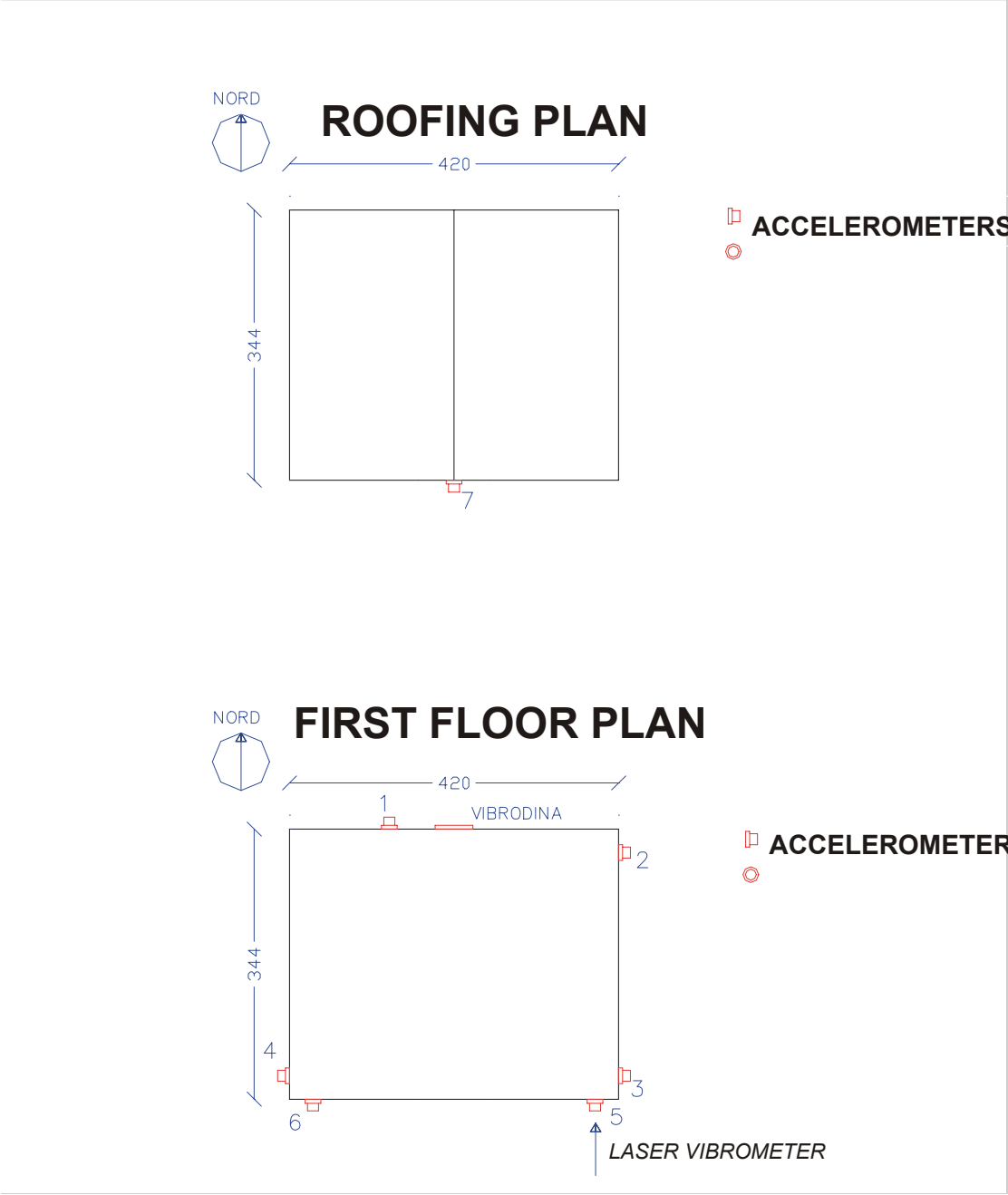
Once a datum system has been fixed – where x axis is in East-West direction, y axis in North-South direction, and z axis is equidirected with increasing elevations measured from the foundation pier layout – the accelerometer signals have been processed in order to obtain the three motions of rigid plane concerning the two levels into consideration.

Thanks to the spectrum tensor concerning the accelerometer measurements, through the pre-and postmultiplication by the pseudoinverse of the positioning matrix of the instruments, it has been possible to find out the spectrum tensor concerning the plane motions of the two instrumented levels.

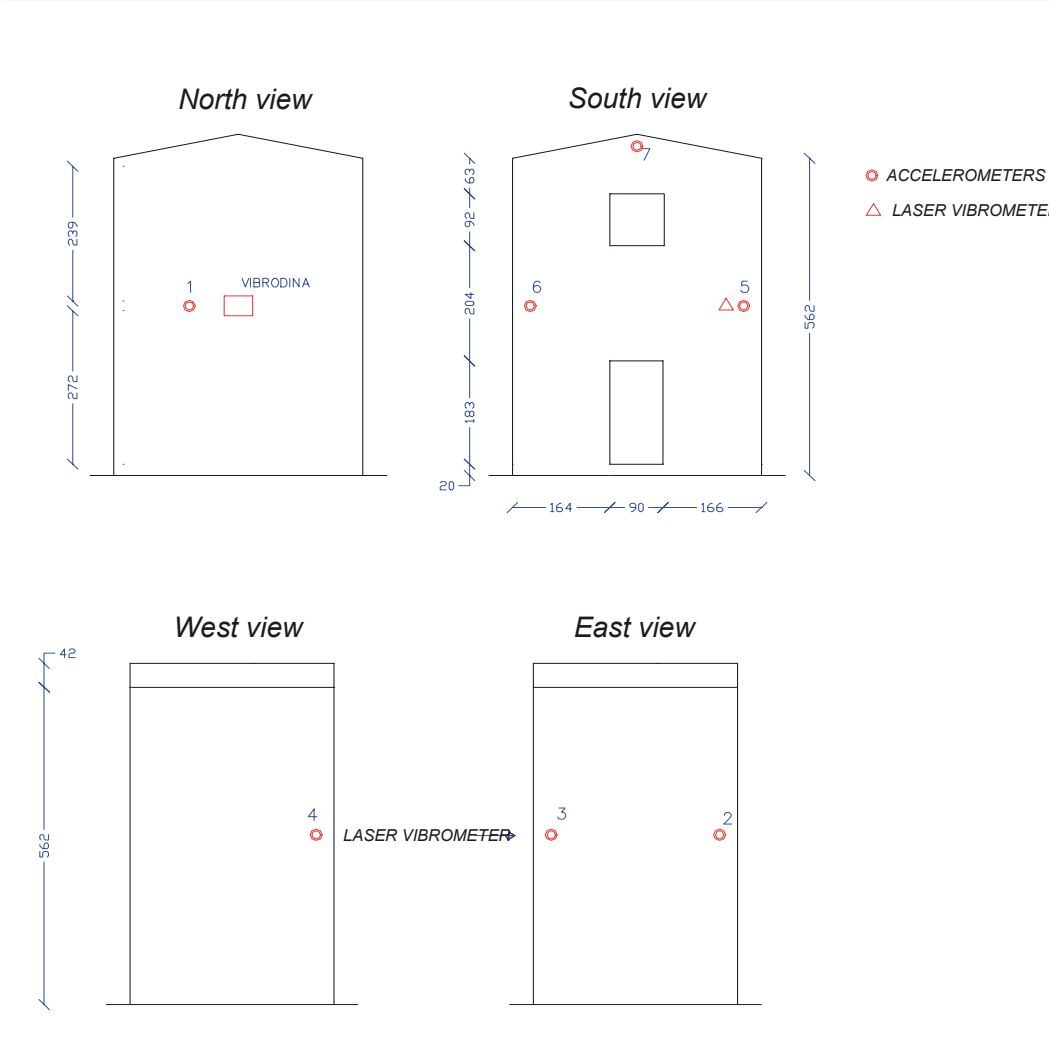
1.3 First sequence of tests

Mechanical exciter arranged at floor elevation (level 1), North view, North-South excitation.

As for these tests, the results of which can be seen in the first part of this report, the load has been applied along the North side at the first floor level, with a fixed acceleration of $\pm 4 \text{ m/sec}^2$ ($\cong 0.4 \text{ g}$) as for the first two excitations and above $\pm 5 \text{ m/sec}^2$ ($\cong 0.5 \text{ g}$) as for the other two excitations. While processing the results, we have noticed a non-symmetrical behaviour of the structure as to the plane through the center of the mechanical exciter, perpendicular to the North side, probably due to the non-symmetry of the structure itself because of the staircase on the east side. At the point which is more stressed, that is the ridge of the roof on the South side, the structure has reached an acceleration over $\pm 5 \text{ m/sec}^2$ ($\cong 0.5 \text{ g}$); this condition occurred during the two second tests when the oscillation reached a frequency equal to 20 Hz. Furthermore, at the first and third test, when a stress having maximum load equal to 18.2 kN corresponding to the frequency of rotation of the mechanical exciter equal to 20 Hz, the presence of a resonance frequency around 16-17 Hz has been noticed. Observing the quantities detected by the vibrometer at the point in which the laser ray collimates, a movement of 0.132 mm is noticeable in the second test.



Picture 1.1-Instrumentation arrangement (plans)

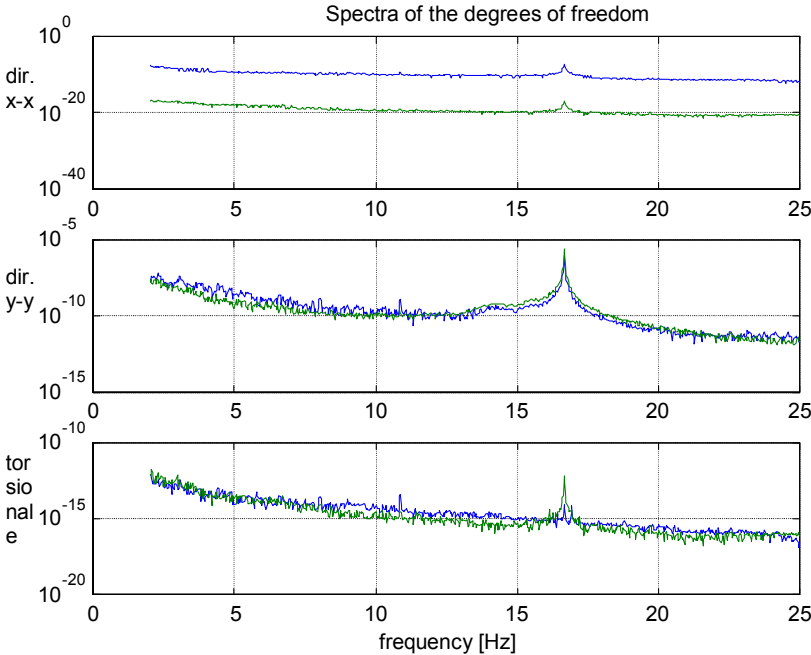


Picture 1.2- Instrumentation arrangement at the views

1.3.1 Test processing

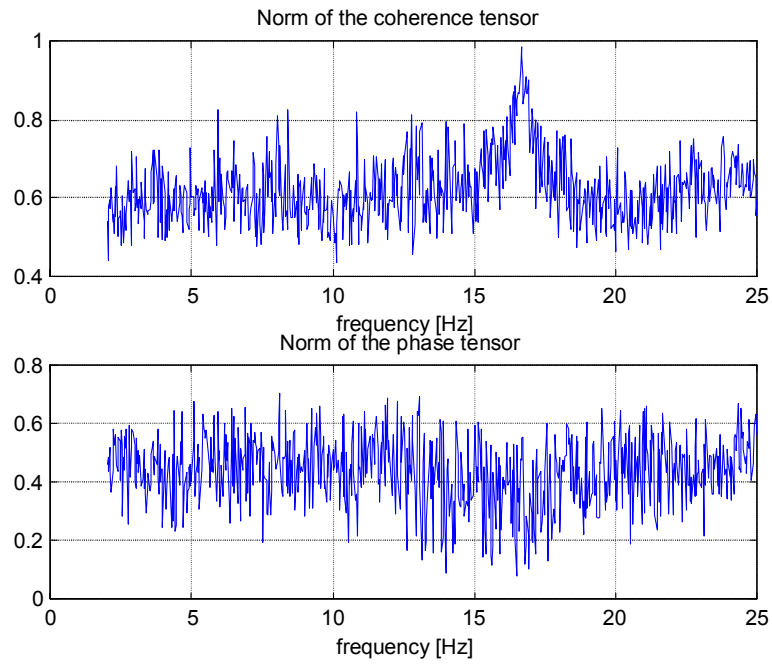
The tests no. 1 and no.3 have been processed; in the diagrams the level 1 is in blue and level 2 is in green.

Test no.1



Picture 1.3 – Spectra concerning the plane motions in E-W, N-S and torsional direction of the two instrumented levels.

SUPPLEMENTARY NUMERICAL REPORT



Picture 1.4 – Norm of the phase tensor and coherence tensor of the signals according to frequency

Observing the spectra of the plane motions, a peak close to 16.3 Hz is noticeable. The presence of a resonance near this frequency would be confirmed by the norm of the tensor of coherence close to 1 and by the norm of the tensor of phase close to zero.