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Reliability of Ambient Vibration Techniques in Structural Health Monitoring of both Historical and Modern Buildings

Rosastella Daminelli (1), Alberto Marcellini (1), and Daniele Gerosa (2)

(1) CNR Institute for the Dynamics of Environmental Processes, Milan, Italy (rossella.daminelli@idpa.cnr.it), (2) Signa Srl, Boltiere (BG), Italy (info@signasrl.it)

Earthquake risk reduction strategies largely rely in vulnerability mitigation of existing buildings; therefore structural health monitoring is a major issue.
Ambient vibration analysis, currently adopted in geophysical investigation (like HVSR for site effects analysis) are nowadays gaining relevance to assess major dynamical parameters of buildings.
Our study deals with the evaluation of the principal vibration periods of a XI century masonry tower and of a modern primary school building by ambient noise analysis adopting FDD technique.
To check the reliability of this approach we compare the results with the ones obtained using forced vibrations by ISMES Spa.
The XI century Velate (Varese) tower is a 30 meters high masonry building, presently consisting in 2 orthogonal walls partially ruined. To evaluate the principal modes and the damping factors in order to design the retrofit, force excitations were produced by a vibrodine installed at the base of the tower. The vibrations were recorded by 22 seismometers placed on the tower at different elevation (from 4.7 to 26.6 meters). First and second vibration mode have been estimated to be 1.45 Hz and 2.0 Hz, respectively.
Ambient vibrations were recorded by 3D Lennartz 1Hz seismometers. The results obtained by applying the FDD technique to the density power spectra of the recorded signals were: 1st mode=1.42 Hz; 2nd mode=1.95 Hz.
A similar experiment has been conducted on the Filago (Bergamo) primary school, that is a two story modern reinforced concrete structure. We obtained 6.81 Hz and 7.25 Hz for the first and the second natural period by vibrodine excitation against 6.75 and 7.55 Hz by ambient noise analysis.
To note that the asymmetric plan of the school causes a difference of frequency estimation of about 10% between the two orthogonal major directions.
The good match of the results in both the experiments endorses the validity of the ambient vibration techniques. This cheap and non-destructive method is growing as a fundamental tool for dynamical parameters assessment of buildings.
The results obtained in the Velate Tower forced excitation experiment merit a special attention: the retrofit did not change the 1st and 2nd mode frequencies, but caused a relevant increase of the frequency of the 3rd, 4th and 5th mode. That is, the natural period is an estimation of the validity (or of the degree of reliability) of the retrofit. In the present case the data show that the retrofit increased the tower stiffness, given that the mass remains unchanged. Unfortunately the evaluation of these higher modes by the ambient vibration analysis is still affected by significant uncertainties.