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# Innovative technique for seismic retrofitting of traditional masonry buildings

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## Abstract

Despite the extensive use of modern construction materials, old masonry buildings, characterized by high consumption of energy and a high risk of partial or complete destruction during earthquakes, still represent a great majority of both residential and public building stock in many earthquake-prone countries, such as the countries in the Balkan region. Improvement of seismic resistance and energy efficiency of these buildings is very important and actual topic worldwide. The delicate problem of proving the effectiveness of the selected consolidation, retrofitting or strengthening system can be successfully overcome by using the methodology of design assisted by testing, which as methodology, has been codified in all Eurocodes.

***Key words:*** traditional brick masonry, shaking table testing, seismic retrofitting, energy efficiency, innovative materials

The main goals of the research project realized by the Institute of Earthquake Engineering and Engineering Seismology UKIM-IZIIS, Skopje, in collaboration with the RÖFIX Company, Austria, has been experimental investigation of the efficiency of the proposed methodology for seismic and energy efficiency upgrading of traditional masonry buildings using innovative *System RÖFIX SismaCalce*, [1].
For experimental verification of the retrofitting methodology, shaking table testing of a 1:2 scaled model of a hypothetical masonry building has been performed both in its original and retrofitted state, (Fig.1 and Fig. 2, respectively). The model has been subjected to three characteristic earthquakes (El Centro, Petrovac N-S, and Northridge), applied gradually increasing the peak ground acceleration (PGA) and using the time histories scaled in compliance with the principles of model analysis. During the test the building behaves as a rigid body in the initial elastic range, followed by development of damages up to a state close to failure for final test with PGA=0.35g, proved by the decrease in natural frequency from 10.95 to 8.7 Hz and from 17.0 to 12.2Hz for E-W and N-S direction, respectively.


**Figure 1. Original non-retrofitted model before testing (left) and after the final test (right)**

The repair and seismic retrofitting of the damaged model was undertaken using *System RÖFIX SismaCalce;* first the model was repaired by injection of lime-cement based mixtures, then it was retrofitted by the innovative technique that was originally developed, and for this particular case designed and applied, by the RÖFIX Company, (Fig. 2). The retrofitting consists of applying of:
- the layer of *RÖFIX SismaCalce* NHL- based mortar as primer,
- *RÖFIX SismaProtect* anti seismic eq-grid on the outer side of the walls,
- *RÖFIX SismaDur* mortar for facade finishing and thermal insulation, (Fig.2)


**Figure 2. Retrofitting of the model using *System RÖFIX SismaCalce***

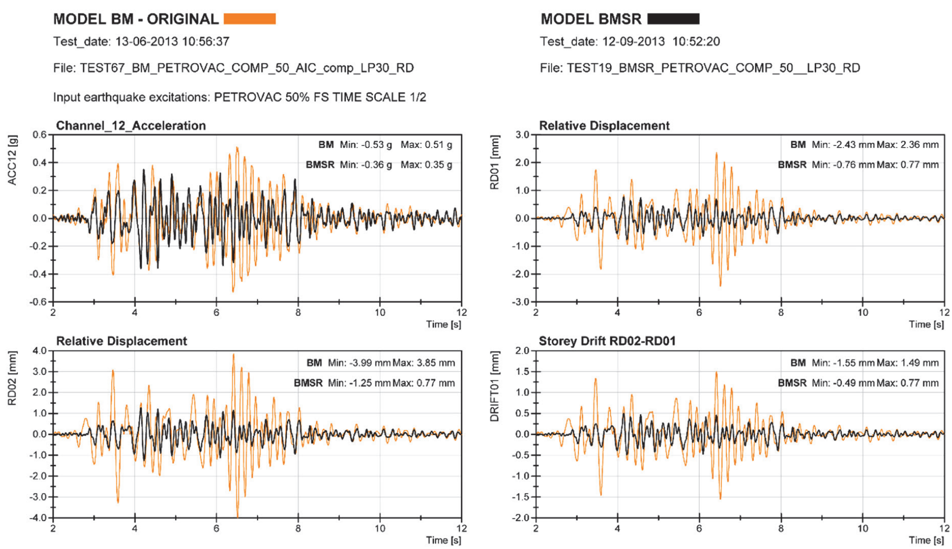


**Figure 3. Comparison of the results for original and retrofitted model, Petrovac, PGA=0.35g**

Both models were subjected to the same experimental programme, however, due to the obviously higher resistance of the retrofitted model, the tests were continued under higher intensities of input excitation, (Fig.3). Comparison the final test results points out that for about triple excitation level, the damage level of the retrofitted model is considerably lower, thus proving the effectiveness of proposed retrofitting methodology and its contribution to overall improvement of structural dynamic behaviour by increasing bearing and deformation capacity of the structure up to the required seismic protection level.

## References

[1] Shendova, V., Zlateski, A., Jekic, G., Rakicevic, Z. (2013): Experimental verification of innovative technique for seismic retrofitting of traditional masonry building, IZIIS Report 2013-44, N.Macedonia.