SEISMIC RETROFIT OF HISTORICAL AND EXISTING BUILDINGS

Salim CHEMALY
Engineer ENPC- Paris, MESC, Beirut, Lebanon
salimchemaly@gmail.com

Keywords: Earthquake Engineering, Retrofit, Old and New Buildings, Saves Lives, Easy to Use

Traditional stone and brick masonry buildings, whether old or new, have low ductility, and, due to their stiff and brittle structural components, are usually severely damaged during strong earthquakes. Their collapse could cause building destruction, their occupants and passersby loss.

Karlsruhe Institute of Technology (KIT) and RÖFIX has developed an anti-seismic reinforcement system consisting of *(1)* RÖFIX SismaProtect, a multi-axial hybrid high-tech tissue, synthetic and glass fibers, alkali- and corrosion- resistant, with *(2)* RÖFIX SismaCalce coating, a mineral mortar on NHL-Lime +white cement +polymer +bonder by penetrating chemical reaction agent. This mortar is characterized by high ductility and low modulus of elasticity and perfectly adapted to the different requirements of old and new buildings. During earthquake, the system improves the seismic stability of the global structure: retrofitted masonry walls becoming the main elements of building stability, working as sheer resistant walls holding the slabs.

The earthquake-induced movements and energies in the masonry can be absorbed, through the fiber mesh. Forces and force peaks are distributed in the mesh *(1)* and reduced by special fibers *(2)*. Although cracks and partial damages of the structure develop, a complete collapse, however, can be prevented, saving human lives.

This innovative and economic system also offers thermal insulation and vapor diffusion permeability, it ensures safety, energy conservation, quality of life and property value. It is easy to handle and can be embedded on all masonry walls.

Experiments and Tests - Padua (Italy) and Iziis (Skopje-Macedonia):

The Faculty of Civil and Environmental Engineering at the University of Padua and the Institute of Earthquake Engineering and Engineering Seismology (IZIIS) Skopje executed a series of experiments to evaluate the system performance, in particular with regard to the problem of nonbearing walls.

The performed tests on retrofitted non bearing masonry walls, confirmed the high level of dispersion of the seismic energy which has improved deformability and the reduction of the tensile stress of the masonry. Thanks to the enormously increased ductility a large number of cracks developed, but no major damage. Not least, the tests showed the improved stability at maximum deformation capacity.

Table 1. Tests results on masonry wall elements of type W2 R/S (Retrofitted wall under diagonal pressure)

Wall	Date	Max axial force Pmax (kN)	Compressive, Shear Stress σc=TU=Pmaxcos45o/A (kpa)	Tensile Strength ft (kPa)	Ductility Capacity
W2-4 R	August 22, 2013	150	1462	903	5,1
W2-5 R	August 23, 2013	128	1248	771	5,9
W2-6 R	August 27, 2013	97	946	584	7,1
W2-7 S	August 29, 2013	138	1345	831	5,1
W2-8 S	August 30, 2013	140	1365	843	5,5
W2-9 S	September 2, 2013	165	1579	976	7,5
W2-10 S	September 2, 2013	148	1443	891	2,6
W2-11 S	September 3, 2013	160	1560	964	2,1

The results on the compressive strength σc and of tensile strength ft comply with the regulations and the recommendations on the tensile strength/compressive strength ratio of masonry.

The proposed and applied retrofitting contributes to increase of elastic limit, bearing and deformation capacity. Thus tensile strength of retrofitted elements ranges within 0.77 MPa to 0.976 Mpa, which is three times greater than that for original ones. The ductility capacity was increased with retrofitting three times too.

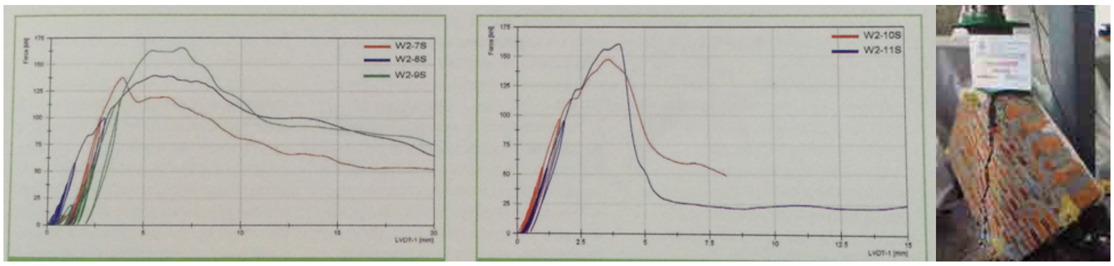

Figure 1. Force-displacement relationships for walls retrofitted respectively on 2 sides and 1 side

ShakIng table tests on 1:2 scaled house model, orIgInal (BM) and retrofItted model (BM-SR):

To experimentally verify the methodology for seismic retrofitting of traditional masonry structures pertaining to historic and old buildings, a model of a hypothetical prototype house (scale 1:2) was constructed and tested on the seismic shaking table in the Dynamic Testing Laboratory of IZIIS. The dynamic charachteristics of the both non-retrofitted and retrofitted model were checked before being subjected to earthquake excitation by ambient vibration technique.

The shaking table tests (of several phases) confirmed the seismic stability of masonry houses (up to 3 floors). Further tests are scheduled for higher RC + masonry buildings (up to 8 or 9 floors).

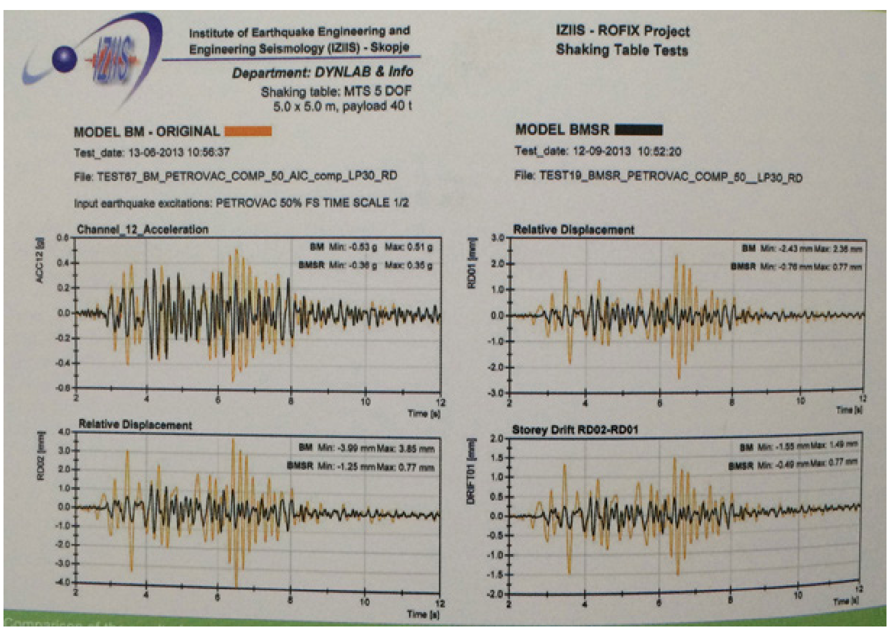

Figure 2. Comparison of the results for original (Red) and retrofitted (Black) model, amax=0.50g

Calculation Of Fibres Reinforcement (From Kit Formulas Sheet):

<u>Modification of tensile strength with Sismacalce:</u>

$f_{vk}^{\ reinforced} = f_{vk0} + (n / t) \cdot \Psi_f^{30} \cdot f_f^{30} \cdot \cos 30^o$; n = Number of fiber layers ; t = wall thickness (mm)

Ψ_f^{30} = Efficiency factor (bonding) for SismaCalce 43,3% ; f_f^{30} = Strength of fibres

$f_f^{90} = 1960$ N / 50mm ; $f_f^{0} = 1817$ N / 50mm ; $f_f^{30} = 895$ N / 50mm

<u>Modification of tensile strength with SismaCalce:</u>

$$f_{bt,cal}^{\ mo} = f_{bt,cal} + n \cdot \Psi_f^{\theta} / t. \left(f_f^{90} \cdot \cos^2 \varphi + f_f^{0} \cdot \sin^2 \varphi + f_f^{0} \cdot \cos^2 | \varphi - \theta | \right)$$