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Innovative Method for Repairing Masonry Buildings

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Summary

The paper presents an approach of testing several models of reinforced masonry with polymer grids. Three techniques of reinforcing were used: by insertion, coating and confining. The results of testing programs show an essential improvement of the behavior under static and dynamic loads of the reinforced masonry. Structural performances also increase more than the cost of reinforcing. The method applies to repair the buildings of brick and stone masonry damaged by long service and/or severe earthquakes. It allows replacing R/C or steel structural members with reinforced masonry ones in achieving more homogeneous and long lasting buildings. Nondestructive tests, performed with mobile acoustic equipment, allow assessing the quality of repairing work.

Keywords: coating, confining, insertion, rehabilitation, reinforcing, remodeling, repairing, restoring, retrofitting, strengthening.

The art of construction the masonry buildings is known on Romanian territories since the Roman Empire. In spite of natural disasters many vestiges of the former ancient settlements like Apulum, Callatis, Tomis and Ulpia Traiana are still preserving. There are also proofs that during centuries some of monumental masonry buildings and churches have been anti-seismically shaped. Although brittle masonry remains a preferred construction material. However, this artificial stone should be often repaired and strengthened. During the last decades the behavior of masonry buildings under different loads was intensively searched. A European Masonry Data Bank was also created. Advanced technologies are used for retrofitting masonry works. Romania, as a Balkan country where frequent earthquakes occur, is highly interested in the field. A method of reinforcing the masonry works with polymer grids was recently proposed. There are three ways of using the synthetic reinforcement: by inserting it on horizontal layers, by coating vertical surfaces and by confining structural members or building bodies. The paper presents the results of three testing programs showing the advantages and also the limits of this simple method, so easy to be applied.

A series of six identical short columns with the dimensions 375x375x874 have been made by using solid clay bricks 240x120x60 with typical strength 7.5 MPa and standard mortar with the cement-lime-sand ratio 1:1:12. Three columns by plain masonry remained as reference, while the other three were reinforced with polymer grids *Tensar SS40*. The reinforcement was inserted in the mortar between bricks on three horizontal layers, namely in the joint no. 2, 6 and 10, upwardly. No outer plastering or coating was provided. The columns have been tested to axial compression up to their ultimate limit state. Between the extreme cases, by reinforcing with only three grids weighting in total 166 grams, the compressive strength of one typical short column increased with 24.32%, while its ductility increased with 30.90%.

Another series of twelve identical wall panels, with the dimensions 875x240x874, have been two by two let plain as reference, plastered and reinforced by insertion and coating. Six wall panels were tested to axial compression and the other six were tested to diagonal tension, both up to their ultimate limit state. The results are comparatively shown in drawings and tables. Since through insertion, coating or insertion and coating the masonry with polymer grids the structural performances typically increase with 10 to 30%, while the cost rises only with 0.6 to12%, the method of reinforcing proves to be advantageous. In order to put in value the own strength of bricks the masonry should be confined. That means to close the masonry structural members with synthetic reinforcements in all directions. Confined in this way all vertical and lateral loads induce in them three-axial compression, and their bearing capacity increases several times.

Two testing programs were carried out on confined masonry. First consists in a 3D model of a two-story masonry building reduced to a scale of 1:2. The model was submitted to seismic actions on the shaking table of ISMES in Bergamo. After reaching the limit state of cracking the model was repaired by confining with two reinforced belts. Tested again, to the same dynamic actions, the retrofitted model showed a higher strength. Beside the usefulness of the repairing method it was shown that masonry buildings could be homogenized. Indeed, it allows replacing R/C or steel structural members with reinforced masonry ones improving in this way the behavior of masonry buildings to lateral actions. The second program was an attempt to compare the behavior of plain and reinforced infills with typical dimensions of 2100x1625x150. The infill reinforced by confining with polymer grids *Tensar SS30* was tested together with similar plain infills on the shaking table of LNEC in Lisbon. Due to the weak strength of horizontally hollowed bricks and the poor connection between grids and masonry the test results appeared as irrelevant. However, it was shown that the provision 2.5.6 of Eurocode 8 regarding *Damage Limitation of Infills* could be solved by confinement. This is why the testing program will be resumed through INCO Copernicus project IC15-CT97-0203.

The test results presented above show an essential improvement of the behavior under static and dynamic loads of the masonry reinforced with polymer grids. The method is worth to be used for reconstruction or renewal of any part of a damaged or deteriorated masonry building to provide the same level of strength and/or ductility, which the building had prior to the damage. Nondestructive inspection, performed with mobile Impact-Echo equipment , allows assessing the quality of repairing work.