Engineering Structures 31 (2009) 1321–1330

Contents lists available at ScienceDirect

Engineering Structures

journal homepage: www.elsevier.com/locate/engstruct

Shaking table tests of two different reinforcement techniques using polymeric grids on an asymmetric limestone full-scaled structure

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ARTICLE INFO

Article history:
Available online 24 June 2008

Keywords:
Limestone masonry
Reinforcement techniques
Polymeric grids
Full scale specimen
Shaking table tests

ABSTRACT

This paper describes shaking table tests, and their main results, of an asymmetric limestone masonry building, under two different reinforcement techniques. The work was developed within the scope of the project "Enhancing Seismic Resistance and Durability of Natural Masonry Stone" for User Group 3 of the European Consortium of Laboratories for Earthquake and Dynamic Experimental Research (ECOLEADER). The experimental program was developed in LNEC facility using the 3D shaking table.

The design of the structure was a common decision of the specialists involved from the University of Bucharest, the Slovak Academy of Sciences and the IRIDEX Construction Group, on the basis of an architectural conception typical of the buildings under study as well as on pre-existing buildings in Romania. The construction was operated and supervised in the LNEC earthquake-testing hall.

For the first phase of the tests the specimen was horizontally reinforced with polymeric grids. For the second phase (with similar input signals) it was also vertically confined with polymeric grids and a fibre-added mortar was used.

The construction of this full-scale specimen, its reinforcement, the testing procedure and the main testing results are presented and compared. The geometry and the materials chosen and the construction procedure are detailed as well as the instrumentation and the different input signals adopted. Finally, the main damage observed is shown.

A comparison of the results obtained for both testing phases is made showing an important improvement reached in the behaviour of the structure that has allowed inputs of clearly higher values for the very final steps with no evidence of any major damage.

1. Introduction

In many European countries, like France, Greece, Italy, Portugal, Romania, Slovakia and Spain, there is a long tradition for using natural stone masonry in buildings and structures. They are long-lasting constructions, very durable under severe conditions of climate and foundations. Stone masonry can be used either partially for foundation and first storey walls or for the whole structure; the high cost of labour being the limiting condition for their use during the last decades. Recently, the rapid rise of energy costs and increasing losses due to natural catastrophes return attention to natural stone masonry. By comparative analyses it was found out that it is much cheaper to shape and cut soft stone like lime and sandstone than to burn clay for producing cored or solid bricks. However, stone masonry is stiffer and therefore unable to develop elastic deformation thereby accumulating potential energy, so all consequences of stress concentration around any structural faults are only supported by mortar. Originally, stone masonry was made with lime mortar that, despite its low tensile resistance, presents considerable ductility which contributes a reduction of the effects of stress concentration.

To improve general characteristics of stone masonry construction, including the response to seismic action, reinforcing the masonry structural members with polymer grids shows a great potential. This synthetic reinforcement compensates for stone masonry's lack of ductility and enhances its natural strength capacity. The methodology described in the present paper for using polymeric grids as masonry reinforcement is duly patented [1].

Based on the experience achieved with previous research programs [2–7] the following objectives were considered:

(a) Demonstration of reinforcing natural stone masonry with polymeric grids,
(b) Behaviour analysis of new stone masonry horizontally reinforced with polymeric grid layers,
(c) Behaviour analysis of repaired stone masonry confined with polymeric grids,
(d) Data collection for validation of numerical analysis.

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doi:10.1016/j.engstruct.2008.04.039