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Revised version, modifications highlighted in color YELLOW

Ancient masonry arches and vaults strengthened with TRM, SRG and FRP composites: Experimental evaluation

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Abstract

Composite materials made with textile fibers both with polymeric and cementitious matrices are often adopted for the retrofitting of masonry arches and vaults. A specific project that analyzes the performance of ancient masonry arches and vaults strengthened with composite systems has been recently concluded at Politecnico of Milan. The project involves the experimental evaluation and the development of numerical and analytical simulations. In this paper the experimental campaign is described, whereas the numerical validation is provided in an accompanying paper [1]. The tests were performed in-situ on ancient masonry arches and vault elements. In particular, three barrel vaults and two arches either unreinforced or reinforced with Steel Reinforced Grout (SRG), Textile Reinforced Mortar (TRM) and Fiber Reinforced Polymer (FRP) were tested.

The arches had a span equal to 3.30 m, a rise equal to 0.83 m and were built with common Italian bricks regularly spacing out two bricks laid edge on (thickness of the arch 12 cm) with two bricks (one over the other) disposed in single leaf. Barrel vaults had the same geometry of the arches but were made with a single leaf. In all cases, an eccentric vertical load was applied at ¼ of the span and was increased up to failure. The experimental results on unreinforced structures are compared with those obtained on the strengthening ones in terms of failure mode, maximum load, stiffness and ductility.

Keywords: masonry; arches and vaults; Textile Reinforced Mortar TRM; FRP; in situ experimentation

1 Introduction

1.1 Problem statement

Masonry arches and barrel vaults are quite widespread all over Europe, especially in Italy. They have been used for centuries in different kinds of constructions, such as monuments but also in common residential buildings and bridges, the main advantage is the capability to cover larger spans and carry relatively heavy gravity loads. The structural stability is guaranteed when thrust lines remain all inside the thickness. This is a consequence of the fairly good masonry compression strength and the almost vanishing tensile resistance. In the past, starting from Roman age ongoing the arch design was essentially based on empirical rules, but what was intuitively correct for vertical loads, i.e. to enforce masonry working in compression, is unfortunately not very straightforward in presence of horizontal inertia forces induced by an earthquake. As a matter of fact, in presence of a seismic excitation, the line of thrust shifts easily outside the arch thickness, resulting into a damage spreading and the progressive collapse characterized by the formation of a typical four hinges mechanism. Such

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