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Structural Analysis of Historical Constructions

Anamnesis, diagnosis, therapy, controls

Koen Van Balen & Els Verstrynge
Editors

help open

Structural Analysis of Historical Constructions –
Anamnesis, diagnosis, therapy, controls – Van Balen & Verstrynge (Eds)
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Retrofitting of masonry vaults with composite materials

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ABSTRACT: Externally Bonded composite materials are fast becoming the standard solution for structural strengthening, substituting traditional techniques (reinforced concrete, steel, etc). Polymer-reinforced fibres are now commonly applied to buildings for structural retrofitting purposes. These materials add greater tensile strength to structures, at the expense of a slight increase in weight. However, they also have other drawbacks as lack of water vapour permeability and brittle behaviour, which are not desired in the conservation of heritage buildings.

Alternative to this composite materials are inorganic matrix-based composite materials which show advantageous properties and solve some of the drawbacks associated with organic matrices. This research presents long steel fibres and basalt textiles embedded in inorganic matrix to produce mortar-based composite.

Initially, a mechanical characterization of the individual components and the resulting composite material was performed. Afterwards, real-scale (3 m span) brick masonry vaults were strengthened by means of these composite materials and tested up to failure, in order to demonstrate their mechanical effectiveness.

The experimental campaign demonstrates that composite mortar is an effective alternative to polymeric composites for the reinforcement of masonry brick vaults, which is physically compatible with masonry structures and easy to apply.

1 INTRODUCTION

The present work is focused on inorganic matrix composites, i.e. Textile Reinforced Mortar (TRM) and Steel Reinforced Mortar (SRM) (Larrinaga et al. 2014, Olivito et al. 2014, De Santis 2015, De Santis 2015b, Valluzzi 2014), which is a novel area of experimental research. These composite materials offer advantageous solutions due to their water-vapour permeability, applicable over humid substrate (common situation in masonry structures), lack of toxic substances emission in case of fire, fire resistance, ease-of-application and of removability (de Felice et al. 2014). Although their mechanical properties in comparison to organic composites (i.e. Fibre Reinforced Polymers) can be less effective, and may require longer curing periods (weeks), for example, their overall behaviour makes them an attractive solution for the retrofitting of masonry structures (Garmendia et al. 2014 and 2014b, Oliveira et al. 2012). TRM and SRM solutions are designed to preserve existing masonry structures and to prevent brittle failure. For this purpose, constitutive materials of the composite must be appropriately selected.

The externally bonded (EB) reinforcement is highly dependent on the bond between the composite and the substrate, and the interaction between the matrix and the inner reinforcement. Interface behaviour and the mortar-reinforcement bond are therefore key factors in the performance of the strengthening technique. Hence, the most important characteristics of the matrix should be as follows: adequate consistency to penetrate the textile (dependent on textile density and geometry), workability, chemical and physical compatibility with the substrate, adequate mechanical properties, low creepage and shrinkage, and good fire resistance.

In this research work, long steel fibres and basalt textiles are applied to the resistant core of the inorganic matrix to produce a steel-basalt reinforced mortar-based composite. In the case of TRM, bidirectional textiles such us BRM (basalt fibres embedded in the EB matrix) are usually applied, in order to improve bond behaviour. Normally, when loads are applied in a single direction, transversal fibres are designed

The final deformability of the SRM strengthened vault at the collapse stage presented a ductility that was over 40 times higher than the non-strengthened ones.

The improvements in the strengthened vaults implies that the strengthening system absorbed the tensile stresses that the vault would otherwise not have withstood, therefore, avoiding or postponing the formation of the kinematic mechanism. The trust line can lie outside the thickness of the arch and, consequently, its load resistant capacity and deformability is increased.

5 CONCLUSIONS

The experimental campaign has shown that the two composite materials are effective solutions for the strengthening intervention, as they enable the masonry structure to carry substantial tensile stresses and prevent brittle failure.

The research has shown that steel and basalt reinforced mortar (SRM/BRM) are effective externally bonded composite solutions for masonry barrel vault strengthening.

Future research is desired to increase practitioner confidence and to reduce the safety factors associated with this retrofitting technology.

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