

# **Extrados strengthening of single-leaf vaults against seismic actions**

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## **ABSTRACT**

Single-leaf vaults are acknowledged among the most vulnerable components of historical masonry constructions with respect to earthquake loads, particularly when featuring quite large span to thickness ratios, as in the case of single leaf covering the main nave of churches. These elements often require structural strengthening against seismic actions. In this paper, two different extrados techniques are tested: lightweight plywood restraining elements and FRP laminates embedded in a lime mortar layer.

Lightweight plywood centrings, applying passive confinement to the vault extrados, are shown to inhibit the onset of the typical four-hinges failure mechanism. This lightweight, dry solution can be easily prefabricated, transferred and assembled at the construction site. The technique is reversible and fully compliant with the major preservation principles. FRP is also effective against the onset of the failure mechanism but entails larger deformations of the retrofitted vault, which may be detrimental in the case of possible decoration. The solution requires special man labour to ensure correct smoothing and cleaning of the vault extrados and to trigger effective bond between the mortar and the vault extrados. Both solutions are shown to enable small relative displacements of the vault springing, which may follow the deformation of possible internal ties.

The effectiveness of the retrofit techniques was comparatively verified through experimental tests on full scale single-leaf barrel vault stripes subjected to cyclic distributed unsymmetrical loads and through comparison with the seismic response of a reference unreinforced single leaf vault.