Abstract

Arches, vaults and domes constitute a milestone for the transition from the older method of construction, using masonry, to the modern one, based on concrete and steel. The arched masonry structures are still recurring within our architectural heritage, ranging from historic constructions to common residential buildings.
Although high efforts have been employed to assess the structural response, with and without reinforcements, the issue of fire resistance has remained unaddressed for masonry curvilinear structures. In particular, the assessment by direct tests is not feasible, exhaustive experimental campaigns have never been undertaken, and simplified tabulated methods are not applicable.

In the event of fire, a certain level of performance is required to meet the new needs, and the new use of these buildings. Thus, structural engineers and architects are often called to assess arches and vaults, even if no numerical model has been developed so far.

Hence, the aim of this thesis is to give a contribution to the assessment of masonry arched structures subjected to elevated temperatures under the most common fire scenario, in addition to the self-weight and external loads. It consists of full-scale experimental analyses conducted on masonry barrel vaults subjected to fire and numerical models as well. More specifically, with the aim of providing a practical tool for existing curvilinear masonry structures under fire, a simplified numerical method is firstly introduced. It is based on the well-known Heyman's Safe Theorem combined with the residual cross-section method, currently used for walls and columns.

Furthermore, an advanced numerical model have been also developed and presented in this thesis. It is able to take into account the actual degradation of the material and the thermal expansion by means of the Colonnetti's Theory of the elastic coactions.

Both the models have been validated by the comparison of the predicted numerical results and those experimentally measured with the tests.

Finally, the simplified model has been applied to assess the fire resistance of an historic structure, extending the applicability to cross-vaults reinforced with concrete shell. The calculations have been performed according to the Italian code rules and the recommendations of the Italian fire brigade. Results shown that, from a practical point of view, only a low level of knowledge can be sufficient to correctly assess the masonry existing structures.