Investigation of the Role of Constructive Aspects on the Structural Response of Masonry Vaults

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Masonry vaults are common structural elements in historical buildings, often employed because more durable than timber floors. They were built with various materials and construction techniques, but when blocks were adopted (i.e., stone or bricks), specific rules had to be followed to create the masonry apparatus. Great attention to this topic was given in the European technical literature published between the 18th and the 20th centuries, which has deeply dealt with the constructive phases of vaults. This careful description of brick laying techniques, often accompanied by technical drawings, probably highlights the desire to increase the strength of vaults, also through the building process, namely brick laying and the orientation of principal joints. Various authors (Breymann 1849; Chevalley 1924; Donghi 1906; Formenti 1893; Gelati 1907; Levi 1932) describe different possible brick configurations for various vaults typologies and offer some considerations regarding when and why it is more suitable to choose a pattern instead of another. However, this speculations were grounded on empirical observations of vaults' behavior. In recent structural engineering literature, despite the structural behavior of vaults has been extensively investigated (e.g., Lourénço, De Borst, and Rots 1997; Huerta 2001; Milani et al. 2006; Milani et al. 2016; Rossi et. al 2016; Tralli et al. 2014), the role of the masonry apparatus is still addressed far less often.

The present thesis aims to deepen our knowledge about the structural behavior of masonry vaults, by taking into account some novelty aspects that have not been thoroughly tackled by the scientific literature, i.e. the masonry apparatus and construction techniques, that may increase the accuracy of interpretative models. A simplified micro-modelling approach is employed, in which real brick dimensions and configuration are taken into account. A commercial software with built-in interface models is employed and the proposed simplified-micro modelling approach is validated through experimental tests on an in-scale specimens of a cross vault and a round arch. The validated modelling strategy is then applied to ideal masonry cross vaults and barrel vaults arranged with different brick patterns and subjected to various load conditions, in order to investigate the advantages (constructional and structural) that different masonry apparatus could offer. Finally, the modeling strategy is proposed for the analysis of a real case study. Comparison of results allows observing different structural behaviour (displacement field, elastic stiffness, reaction forces, collapses shapes) for different brick patterns and makes it possible to provide a scientific validation to some speculations found in historical technical literature regarding vault construction. Moreover, interpretation of results can offer a guide for the explanation of crack patterns on existing structures, which may help professionals in designing less invasive and more cautious strengthening interventions on historical masonry vaults.