POLITECNICO DI TORINO
FIRST SCHOOL OF ARCHITECTURE
Master of Science in Architecture (Construction)
Honors theses

Structural behaviour of masonry vaults

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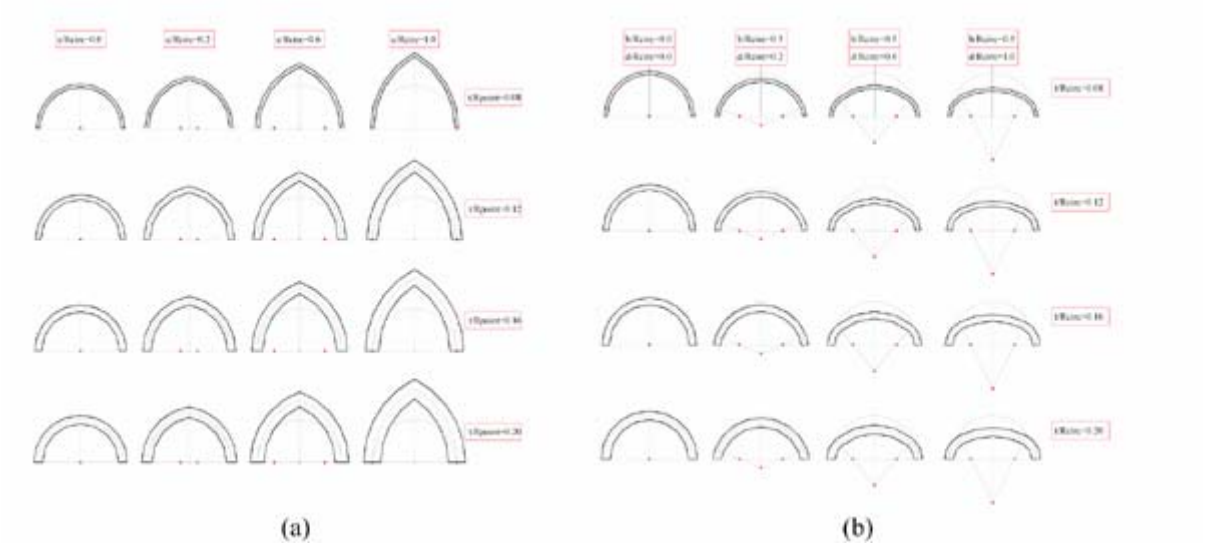
This work includes the most recent publications carried out relative to the structural behaviour of masonry vaults such as the arch, the vault and the dome alongside.
It has been considered best to study the oldest theories alongside this aspect of research and on analysis of recent works, both oriented to understand further the themes of investigation and to have a historically oriented point of view.
This work has been structured in the following way: in the first chapter, the theories inherent to the masonry arch, such as the common element at the base of the studies of vaults and domes, have been investigated; in the second chapter, theories about the structural behavior of masonry vaults have been analysed. Finally, the third chapter is dedicated to the theories related to the masonry dome.
In order to deal in depth with the structural behaviour of masonry vaults, it has been chosen for each chapter to add a section concerning the investigation of some meaningful study examples (Experimental Analysis), in order to set the matches and the needed verifications of the theoretical laws.

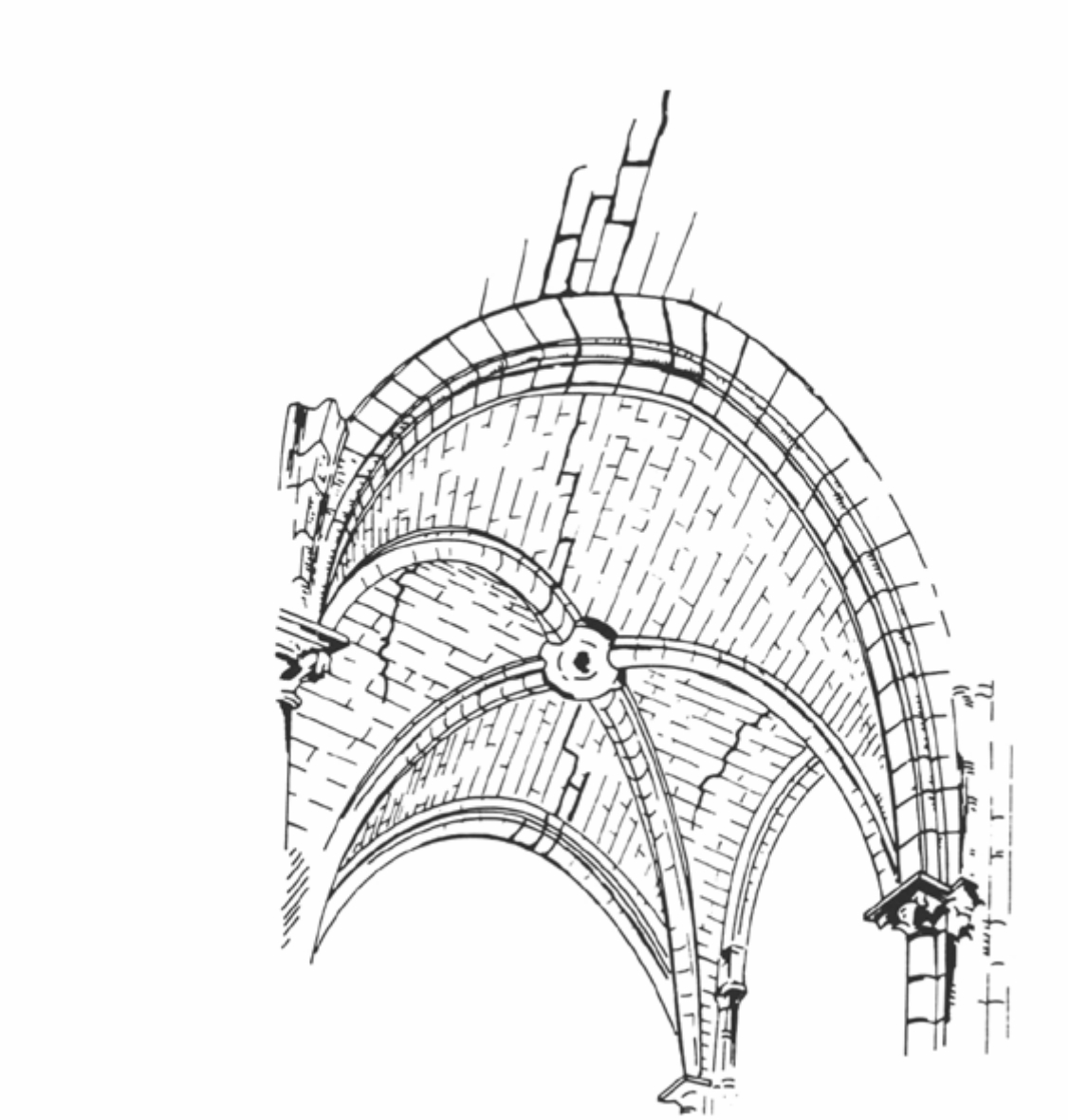
In the first chapter, the main theories about the masonry arch have been investigated, such as the theoretical contribution of Philippe De La Hire (1730), the *Exercitationes* of Bernardino Baldi (1621), who for many experts seems to be the author of the first work on the mechanics of the masonry arch, the work of De Belidor (1729), the work of Lorenzo Mascheroni (1785), containing a still empiric enunciation of the principles of virtual works, the methods of Mery (1840) and Alfred Durand-Claye (1867), the recent contributions of Anthony Kooharian (1952) and Jacques Heyman (1964), to arrive at the analysis of Ochsendorf (2006).



Representation of the case studio by Ochsendorf; (a) pointed arch, (b) basket-handle arch

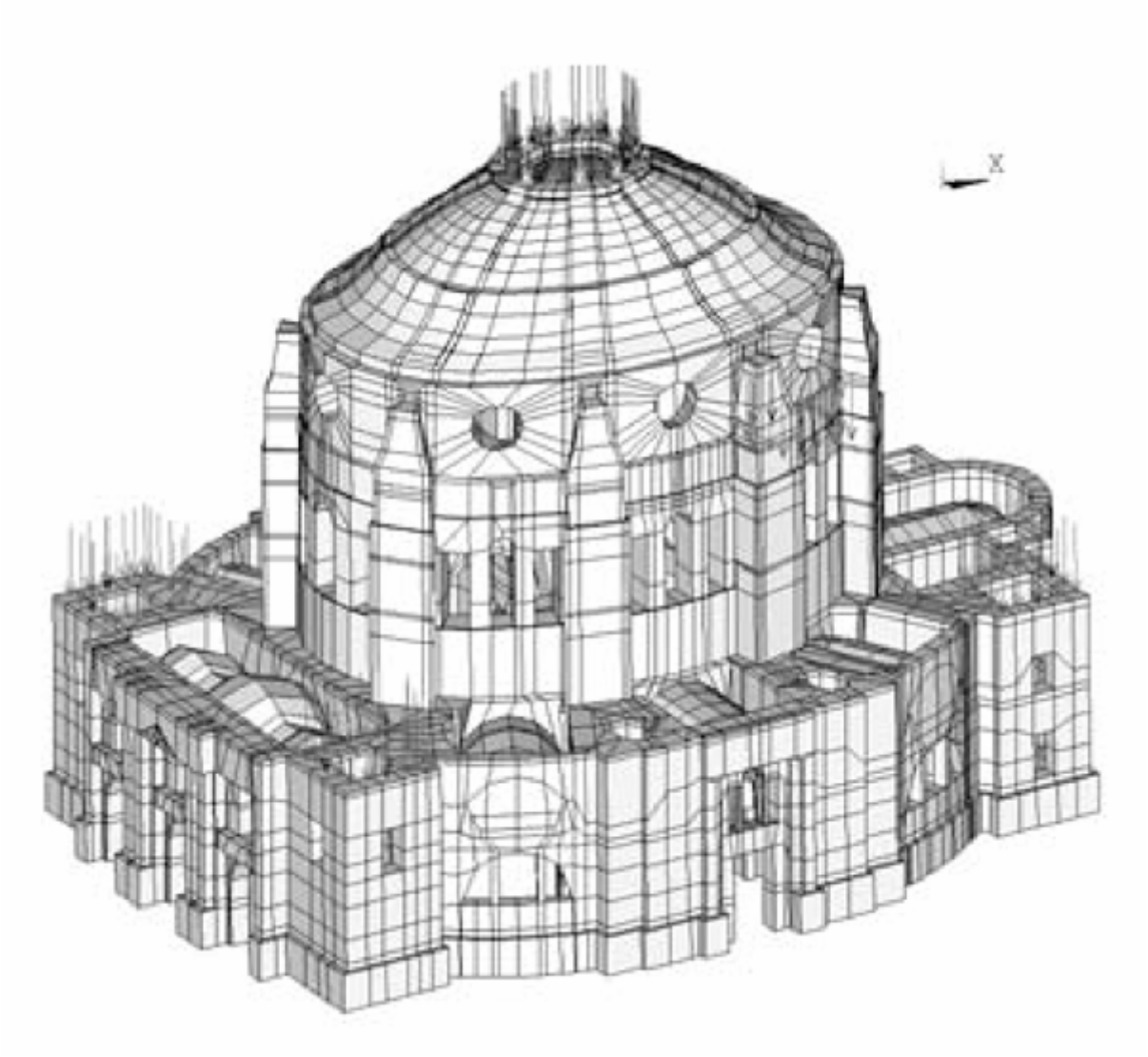
It is interesting to notice how the theoretical views of the different authors change when they describe the structural behaviour of the masonry arch. Afterwards, some case studies on the static behaviour of the masonry arch have been pointed out, within which the previous theoretic points of view are applied.

In the second chapter, this work concentrates on the historical evolution of the theories concerning the masonry vaults. In the first studies, developed in the seventeenth century, the structural behaviour of the masonry vault was, for some authors such as Couplet (1731 - 1732) and Coulomb (1773), associated with the study of the arch. The works of authors such as Leonardo Salimbeni (1787), Louis Navier (1825), F.J. Gerstner (1831), H. Moseley (1833) and the work of Scheffler are analised. After these different theories, some methods of analysis for different types of vault have been described, always with reference to the limit approach and the elastic approach of the study of masonry structures. In this work a manuscript written in the seventeenth century by the Spanish civil engineer Joaquin Monasterio, but only recently published, has been examined; this manuscript contains the analysis of the structural behaviour of the masonry vaults from a statistic point of view, with a method completely different from classical ones. Limit analysis made by Heyman on the structural behaviour of the masonry vaults, understood as being bi-dimensional, have been considered.
In the experimental section, some interesting research on the diagnostic methods used has been analyzed, for instance the studies of A.Carpinteri, G.Lacidogna and S.Invernizzi on a XVIII-century vault and also the one by R.Capozucca and D.Gerboni, in which a XIX-century vault was investigated.



Representation by Heyman of the cracks on the intrados of a cross vault

In the third chapter, masonry domes have been investigated, starting from the definition of *catenaria* associated with the structural behavior of a single slice of dome. This concept was delved into in the work of Bouguer (1730), of the abbot Charles Bossut (1772), in the studies of Giovanni Venturoli (1806), up till the intervention of Giovanni Poleni for the dome of St.Peter's in Rome. In accordance with the elastic theories on the masonry dome, the equations of the *shell theory* in membrane condition have then been considered. Finally, the limit analysis of structural behaviour of the masonry domes have been mentioned, developed in the case study of the dome of the Sanctuary of Vicoforte (Italy), the biggest elliptical dome realized to date. In the experimental section of this chapter, the studies of the dome of S. Maria del Fiore in Florence and again the studies on the dome of the Sanctuary of Vicoforte have been investigated, with particular attention to the surveys carried out in line with the finite-elements method.



Finite-elements method model of the Sanctuary of Vicoforte (Italy)

In conclusion, this work has enabled one to define the orientation of the contemporary studies related to the structural behaviour of the masonry vaults and, not least, to create an exhaustive base of study for further analysis on the topics examined.

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