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Computational morphogenesis and digital simulation of the building process of masonry domes built without centrings

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Abstract

This paper reassume the Master Thesis of G. Boccia, L. Esposito, A. Luporino under the tutorship of Prof. S. Pone at the Università di Napoli Federico II.

This study presents a computational framework for the design and construction of masonry domes built without the use of centrings. In particular, it focuses on those built using a 'compass', i.e. an erection device which simplify the building operations and guarantee the accuracy of the bricklaying process. The foundation of this research project can be found in the work of Fabrizio Carola (1931-2019), who, since the 70s', had built dozens domes without centrings in North Africa. The technique adopted by Carola is derived from the 'Nubian vault tecnique', a traditional construction process which was unearthed by Hassan Fathy during the construction of the village of New Gourna.

The design and construction processes described by Carola have been analyzed with the aim of defining a sequence of operations and build a parametric model upon them. The construction process was simulated by means of recursive algorithms in order to control the laying of each brick and avoid the overlap of the mortar joints between successive courses.

Then, the study moved to the implementation of two bespoke designed erection devices which can be used to build non-spherical domes. These are characterized by more degrees of freedom than their predecessor and can be used at the design stage to generate new shapes without exacerbating the complexity of their construction.

The result of this study is a computational tool which can be used to design masonry domes and simulate their building process; the introduction of new building devices has demonstrated to greatly increase the range of geometric possibilities of this technology.