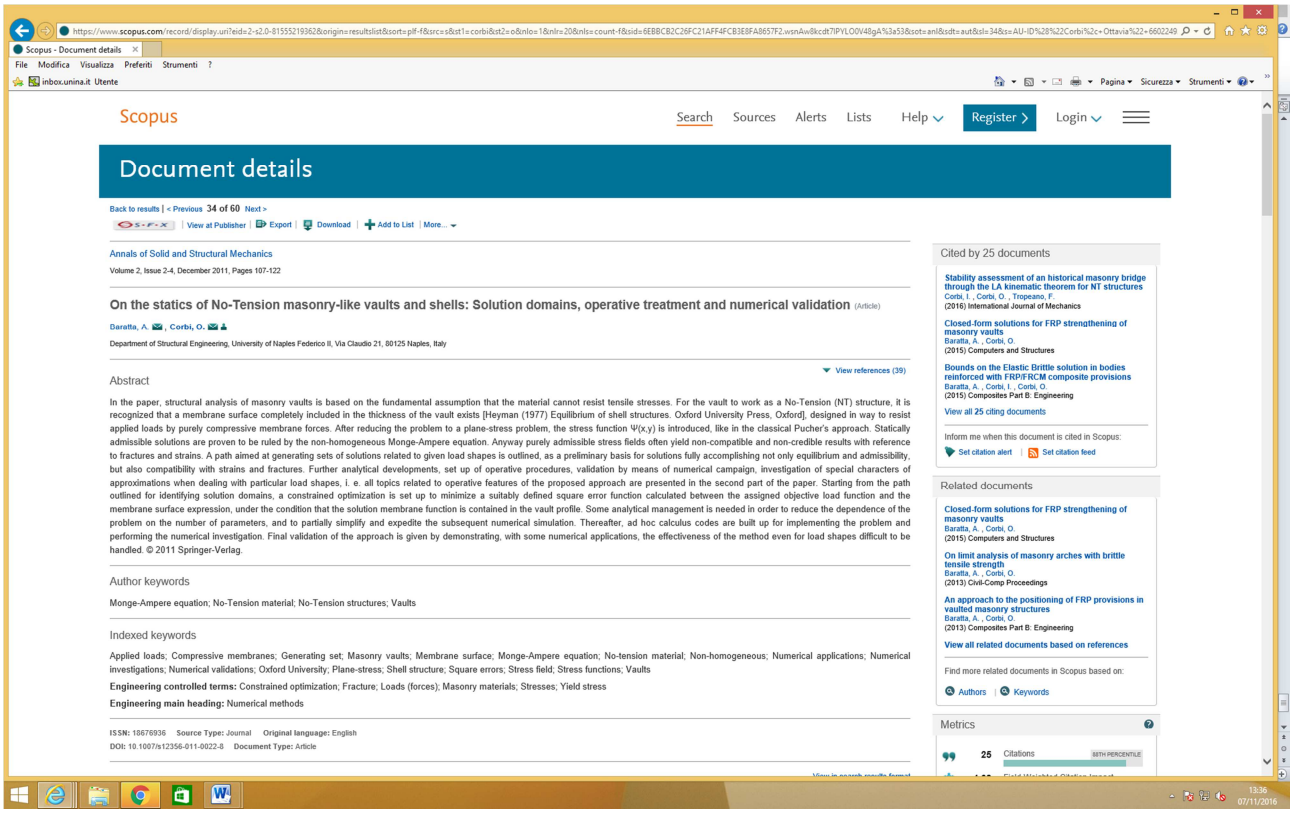

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On the statics of No-Tension masonry-like vaults and shells: Solution domains, operative treatment and numerical validation (Article)

Baratta, A. , Corbi, O.

Department of Structural Engineering, University of Naples Federico II, Via Claudio 21, 80125 Naples, Italy

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Abstract

In the paper, structural analysis of masonry vaults is based on the fundamental assumption that the material cannot resist tensile stresses. For the vault to work as a No-Tension (NT) structure, it is recognized that a membrane surface completely included in the thickness of the vault exists [Heyman (1977) Equilibrium of shell structures. Oxford University Press, Oxford], designed in way to resist applied loads by purely compressive membrane forces. After reducing the problem to a plane-stress problem, the stress function Ψ(x,y) is introduced, like in the classical Pucher's approach. Statically admissible solutions are proven to be ruled by the non-homogeneous Monge-Ampere equation. Anyway purely admissible stress fields often yield non-compatible and non-credible results with reference to fractures and strains. A path aimed at generating sets of solutions related to given load shapes is outlined, as a preliminary basis for solutions fully accomplishing not only equilibrium and admissibility, but also compatibility with strains and fractures. Further analytical developments, set up of operative procedures, validation by means of numerical campaign, investigation of special characters of approximations when dealing with particular load shapes, i. e. all topics related to operative features of the proposed approach are presented in the second part of the paper. Starting from the path outlined for identifying solution domains, a constrained optimization is set up to minimize a suitably defined square error function calculated between the assigned objective load function and the membrane surface expression, under the condition that the solution membrane function is contained in the vault profile. Some analytical management is needed in order to reduce the dependence of the problem on the number of parameters, and to partially simplify and expedite the subsequent numerical simulation. Thereafter, ad hoc calculus codes are built up for implementing the problem and performing the numerical investigation. Final validation of the approach is given by demonstrating, with some numerical applications, the effectiveness of the method even for load shapes difficult to be handled. © 2011 Springer-Verlag.

Author keywords

Monge-Ampere equation; No-Tension material; No-Tension structures; Vaults

Indexed keywords

Applied loads; Compressive membranes; Generating set; Masonry vaults; Membrane surface; Monge-Ampere equation; No-tension material; Non-homogeneous; Numerical applications; Numerical investigations; Numerical validations; Oxford University; Plane-stress; Shell structure; Square errors; Stress field; Stress functions; Vaults

Engineering controlled terms: Constrained optimization; Fracture; Loads (forces); Masonry materials; Stresses; Yield stress

Engineering main heading: Numerical methods

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Authors Authors and affiliations

Alessandro Baratta , Ottavia Corbi

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