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An approach to masonry structural analysis by the no-tension assumption - Part I: Material modeling, theoretical setup, and closed form solutions (Article)

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Abstract

The prevalent feature that characterizes masonry structures and makes them dissimilar from modern reinforced concrete and steel structures is quite definitely their inability to resist tensile stresses. Therefore, it is natural that the material model that is intended to be an "analog" of real masonry cannot resist tensile stress but possibly behaves elastically under pure compression, opening a perspective on the adoption of the no-tension (NT) material constitutive assumption. Founded on the NT theory, the basic direction and aim of the present work is to propose a unified treatment of masonry structures presenting an overall and comprehensive up-to-date insight in the analysis of masonry constructions while providing basic and advanced concepts and tools already available or original. The note is intended to lead to several notable results including, just to mention some of the outcomes, that the St. Venant's postulate does not hold in NT solids, no energy is dissipated by fracture, special accommodations for discontinuous loads are needed, and the relevant developments are provided, among other significant outcomes such as the identification of operative procedures for engineering solutions of structural problems. In the first part of the paper, the basics for the foundation of a NT material theory are illustrated, and the relevant principles for structural analysis, mainly identified in the classic energy theorems and suitably adapted to the material at hand, are formulated. In (apparently) simple cases, closed-form solutions can be obtained, or, at least, the solution process can be prepared after a preliminary screening of the equilibrium scenario. The application to two-dimensional no-tension elasticity is then illustrated in the last section, with reference to two sample cases. The first example proves that the solution in a NT panel acted on by vertical loads on the top is clearly identified in terms of stress, but if discontinuities are present in the load pattern, these reflect in some strong singularities in the deformation field that requires to deepen the problem. The second example is concerned with a NT-elastic half-plane, and a technique to find approximate solutions is outlined and carried on in detail. In Part II of the note, it is demonstrated that discontinuous or lumped load patterns can be looked at as frontier cases: They are not in contrast, but in some sense they are not natural to NT solids. Still in Part II, it is shown how the equilibrium problem can be managed both through the strain and the stress approach. © 2010 American Society of Mechanical Engineers.

Indexed keywords

Approximate solution; Closed form solutions; Constitutive assumption; Deformation field; Energy theorem; Engineering solutions; Equilibrium problem; Half-planes; Load patterns; Lumped loads; Masonry structures; Material modeling; Material models; Solution process; Structural problems; Vertical load

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An Approach to Masonry Structural Analysis by the No-Tension Assumption—Part I: Material Modeling, Theoretical Setup, and Closed Form Solutions

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