Proposed Algorithm to Accelerate the Anisotropic Rankine-Hill Model in Nonlinear Analysis of Masonry Structures

A.Yaghoubifar[1], A.A.Tasnimi[2]

1- Ph.D. Student, Faculty of civil & Envi. Eng., Tarbiat Modares University
2- Prof. in Structural Eng., Faculty of Civil & Envi. Eng., Tarbiat Modares University

amiryaghoubifar@yahoo.com

Abstract

In order to analyze the masonry structure with large number of unit and joint, usage of the macro-modeling is un-avoidable. An accurate analysis of masonry structures in a macro-modeling per-spective requires a material description for all stress states. Difficulties arise especially due to the fact that almost no comprehensive experimental results are available (either for pre- and post-peak behavior), but also due to the intrinsic complexity of formulating anisotropic inelastic behavior. Only a few authors tried to develop specific macro-models for the analysis of masonry structures, in which anisotropic elasticity is combined with anisotropic inelastic behavior. In this paper, the Rankine-Hill macro-model detailed in practical user code, with purpose the accelerate localized solutions of nonlinear analysis in masonry structure.

Keywords: Masonry structure, Nonlinear analysis, Macro-model, Proposed Algorithm.

1. INTRODUCTION

The analysis of masonry structures built from a large number of units and joints can only be carried out with macro-models, in which a relation between average stresses and strains in the composite material is established. The effective constitutive behavior of masonry features anisotropy arising from the geometrical arrangement of units and mortar, even if the properties of these constituents are isotropic.

The representation of an orthotropic yield surface in terms of principal stresses or stress invariants only is not possible. For plane stress situations, which is the case of the present study, a graphical representation in terms of the full stress vector (σ_x, σ_y and τ_{xy}) is necessary. The material axes are assumed to be defined by the bed joints direction (x direction) and the head joints direction (y direction). Another possible representation can be obtained in terms of principal stresses and an angle θ . The angle θ measures the rotation between the principal stress axes and the material axes. Clearly, different principal stress diagrams are found according to different values of θ.

General anisotropic plasticity models have been proposed for a number of experimental and theoretical viewpoints. Among these models to the Hill (1948), Hoffman (1967) and Tsai & Wu (1971) noted. Later De Borst and Feenstra (1990) and Schellekens and De Borst (1990) which fully treated the implementation of, respectively, an elastic-perfectly plastic Hill yield criterion and an elastic-perfectly plastic Hoffman yield criterion [1, 2]. The hardening behavior could be simulated with the fraction model of Besseling (1958) but not much effort has been done in this direction. Swan and Cakmak (1994), which included linear tensorial hardening in the Hill yield criterion, and Li et al. (1994), which included linear hardening in a modified Von Mises to fit either the uniaxial tensile or compressive behavior, but not both [3]. Dhanasekar et al. (1985,1986) and Seim (1994) based on the work of Ganz (1985) dealt with the implementation of a specific numerical model for masonry. The cited authors proposed rather complex yield surfaces which almost preclude the use of modern plasticity concepts and an accurate representation of inelastic behavior (hardening and softening rule) [4-7].

Basically, two different approaches for the macro-modeling of masonry can be used. The first approach is to describe the material behavior with a single yield criterion. The Hoffman yield criterion is quite flexible and attractive to use, see Schellekens and De Borst (1990) and Scarpas and Blaauwendraad (1993), but yields a non-acceptable fit of the masonry experimental values. A manual fit through the different uniaxial strengths and the compressive failure obtained upon loading with $\sigma_1 = \sigma_2$ and $\theta = 0°$ gives a very poor representation of the diagrams for the other θ values and a critical overestimation of strength in the tension-compression regime. A single surface fit of the experimental values would lead to an extremely