INTERFACE MODEL FOR THE NONLINEAR ANALYSIS OF BLOCKY STRUCTURES OF ANCIENT GREEK TEMPLES

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ABSTRACT

A frequent problem for structural analysis is the study of structures where are present singularity sufaces in the displacement field. Strong discontinuities are present in old masonry structures where dry joints connect the blocks or the mortar ageing suggests to neglect the adhesion properties. To fully analyze the behaviour of such structures is necessary to take in account the deformation modes of the joints. The different ways in which these deformation modes are modelled characterize different approaches.

Two wide classes of approaches could be identified: *Continuum* approach and *Discrete* approach. The first one tries to model the structure considering an homeogeneous *equivalent* continuum where the deformation modes of the joint are incorporated in the constitutive relations. Typical examples are *notension* material (Fuschi et al. 1995) where the opening mode of the joint is modelled, Cosserat continuum theory (Cerrolaza et al. 1995) where additional degrees of freedom are considered and leads to the definition of additional material parameters, nonsmooth multisurface plasticity (Mistler et al. 2006) where specific failure and damage mechanisms are simulated introducing separate softening functions for each strength parameter.

In the *Discrete* approach the structure is considered as an assembly of blocks connected by contact joints. In this way the deformation modes of the joints could be modelled by apposite interface laws. This detailed approach is usually more time consuming but for many real world cases is the only approach capable to consider the several mechanical aspects the structural problem presents.

The *Discrete* approach is followed in the present work, using interface laws derived from the *double asperity* interface model (Mróz and Giambanco 1996). The classical interface model assumes that the contact surface between two bodies Ω^1 and Ω^2 could be assumed as a as a contact layer of thickness h. In the double asperity model the planar joint is modelled by spherical asperities of different radius.

After a brief description of the interface model adopted, the discrete interface laws, suitable for the adoption in a finite element code are illustrated.

The numerical applications regard the analysis of a couple of greek temples of Agrigento in Italy. The temples of *Giunone Lacinia* and *Concordia* are old monumental structures that belong to the ancient greek city of *Akragas*, examples of the extraordinary monumental complex of *Valle dei Templi di Agrigento* inserted, from 1997, in the world heritage list by Unesco. For the temple of *Giunone Lacinia* it was modelled a structural element composed by two columns and the architrave, *trilite*, subjected to dynamic analysis and a time-history of acceleration, obtained by a response spectrum defined according to European Standard EC 8. For the temple of *Concordia* it was modelled the west front composed by six columns, the architrave and the *timpano* subjected to a pseudostatic analysis with increasing horizontal forces till the collapse.

REFERENCES

Cerrolaza, M., J. Sulem, and A. Elbied (1995). A cosserat non-linear finite element analysis software for blocky structures. *Adv Eng Softw 30*, 69–83.

Fuschi, P., G. Giambanco, and S. Rizzo (1995). Non linear finite element analysis of no-tension masonry structures. *Meccanica 30*, 233–249.

Mistler, M., C. Butenweg, and K. Meskouris (2006). Modelling methods of historic masonry buildings under seismic excitation. *J Seismol 10*, 497–510.

Mróz, Z. and G. Giambanco (1996). An interface model for analysis of deformation behaviour of discontinuities. *Int. J. Numer. Anal. Methods Geomech. 20*, 1–33.