A computational python-based tool for Discrete Element Modeling: COMPAS DEM

A. Dell'Endice*, A. Iannuzzo †, T. Van Mele†, and P. Block†

*, † ETH Zurich, Institute of Technology in Architecture, Block Research Group
Stefano-Franscini-Platz 1, HIB E, CH-8093 Zurich, Switzerland
dellendice@arch.ethz.ch, iannuzzo@arch.ethz.ch, van.mele@arch.ethz.ch,
block@arch.ethz.ch - Web page: https://www.block.arch.ethz.ch

ABSTRACT

In the analysis of Unreinforced Masonry (URM) structures, the Discrete Element Modeling [1] (DEM) have shown reliable results in the simulation of three-dimensional collapse mechanisms and in the investigation of the displacement capacity [2]. In DEM blocks can be considered rigid or deformable, and contacts can be modelled with no tensile strength and arbitrary friction angle. These features make this method suitable for URM structures, even allowing an approximation of Limit Analysis as applied by Heyman [3]. Unlike more traditional tools, DEM allows the analysis of complex 3D models and to investigate their three-dimensional behaviour.

This paper presents a python-based computational tool, COMPAS DEM, framed within COMPAS masonry, that extends the modelling possibilities and the comprehension of DEM analyses, performed in the background using the software 3DEC by Itasca as solver. Through the COMPAS DEM user-friendly interface, the user can easily create and manage complex parametric three-dimensional geometries, and directly generate 3DEC files containing mechanical parameters and analysis details. In this process geometric and mechanical imperfections can be generated, in order to simulate assembly errors and material tolerances. The 3DEC results are then extracted and post-processed for a better understanding and more clear visualization (e.g. unbalanced forces are plotted for each block at each calculation step). As one of the main features (still not present in 3DEC), COMPAS DEM, allows the user to visualize resultant contact forces at the interfaces among the blocks. Furthermore, in order to understand where the sliding occurs, COMPAS DEM provide appropriate visualization tools for verifying if the contact forces are within the friction cone or not, and for splitting resultant forces in normal and tangential components. This allows the visualization of the flow of forces within the structure. In particular the influence of geometrical imperfection and the effect of finite displacements, which can change considerable the flow of forces, can be easily investigated. The visualization of flow of forces, beyond a better understanding of the structural behaviour under non-homogeneous boundary conditions, allows to enlarge considerable the space of admissible solutions. That is, with reference to a single block, equilibrium state due to non-coplanar and non-concurrent forces can be found. In this sense COMPAS DEM can provide solutions that with other more conservative methods, such as Thrust Network Analysis [4], cannot be found.

A case study is presented to show in detail all the possibilities offered by COMPAS DEM and to highlight the potential of this method for the assessment of URM structures.

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