14th World Congress in Computational Mechanics (WCCM)
ECCOMAS Congress 2020
11 – 15 January 2021, Paris, France

A Multiscale Model for Numerical Modelling of Homogenized Elastic-Viscoplastic Behavior of Mortarless Refractory Masonry Structures

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Key Words: *Mortarless Masonry, Refractories, Nonlinear Homogenization, Creep, Modelling.*

Mortarless refractory masonry is widely used in the steelmaking industry for the linings of high-temperature components including steel ladle [1,2]. The design and optimization of these linings require accurate numerical models that consider the presence of joints, joints closure and reopening and the nonlinear elastic-viscoplastic behavior (creep) of refractories at high temperature. The present study reports on the formulation, numerical implementation, and application of a homogenized elastic-viscoplastic model for simulation of refractory masonry structures with mortarless joints. Refractory bricks are considered to exhibit linear elasticity as well as rate-dependent plasticity (creep). Four joint patterns have been predefined based on the state of bed and head joints. The homogenized elastic-viscoplastic behavior of each joint pattern has been determined using finite element based nonlinear homogenization approach [3]. The transition criterion between the four patterns is defined as function of macroscopic stresses and strains. Verifications of the developed homogenized constitutive laws have been carried out by comparing the numerical results of detailed micro models (brick and joints are considered) with the homogeneous equivalent material models. Then, the verified models have been used to simulate refractory masonry walls subjected to different loading conditions. The present numerical model is able to simulate the orthotropic, compressible, rate-dependent homogenized behavior of mortarless refractory masonry structures, and accounts for joints closure and reopening.

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Acknowledgments

This work was supported by the funding scheme of the European Commission, Marie Skłodowska-Curie Actions Innovative Training Networks in the frame of the project ATHOR - Advanced THermomechanical multiscale modelling of Refractory linings 764987 Grant.