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PERFORMANCE EVALUATION OF MASONRY INFILL WALLS SUBJECTED TO AXIAL AND IN-PLANE SHEAR LOADING: MESO- AND MACROSCOPIC EXPERIMENTS AND SIMULATIONS

*** Kaspar J. Willam[1], Ben Blackard[2], Carlo Citto[3] and Sivaselvan Mettupalayam[4]**

[1] Uni. of Colorado Boulder
CEAE Department
428 UCB
Boulder, CO 80302-0428
USA
willam@colorado.edu

[2] Uni. of Colorado Boulder
CEAE Department
428 UCB
Boulder, CO 80302-0428
USA
blackard2@hotmail.com

[3] Uni. of Colorado Boulder
CEAE Department
428 UCB
Boulder, CO 80302-0428
USA
carlo.citto@colorado.edu

[4] Uni. of Colorado Boulder
CEAE Department
428 UCB
Boulder, CO 80302-0428
USA
siva@colorado.edu

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ABSTRACT

This paper describes the findings of an experimental and computational investigation of a 2/3 scale masonry infill wall bounded by a reinforced concrete frame. This study is part of a NEESR small group project directed by Prof. B. Shing, University of California San Diego, and involving Prof. S. Billington, Stanford University, as well as the team at the University of Colorado Boulder. While the overall effort is focused on the seismic performance of masonry infill buildings with and without ECC retrofits, our share of the project considers single story-single bay masonry infill structures with and without openings which are subjected to quasi-static cyclic shearing after axial prestressing. The masonry wall is comprised of two wythe brick walls of fired solid brick units. The layout is a standard running bond with a header course placed at every sixth coursing. The prototype structure for the RC frame is that of a multistory building of the 1920's era. As such pre 1970 design standards are implemented with a shear critical layout of transverse stirrups in the $11 \times 11\, in^2$ concrete columns. So far a good number of material experiments accompanied testing of two masonry infill walls with and without a window opening. The material tests included extensive experiments on mortar specimens, brick units, concrete specimens, steel bars and brick-mortar interface properties. Small prism tests were carried out to examine the performance of brick-mortar construction in order to verify and validate the underlying material models at relatively simple rectilinear and skewed mortar-brick prisms.

The paper focuses on the underlying modeling issues which come to the forefront when the composite action of the masonry wall with the bounding reinforced conmcrete frame is considered. Aside from the reinforced concrete frame the performance of the masonry wall is the main topic of our investigation when the brittle brick units are interacting with the ductile mortar layers in the bed and head joints. Thereby the interface transition zone plays a fundamental role in adhering constituents of different properties. The presentation highlights the fundamental bond issues related to *'finite thickness interphase formulations '* versus *'zero-thickness interface models'* which exhibit adhesive as well frictional

resistance and are primarily responsible for the loss of triaxial confinement due to mismatch. The bond issues are of interest not only at the macro-scale of observation, they are of fundamental importance at the meso- and micro-scales of observation when strength and ductility issues in layered masonry materials are of interest.

The paper illustrates the underlying modeling issues at the example of masonry when the composite action of clay units and mortar layers leads to axial splitting in compression [1]. Starting from the laboratory identification of the mechanical properties of brick units and mortar joints, failure in compression, tension and shear reveals the importance of mismatch among the elastic and inelastic properties of brick and mortar. The studies illustrate the critical role of the interface transition zone in the layered construction which exhibits a life of its own quite aside from the brittle behavior of brick units and the ductile behavior of mortar joints. Hence the question of upscaling and homogenization of the three component material system poses fundamental mechanics questions when effective stiffness, strength and ductility properties are to be determined for the macroscopic behavior of masonry composites.

At the core of the constitutive formulation brick and mortar may be characterized as cohesive-frictional materials which are very sensitive to triaxial confinement in fact their degradation strongly depends on the level of bond in the interface transition zone. The relevant constitutive aspects are reviewed in terms of the thermodynamic concept of *'generalized standard materials'* within the format of micromorphic continua. This raises a number of fundamental questions as to whether and how hardening and softening may be captured at multiple scales of observation. In other terms, the issue of multi-scale analysis deserves special attention when brittle failure mechanisms need to be transported across different scales of observation.

REFERENCE

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