Using NHERI SimCenter Software and NHERI DesignSafe Computing Resources to Calibrate an OpenSees Model for Reinforced Concrete Walls

J. Stokley[1] and L.N. Lowes[2]

ABSTRACT

Reinforced concrete walls are used commonly in mid- and high-rise buildings to resist lateral loads; typically, the concrete walls have three-dimensional configurations to maximize stiffness and strength and to accommodate architectural constraints. Seismic design, evaluation, and retrofit of concrete walled buildings often requires nonlinear analysis to predict performance, and assessment of earthquake risk for regions and individual buildings often requires nonlinear analysis of walled buildings to predict damage, loss of functionality, repair time and cost, and impact on the surrounding neighborhood. Regardless of the motivation, there is typically the need for models that provide accurate simulation of concrete walled-building response, with minimum computational time. Layered shell element models are an ideal tool for this as they easily represent three-dimensional geometries as well as nonlinear stress-strain profiles along the length and through the thickness of the wall, are more computationally efficient than solid-element models, and are more accurate than fiber-type beam-column elements that require the user to assume "plane sections remain plane", which is particularly inaccurate for non-planar walls. The research present here used the *PlaneStressUserMaterial* developed by Lu et al [1], which characterizes concrete response under general 2D loading, in combination with layered shell-element formulations that are implemented in the OpenSees [2] platform; the experimental data set published by Shegay et al. [5] was used to calibrate and then validate modeling recommendation for simulating the earthquake response of walled-buildings through to strength loss.

Calibrating a many degree-of-freedom, nonlinear structural response model using a large experimental data set is a computationally demanding task. Jupyter notebooks were used to create and run OpenSees models of individual walls as characterized using data from the Shegay dataset, and Jupyter notebooks were used to define error functions that formed the basis of the model calibration effort. Computational demand associated with model calibration was reduced by using the algorithms embedded in Dakota (https://dakota.sandia.gov/), and total computational time was reduced by using the computing resources provided by the NHERI DesignSafe-CI facility [4]. Creation of an efficient research workflow was enabled by use of the NHERI SimCenter quoFEM software [3]. Results of the effort include recommendations for meshing wall models and defining material parameters that determine concrete material behavior.

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[1] Graduate Student Research Assistant, Dept. of Civil and Environmental Engineering, University of Washington, Seattle, WA 98195 (stokljos@uw.edu)

[2] Professor, Dept. of Civil and Environmental Engineering, University of Washington, Seattle, WA 98195 (email: lowes@uw.edu)