ANALYTICAL MODELING OF 3D BUCKLING OF ZIPPER-FRAME BRACES

M.Schachter[1] and A.M. Reinhorn[2]

ABSTRACT

Three shaking table tests have been performed to evaluate the seismic response of a 3 story suspended zipper frame model. Analytical simulations of the zipper frame were carried out before the tests. In all of them, the frame was idealized as a planar i.e. the braces buckled in plane without out-of-the-plane movement. The "zipper-frame" was expected to have (1) buckling in the 1st floor braces in first stage, (2) transmition of the unbalance vertical force to the vertical "zipper-column" in the second stage, (3) buckling in the 2nd story braces, next, and (4) continuation of stage (2) and (3) up the next floor until reaching the top story. The unbalanced vertical force from lower levels is transmitted to the top story (third in the model for this study), which is designed to remain elastic.

However, the braces buckled out of plane, in all shake table tests performed. It was also found that the 1st floor gusset plate connecting the diagonal braces to beam affects strongly the development of the "zipper mechanism". If the gusset is too stiff, the out of plane moment is transmitted to the beam at top of the diagonal braces, rotating, yielding in torsion it, and interrupting the zipper mechanism. On the other hand, if the gusset plate is flexible, then the beam stays straight and the "zipper mechanism" develops.

Following the tests, a new analytical-numerical model was developed for the diagonal braces to capture the dynamic three-dimensional buckling. The new model is based on a "corotational formulation" (CRF) and it is capable of large rotations and large strains. Every element is described independently. The rigid body modes are considered and removed from the individual members by using the corotated coordinate system. Within the deformed shape, the elements can undergo large rotations and large strains, which are evaluated in respect to the corotated origin. The structural problem is formulated finally using the "state space" approach (SSA), where displacements as well as displacement-rates (velocities) are considered as independent variables. The formulation results in a combination of differential and algebraic equations (DAE) that are solved using the IDA software.

The braces of the 1st floor were modeled using this new approach and the results were compared to the measurements made during the shake table testing using the imaged based coordinate tracking system (Krypton). A brief summary of the methodology and the results of these comparisons are presented in the paper.

---

[1] PhD Candidate, and [2] Professor, Dept. of Civil, Structural and Environmental Engineering, University at Buffalo, Buffalo, NY 14260