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Behavior of Three-Dimensional Reinforced Concrete Shear Walls

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Results from two large-scale flanged shear walls tested under static cyclic displacements are presented. The objectives of the tests were to provide insight into the behavior of shear walls under cyclic displacements, and more importantly, to provide data to help corroborate constitutive models for concrete exposed to arbitrary loading conditions. The results indicated that the presence of an axial load, although relatively small, and the stiffness of flange walls have a significant effect on the strength, ductility, and failure mechanisms of the shear walls. Finite element analyses using provisional constitutive models are also provided to show that the procedures employed are stable, compliant, and provide reasonably accurate simulations of behavior. The analyses presented also indicated that two-dimensional analyses capture main features of behavior, but three-dimensional analyses are required to capture some important second-order mechanisms.

Keywords: load; reinforced concrete; shearwall.

INTRODUCTION

To assess the seismic safety factor of nuclear reactor buildings, the Nuclear Power Engineering Corporation of Japan (NUPEC) recently conducted an extensive experimental investigation. Two large-scale flanged shear walls were subjected to dynamic loading using a high-performance shaking table. The results of the tests were made available to participants of the Seismic Shear Wall International Standard Problem (SSWISP) Workshop.[1]

It became evident from the competition results that the ability to predict the peak strength of shear walls under seismic excitations was not well established. More importantly, however, was the apparent inability of leading researchers to accurately predict structural ductility. The predictions were based on finite element method (FEM) static monotonic and static cyclic analyses, FEM dynamic analyses, simplified static and dynamic analyses, and lumped-mass dynamic analyses. Figure 1(a) and (b) show the analytical results of the predicted maximum load and the predicted displacement at maximum load for the FEM static analyses, respectively.

The results indicated that the methods and models used were able to predict the maximum load more accurately than the displacement at maximum load. The maximum load reported by NUPEC was 1636 kN, and the corresponding displacement was 10.96 mm. The analytical maximum load results varied between 65 to 115% of the experimental value, with the majority of the participants underestimating the peak strength. The variation was, however, smaller than that of the displacement at the maximum load. The range in predicted displacements was from 35 to 180% of the actual amongst those participants who submitted results. Again, the majority of predictions underestimated the ductility of the shear walls.

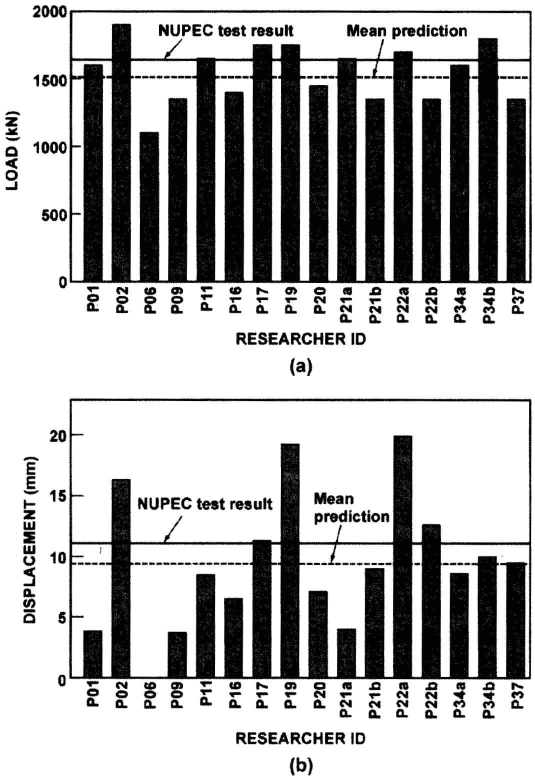

Fig. 1—NUPEC results: (a) maximum predicted load; and (b) predicted displacement at maximum load.

These apparent difficulties with accurately modeling ductility led to large-scale testing of flanged shear walls at the University of Toronto. The purpose of this experimental program was to investigate the behavior of shear walls under cyclic loading, to provide test data to formulate improved cyclic models, and to assess current capabilities in predicting structure ductility using in-house FEM programs.

The main objective of this paper is to present and discuss the results of the experimental program conducted at the University of Toronto. Analyses using provisional constitutive models are presented to show that computational procedures can be stable and compliant, and can provide reasonably accurate simulations of behavior. A companion paper will discuss the theoretical models and finite element studies.

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