

ABSTRACT

Villalobos Fernández, Enrique J., Ph.D., Purdue University, August 2014. Seismic Response of Structural Walls with Reinforcement and Geometric Discontinuities. Major Professor: Santiago Pujol.

Discontinuities in the geometry and the reinforcement of structural walls create stress concentrations that have detrimental effects on wall seismic response. This study focused on discontinuities associated with changes in the geometry of the cross section along the height of planar walls. It also addressed longitudinal reinforcement discontinuities and their effects on the seismic performance of structural walls resisting seismic demands. Two series of tests were conducted to investigate these two types of discontinuities.

To study the effects of reinforcement discontinuities, six test walls were subjected to lateral displacement reversals of increasing amplitude up to failure. The effects lap splices, splice length (60 bar diameters and 40 bar diameters), and boundary-element confinement were studied. The measured drift capacity ranged from 2.5% to 3% for the walls without lap splices and from 1.5% to 2.5% for the walls with lap splices. The increase in drift capacity caused by the boundary-element confining reinforcement ranged between 20% and 67%. Lap splices caused tensile-strain concentrations at the bases of the walls after yield. The rate of increase in maximum unit strain with increasing drift observed in walls with splices was approximately twice the rate observed in walls without splices. This difference results in longitudinal-bar buckling at smaller drift ratios in walls with lap splices. A method to estimate the drift capacity of walls vulnerable to longitudinal bar buckling is proposed. Lap-splice failures did not occur in the tests conducted in this study. These types of failures have occurred in beams subjected to nearly constant moment and with lap splices with configurations resembling those of splices in wall boundary elements. It was concluded that the response of a splice is sensitive to moment gradient because it causes differences in the bar stresses on both ends of the splice.

To study the combined effects of reinforcement and geometric discontinuities, two walls with elevations in the shape of inverted trousers were tested under static lateral loads. In both walls the region intended to represent a first story in a structural wall had no openings. The region intended to represent higher stories had a central opening. The difference between the specimens was the continuity of the longitudinal reinforcement flanking the opening. This reinforcement was anchored beyond the section meant to represent the foundation in one specimen, and it was anchored in the region meant to represent the first story in the other specimen. The panel zones (i.e., regions of wall directly below the opening) in both test walls reached shear stresses approaching or exceeding their nominal capacities. Nevertheless, the panel zone flanked by continuous reinforcement performed better in that: 1) it reached smaller shear strains at similar drift ratios, and 2) despite the fact that it reached its capacity, its deterioration did not cause an anchorage failure of the longitudinal reinforcement flanking it. Anchorage failure limited the lateral-load carrying capacity in the specimen in which the longitudinal reinforcement flanking the panel zone was cutoff in the region meant to represent the first story, and the wall did not develop its expected flexural capacity. Expressions to estimate the shear stress demand and strength of panel zones in walls with aligned stacks of openings terminated in the lower stories are proposed and evaluated.