

Public Abstract

First Name: John

Middle Name: David

Last Name: Marcanik

Adviser's First Name: Sarah

Adviser's Last Name: Orton

Co-Adviser's First Name:

Co-Adviser's Last Name:

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Title: Evaluation of Tensile and Compressive Membrane Action in Isolated Slab-Column Specimen

Flat-plate buildings are susceptible to progressive collapse in which the failure of one slab-column connection propagates to the other connections and causes a full collapse of the building. The failure of the connection is commonly caused by the mechanism of punching shear. Alternative resistance mechanisms such as compressive and tensile membrane action may enhance the punching shear strength of a slab-column and arrest the progression of the collapse. This thesis seeks to determine the effect of in-plane lateral restraint on an isolated slab-column specimen with continuous reinforcement.

A slab at 0.73 scale with continuous top and bottom reinforcement was cast and tested with lateral restraint to evaluate the potential beneficial effects of in-plane compressive forces. The isolated slab specimen had column studs on top and bottom to simulate a progressive collapse scenario in which a nearby supporting column was removed.

The slab was able to achieve a centric load of 70 kips before the first punching failure then achieved nearly the same residual capacity following the initial failure. It was found that nearly all of the tension reinforcement had yielded before the punching failure occurred and the bars located closest to the column were experiencing the most stress. The compression reinforcement began fracturing around the column near the peak residual capacity due to amplified stresses as the tension bars were no longer resisting as much of the load. In-plane compressive forces reached a maximum of 5 kips before the punching failure which corresponded to a horizontal stiffness of 570 kip/in. Using a static analysis on the compression arch action, it was found that the 5 kip lateral compressive load increased the capacity of the slab by 0.5 kips, or a 1% overall increase.

In conclusion, the compressive membrane action only enhanced the punching shear strength of the slab by about 1%. However, the horizontal stiffness was only 36% of what was initially designed for, so changes in test setup design must be made to improve the in-plane lateral restraint for future tests. The slab showed tremendous post-punching capacity, as it reached a residual strength of 69 kips. The continuous tension and compression reinforcement was able to develop the full tensile membrane action in the slab and improve the ductility significantly. Future tests will be performed on 7 additional isolated slab-column specimens to further investigate the effects of different reinforcement ratios, in-plane lateral restraint, and dynamic loading on the punching strength of flat-plates to better resist progressive collapse.