EVALUATION OF THE EFFECTS OF IN-PLANE LATERAL RESTRAINT AND REINFORCEMENT RATIO ON THE PUNCHING SHEAR CAPACITY OF FLAT SLAB COLUMN SPECIMENS

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ABSTRACT

Localized damage to certain structural members in a building can trigger a chain reaction which results in a partial or complete collapse of the building. A collapse of this nature is called a progressive collapse and has the potential to cause significantly more damage than would be expected from the failure of the first member. This research project is particularly concerned with the potential of progressive collapses in older flat plate reinforced concrete structures. The nature of the design of these structures puts them at risk for progressive collapses normally resulting from punching shear failures at the slab column connections.

The goal of this research is to investigate the behavior of slab column specimens in a setup that more closely resembles a complete structure by applying in-plane lateral restraints. In a structure compressive membrane action can help to increase the capacity of the connection prior to a failure occurring and tensile membrane action can increase the residual capacity of a connection after it has failed. Specifically the experimental tests examine the effects of in plane lateral restraint on the punching shear capacity of the slabs prior to failure and the effects of reinforcement ratio before and after the failure occurs. Better estimation of the punching shear capacity will lead to better prediction if the punching shear failure will cause a progressive collapse.
Isolated slab column specimens were constructed with two different reinforcement ratios (0.5% and 1.0%) and tested in two different test setups (without lateral restraint and with lateral restraint). The slab column specimens were constructed following the provisions in the 1971 American Concrete Institute design code. The goal of the testing was to simulate a progressive collapse scenario where a nearby supporting column had been damaged.

Slabs tested with the higher reinforcement ratio had punching shear capacities that were at least 130% of the capacities of the specimens with lower reinforcement ratios. It was found that the unrestrained slab with the 1.0% reinforcement ratio had a punching capacity just over 69 kips which is very close to the ACI equations capacity estimation (70 kip) while the unrestrained slab with the 0.5% reinforcement ratio had a punching capacity of just under 52 kips.

The effects of the addition of in-plane lateral restraint were not as well defined. The restrained slab with the 1% reinforcement ratio had a punching capacity of 74 kips and the retrained slab with 0.5% reinforcement had a capacity of 54 kips. The restrained slabs showed little to no increase in punching shear capacity due to the in-plane lateral restraint. However, the actual stiffness of the test setup (500 kip/in) was much lower than the designed stiffness (1600 kip/in) therefore the full benefits of the in-plane restraint may not have be realized.

The post punching capacity of the slab column specimens was also investigated. All four of the specimens tested had peak residual capacities of more than 70% of the punching capacity. This residual capacity may be capable of arresting the progression of collapse. These residual capacities are higher than the estimated residual capacities based on previous research work possibly the result of the reinforcement being hooked at the edges of the slab specimens.