Designing Precast Concrete Cross Wall Joints Against Progressive Collapse

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Introduction

Progressive collapse has attracted the attention of engineers since the structural failure of Ronan Point apartments, London, UK, in 1968. Progressive collapse and robustness have become important issues in precast concrete cross wall constructions.

Ronan Point Collapse (http://en.wikipedia.org/wiki/Ronan_Point)

Due to the importance of this type of collapse, a number of researchers have attempted to conduct studies to develop design guidelines that would reduce or eliminate the susceptibility of buildings to this form of failure. Today there are three methods to design against progressive collapse, which are:

- Indirect method. In this method, the overall robustness of the structure will be increased through tie reinforcements.
- Specific local resistance method. This method requires the designed elements to be able to resist a sudden accident which can lead to a removal of one member or more.
- Alternative load path method. DOD (2005) declares that this method can be used in two situations:
    a. When a vertical structure element can not provide the required tie strength; and
    b. For structures that require medium or high levels of protection.

There are still some limitations in the previous studies regarding progressive collapse. Summary of the knowledge gap is listed as follows:

- Limited number of studies for designing precast concrete cross wall constructions against progressive collapse.
- No systematic study has lead to a rational and justifiable method to design for such a failure. All of the current codes suggest ties as a preferable solution to that collapse. Most of them have been proved to be workable by the project evidence, and therefore may be deemed sufficient but not always necessary.
- Limited studies regarding ductility and in particular, its impact on progressive collapse.

Aims and Objectives

This PhD project aims to study the impact of joint design on progressive collapse behaviour for precast concrete cross wall constructions. As a result of the study a rational joint design should be developed to reduce the hazards of a progressive

failure due to a sudden loss of a vertical component. The design will be underpinned by rigorous experimental and numerical studies. The approach included in this study to address progressive collapse is a direct one, i.e. the combination of the local resistance and alternative local path methods. A pre-defined damage is introduced, and the joint reinforcement details and the associated performance will be studied.

The study objectives are:

- Conduct a series of lab testing to understand the strength, ductility and robustness of individual elements, floor slab joints and slab-cross wall assemblies.
- Model the samples in testing condition with aim of reproducing the test results.
- Carry out parametric studies numerically and to propose general design guidance.

Methodology

The work of this research will be carried out in three parts as outlined as follows:

1. Lab work, which consists of three phases of tests :
    - Phase 0: evaluating the influence of reinforcement type and shear link spacing on ductility and bond strength.
    - Phase I: investigating the performance of floor joints in case of a sudden loss of a vertical component.
    - Phase II: studying the performance and failure of cross wall/floor assembly subject to a sudden loss of a vertical component.

2. Analytical prediction. The behavior and results for Phases 0, I & II will be predicted before conducting of each test.

3. Numerical analysis. On the completion of lab tests, numerical analysis will be performed by using finite element analysis software. Numerical

modeling aims to reproduce test results and parametric analysis will follow.

Reference

Department of Defense (2005). Unified Facilities Criteria (UFC-4-023-03): “Design Buildings to Resist Progressive Collapse”. DOD, Washington, D.C.