PROGRESSIVE COLLAPSE ANALYSIS OF PRECAST CONCRETE CONNECTIONS USING THE APPLIED ELEMENT METHOD

By

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Dedication

The author would like to dedicate this work to her passed away father, may god bless his soul.

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Abstract

Precast concrete structures become widely used recently due to high quality of manufacturing as well as its good behaviour under gravity. The most critical part in the precast structures is beam to column connections in precast frame system due to the different variables involved in the assemblages.

Many code regulations scoped on the design of the whole structure to resist different column loss scenarios regardless of beam connection joint behaviour. Also, many researches are conducted to study the overall behavior of the structure due to different column loss scenarios as well as studying different types of monolithic column beam connections and its behavior under column loss scenario. Many approaches are developed to strengthen the main structural elements as well as enhancing the overall behavior of the structure to resist the progressive collapse. However, few researches scoped on studying precast beam-column connection behavior under column loss scenario. This can be explained due to the limitations of the experimental and numerical testing of the connection to simulate the actual behavior under the column loss.

Many limitations and difficulties could take place during experimental testing such as:

1- Constructing the connection with its actual size
2- Simulating the column removal scenario
3- Testing the effect of different column loss scenarios on the whole structure

In this thesis, a detailed study is carried out on a prototype precast concrete structure to study the behaviour of the precast beam-column connections under column loss scenarios. One type of connections is used, gravity moment connections. The choice of the structure is based on different column removal scenarios as well as different frame arrangements. The structure is designed according to the American Concrete Institute and Precast/Prestressed Concrete Institute Design Hand book.

The study is divided into three main phases; the first phase is to study the local beam-column connection and its behaviour under column loss. The second phase is to study the connection behaviour under the column loss by modeling the full structural without slab contribution. The third phase is to study the connection behaviour under column loss by modeling the full structure model with slab contribution.

The Applied Element Method is implemented in the study to construct a 3D detailed model of the studied connections by using Extreme Loading of Structures Software. The performance of the connections is presented in terms beam, column and joint behaviour. Maximum beam deflection, rotation and internal axial force are calculated. Connection reinforcement normal and shear stresses are obtained as well as column behaviour in terms of rotation and internal axial forces are discussed. From the results obtained an enhancement design is suggested for the failed connections and studied its effect in resisting the local failure due to column removal.

The outcomes of the current research can be stated as follows:

1- Observing the different connection behavior that took place due to column loss for local and full structure model.
2- Observing the actual failure pattern
3- Suggesting an enhancement technique to prevent the local connection failure.
4- Considering the slab and its effect on the structural behavior with and without connection enhancement.

5- Calculating rotations of the elements connected to the concerned connection (Beams and columns) and compare their values with the UFC code requirements.

The results emphasized that the enhancement technique suggested for the different cases can work effectively in strengthening the precast beam-column connection as well as preventing local and global system failure due to column loss. Slabs played an important role in increasing the system strength against failure due to column loss and cannot be neglected in future research. finally, the enhancement technique succeeded in meeting the Unified Facilities criteria limitations as a result of no need for extra design consideration to prevent progressive collapse due to column loss.