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ANALYTICAL MODELING OF PRECAST CONCRETE GROUTED BEAM-COLUMN JOINTS UNDER CYCLIC LOAD

Mehrafarin NASERKHAKI
M.Sc. Graduate Student, IIEES, Tehran, Iran
mhrnsr1994@gmail.com
Akbar VASSEGHI
Associate Professor, IIEES, Tehran, Iran
vasseghi@iiees.ac.ir
Babak MANSOURI
Associate Professor, IIEES, Tehran, Iran
mansouri@iiees.ac.ir

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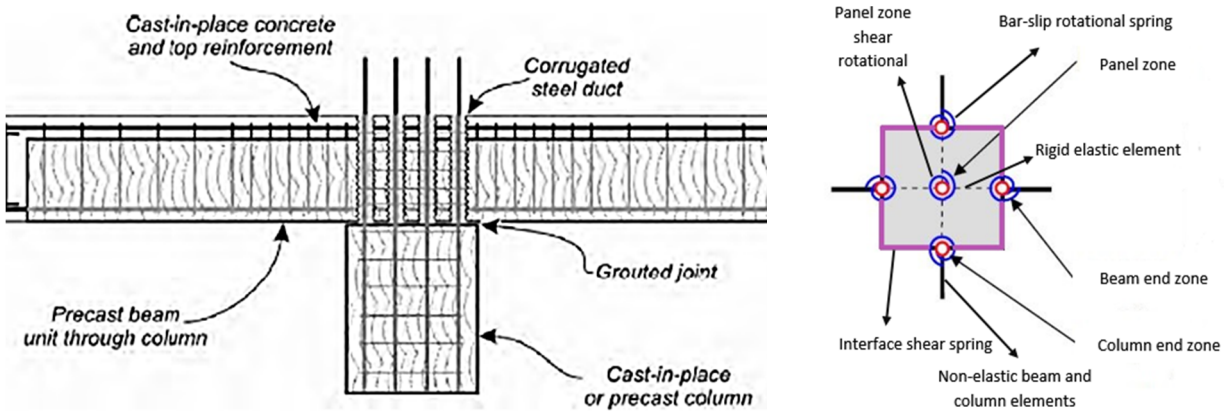
INTRODUCTION

Precast concrete frame structures are in many respects such as quality, amount of site work and construction speed superior to the cast-in-place concrete structures. However, seismic performance of these structures is significantly affected by the behavior of beam-column connections. Figure 1-a shows a typical connection in which the column reinforcements are passed through corrugated steel ducts within the precast beam. The moment resisting connection is finally formed by grouting the ducts after the top column is set in place. In this paper, a simplified model is presented to simulate the behavior of such joints under cyclic loading condition. The analytical model is verified with experiments which were carried out on large-scale specimens representing such connections.



(a) (b)

Figure 1. (a) Precast concrete grouted beam-column joint, (b) Analytical model of the beam-column joint.

METHODOLOGY

In this paper, the joint is modeled using the method presented in Naserkhaki's research (2018). Figure 1-b shows the analytical model of the joint. The following elements are used to simulate the three possible failure mechanisms:

- Four rotational springs located at the interface of joint with beams and columns that simulate the rotational response due to bar-slip occurring at beams and columns interface with the joint;

- Four transitional springs that simulate the shear response at the interface of joint with beams and columns;
- A rotational spring located at the center of the joint which simulates the shear behavior of the panel zone.

The nonlinear response of each rotational spring is modeled using Ibarra et al. (2005) hysteretic model. The joints are modeled in the Seismostruct platform (SeismoSoft, 2018). Fiber elements are used to model beams and columns. Concrete and steel behaviors are modeled using Mander et al. (1988) and Mengotto and Pinto (1973) models respectively.

Experimental Study

In the experimental study conducted by Lin in the University of Canterbury (1999), seismic behavior of several precast concrete joints was investigated. The specimens were first loaded axially and then subjected to cyclic lateral loads. In this paper, the test results from five specimens with various details and axial loads are used to verify the analytical model.

RESULTS AND DISCUSSION

As compared in Figure 2 the results from the analyses are in good agreement with the experimental results. The initial stiffness, the ultimate strength, the unloading stiffness, and the pinching characteristics are adequately predicted in all specimens. The analytical models also accurately predict the failure mechanisms observed during the tests.

CONCLUSIONS

The analytical model presented in this study adequately simulates the hysteresis response of the grouted precast beam-column connections under cyclic loading. The model also adequately predicts the failure mechanism within the joint.

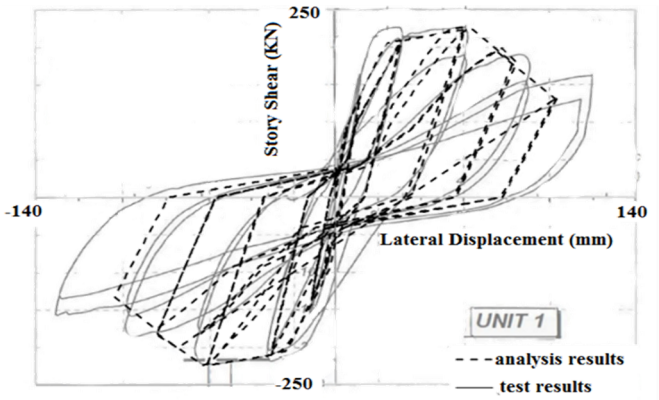


Figure 2. Comparison between the experimental and analytical hysteresis curves.

REFERENCES

Ibarra, L.F., Medina, R.A., and Krawinkler, H. (2005). Hysteretic models that incorporate strength and stifness deterioration. *Earthquake Engineering and Structural Dynamics*, *34*, 1489-1511.

Lin, C.M. (1999). *Seismic Behaviour and Design of Reinforced Concrete İnterior Beam Column Joints*. Ph.D. Dissertation, University of Canterbury, Canterbury, New Zealand.

Mander, J.B., Priestley, M.J.N., and Park, R. (1988). Theoretical stress-strain model for confined concrete. *Journal of Structural Engineering, 114(8)*, 1804-1826.

Menegotto, M. and Pinto, P. E. (1973). Method of analysis for cyclically loaded R.C. plane frames including changes in geometry and non-elastic behaviour of elements under combined normal force and bending, *Proc of Symposium on the Resistance and Ultimate Deformability of Structures Acted on by Well Defined Repeated Loads, International Association for Bridge and Structural Engineering*, 15-22, Lisbon, Portugal.

Naserkhaki, M. (2018). *Evaluation of Seismic Performance of Precast Concrete Buildings with Grouted Joints*. Masters Dissertation, International Institute of Earthquake Engineering and Seismology, Tehran, Iran.

SeismoStruct. (2018). Pavia: SeismoSoft Ltd.