



Code Investigation and Experimental Study of Wide Beam-Column Connections

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ABSTRACT: In this paper, the seismic behavior of wide beams was investigated. First, code provisions and results of previous tests on reinforcement concrete wide beam-column connections were reviewed. After a precise investigation of previous test results and a detailed study of the behavior of wide joints, 4 specimens of exterior wide beam-column connections on a scale of 3:5 were cast and tested under constant axial and cyclic lateral loads. The specimens were designed and detailed under ACI 318-14 and ACI 352R-02. In tested specimens, different geometries for columns (square, rectangular or circular) and spandrel beams (wide or conventional) were considered. During the tests, the formation of the full-width flexural plastic hinge of wide beams was observed in all the specimens without any shear or torsional failure. Energy absorption of specimens was relatively high and that is because of using stirrups at the joint area and axial loads applied to columns. The width of the spandrel beam and geometry of columns influenced the seismic performance of tested specimens. A comparison between experimental results and ACI provisions showed that dimensional limitations of ACI 318 on wide beams can be violated. Also, in wide joints with an axial load ratio greater than 15%, the bond performance of column longitudinal bars is improved, and ACI 352R provisions in this context can be relaxed.

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1. INTRODUCTION

Wide beam frames are efficient gravity and lateral systems in which the beam is wider than the column, and some of the wide beam bars are anchored in a spandrel beam. Many codes of practice before 1995 prohibited the use of these frames in highly seismic regions [1]. But, recent research in the last two decades has revealed that the performance of wide frames, when subjected to lateral excitation, may be acceptable [2,3]. The key parameter in the seismic behavior of wide beams as earthquake-resistant structures is the reinforcement detailing, especially at the joint region [4,5]. The torsional failure observed in many wide connections tested in the literature can be avoided by providing adequate transverse and longitudinal reinforcement at the spandrel beam [6,7].

However, there are still some concerns about the seismic performance of wide beam-column connections. The ductility, stiffness, and energy dissipation capacity of wide joints is usually lower than those of conventional ones [8,9]. Generally, the codes do not have comprehensively distinct provisions for seismic designing of wide beams. Most of them only restrict the dimensional parameters of wide beam-column connections [10-12]. The correct implementation of reinforcement details at the joint area seems to be vague and practically difficult.

In the current study, the seismic behavior of wide beams was investigated. The study focused on the reinforcement detailing at the joint region.

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2. METHODOLOGY

The paper is based on an experimental program conducted in the structural laboratory of Tehran University. Four 3:5 scale exterior wide beam-column connections were tested under constant axial and quasi-static lateral loads. The test setup is shown in Fig. 1. The test specimens were derived from a five-story prototype building. Different spandrel beam types, namely conventional and wide beams, and various column geometries, including square, rectangular and circular, were used in the specimens.

All the specimens were designed according to rules and regulations of ACI 318-14 and ACI 352R-02 [13,14]. Some violations from the code requirements were considered to facilitate the construction of the connections. The number of stirrups used in wide beams was significantly relaxed compared with that provided by ACI 318-14. The anchorage ratio of column longitudinal bars (the ratio of beam height to the diameter of column bars) was lower than the minimum value suggested by ACI 352R-02. Some dimensional restrictions of the beam width in ACI 318 were also violated.

The spandrel beams were designed to resist the torsional demand under ACI 352R-02. The transverse reinforcement of wide beams was continued at the joint region in conforming to ACI 318-14. This detailing was not thoroughly used in previous studies, maybe because of difficulties in the execution.



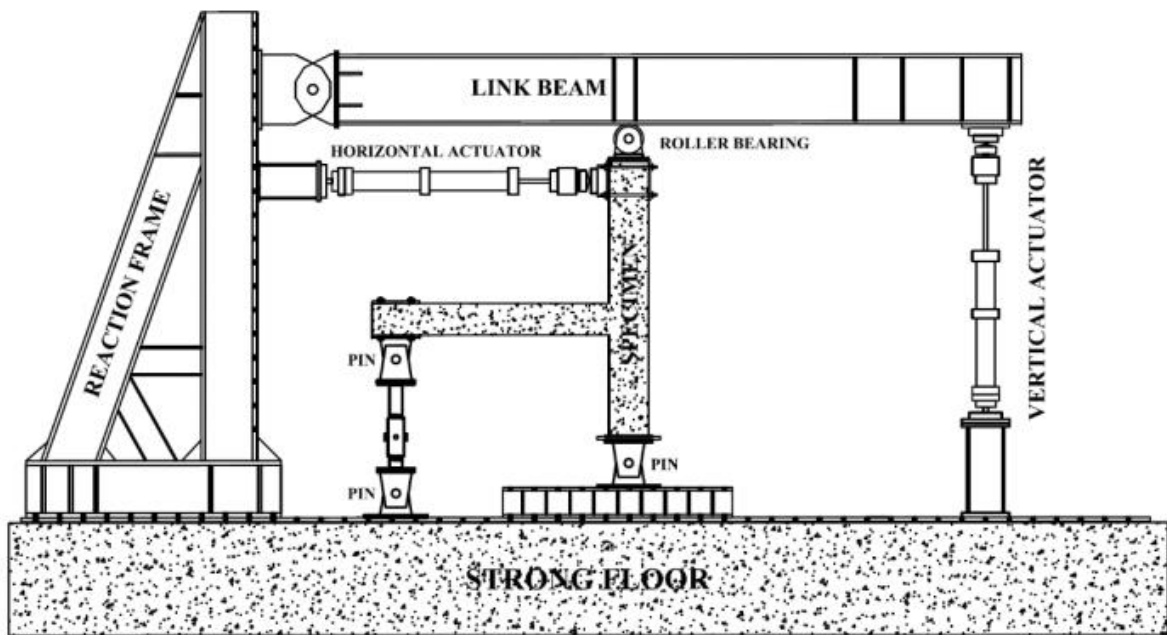


Fig. 1. Test setup

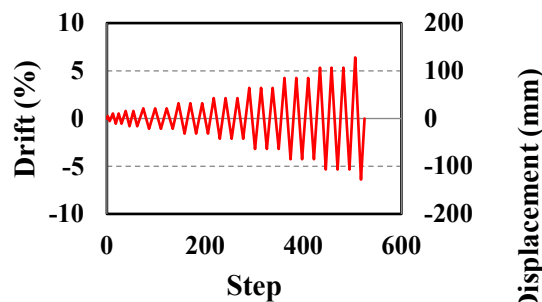


Fig. 2. Lateral loading protocol

The axial load of specimens was $0.15A_g f_c$ (A_g is the column area and f_c is the compressive strength of concrete). The lateral loading pattern was obtained from ACI 374.2R13 [15] and is shown in Fig. 2.

3. RESULTS AND DISCUSSION

Fig. 3 shows the lateral response of wide beam-column connections studied in this research. The specimens had a lateral drift capacity near 6.0%. The hysteresis loops shown in Fig. 3 are relatively wide, which means that the behavior of specimens in terms of energy dissipation was fine. Full flexural hinges developed in test specimens and no sign of immature shear or torsion failure was observed in the tests.

In specimens with conventional spandrel beam, the plastic hinge formation was observed at the intersection of wide beam and column, while in specimens with wide spandrel beam the plastic mechanism occurred at the intersection of wide and

spandrel beam, far from the column face. The specimen with a circular column had lower energy dissipation and greater ductility in comparison with that with the square column.

Although some of the code requirements were neglected in test specimens, the overall performance of tested connections was satisfactory in terms of ductility, stiffness, and energy dissipation.

4. CONCLUSION

The wide beam-column connections investigated in this study had good seismic performances. The acceptable seismic behavior of these specimens mainly can be attributed to fine reinforcement detailing at the joint region. Violating some of the requirements in test specimens did not disturb the overall performance of the connections.

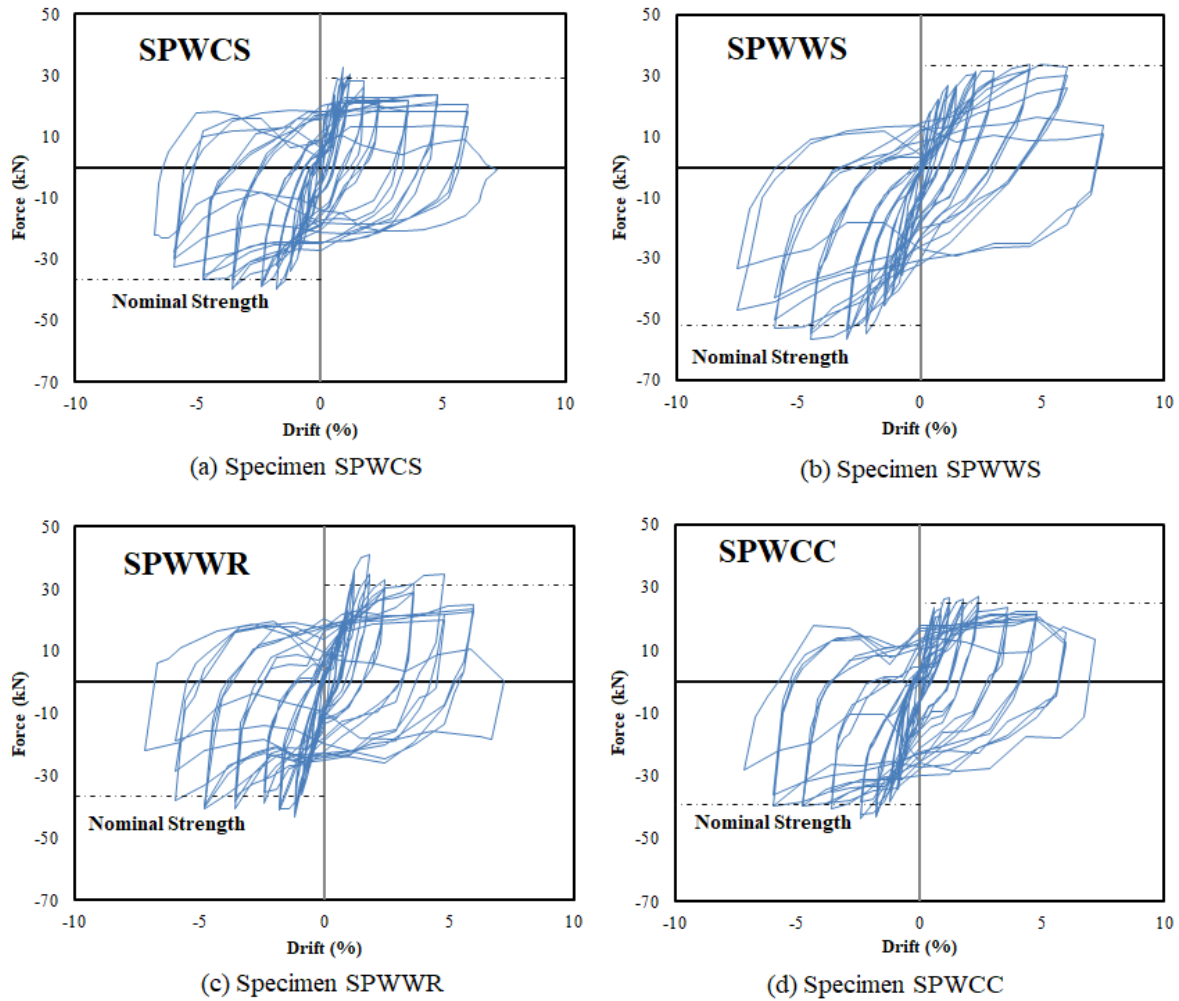


Fig. 3. Force-displacement hysteresis response of specimens

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