Effects of Axial Compression Load and Eccentricity on Seismic Behavior of Nonseismically Detailed Interior Beam-Wide Column Joints

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Abstract: Six full-scale nonseismically detailed reinforced concrete interior beam-wide column joints were tested to investigate the seismic behavior of the joints. Axial compression loads varying from zero to high magnitude, as well as quasi-static cyclic loading simulating earthquake actions were applied. The overall performance of each test assembly was examined in terms of lateral load capacity, drift, stiffness, energy dissipation capacity, and joint shear strength. Three levels of axial compressive column load were investigated to determine how this variable might influence the performance of the joint. The tests also explored the effects of centerline eccentricity on the performance of interior beam-wide column joints subjected to earthquake loading. All the specimens failed at the joint panel with drift ductilities in the range of 0.05 to 0.08. This produces additional joint shear stresses. Extensive experimental research on concentric interior beam-column joints, conducted in different countries in the past decade, has given a better understanding of the behavior of the concentric joints. Unlike the large database of concentric joints, only limited amounts of experimental test results are available for eccentric joints. The following are the experimental works on eccentric interior beam-column joints.

Joh et al. (1991) reported a series of five tests on large-scale interior beam-column joints, including two eccentric joints. It was found that the displacement ductility of the eccentric joints was much smaller than the concentric joints. The joint shear deformation at the flush side of the joint was four to five times larger than those at the offset side of the joint.

Lawrance et al. (1995) carried out tests on two interior beam-column joints, which included one eccentric joint. The eccentricity was found to have no effect on the global strength of the specimen. The strength degradation in the eccentric specimen was observed to occur at a lower displacement ductility than in the companion concentric specimen.

Raffaele and Wight (1995) reported the test results of four reinforced concrete eccentric interior beam-column joints. The major design parameters that varied in the specimens were the beam width, the beam depth, and the amount of top and bottom longitudinal reinforcement in the beam. Based on the test results, it was concluded that the presence of eccentricity in the joint reduced the joint strength to an extent that none of the specimens were able to attain their predicted story shear strength.

Teng and Zhou (2003) conducted tests on six large-scale interior beam-column joints designed according to ACI-ASCE 352 recommendations (ACI-ASCE 1985). The variables in the specimens were the joint eccentricity and the cross section of column. All specimens were subjected to a column axial load level of 0.08/Ag. Teng and Zhou (2003) found that ACI 318 formula

Introduction

Reinforced concrete structures consisting of wall-like wide column elements are very common in regions of low to moderate seismicity; such structures predominate Singapore structural system. Recent post-earthquake investigations have indicated that the extensive damage to the beam-wide column joints in nonseismically detailed frames is the result of excessive shear deformation and severe strength degradation. These can eventually lead to a structural collapse. The BS 8110 (BSI 1997) code used in Singapore does not specify any provisions for seismic design or detailing of reinforced concrete structures. Therefore, it is of great concern that the strength, ductility, and energy dissipation capacity of these structures may not be adequate to sustain earthquake-induced loads in regions of low to moderate seismicity. The needs for evaluating and improving the detailing of such existing structures are obvious.

In an eccentric joint, the column centerline is offset from the beam centerline. When an eccentric beam-column joint is subjected to seismic loadings, the eccentricity between beam and column centerlines induces torsional moment in the joint region as illustrated in Fig. 1. This produces additional joint shear stresses. Extensive experimental research on concentric interior beam-column joints, conducted in different countries in the past decade, has given a better understanding of the behavior of the concentric joints. Unlike the large database of concentric joints, only limited amounts of experimental test results are available for eccentric joints. The following are the experimental works on eccentric interior beam-column joints.

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