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Short communication

Enhancement of seismic performance of reinforced concrete columns with buckling-restrained reinforcement

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ABSTRACT

Reinforced concrete (RC) columns with light confinement prevalent in developing countries exhibit low ductility with brittle shear failure, especially when buckling of longitudinal rebars takes place. This study applies the buckling restraining concept widely used in seismic resistant steel structures to reinforcing bars. Two RC columns 270 mm × 300 mm in cross section with a height of 1200 mm and minimum (non-seismic) transverse reinforcement were tested under cyclic lateral loading. Buckling-restrained reinforcement was provided over the critical zone. The buckling-restraining casing effectively prevented buckling of slender vertical bars under a substantially high axial load level, resulting in a more ductile mode of failure with the evident formation of plastic hinge at the base of the column. Prior to gravity load collapse, the drift capacities and the degraded concrete shear capacities of the specimens were significantly increased compared to their counterparts without casings.

1. Introduction

Reinforced concrete columns with light longitudinal and transverse reinforcement are prevalent in existing low rise buildings in regions of low or even moderate seismicity, especially in developing countries. These structures are vulnerable to damage or even collapse in the event of a strong earthquake. Unfortunately, research work on lightly reinforced concrete columns is quite limited [1–7]. RC columns with light transverse steel subjected to cyclic lateral load exhibit rapid loss of lateral load resistance soon after attaining the peak capacity. Shear mode of failure often prevails with small drift capacity [1,3]. Under moderate to high axial load ratios, longitudinal bars tend to buckle, with the consequence of abrupt shear failure as reported by Wibowo et al. [7]. Sezen and Moehle [5] earlier reported that for columns with light axial load, shear failure would be triggered due to apparent strength degradation after development of the flexural strength whereas columns with high axial load would suffer abrupt shear compression failure.

It was speculated that preventing longitudinal bar buckling would greatly enhance the seismic performance of RC columns since it would eliminate the transfer of vertical load from the buckled steel to concrete, which was the cause for abrupt shear failure as reported by Wibowo et al. [7]. The buckling-restraining concept successfully applied in seismic resistant steel structures was adopted to provide buckling-restrained reinforcement (BRR) for application in new construction. RC column specimens with BRR were cyclically loaded in the horizontal direction under constant axial load, and their performances compared with their counterparts without BRR.

2. Performance of control columns without buckling-restraining casing

The specimens S2 and S3 tested by Wibowo et al. [7] served as the control specimens. The columns, 270 mm × 300 mm in cross section, were reinforced with four ø16 mm Grade 400 MPa longitudinal steel bars. Hoop ties, 6 mm in diameter, were provided at 300 mm spacing corresponding to a transverse reinforcement ratio ρ_H of 0.0007. The nominal concrete compressive strength f_c' was 20 MPa. The column was loaded in single curvature under cyclic loading with the lateral load applied at a height of 1200 mm from the base. A constant axial load of 20% the axial load capacity based on $f_c' A_g$ was applied to specimen S2, while that for S3 was 40%.

The specimens exhibited flexure-dominated inelastic behavior with well-distributed flexural cracks up to the peak strength at about 1.5% and 1.0% drifts for specimens S2 (20% axial load ratio)

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