Seismic Performance of Reinforced Concrete Beam-Column Joint: A Review

B. A. Solahuddin[1,*]

[1]Faculty of Civil Engineering Technology, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Kuantan, Pahang Darul Makmur, Malaysia

*Corresponding author's E-Mail: solahuddin.08@yahoo.com

ABSTRACT: The beam-column joint is a key zone where the elements connect in three directions in a reinforced concrete structure. Constructing a reinforced beam-column junction has practical obstacles. This review aims to highlight the typical behaviour of RCBCJ on the exterior, interior and top levels. Previously published research investigated beam-column joint under gravity and seismic load, as well as the effect of a variety of parameters on the mechanical behaviour of beam-column joint based on experimental investigation and simulation. The effect of reinforcement configuration, eccentricity, joint aspect ratio (h_b/h_c), concrete compressive strength and compressive column axial load are investigated in the current studies. A beam-column joint is introduced in accordance with ACI 318-02 (2002) [1] and Egyptian code (2007) [2]. All equations and guidelines in national codes pertaining to beam-column joint are evaluated from time to time.

Keywords: *Seismic performance; Beam; Column*

1. INTRODUCTION

During an earthquake, structures and lifelines built for normal stress are frequently severely damaged or collapse. Recent earthquake data indicate that numerous reinforced concrete constructions have failed due to the brittle behaviour of beam-column connection due to a lack of seismic features in the joint zone. Joint shear failures have been documented in many existing reinforced concrete structures that have been subjected to significant earthquake loadings. Numerous researchers have explored the seismic performance of reinforced concrete beam-column joint (RCBCJ) experimentally, including Minakshi Vaghani et al. (2015) [3], Benavent et al. (2009) [4], Elsouri and Harajli (2013) [5]. This study includes the following parameters such as strength, displacement, ductility, energy dissipation capacity, drift reversals and reinforcement detailing requirements.

2. SEISMIC EXPERIMENTAL INVESTIGATION OF REINFORCED CONCRETE BEAM-COLUMN JOINT

Leslie M. Megget et al. (2004) [6] published a study on the seismic design and behaviour of external RCBCJ strengthened with steel reinforcement of 500E grade. They examined two distinct methods of beam bar anchorage: the typical 90-degree hook and the continuous U-bar detail. The farthest point of the beam bar anchorage was placed in all units at the minimum limit specified in the New Zealand Concrete Standard (2006) [7], namely 3/4 of the column depth from the inner column face.

The design method for a new building and the assessment procedures for the existing structure specified in previous seismic codes have generally concentrated on structural members such as beam and column and have given less attention to the region of the beam-column intersection that called joint panel. Thus, Masi et al. (2013) [8] analyzed some test results obtained as part of a large experimental program on RCBCJ, while Fu et al. (2000) [9] analyzed the effect of axial load ratio on seismic behaviour of internal beam-column joint.

Goto and Joh (2004) [10] hypothesized that older beam-column joint had poor earthquake performance. Although the current ACI criteria see the joint hoop as restricting the concrete core, Hwang et al. (2004) [11] evaluated the influence of joint hoop on the shear strength of external reinforced concrete beam to column connection subjected to seismic loading. The result indicated that the joint hoop operated as both tension tie and constraint on the crack width.

Numerous studies were conducted on the objective of seismic performance of RCBCJ interior and exterior. Numerous parameters were examined by the researchers. Owada (2000) [12] and Eom et al. (2015) [13] studied the failure mode and bond-slip of beam flexural bar, as well as the joint shear deformation that occurred at the joint panel. Lowes and Altoontash (2003) [14] created a model to represent the reaction of RCBCJ to reversed cyclic loading. The use of ductile fibre reinforced cement based composite in designing and retrofitting a structure subjected to severe loading conditions was researched. The material was substantially more ductility than conventional concrete (Han et al., 2003) [15]. Alena avojcová (2014) [16] presented experimental testing of a reinforced concrete member subjected to cyclic loading. Several studies had investigated the effect of cyclic loading on reinforced concrete members such as beam, column and beam-column joint (Zheng Li, 2012 [17]).

Rajesh Prasad Dhakal et al. (2005) [18] carried out a cyclic loading experiment on full scale reinforced concrete beam-column subassembly. At various speeds, the displacement cycle applied on the specimens were gradually increasing. The specimens were solely designed for gravity load and also lacked a hoop inside the joint core. They concluded that when gravity designed reinforced concrete frame with the junction as the weakest component was subjected to lateral force, substantial damage occurred in the joint panel and eventually resulted in joint shear failure prior to forming a plastic hinge between the adjacent member.

Minakshi Vaghani et al. (2015) [19] introduced an experimental investigation of RCBCJ specimen tested cyclic loading. A two sets of hydraulic jacks were used to apply reversible cyclic loading at the bean end. Gradually, increasing reversed cyclic loading was applied at the top of the beam, with the displacement increment in each step being 5 mm. The 5 mm displacement indicated 5 mm positive as well as negative displacement. The increment of 5 mm displacement was given in consecutive cycles up to the failure. A constant column axial load was applied at the top of the column. At the same time, the bottom end of the column was displaced laterally following the pattern to simulate the working condition of the beam-column assembled under the load reversals.

3. CONCLUSION

First, the compressive strength of concrete has a greater effect on the joint shear strength than the column axial force ratio or the joint shear reinforcement ratio. Next, the compressive column axial load less than 20% of nominal capacity has no effects on the shear strength of the unreinforced external joint. Then, according to AIJ Guidelines (1999) [4], the minimum amount of joint shear reinforcement is 0.3%.. After that, the hysteretic energy dissipation is enhanced by the usage of X-bar as joint shear reinforcement. Finally, a joint without stirrup fails in shear when the beam strength reaches only 68% of the design flexural capacity, but a joint with transverse reinforcement has significantly superior seismic behaviour and fails when the beam strength exceeds 83% of its final flexural capacity.

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