7th International Conference on Seismology & Earthquake Engineering
18-21 May 2015
00042-SD

EVALUATING SHEAR STRENGTH OF RC INTERIOR WIDE BEAM-COLUMN JOINTS UNDER SEISMIC ACTION

Hamdolah BEHNAM
PhD Student, Hong Kong University of Science and Technology, Hong Kong
hbehnam@ust.hk

Jun Shang KUANG
Professor, Hong Kong University of Science and Technology, Hong Kong
cejkuang@ust.hk

Keywords: Joint Nominal Shear, Wide-Beam-Column-Connections, Codes of Practice, Seismic Lateral Loading

Owing to several advantages, many reinforced concrete wide beam column framing system have been constructed in earthquake-prone regions worldwide. Despite this fact, there is limited information about the behavior of this type of buildings under strong earthquakes. Thus, evaluating performance of them under lateral loading becomes particularly important.

Beam-column connections in wide beam floor system have been identified as potentially one of the weakest components subjected to seismic lateral loading. In these connections, the beam width is larger than the column width, which requiring some beam bars to be anchored or to pass outside the column core. Although extensive research work has been carried out on the behavior of the conventional beam-column connections under cyclic loading throughout the world, research on the seismic behavior of the wide beam-column connections are quite low and most of the problems in this field are still remaining unsolved.

One of these problems is how to calculate joint nominal shear strength and the level of shear stress in wide beam-column joints. Level of shear stress is an important factor affecting both strength and stiffness of the joint. The codes restrict the nominal shear stress depending on the compressive strength of concrete and axial load acting on the column. Limitation on maximum shear stress at the beam-column joints are intended to insure that joint shear failure will not curtail ductile response of the frame under seismic loading. Using wide beam is one way to effective reduction of joint shear. In wide beam-column connections, beam wraps around column at the joint, and this region participates in resisting joint shear and reducing the average joint shear stress. However, this effect is not clearly considered by the codes in design process of wide beam floor system.

In this paper, applicability of the nominal joint shear strength specified in codes of practice, including ACI 318-08, NZS 3101: 2006 and EN 1998-1: 2004 for the wide beam-column joints is evaluated. This is particularly important because the codes provisions were developed for conventional beam-column joints that are much different in dimensions and reinforcement layout.

To this end, in the first part of the paper, results of all past published experimental studies are collected. The measured joint shear force for all tested specimens are calculated by three codes provision and results are compared with related specific codes limit on the joint nominal shear strength. Results shows that the actual joint shear force exceeds the ACI 318-08 limit in most cases. However, despite exceeding the ACI 318-08 limits, these joints did not encounter shear failure or shear strength degradation within the joint core. This implies that the limit specified in ACI318-08 is conservative when applied to wide beam-column connections. Compared with ACI 318-08 provision, Both NZS 3101 and EN 1998-1 considered the greater effective area for joint in wide beam, Consequently, the predicted actual joint shear becomes smaller than the constraint limits in most cases. Comparison of three codes predictions demonstrates that the accuracy of Euro code provision for predicting joint shear in wide beam-column joint is higher than the two others.

In second part of the paper, a modification is made on ACI 318-08 equation in order to predict joint nominal shear in wide beam-column joints. It is based on the strut-and-tie concept and the assumption that a compressive strut will form at the side face of the column and the effectiveness of the compressive strut is a function of the column depth. This modification reduces the joint nominal shear in wide beam by an average of 38.5%. The impact of this modification on ACI approach is efficiently on the accurate design of the wide beam-column connections under strong earthquake loading.

Third part of the paper describes design, construction, and testing of two exterior wide beam-column connections tested at the Hong Kong University of Science and Technology Structural Engineering Laboratory. Design of the specimens, test setup, specimen configurations, data taken during testing and logic behind the selection of specimens are presented. Two 3/5 scale beam-column connections are designed and constructed in turn, according to ACI 318-08 and ACI 352R-02[4]. The beam width to column width are one and two and other factors such as beam depth and column section and spandrel beam dimension are kept constant. The specimens are subjected to cyclic lateral load histories so as to provide the equivalent of sever earthquake damage. An attempt is made in order to find joint effective width. Specimens are cut at points of inflection for the bending moment diagram due to lateral loads as mid-height of supporting column and mid-span of beams. Height of the column is 1.9m and the beam length is 1.65m from face of the column. Due to laboratory equipment's limitation, the scale factor of 3/5 is selected. Figure 1 shows a sketch of prototype sub-assemblage.

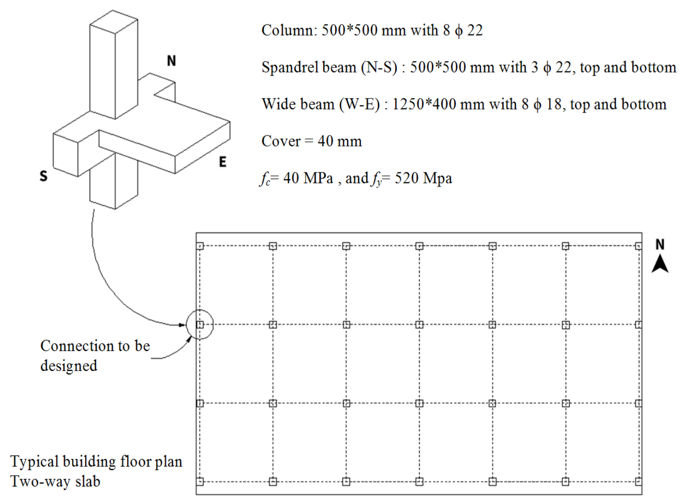

Figure 1. Prototype Subassembly

REFERENCES

ACI Committee (2008) American Concrete Institute, and International Organization for Standardization, Building Code Requirements for Structural Concrete (ACI 318-08) and Commentary, American Concrete Institute, USA

De Normalisation CE (2004) Eurocode 8–Design of Structures for earthquake resistance–Part 1: General rules, seismic actions and rules for buildings, European Standard NF EN, V. 1, London, UK

Joint ACI-ASCE Committee 352 (2002) Recommendations for Design of Beam-Column Connections in Monolithic Reinforced Concrete Structures (ACI 352R-02), American Concrete Institute, Farmington Hills, Mich., USA

NZS 3101 (2006) The Design of Concrete Structures, Standards Association of New Zealand, Wellington, New Zealand