9th International Congress on Civil Engineering, May 8-10, 2012
Isfahan University of Technology (IUT), Isfahan, Iran

Investigation on link-to-column connection in eccentrically braced frames by considering the welding effects

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Abstract

Eccentrically braced frames (EBFs) are expected to withstand significant inelastic deformations in the links when subjected to the forces resulting from the motions of earthquake. In this study, behavior of various examples of link-to-column connections is investigated using finite element analysis. Parameters which are considered in the finite element models for investigation include connection details, length of links, welding modeling, various weld access holes, and loading protocol (constitute of revised and old cyclic loading protocol given in the 2005 and 2002 AISC seismic Provisions, respectively). In order to show the validity of the analysis, results are compared with those obtained experimentally in the laboratory in America by Okazaki et al. in 2009. Finally, the results show that most of the connections are susceptible to failure at link flange near the weld before to achieve required plastic rotation capacity acknowledged in AISC-2005 Provision.

Keywords: Link-to-Column Connection, Eccentrically Braced Frame, Finite Element Analysis.

1. INTRODUCTION

Eccentrically Braced Frames (EBFs) are widely used as lateral resisting system of the structures subjected to earthquake. The main advantages of EBFs are good hardness, high ductility and high energy absorption capability. During the past decades, link-to-column connections were typically constructed in a manner substantially similar to beam-to-column connections in special moment frames (SMF), but after 1994 Northridge California earthquake, most of the frames designed by this method were damaged. Thus, 2002 AISC Provisions [1] have considered the development of satisfactory link-to-column connection details as the subject of ongoing research studies which have not been published the definitive results yet. The 2005 AISC seismic provisions [2] for structural steel buildings prescribes design rules for EBFs to ensure ductile performance of the links such that inelastic frame deformations occur primarily in the links. Under these conditions, the amount of required plastic rotation must be achieved prior to connection failure. Link-to-column connections are required to transfer the large shear and moment developed in a fully plastic link. Force and deformation at the connection are controlled by the geometry of the link.

A shear yielding link, with a link length of $e < 1.6(M_p/V_p)$ develops very large shear force and less moment, while undergoing a plastic rotation as much as 0.08 rad. Mp is the plastic moment capacity of the link section, and Vp is the plastic shear capacity. A flexure yielding link, with a link length of $e > 2.6(M_p/V_p)$, develops very large moment and less substantial shear, while undergoing a plastic rotation of 0.02 rad.

The behavior of the EBF connections under cyclic loading was title subject of several investigations. Popov and his coworkers [3], tested a bolted web and welded flange connection. They found that the bolt slippage contributes to lowering the connection stiffness. Krawinkler and Popov added that in a bolted connection deterioration may be caused by slippage flange connection even with friction type bolts. On this basis, all welded link to column connections were recommended for link with large ductility demand.

Previous studies have been performed exclusively on wide flange profiles, using the Old and Revised protocols specified in AISC 2002 [1] and AISC 2005 [2], respectively.

In the present paper, an analytical investigation using finite element modeling is performed to evaluate the seismic behavior of the link-to-column connection in EBFs by considering various types for connection details.