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Analytical study on new types of reduced beam section moment connections affecting cyclic behavior

R. Rahnavard [a,*], A. Hassanipour [b,1], N. Siahpolo [a,2]

[a] Dep. of Civil Engineering, Institute for Higher Education ACECR Khouzestan, Ahvaz, Khouzestan State, Iran
[b] Dep. of Civil Engineering, Jondi Shapour University of Dezful, Dezful, Khouzestan State, Iran

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ABSTRACT

Recent earthquakes have shown that steel moment frame (SMF) with weld connections are so brittle. According to the studies conducted, great damages are due to the cracking of the weld between the beam flange and the column face and inducing concentrated stresses in this area. A useful approach to reduce the stress concentration at the panel zone could be the use of reduced beam section (RBS). Given the enormous impact of seismic behavior and ductility of the panel zone, RBS moves plastic hinge formation at an appropriate distance from column face. In this study, eight moment connections with different shape of reducing beam flange have been modeled using ABAQUS computer program and compared with each other during cyclic behavior. The obtained result of this study showed that using varied holes, reduced beam section is more ductile and will dissipate energy more than other connections.

Introduction

Since 1994 Northridge earthquake, a bulk of research have been performed to replace better connections for new steel moment frame and to enrich poor moment connections for exiting steel moment frames. The prior and post-Northridge laboratory observations have also demonstrated the inherent disability of the conventional moment connections to develop enough ductility (Calado, 2000) [1].

Since the Northridge earthquake, a number of various studies have been carried out in order to improve the seismic performance of the conventional welded connections. One of the most promising ways to modify the behavior of the conventional moment frame is to soften a portion of beam flanges near the column face (Plumier, 1997, Engelhard et al. 1998, Yu et al. 1999, Yu and Yang 2001) [2]. The connection softening may be accomplished by trimming circular selectors from the beam flanges near the column. This solution known as reduced beam section (RBS) method, leads plastic hinges toward the beam span away from column face, resulting in the reduction of stress concentration at the interface of beam and column. However, as the result of reducing beam section within a sensitive zone, the beam becomes more prone to buckling. Some studies have been conducted to assess key issues influencing the instability of RBS beams (Deylami and Moslehi Tabar 2008) [3]. Deylami and Moslehi Tabar (2008) [3] defined a new lateral slenderness parameter, which is in good agreement with the experimental data. According to their definition, the cyclic behavior of RBS beams is mostly affected by their lateral instability and the beam depth-to-length ratio. Column panel zone flexibility is another issue affecting the behavior of RBS

* Corresponding author. Mobile: +98 9384723905.
E-mail addresses: Rahnavard1990@gmail.com (R. Rahnavard), hassanipour@gmail.com (A. Hassanipour), N_Siahpolo@mjdkh.ac.ir (N. Siahpolo).
1 Mobile: +98 9161424718.
2 Mobile: +98 9161111501.

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connections. Tsai and Chen (2002) and Jones et al. (2002) experimentally illustrated that RBS moment connections with moderately strong panel zones show appropriate performance. Sang-Whan Han, Ki-Hoon Moon and Bozidar Stojadinovic (2009, 2010) [4,5] studied the design equations of RBS connections and found that RBS-B connection moment strength equation specified in FEMA-350, consistently overestimates the actual strength of the RBS-B connections measured in tests and the reduction of beam sections according to FEMA-350 which may therefore be insufficient to protect the RBS-B connections. This, in turn, may lead to RBS-B connection failure before a plastic hinge forms at the reduced beam section of the beam. Rahnavard and Siahpolo (2013) [6] studied bolt and weld moment connections in both with and without reduced section. They made some models in ABAQUS software and compared them to find that the RBS connections would increase ductility of beam and panel zone and also would result in the reduction of stress and plastic strain concentration at the interface of beam and column. Moslehi Tabar and Deylami (2013) [7] considered a new detail and proposed that the RBS performance be enhanced by delaying beam buckling. The efficiency of the proposed detail was investigated by a large scale laboratory testing under cyclic loading. The results of their study showed that the proposed RBS connection had superior performance as

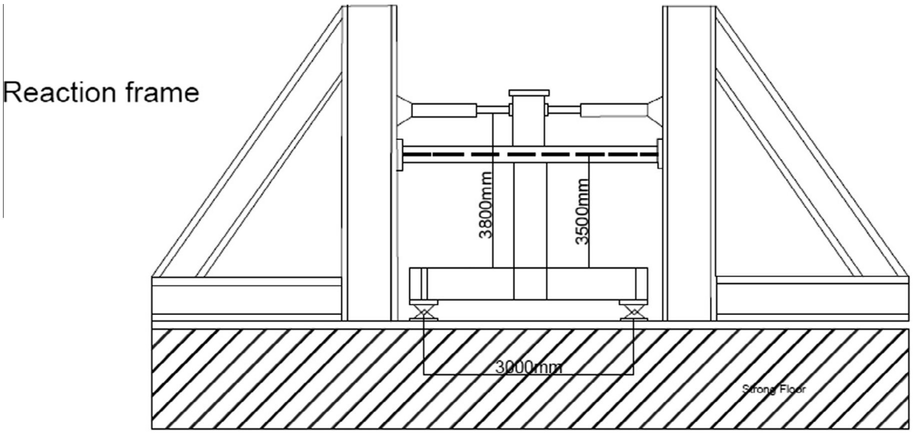

Fig. 1. The specifications of specimens and test set-up.

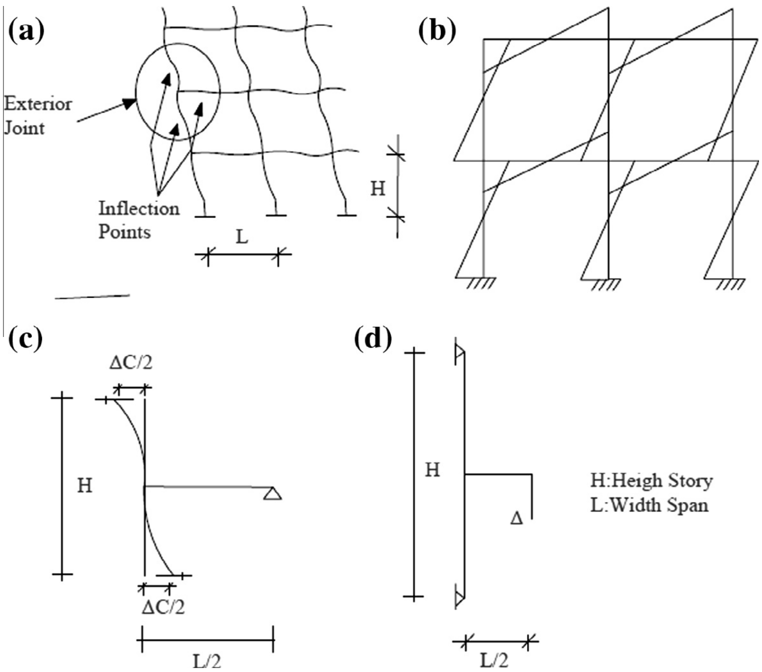

Fig. 2. (a) Deflection diagram of the moment resisting frame, (b) Moment diagram, (c) Exterior connection separated from inflection point, (d) Applied substructure in numerical study.