

APPLICATION AND ADVANTAGES OF REDUCED BEAM SECTION (RBS) IN STEEL BEAM-COLUMN MOMENT CONNECTION

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ABSTRACT Reduced beam section (RBS) moment resisting connections have been known as a famous steel moment connections for steel structures, because of their economical advantages and seismic ductility. Improvement of seismic ductility and decreasing the stress concentration in the end of the beams, that connect to the column with RBS connection. In the common RBS connection, plastic section modulus of beam decreases with diminishing of beam flange width in the plastic hinge zone, and forming of plastic hinge transfer to the reduced region from the column face. Using of steel corrugated plates in the beam web is a manner of section weakening in the beam plastic hinge zone. In this method the beam web is omitted in the plastic hinge limit and corrugated plates are placed in this limit, substitute of beam flat web. Corrugated plates because of their accordion effect don't have bending rigidity and they don't participate in the bending load carrying. Then using of these plates in the plastic hinge region reduces the beam plastic section modulus and plastic hinge is formed in corrugated region. This proposed RBS connection, in addition to providing the requirement of reduced section, with increasing the beam out of plane stiffness in the plastic hinge zone because of corrugated plates shape, prevents any buckling modes in this region. In this paper after presentation of new RBS connection with corrugated plates in the beam plastic hinge zone, seismic design procedure of this connection is presented with using of finite element analysis and notice to code limitations about design methods, construction and installation of RBS connections.

Key Words: RBS moment resisting connection, steel structures, seismic ductility, plastic hinge, steel corrugated plates, finite element analysis.

INTRODUCTION

Seismic loading is one of the most important factor in the buildings and any other structure which is resistant towards earthquake. The improvement of building technology has made it feasible to utilize new materials and techniques in the aforementioned structures. Steel is one of the appropriate materials for designing buildings which resistant to gravity and earthquake loads. Special moment-resisting frame system is one of common systems that are used in the design of steel structures.

Post-Northridge earthquake observations made upon the steel structures to explore the ductile and safe behavior of the steel moment-resisting frame connections brought about some modifications in the design methods, concepts, construction, installation and the quality control of the structures. In fact the Northridge earthquake in 1994 is a turning point in the design of the seismic steel structures especially the steel moment-resisting frame connections. RBS connections which are also known as the dog bone connections were presented for the first time in USA in 1992. This connection was developed after the Northridge earthquake in 1994 (Engelhardt, 2000). Improvement of seismic ductility and decreasing the stress concentration in the end of the beams, that connect to the column with RBS connection, cause to use of these connections increase after the 1994 Northridge earthquake. Since the RBS beams are reduced in the plastic hinge the aforesaid reduction causes the dwindling of the plastic section module of reduced section and diminishes the seismic demand exerted upon the connection. In the ordinary RBS connection, reduction of the section plastic modules is performed through the weakening of the flanges in the regions where plastic hinge are formed and the web of beam is retained unchanged in reduced section; they have local problems such as lateral-torsional buckling, local buckling of web and flange in the plastic hinge region, formation of fragile cracks before yielding in the section,

intricacy of designing and detailing in order to avoiding the stress concentration effects, construction and installation problems specially in circular cut of common RBS connections, and the exclusive utilization of these techniques in the moment resistant structures and etc (Iwankiw,2004).

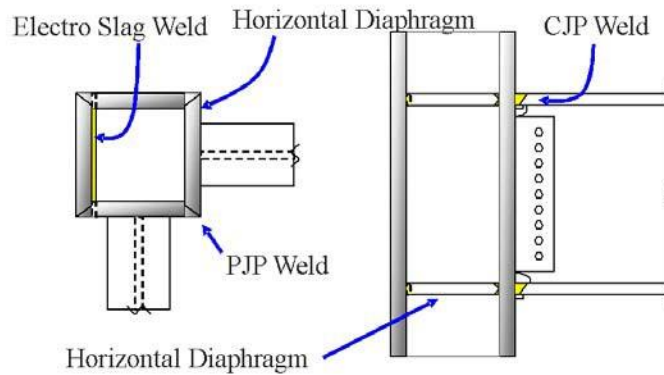


Figure 1. Connection details between H-shaped beams and a box column

In this investigation a new alternative of RBS connection, that has been utilized corrugated plates in the web of beam within the plastic hinge region, is presented; therefore we reach a suitable reduced section in the plastic hinge zone of beam in comparison with common RBS connection. Using of steel corrugated plates in the beam web is a manner of section weakening in the beam plastic hinge zone. In this method the beam web is omitted in the plastic hinge limit and corrugated plates are placed in this limit, substitute of beam flat web. Corrugated plates because of their accordion effect don't have bending rigidity and they don't participate in the bending load carrying.

Then using of these plates in the plastic hinge zone reduces the beam plastic section modulus and plastic hinge is formed in corrugated region. Proposed connection provide the requirement of a RBS connection, besides with increasing the beam out of plane stiffness in the plastic hinge zone because of corrugated plates shape, prevents any buckling modes in this region. Figure-1 illustrates a sample of proposed RBS connection.

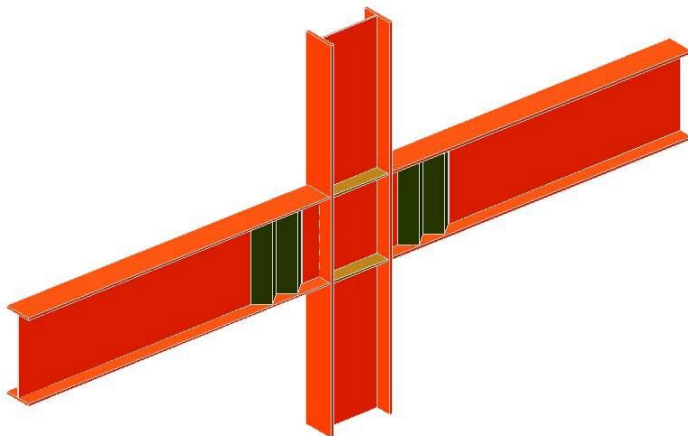


Figure-2. New RBS connection with two box cells made from corrugated plates

ADVANTAGES OF USING THE CORRUGATED PLATES IN THE PLASTIC HINGE ZONE OF THE STEEL MOMENT FRAME BEAMS

The features of using the corrugated plates in the plastic hinge zone of the beams are summarily as follows:

- 1 The reduced section in the plastic hinge zone is an ideal one, because the flexural capacity of beams in the hinge zone is equal to the plastic moment of the flanges and the web will only participate to sustain the shear stress.
 - 2 The geometric shape of the corrugated plates causes the increase the beam out of plane stiffness and they will be resistant towards the lateral-torsional buckling modes without requires to any stiffness.
 - 3 The local buckling of components in the plastic hinge zone is precluded due to the reduction of width to the flange thickness ratio in this region.
 - 4 If the web is corrugated, the axial stiffness will diminish, hence the axial forces exerted in the web due to the bending will dwindle and the web won't be very sensitive to the buckling and the construction effects will not have large impacts upon axial stresses.
5. RBS connections with corrugated plates are not a complicated procedure like reinforced moment connections and do not require high costs and plenty of materials.

CONCLUSIONS

The main conclusions that can be drawn from this paper include:

- 1 The results of finite element analysis indicate formation of plastic hinge zone in the beam reduced section along the corrugated plate's location away from the beam-to-column interface, and satisfy the requirements about location and length of beam reduced section, that designing is accomplished in regard to these recommendations. All the requirements is suitable for proposed RBS connection and satisfied the requirements of new RBS connection as a rigid connection of steel moment frame about transferring the plastification zone within the beam and minimizing the bending moment demand on beam to column connection for designing of connection. The proposed seismic design procedure for new RBS connection with corrugated plates in plastic hinge zone, cover all limitation and requirement of reduced beam connection and steel moment frames with reduced beam sections, and also the proposed seismic design procedure verify the codes recommendations about RBS connection design.
- 2 The Number of corrugated plates, which is placed in the beam web within plastic hinge zone, depends on beam depth and beam flange width; so detailing of connection which is used more corrugated box in it, will be similar to aforesaid procedure.
- 3 Detailing, construction and installation procedure of new RBS connection in comparison to common RBS connection is very simple and flexible to changing of beam depth, span length, and beam flange width; especially in high-rise steel moment resistant frames that numbers of these connections are enormous and detailing of all of them is complicated and time consuming work. Besides proposed RBS connection detailing, decrease the stress concentration effects in the plastic hinge region of beam.
- 4 All of the analytical results of new RBS connection that were compared with ordinary RBS connection results show that the corrugated webs will improve the plastic stability and provide capability of large plastic rotation at the plastic hinge location without any appreciable buckling and brittle fractures in this region.

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