International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 03 | Mar-2018 www.irjet.net p-ISSN: 2395-0072

STUDY ON STEEL BEAM COLUMN JOINT USING DIFFERENT CONNECTIONS – STATE OF ART

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INTRODUCTION - *Structural engineering is one of the important field in the field of science which makes the design more economical with ensuring safety of the structure. Structural systems and their components are planned, designed, constructed, inspected, monitored, maintained using Structural Engineering concepts. Northridge and Kobe earthquake in the past created the need to investigate the local brittle damage of beam-to-column connection of SMRF. Post-Earthquake research revealed two critical factors causing failure. Large ductility demand at the connection and High Stress concentration in the welded web and flanges were the factors observed. An easy way to solve the problem is to repress the ductility demand on the welded areas and mitigate the stress concentration level. There are different types of connections in beam-column joint they are, Welded moment connection on the flanges, Bolted, end-plate moment connection on the flanges, Simple shear connection on the flanges or on the web, Gusset plate connection with double plate flange splice of I sections or plate splice of hollow sections on the flanges or on the web.*

Key Words: *Reduced Beam Section, Steel structure, Steel Section, Moment Connection, Cyclic Loading, Stiffener*

HongChao Guoa et al (April 2017) founded that there is complicated interaction between the infill steel plate and frame edges in the Steel Plate Shear Wall (SPSW) structure. The bearing capacity and stiffness of SPSW structure not only relies upon the section sizes of frame and wall, but also pertains to the stiffness of joint connection. The beam-column connection enhances the deformation and power dissipation capacities of SPSW structure and significantly avoids the brittle failure of welded joint. The cross stiffened SPSW structure with semi-rigid connected steel frame, makes full use of the advantages of semi-rigid joint and SPSW, which include the good deformation and rotation ability, simple construction, smooth set up of semi-rigid joint, and robust lateral stress, stable hysteretic behaviors, good energy dissipation capacity of SPSW. This system not only meets the requirement of structural ultimate bearing capacity, however additionally takes structural ductility into consideration. The cross stiffeners arrangement decreases the height-to-thickness ratio of plates, repress the buckling of thin plate, and increases the stiffness and bearing capacity of the wall. The cross stiffened SPSW structure with semi-rigid linked frame not only has great deformation and rotation capacity, but also smooth to assemble and install. it is characterized with the aid of simplified construction, advanced seismic performance, and high material utilization, which has excellent applications value in seismic fortification zone. [1]

Lewei Tong et al (September 2016) studied energy dissipating capacity of Steel beam-column joints equipped with weld-free steel connectors. The fundamental idea was to make the connectors as the main source of deformation and energy dissipation, and to recognize fast repair of the joints by using easy alternative of these connectors after earthquakes. A preliminary numerical study was executed in addition to inspect the behavior of the proposed joints, where it was observed that the numerical results agree properly with the test results. The geometric configuration of the energy-dissipating elements had reasonable impact in the result which could form an important basis for future practical design of such connectors. There was no improvement in the energy dissipation capacities of the specimens with the presence of the shear tab. degradation was more evident for the specimen with conventional welded T-stubs. Loss of bolt pre-tightening force for the specimens with the cast steel connectors had less significance due to the plastic hinges which were developed away from the bolt axis of the T-stub flange.[2]

Yu-Chen Ou Ngoc et al (2015) tested the panel zone shear behaviour of through-flange connection for steel beams to circular CFST columns by testing four exterior beam-to-column specimens. All specimens reached the peak applied load when the column tubes began to fracture near the through-flange plates. The panel zones of all specimens confirmed significant shear yielding and shear deformation. the concrete infill and stiffeners, suggesting the concrete infill was highly mobilized for shear transfer through diagonal strut mechanism. The concrete infill substantially elevated the panel zone shear. moreover, it helped control the shear distortion of the panel zone. The stiffeners increased the peak applied load through stiffening the column tube to mobilize greater concrete infill to transfer shear than without stiffeners. a wider through-flange plate extended the height applied load. moreover, it decreased the relative displacement between the through-flange plates and the column, decreasing the pinching behaviour. [3]

C.E. Sofias et al (2014) Developed ideas to provide tremendously ductile response and dependable performance: 1. strengthening the connection and weakening the beam framing to the column, 2. strengthening the connection or weakening the beam framing to the column, that allows you to avoid damages of the respective column. The weakening of specific sections of the beam with a purpose to change them into reliable energy dissipative zones. In each specimen the connection region remained in the elastic region due to plastic hinge formation within the RBS zone. Out of the two RBS section one with lesser depth had brittle fracture and the one with higher depth did not show any sign of brittle fracture. The main objective of the RBS configuration was to prevent the connection and its components from plastification. Plastic hinge formation in the RBS zone kept the connection region away from failure. It must be stated that results from experimental and FEM simulation were in excellent correlation making the FEM approach dependable for further utilization. [4]

Kulkarni Swati Ajay et al (June 2013) analytically studied RBS which is one of the numerous connection types, this is cost effective and preferred to be used in new steel moment frame structures in seismic region. To form RBS connection, a few portion of the beam flanges at a quick distance from column face is purposefully trimmed in order that the yielding and plastic hinge takes place inside this area of flanges. Non-linear Finite Element Analysis of the connection models performed using ANSYS Multiphysics and the behavior of different cut profile were compared using Von-Mises Stress diagram. Maximum Von Mises stress for all connections was in between $65x10^3$ psi to $75 x10^3$ psi for 0.05 radians. Stress intensity in the panel zone is in between $35x10^3$ psi to $55x10^3$ psi for all connections. Stress contours of the radius cut Reduced Beam Section were uniform. stress concentration for the trapezoidal and immediately reduced RBS connections determined on the re-entrant corners, moreover result in fracture of the beam flange. Beam lateral torsional buckling of beam and column flange twisting of column at 0.05 radians was found almost same in all cases. [5]

Sang Whan Han et al (2012) estimated the probability of Reduced Beam Section with bolted web (RBS-B) connections to develop rotation capacities larger than 2% radian for existing intermediate moment frames (IMF) systems. Current seismic design provisions in ANSI/AISC 358-05 permits RBS-B connections for only intermediate moment frames. The IMF system connections should provide at least 2% radian of total rotation. Pre-existing researches has proclaimed that some RBS-B connection specimens failed by connection fracture before reaching the 2% radian rotation. They calibrated the moment strength equation specified in ANSI/AISC 358-05 to account for the contribution of bolted web connections, and finally presented a procedure to design RBS-B connections without connection fracture for new building systems with rotation capacities greater than 2% radian. [6]

D.T. Pachoumis et al(June 2010) investigated Reduced Beam Section (RBS) moment-resisting connections were advanced in order to provide a particularly ductile reaction and dependable overall performance. suggestions for the design and detailing of the RBS member were prescribed in EC8, part 3. but, the effectiveness of these suggestions for a European profile is doubtful, because of confined current data from European research. despite the fact that the values of the geometrical parameters were not in line with the recommendations proposed, the plastic rotation surpassed the acceptable 0.03 rad without any weld fracture or any sign of distress at the face of the column, on each specimen. Plastic hinge formation at the RBS area enhances the cyclic performance of the RBS moment- resisting connection. The RBS can be regarded as a ductile `fuse' that forces yielding to arise in the reduced section of the beam, an area which could sustain big inelastic strains while at the same time restricting the stress inside the less ductile region near the face of the column. Two different Reduced Beam Sections exhibited excellent performance when subjected to cyclic loading. [7]

Yousef Ashrafi et al(2009) Numerically studied a reduced web type RBS connection that has more efficiency than those that have been presented formerly. a non-linear finite element analysis changed into performed on each of three frames comprising four, eight and sixteen storeys, respectively. SHELL43 element which allow six degrees of freedom at each node is used for the analysis. It additionally offers the ability of strain hardening. Von-mises yield criterion based model is created and integrated with Bauschingher model to deal with seismic loads. Five RBS configuration: No beams have RBS connections, All beams have RBS connections, Only beams on one side of the sway frame have RBS connections, Only beams above the mid-height of the building have RBS connections and Only beams below the mid-height of the building have RBS connections were established for optimizing the connection to meet energy dissipation requirement while improving the ductility. Numerical inspection have shown that configuration which has Only beams below the mid-height of the building have RBS connections, dissipates more amount of energy yields optimum performance, Important conclusion that can be drawn it is not always necessary to retrofit RBS connections in each storey while retrofitting tall buildings. [8]

Scott M. ADAN et al (2004) investigated RBS with nonlinear finite element models and the behaviour of the moment connection without continuity plates. nonlinear finite element models were developed to match the four full-scale specimens using ANSYS. The study involved an exterior connection with a fully restrained, Welded Unreinforced Flange-Welded Web (WUF-W) connection. FEMA 350 pre-qualifies this type of connection for use in Ordinary Moment Frame (OMF) and Special Moment Frame (SMF) systems and concluded that the full-scale tests showed that all four specimens exceeded FEMA 350 inter-story drift requirements for use in SMF systems without continuity plates. Continuity plate elimination for moment connections in RBS cut-down material and labour cost for steel moment frame construction. [9]

Luis Caladoet al(2000) carried out experimental tests on specimen's representative of frame shape beam-to-column joints. the results have been obtained from the experimental tests on alternative connections, namely top and seat with web angle (TSW) and fully welded connections (WW), designed for the identical beam-to-column joints. The experimental effects allow us to define the collapse modes, the rotation capacity and the ultimate bending strength of bolted and welded beam-to- column connections. the essential factors governing the periodic and the Monotonic behaviour of bolted TSW and welded WW connections were found in experimental results. it has been proven that the panel zone does not have an effect on the behaviour of the TSW connections, which instead is particularly associated with the tension angle geometry and strength properties. [10]

CONCLUSIONS

1.Reduced beam section moment-resisting connection improves the ductility of the steel member.

2.Improved ductility characteristics and cost effectiveness makes RBS preferable in the seismic region.

3.Even after the formation of hinges in the RBS zone the connection remains in the elastic zone hence local failure is presented and failed local member can be replaced.

4.RBS configuration helps us to prevent the connection and its components from plastification.

5.Bearing capacity and stiffness not only relies on size of frame and wall but also on the beam-column connection which improves the energy dissipation capacity of the structure.

6.The stiffeners increased the peak applied load through stiffening the column and transfer large shear than without stiffeners.

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