International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 06 | Jun 2022 www.irjet.net p-ISSN: 2395-0072

Seismic and premature failure enhancement study in Jumbo beams and columns under RBS concept

Mubeena T S[1], Bindu Sebastian[2]

[1]*PG student, Dept. of Civil Engineering, KMEA Engineering College, Kerala, India*
[2]*Associate.Professor, Dept. of Civil Engineering, KMEA Engineering College, Kerala, India*

---***---

Abstract - *There is an increasing demand for jumbo shapes in the constructions of high-rise buildings. Super jumbos are very heavy rolled wide flange sections with up to 140 mm flange thickness and weigh up to 1377 kg/m. An outstanding feature of jumbo sections is their low carbon equivalent values. However, there is a lack of knowledge of the behaviour of these types of construction, especially under seismic loading. As a part of the study, seismic analyses of jumbo sections with and without RBS connections was evaluated and analytically treated to lateral seismic load. The primary goal of the study is to use the ANSYS WORKBENCH software to compare the performance of several types of RBS in order to reduce premature failure and plastic hinge relocation.*

***Key Words*: Jumbo shapes, RBS Connections, ANSYS, Seismic analysis, Plastic hinge**

1. INTRODUCTION

Reduced Beam Section (RBS) moment resisting connections are among the most economical and practical rigid steel connections developed in the aftermath of the 1994 Northridge and the 1995 Kobe earthquakes. Experience shows that steel structures subjected to earthquakes behave well. This may be explained by some of the specific features of steel structures, such as: high ductile and stable hysteretic behaviour under cyclic loading. One of the most common solutions to obtain a ductile behaviour is the utilisation of RBS moment connection, which involves cutting off portions of the beam flange to limit the force at the critical welds between the beam and column.[1] If this solution is adopted, the inelastic deformations are forced to happen in the beam and not in the column. This would lead to a more ductile behaviour reducing the risk of collapse.

The "strong column - weak beam" design concept was investigated by the SAC Joint Venture, which was hired by FEMA. This design idea can help shift the plastic deformation from the column to the beam during an earthquake, preventing the connection between the column and the beam from experiencing inelastic deformations. It is best used in conjunction with ArcelorMittal's RBS connection, which was released from patent in 1995. AISC successfully evaluated the technique, which was then incorporated into the FEMA 350 and 355 documents. [3,4]

2. OBJECTIVES

- To study the behaviour of jumbo structures with and without implementing RBS in beam column connection.
- To investigate the performance of different types of RBS to optimise the plastic hinge relocation and premature failure.

3. METHODOLOGY

The main objective of this study is to improve seismic performance of jumbo beams and columns. As a part of the study to examine seismic behaviour, a jumbo section with and without RBS is investigated. A further study is carried out to analyse the performance of different types of RBS to optimise the plastic hinge relocation and premature failure.

4. NUMERICAL STUDY

4.1 Modelling of frames

An exterior RBS moment connection specimen was modelled using ANSYS Workbench. A jumbo section under inelastic monotonic loading is considered. Beams were A992 Grade 50 steel (f_y = 345 MPa) and has Young's Modulus 200 GPa and Poisson's ratio as 0.3. Columns were A913 Grade 65 steel (f_y = 450 MPa) and has Young's Modulus 200 GPa and Poisson's ratio as 0.3. Plate material was A572 Grade 50 steel (f_y = 345 MPa). Dimensional details of jumbo section are shown in Table1. FEM model of specimens are shown in Fig 1 to 5.

Table -1: Dimensional details of jumbo section

Specimen	Beam	Beam	RBS dimension (a, b,c)mm
SP3	W920×420×1377	W360×410×1299	236,710,99

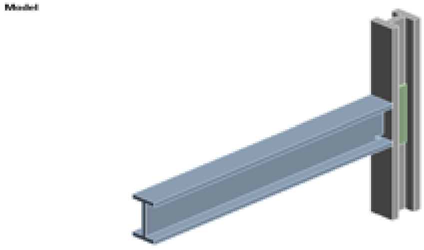

Fig -1: Without RBS

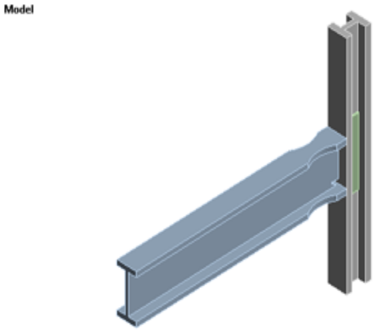

Fig -2: FC RBS (flange cut)

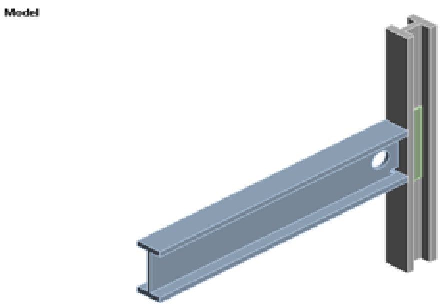

Fig -3: WC RBS (web cut)

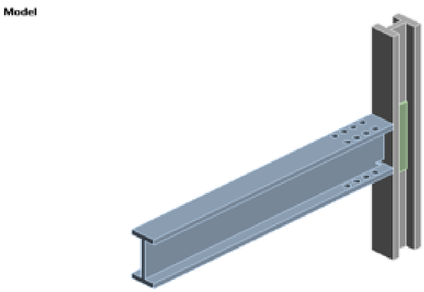

Fig -4: FC-RBS-holes

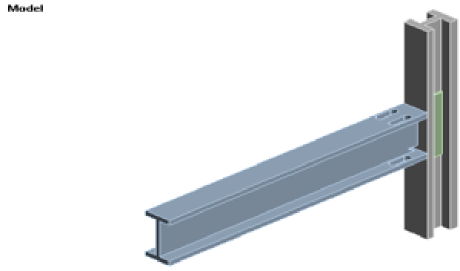

Fig -5: FC RBS slit

4.2 Boundary conditions and loading

The left end of the column was restrained against translation in all three directions while the other three supports for the column were stimulated by restraining translation in one direction only. A monotonic displacement was applied to the beam to achieve a story drift angle up to 4%.

5. RESULT AND DISCUSSIONS

The model is subjected to nonlinear static analysis and Figure 6 to 10 represents the strain distribution results of specimens.

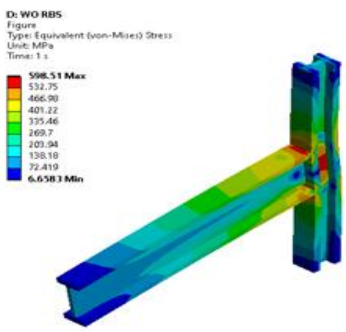

Fig -6: Without RBS

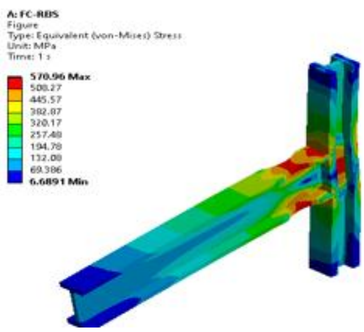

Fig -7: FC RBS

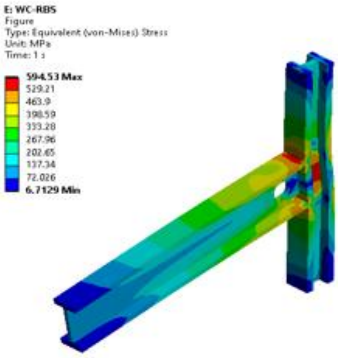

Fig -8: WC RBS

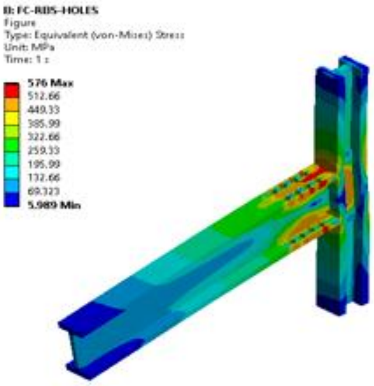

Fig -9: FC- RBS-holes

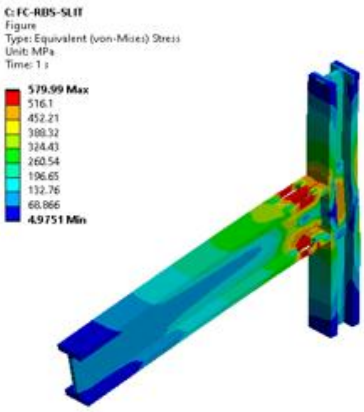

Fig -10: FC- RBS-slit

Chart 1 gives load-drift curve of different RBS section

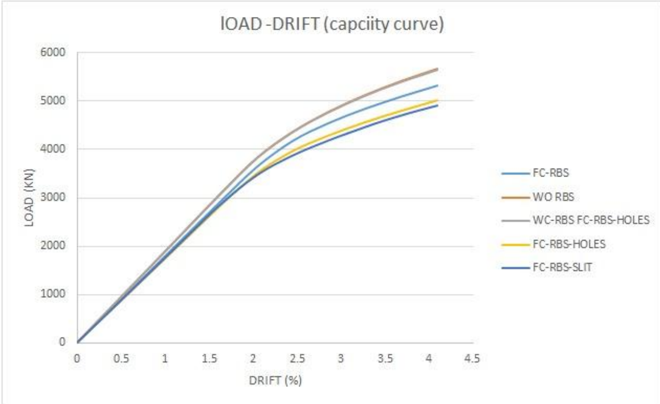

Chart-1: Load-drift curve

Table 2 displays the jumbo section's performance with various RBS kinds.

Table -2: Performance of jumbo section with different types of RBS

MODEL	DRIFT	LOAD	% OF DECREASE IN STRESS OF COLUMN	STRESS ON COLUM	STRES ON BEAM	PEEQ-COLUMN	PEEQ-BEAM
WO RBS	4.089541	5666.3	1.00	598	579	0.011	0.023
FC-RBS	4.09012	5316.4	6.19	561	570	0.0081	0.0169
WC-RBS	4.089348	5645.9	0.67	594	579	0.01	0.024
FC-RBS-HOLES	4.090506	5012	10.70	534	576	0.006	0.028
FC-RBS-SLIT	4.09012	4915	11.71	528	579	0.005	0.037

The results are compared and analysed. The comparison graphs are shown in chart 2 to 6.

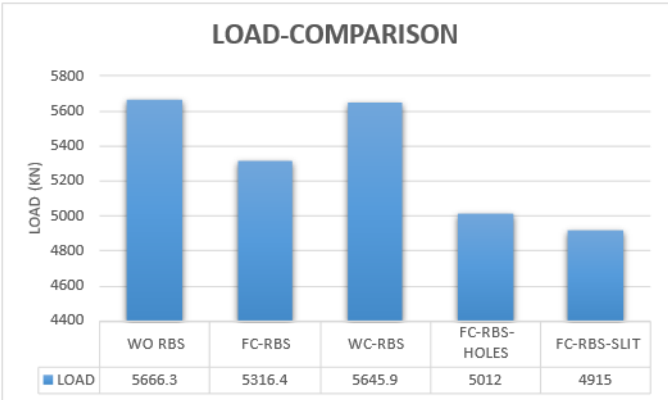

Chart-2: Load comparison of different RBS section

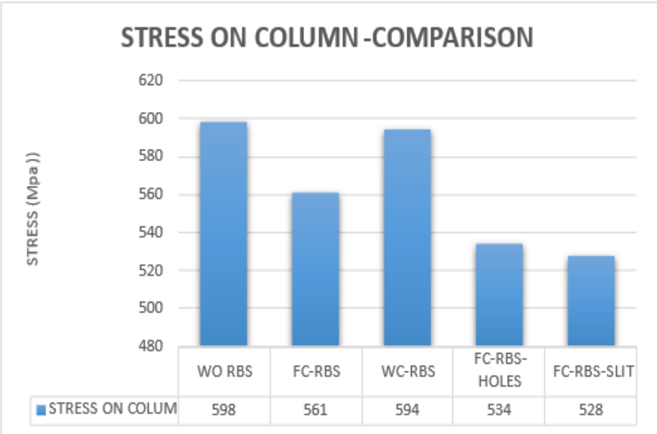

Chart-3: Stress on column comparison of different RBS section

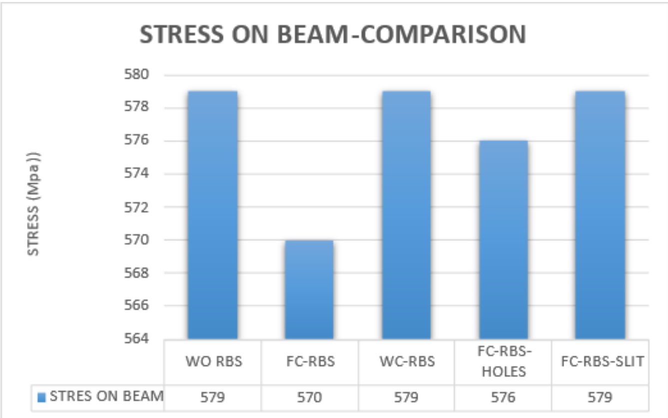

Chart-4: Stress on beam comparison of different RBS section

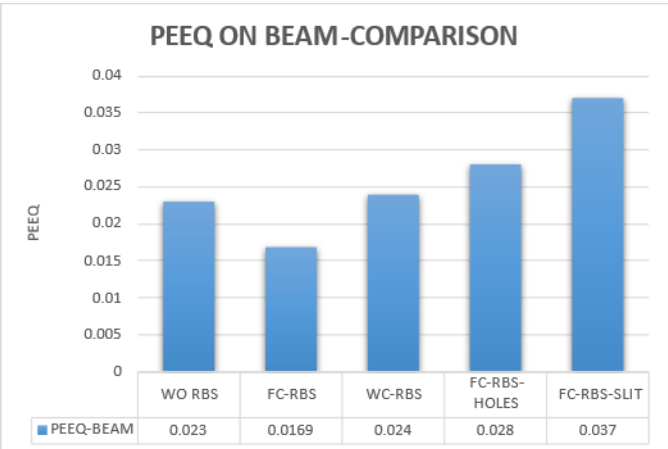

Chart-5: PEEQ on beam comparison of different RBS section

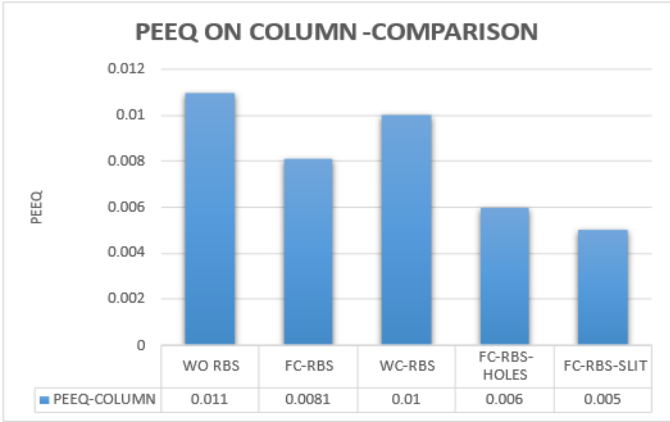

Chart-6: PEEQ on column comparison of different RBS section

6. CONCLUSIONS

Numerical analysis is conducted to evaluate stress strain behaviour of jumbo beams and columns with different types of RBS. After conducting the study, the following findings were obtained:

- The load carrying capacity can be increased with the introduction of RBS in the jumbo section.
- When RBS is used, jumbo section performance is more effective.
- When compared, the stress on the column for FC-RBS-SLIT increases by up to 11.71 percent, while the stress on the beam increases by up to 579 kN/m.
- For FC-RBS-SLIT, the lowest PEEQ (Equivalent plastic strain) column and beam values were found.
- As a result, we may say that the FC-RBS-SLIT section is the ideal RBS section.

REFERENCES

[1] Liangjie Qi, Roberto T. Leon, Matthew R. Eatherton, Jonathan L. Paquette b, "Parametric investigation on the design of RBS moment connections with jumbo beams and columns" J. Struct. Engg, vol.122, 2021, pp 1292–1299.

[2] P Cimagala, "Optimization of Reduced Beam Sections (RBS) for Ductile Detailing of Seismic Joint Connections Using Finite Element Analysis (FEA)" J. Constr. Steel Res., vol. 42, pp 49– 69, 2021.

[3] FEMA, Recommended seismic design criteria for steel moment-framesbuildings,FEMA 350, 2000 (Washington, DC).

[4] FEMA, State of the art report on base metals and fracture, FEMA 355A, 2000, (Washington, DC).

[5] AISC, Prequalified connections for special and intermediate steel moment frames for seismic applications, AISC 358–10. Chicago, IL, 2016.

[6] J. Paquette, "Experimental Investigation of Reduced Beam Section Moment Connections for Jumbo Steel Wide Flange Sections" Virginia Tech, 2018.