SEISMIC BEHAVIOUR OF TAPERED BEAM COLUMN JOINT WITH REDUCED BEAM SECTION

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Abstract - *Non-prismatic beam should mean beams with different cross section along their longitudinal axis. Steel structural elements with variable cross-section, made of welded plates, are largely used in the construction industry. The RBS appears to be the most economical of the new design methods and is already being used by structural engineers for welded SMRF structures in seismic zones. This paper presents an analytical study on steel beam column joint with circular RBS and tapered web beam. Different taper ratios selected are 1.25, 1.5, and 1, to examine the load carrying capacity and column stress. Non-Linear dynamic analysis is conducted in ANSYS workbench 16.1 to observe the cyclic behaviour of web tapered beam with circular RBS. Ultimate load and displacement with corresponding time is observed for comparison. To achieve the nonlinear behaviour of models, dynamic analysis are used by FEM.*

Key Words: **Non-prismatic beams, Tapered beams, Reduced beam section, cyclic behaviour, dynamic analysis.**

1. INTRODUCTION

1.1 General Background

During a severe earthquake, the main structural elements like beams and columns are seriously affected. When a building is subjected to seismic wave, large amount of energy is distributed within in the building and the level of damage sustained by the building depends on the dissipation of this energy. Therefore a great concern is to be given for earthquake resisting systems to dissipate energy effectively from the structure. The primary function of an energy dissipation element is to reduce the damage in main structural components.

Steel structural elements with variable cross-section, made of welded plates, are largely used in the construction industry for both beams and columns in accordance with the stress and stiffness demand in the structure. These types of elements are mainly used for the design of single storey frames with pitched roof rafters and pinned column base. Rafters and columns can be designed as tapered members made of steel welded plates, respecting the bending moment diagrams for gravitational load combination.

Reduced beam section (RBS) is one of the connection types, which is economical and popular for use in steel moment frames in seismic regions. By cutting some portions of the beam flanges near the column face, the RBS connections are designed to form plastic hinge within the RBS zone so that it could enhance the structural seismic performance.

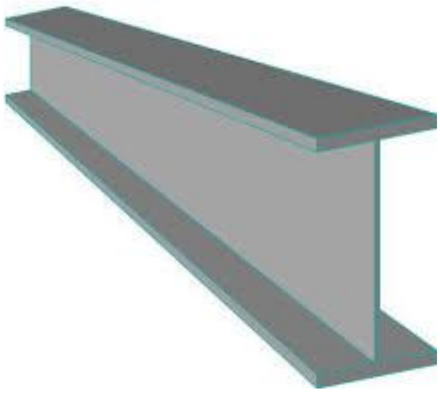

Fig -1: Tapered beam

2. NUMERICAL INVESTIGATION USING ANSYS WORKBENCH 16.1

2.1 Base Model

Numerical modelling of web tapered beam in steel beam column joint with circular RBS were done using ANSYS 16.1 WORKBENCH, a finite element software for mathematical modelling and analysis. Material property for 5 models are same. Dimensions are different. All specimens have the beam of ASTM H-shaped H700mmX300mmX13mmX24mm (dimensions in mm for depth, width, web thickness, and flange thickness, respectively); in addition, the box column is 550mmx550mmx28mmx28mm section. Since the cross sectional geometry of the column affects the force transfer between the beam and column as well as connection behavior , box columns used in practice are adopted in the specimens Built-up from four steel plates.

Table -1: Material Properties of Steel.

MEMBER	COUPON LOCATION	YIELD STRENGTH (N/mm^2)	TENSILE STRENGTH (N/mm^2)
Link beam	Beam flange	387	507
	Beam web	429	527
Stub beam	Beam flange	371	511
	Beam web	373	494
column	Web and flange	431	578

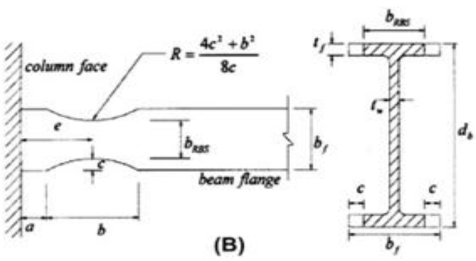

Fig -2: Typical geometry details of RBS.

Table -2: Geometry details of circular RBS.

Distance of RBS from column face (a)	0.6 b_f
Length of RBS (b)	0.75 b_d
Depth of RBS (c)	0.25 b_f

Table -3: Dimensions of web tapering.

SPECIFICATION	MODEL NAME	TAPER RATIO	DEPTH OF WEB (mm)
Weight constant (WC)	WC CRBS TR 1.5	1.5	840/560
	WC CRBS TR 1.25	125	780/624
Section constant (SC)	SC CRBS TR 1.5	1.5	700/467
	SC CRBS TR 1.25	1.25	700/560

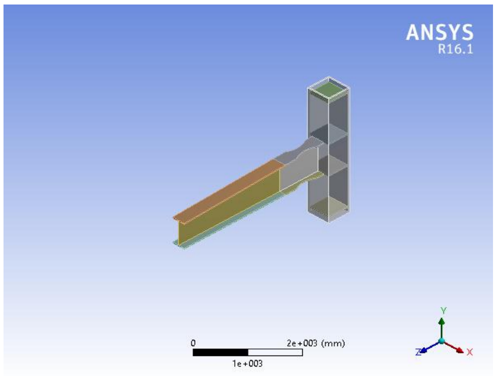

Fig -3: Modelled view of WC beam with TR 1.25.

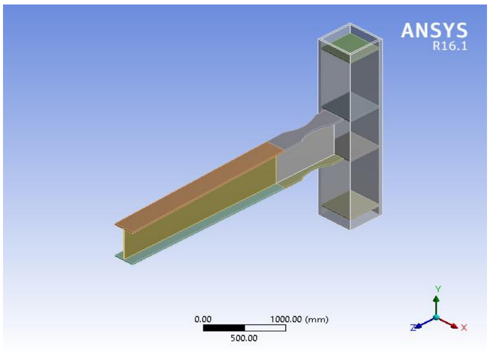

Fig -4: Modelled view of SC beam with TR 1.5.

Circular RBS is found to be best among several configuration. The implementation of RBS reduces the column stress. So we introduce the circular reduced beam section to tapered beam. Analysis done by keeping the weight of beam (WC) constant and second by keeping the depth of web constant(SC). A cyclic predetermined loading sequence with increased displacement amplitudes specified in the AISC seismic provisions was used during the tests. The test history began with six cycles of ±0.375, ±0.5, and ±0.75% rad story drift angle. Subsequently, four cycles of ±1% rad story drift angle and two cycles with amplitudes of over ±1.5% rad story drift angle were applied.

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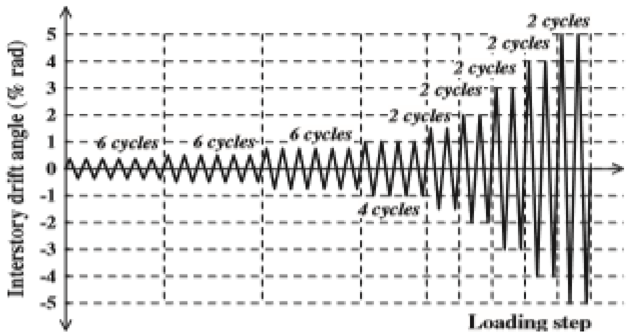

Fig -5: Loading Protocol.

3. RESULTS AND DISCUSSIONS

3.1 Hysteretic behavior

The analytical load-displacement hysteresis curves for the specimens are given below. It is observed that all the specimens shows stable hysteresis curves. Weight constant tapered beam with taper ratio 1.5 with circular RBS shows higher load carrying capacity and less column stress compared to other models.

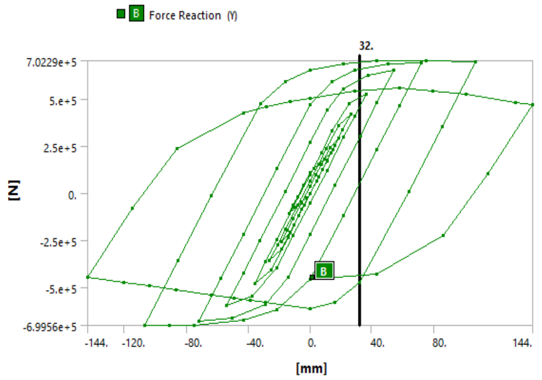

Fig -6: Hysteresis curve for WC CRBS TR 1.25.

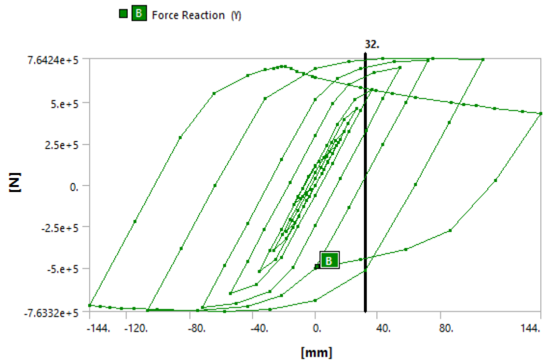

Fig -7: Hysteresis curve for WC CRBS TR 1.5.

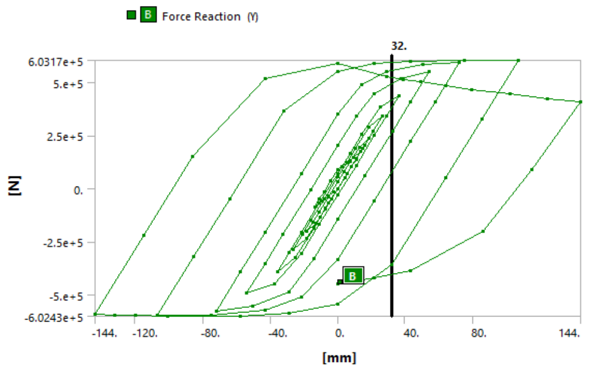

Fig -8: Hysteresis curve for SC CRBS TR 1.25.

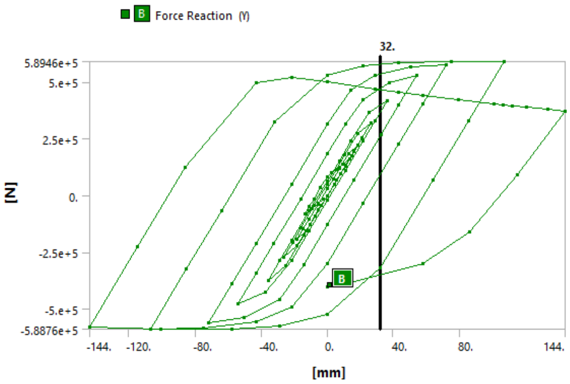

Fig -9: Hysteresis curve for SC CRBS TR 1.25.

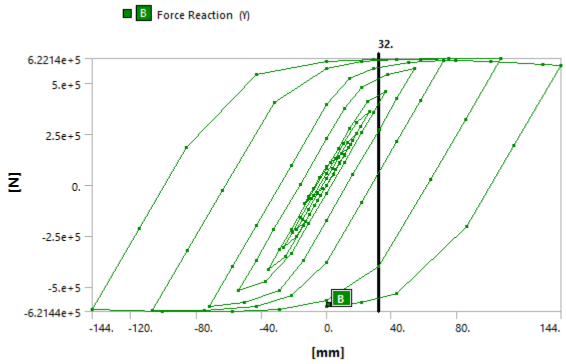

Fig -10: Hysteresis curve for PB CRBS TR 1.

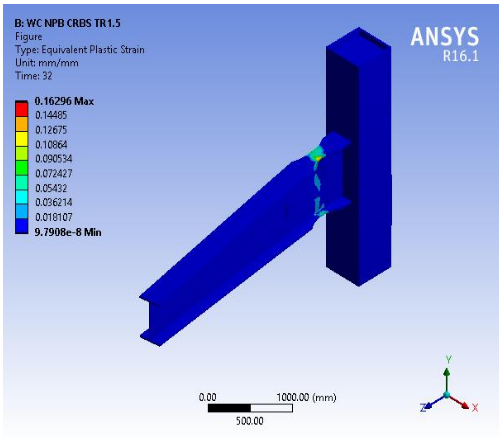

Fig -11: location of plastic hinge.

3.2 Load Deflection Analysis

From the graph show in figure 12 represents the Load Deflection for different models.Section constant tapered beam with CRBS shows decrease in load carrying capacity as compared to prismatic beam with CRBS. But weight constant tapered beam with CRBS shows increase in load carrying capacity.

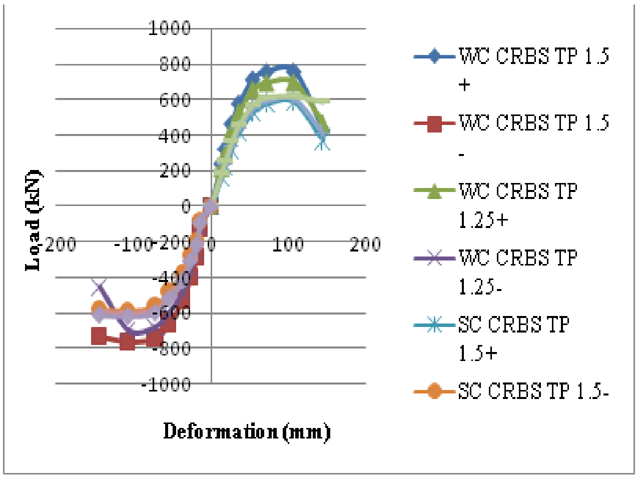

Fig -12: Load vs. deflection graph of different models.

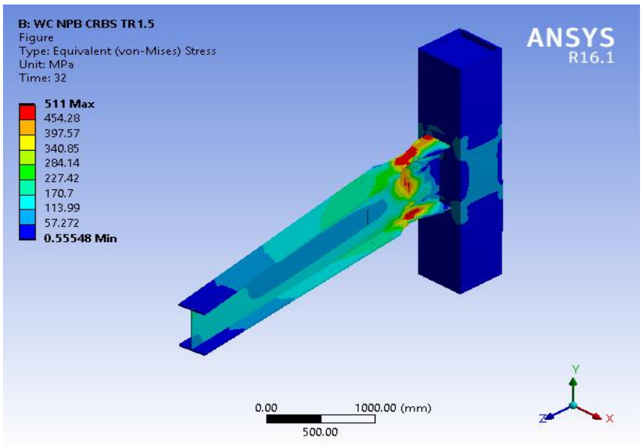

Fig -13: Equivalent von-mises stress for WC CRBS TR 1.5.

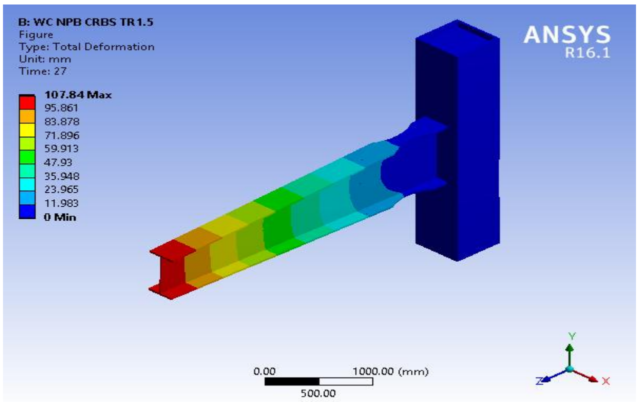

Fig -14: Total deformation for WC CRBS TR 1.5.

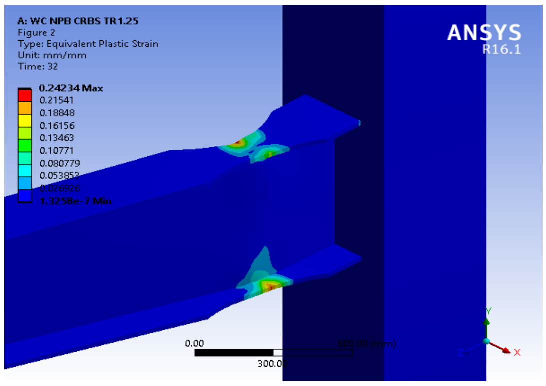

Fig -15:location of plastic hinge formation in WC CRBS TR 1.5.

Table representing maximum load and column stress of various models were illustrated below.

Table -4: Maximum load and column stress of different models

MODEL NAME	LOAD (kN)	COLUMN STRESS (N/mm^2)
WC CRBS TR 1.5	603.17	169.59
WC CRBS TR 1.25	589.46	166.36
SC CRBS TR 1.5	702.29	156.27
SC CRBS TR 1.25	764.24	163.84
PB CRBS TR 1	622.14	175.5

4. CONCLUSIONS

This study proposed a new configuration of different RBS and their application in tapered beam column joint, the conducted analytical study on beam column joint result in following conclusions:

- Section constant tapered beam with CRBS shows decrease in load carrying capacity as compared to prismatic beam with CRBS.
- But weight constant tapered beam with CRBS shows increase in load carrying capacity.
- WC CRBS TP 1.5 exhibited best result showing an increase in load carrying capacity of 22.84%.
- By the effect of RBS and tapering column stress will be also reduced.
- By considering both load carrying capacity and column stress WC CRBS TP 1.5 is selected as good one

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