# Parametric Study of Beam Length on Performance of RBS in Single Bay Single Story System

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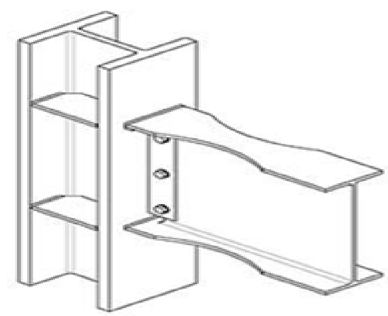
***Abstract***- *In developing India, the demand of steel increasing in height rise building. Mostly the buildings are designed for earthquake resistant, not the earthquake proof. As the concrete is brittle material and steel is ductile material, so the use of steel is more in high rise buildings. Thus the buildings are designed as per the considerations of mainly lateral forces viz. earthquake force. In steel design, the sections are designed along with connection design. Connections are mainly designed for resisting moments during the failure of beam and saving the damage in column. This paper is regarding the moment resisting connections and reduced beam sections. In this paper, the past work and the experimental work done by various people according to their views are studied. To conclude in the end, the reduced beam sections prove to be the better option as the moment resisting connection.*

***Keywords***- Reduced Beam Section, Parameters, Varying length, Moment-Rotation.

## I. INTRODUCTION (REDUCED BEAM SECTION)

After Northridge earthquake, most researches were directed toward making bending connections in steel structures more ductile. One of the different kinds of these connections is RBS (reduced beam section connection). In this kind of connection, reducing flange section near the end of the beam and within a definite length makes the plastic hinge move to the reduced part and expanding plastic hinge in the length of cut area causes a significant ductility in the hinge. In fact, reduced flange section acts like a fuse and prevents the initial cracks in the connection (FEMA 355D 2000)..



The most common kinds of RBS connections are: (i) RBS with straight reduced section (ii) RBS with tapered cut reduced section (iii) RBS with radius reduced section (FEMA350 2000). Other researchers investigated optimal flange shape under monotonic loads. The optimal shape strongly depends on the upper bound of the equivalent plastic strain, which is to be specified in practice based on the performance required for each frame , and other new type of Reduced Beam Section (RBS) connection, ``Accordion Web RBS (AW-RBS)'' were . The AW-RBS decreases the web contribution in moment strength and a reduced section is developed in the beam, so it can’t be used regularly and in wide range in construction of buildings. Most researches approve using different kinds of RBS connections .Most of the experiments which are carried out include the sizes of the beams and the kinds of the steels used in practice. The primary studies on this kind of connection indicate that this connection has got some appropriate unique characteristics such as high ductility, appropriate resistance, less cost in comparison to other bending connections, much less operation time for building and installing structure, much more assurance to the welding and it’s welding at work place. In this kind of connection by cutting some parts of the flange, the plastic hinge moves by the side of the column into the area within the beam, and as a result there won’t be beam-column connection problems at the work place anymore. The reduced area absorbs much more energy by its plastic function and makes a controlled hinge with a wonderful ductility (FEMA 355D-2000).

## II. MODELING OF DIFFERENT PARAMETERS

Using the same method of modeling and analysis, I have made WRBS Restrained, WORBS Restrained and without restrained WRBS and without restrained WORBS models with different parameters to obtain appropriate results. In WRBS Restrained Models, Flange of beam from junction of Beam-column to Starting point of RBS section that is at distance a=100 mm ,is kept restrained in X-direction. For WORBS Restrained section flanges of beam is restrained in X-direction to avoid lateral-torsion buckling of beam.

At present I have used single bay and single storey moment resisting frame with ISWB 200 as beam section and ISWB 250 as column section and analysed the frame in ANSYS with a lateral load at centre of beam column joint.

Table 1. Section Properties

| | BEAM (ISWB200) | COLUMN(ISWB250) |
|---|---|---|
| Depth of Section , H | 200mm | 250mm |
| Width of Flange, $b_f$ | 140mm | 200mm |
| Thickness of Flange ,$t_f$ | 9mm | 9mm |
| Thickness of web,$t_w$ | 6mm | 6.7mm |
| Moment of Inertia $I_{xx}$ | $2624.5*10^4$ $mm^4$ | $5943.1*10^4$ $mm^4$ |
| Moment of Inertia $I_{yy}$ | $328.8*10^4$ $mm^4$ | $857.5*10^4$ $mm^4$ |
| Root radius ,$R_1$ | 9mm | 10mm |
| Extrude length | 6000mm | 3500mm |

Table 2. Reduced Beam Section Parameters

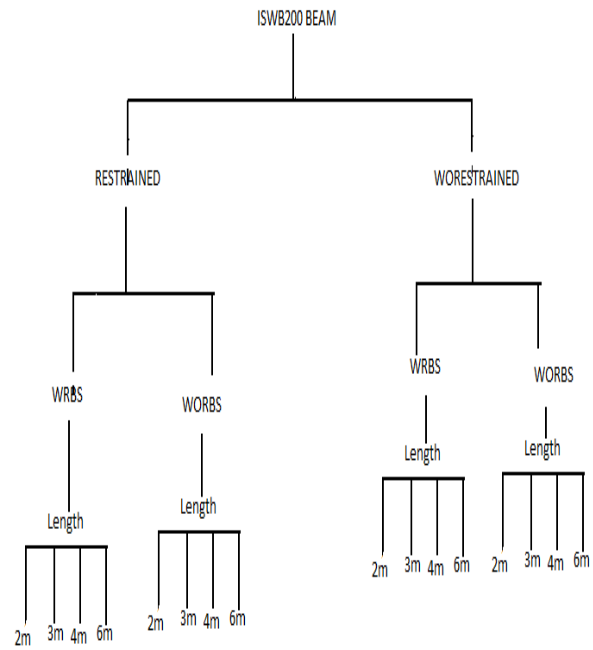
| |
|---|
| a=100 mm |
| b=170 mm |
| c=35 mm |

Table 3. Material Property

| | |
|---|---|
| Young's modulus | $= 2*10^{11}$ Pa |
| Poison's ratio μ | = 0.3 |
| Bulk modulus | $= 1.667*10^{11}$ Pa |
| Shear modulus | $=7.6923*10^{10}$ Pa |
| Yield Strength | =250 MPa |

**Data for model in which only L/ry changes.**

I have made total 16 models out of which 8 models of with restrained beam and 8 models for without restrained beam for different $L/r_y$ ratio. 4 models of WRBS with restrained and 4 models of WRBS without restrained, 4 models of WORBS with restrained and 4 models of WORBS without restrained of different length kipping $b_f/2t_f$ and $h_c/t_w$ ratio constant to analyze effect of Rotation of beam in WRBS as well as WORBS models.




The convergence criteria define how close to this exact balance is acceptable. Program gives estimate and based on that estimate solves equation system for current time step. If the error (difference between calculated and guessed values) is smaller than the Convergence Criteria, the system moves to the next time step. If the error is larger than the Convergence Criteria, system goes to another iteration based on improved estimation. Here in this project i have taken 200 sub steps in 1 load step.

In this research, I have used Beam of ISWB200 and Column of size ISLB275.

Table 4 Beam Slenderness Ratio Data

| Specimen | Length | Slenderness Ratio | | |
|---|---|---|---|---|
| | | $b_f/2t_f$ | $L/r_y$ | $h_c/t_w$ |
| Restrained (WRBS) | 2m | 7.44 | 34.67 | 66.66 |
| Restrained (WORBS) | 2m | 7.44 | 34.67 | 66.66 |
| WORestrained (WRBS). | 2m | 7.44 | 34.67 | 66.66 |
| WORestrained (WORBS) | 2m | 7.44 | 34.67 | 66.66 |
| Restrained (WRBS) | 3m | 7.44 | 34.67 | 100 |
| Restrained (WORBS) | 3m | 7.44 | 34.67 | 100 |
| WORestrained (WRBS). | 3m | 7.44 | 34.67 | 100 |
| WORestrained (WORBS) | 3m | 7.44 | 34.67 | 100 |
| Restrained (WRBS) | 4m | 7.44 | 34.67 | 133.3 |
| Restrained (WORBS) | 4m | 7.44 | 34.67 | 133.3 |
| WORestrained (WRBS). | 4m | 7.44 | 34.67 | 133.3 |
| WORestrained (WORBS) | 4m | 7.44 | 34.67 | 133.3 |
| Restrained (WRBS) | 5m | 7.44 | 34.67 | 200 |
| Restrained (WORBS) | 5m | 7.44 | 34.67 | 200 |
| WORestrained (WRBS). | 5m | 7.44 | 34.67 | 200 |
| WORestrained (WORBS) | 5m | 7.44 | 34.67 | 200 |

## TOTAL DEFORMATION

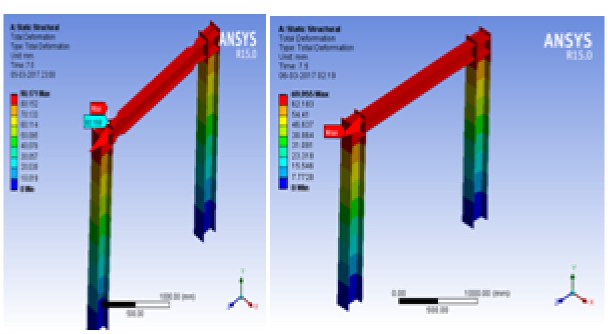



Figure 1(A) For RBS (B) For WORBS

## Z-Axis Normal Stress

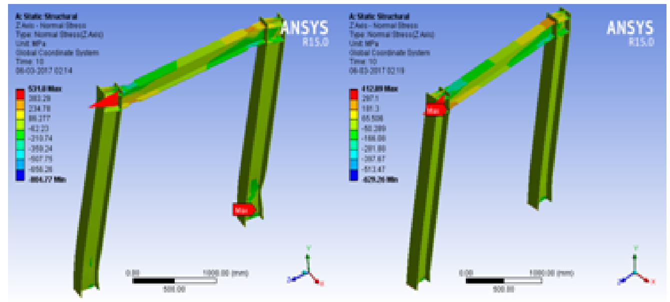



Figure 2(A) For RBS (B) For WORBS

## Rotation for 2m Length

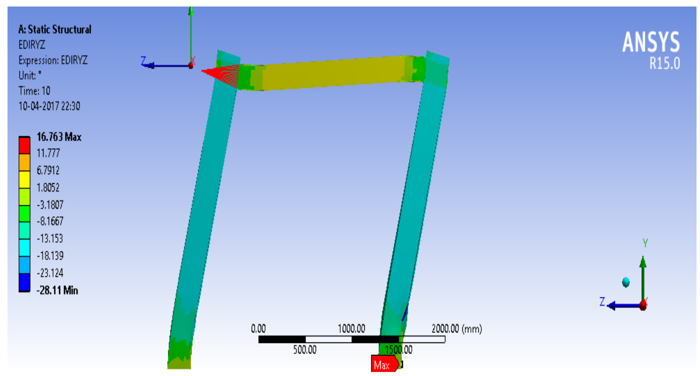
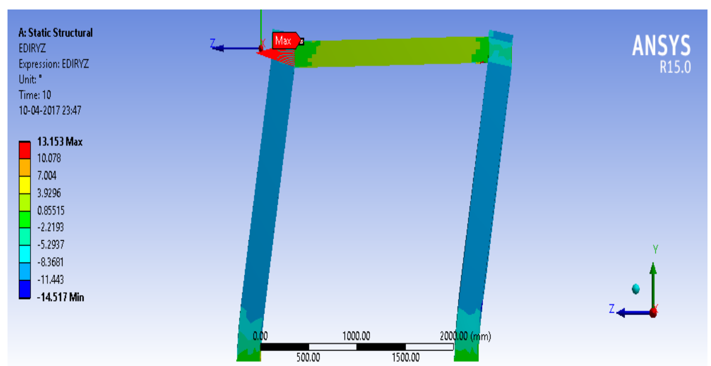



Figure 3 (A) Rotation for Restrained WRBS for L=2m




(B) Rotation for Restrained WORBS for L=2m

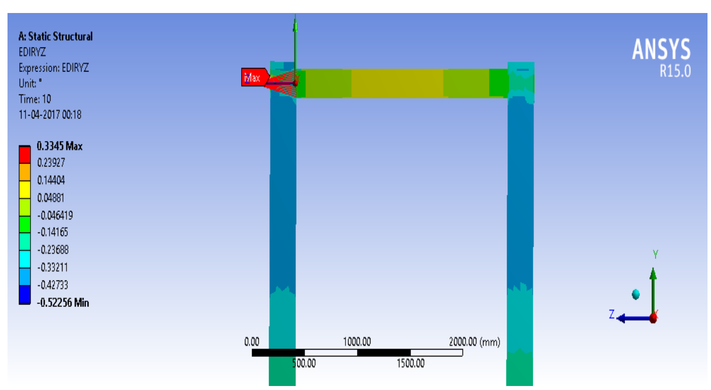
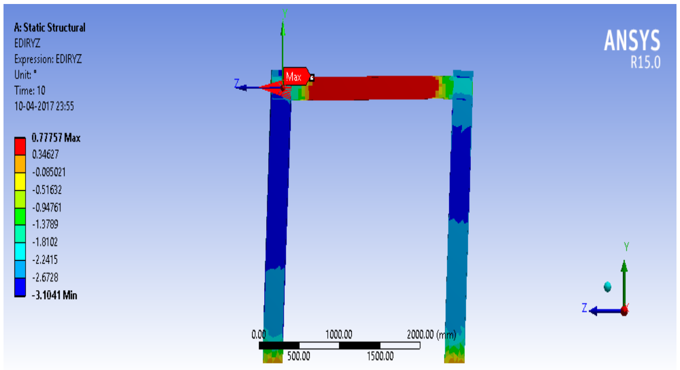



Fig.4(A) Rotation for without restrained WRBS for L=2m




(B) Rotation for without restrained WORBS for L=2m

**Rotation for 3m Length**

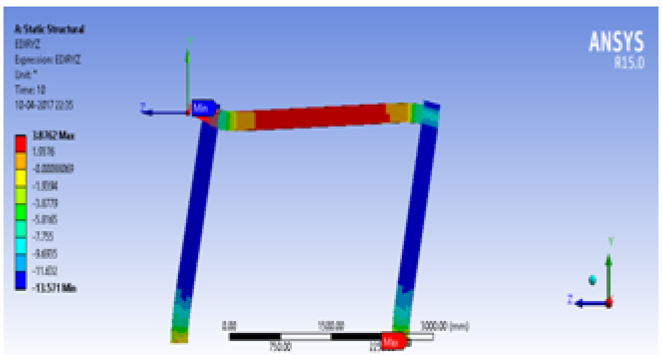



Figure 5(A) Rotation for Restrained WRBS for L=3m

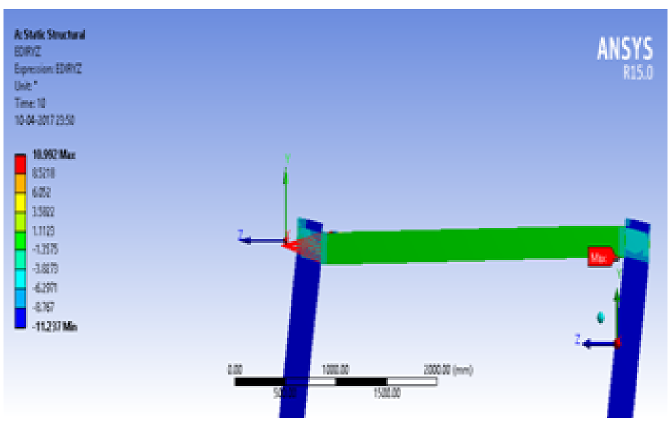



Figure-5 (B) Rotation for Restrained Without RBS for L=3m

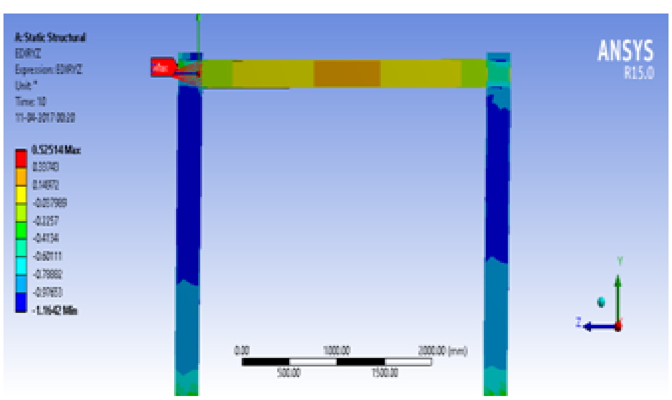



Figure 6(A) Rotation for without restrained WRBS for L=3m

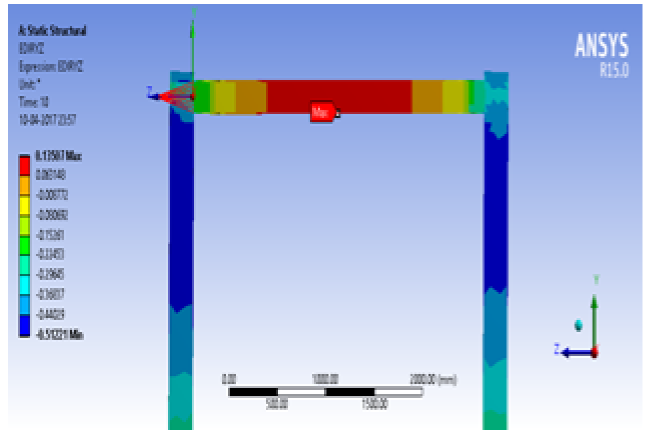



Figure 6(B) Rotation for without restrained WORBS for L=3m

**Rotation for 4m Length**

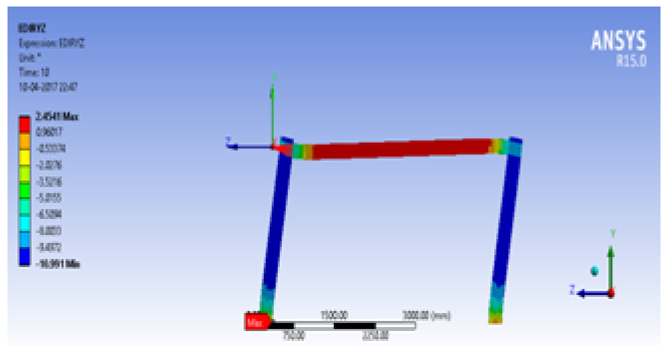



Figure 7 (A) Rotation for Res trained WRBS for L=4m

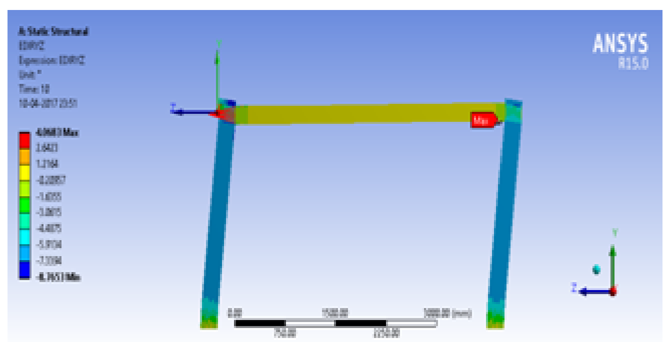



Figure 7 (B) Rotation for Restrained Without RBS L=4m

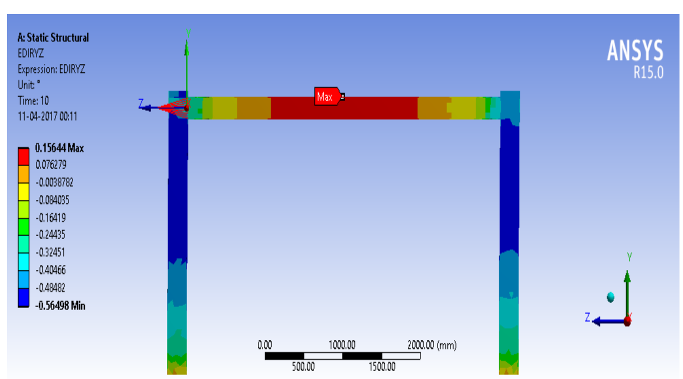



Figure 8(A) Rotation for without restrained WRBS for L=4m

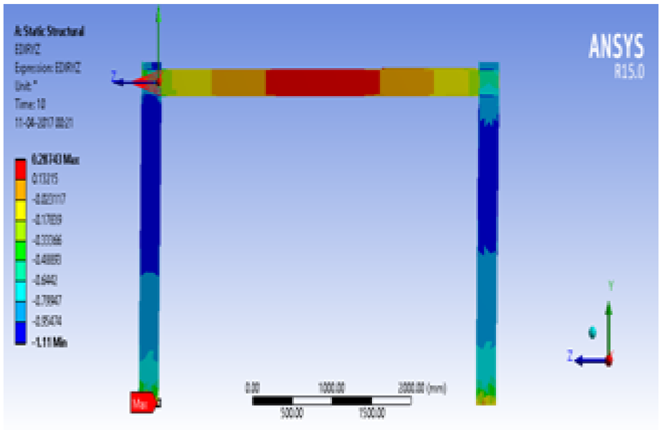



Figure 8(B) Rotation for without restrained Without RBS for L=4m

**Rotation for 6m Length**

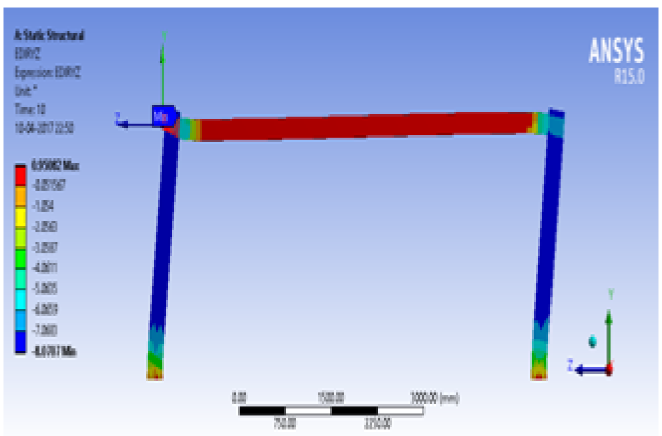



Figure 9 (A) Rotation for Restrained With RBS for L=6

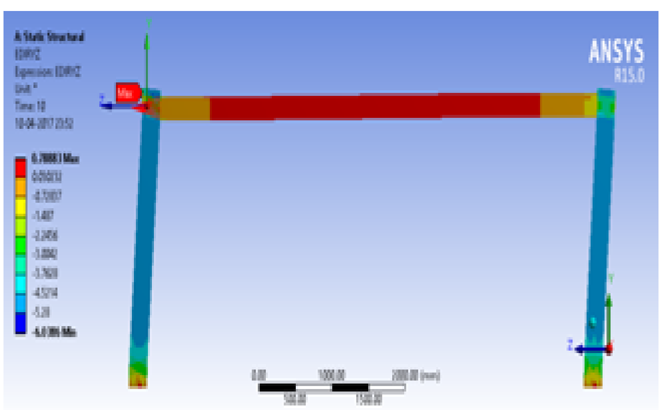



Figure 9 (B) Rotation for Restrained Without RBS for L=6

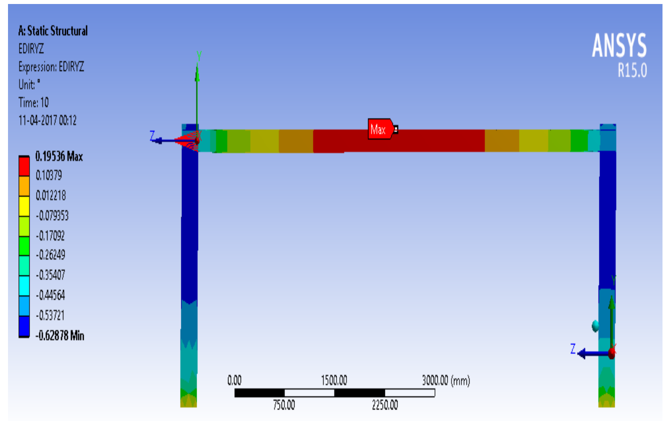



Figure 10 (A) Rotation for without restrained With RBS for L=6m

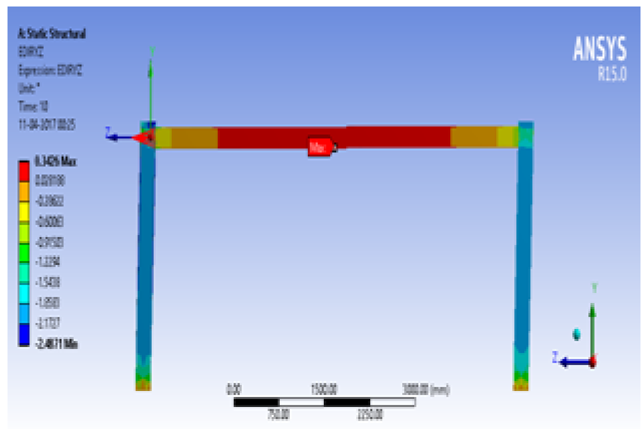
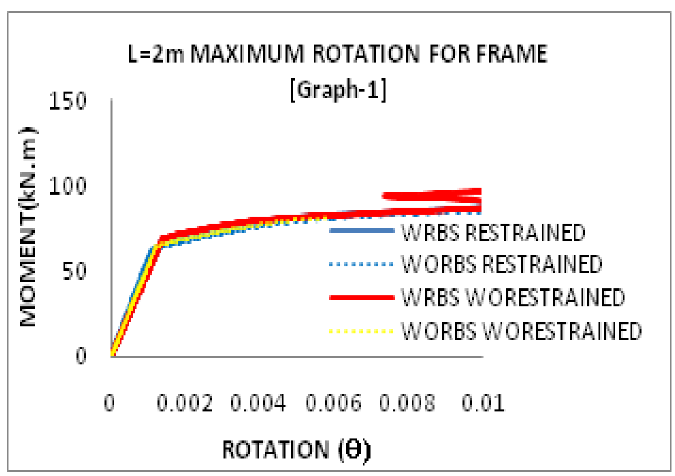
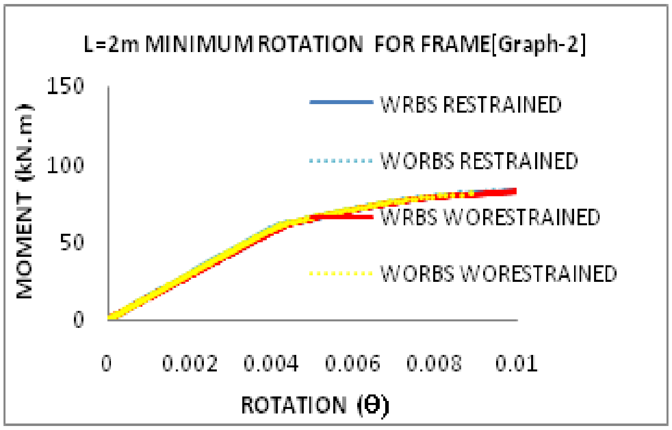
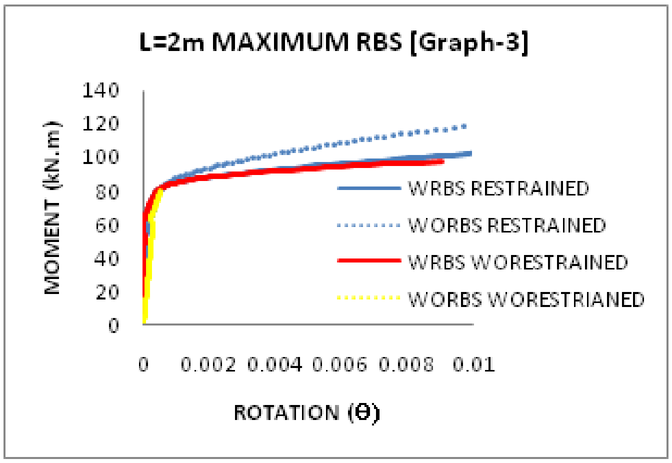


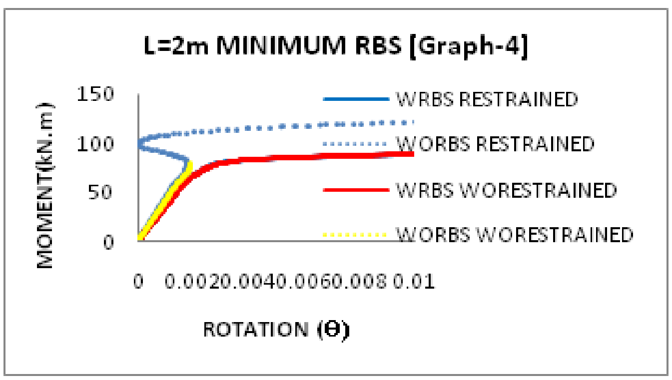

Figure 10 (B) Rotation for without restrained without RBS for L=6m

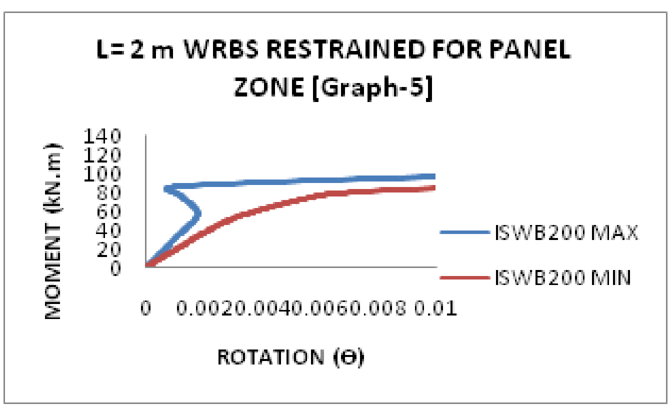
**GRAPHS OBTAIN FOR L=2m**



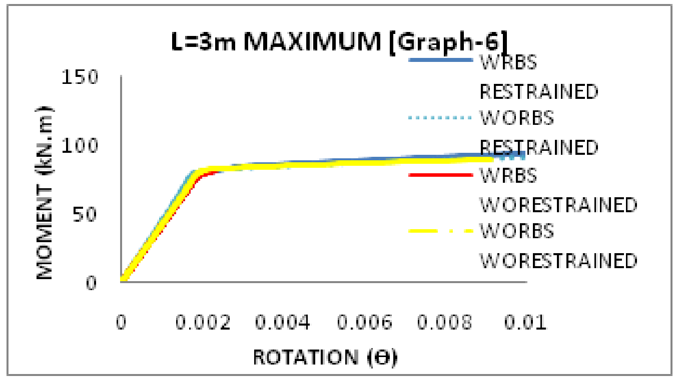


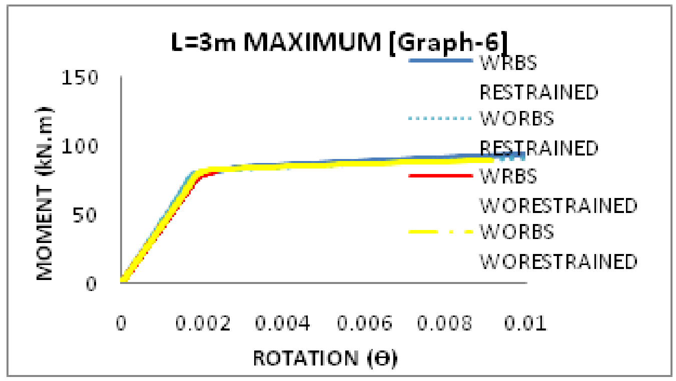



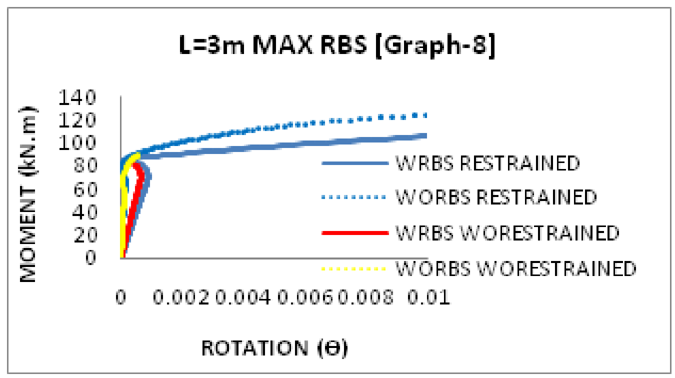



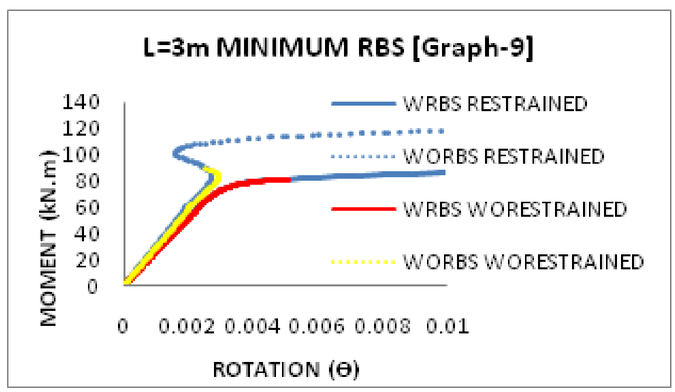




**RESULTS OBTAIN FOR L=3m.**

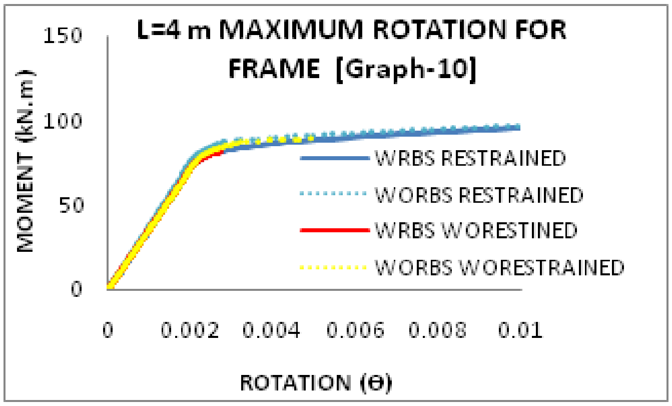


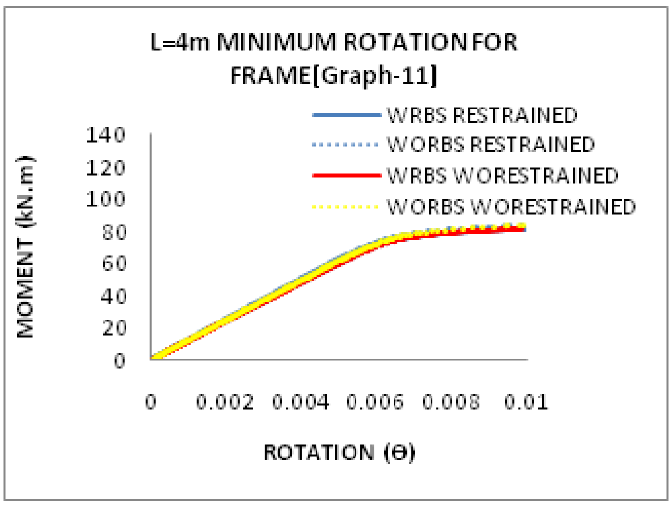



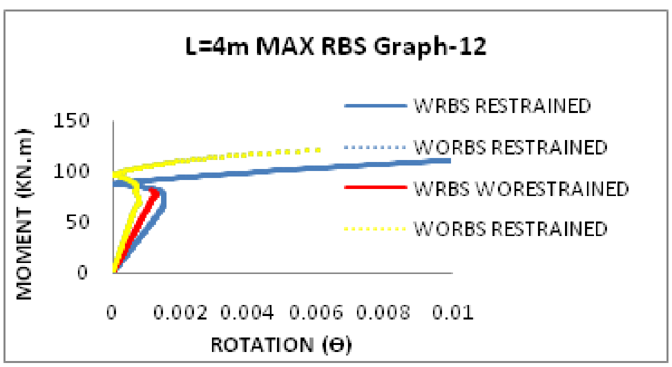



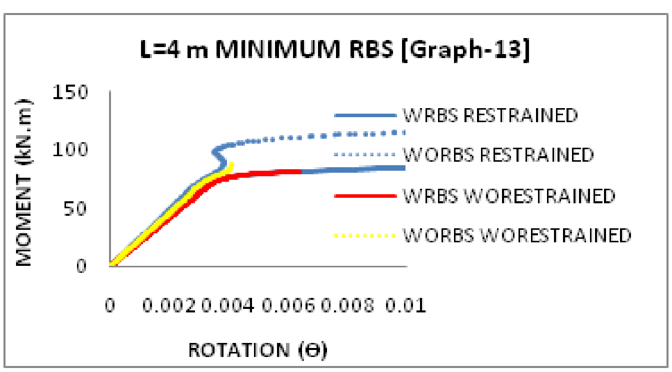



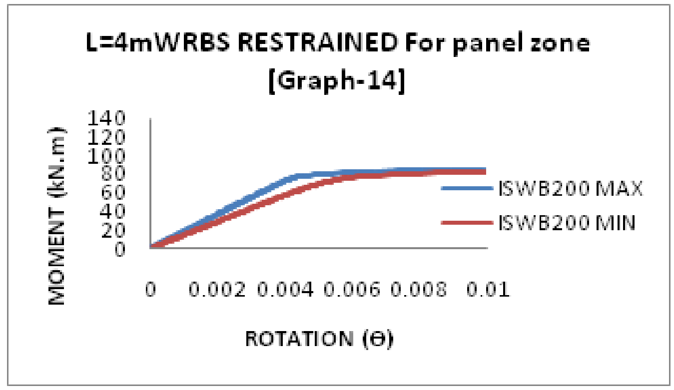
**GRAPH FOR L=4m**



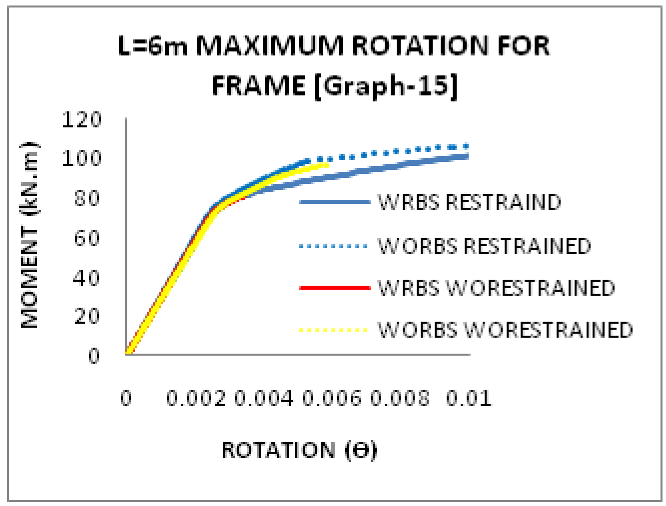



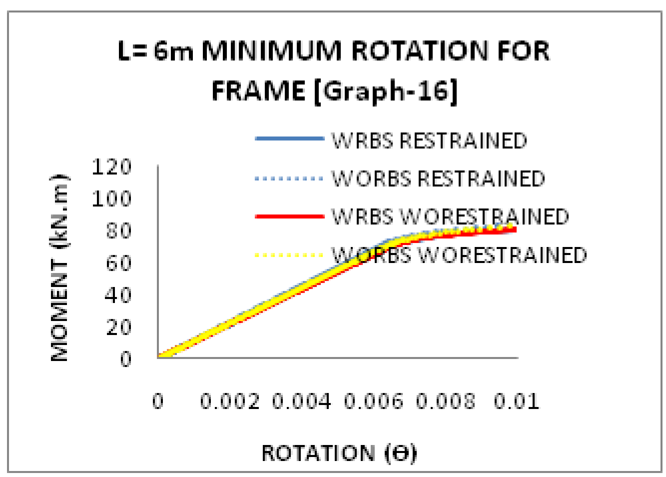



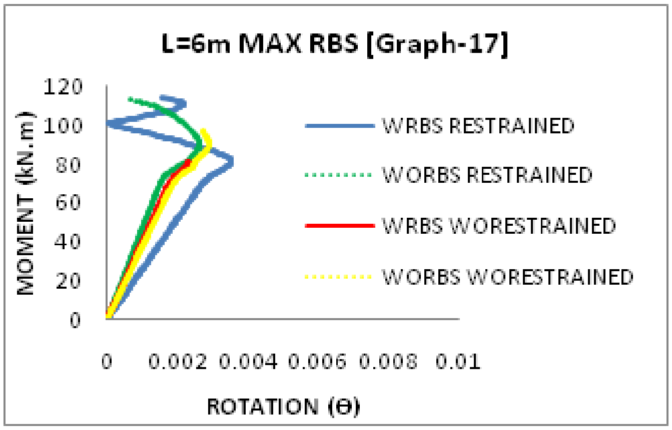



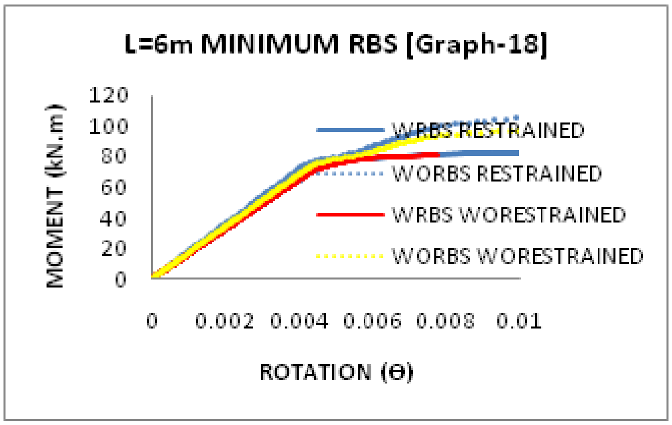




**RESULTS O BTAIN FOR L=6m.**

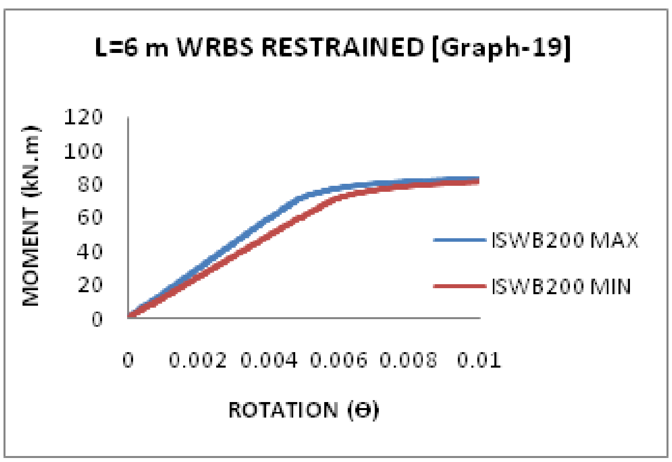





**For panel zone**




## III. CONCLUSION

- From the graphs of results of ISWB200, it is observed that there is a large variation in effect of change in length.
- From Graph-1 of Maximum rotation for full frame,It is observed that Strength of With RBS restrained section is higher than With RBS without restrained structure due to resistance against lateral tortional buckling between or at the centre of the location of RBS.
- From Graph-2 of minimum rotation for full Frame, it is observed that behaviour of all the models are same. So behaviour can not be observed from minimum rotation for all body so conclusion can not be drawn from it.
- From Graph-3 of Maximum rotation value for RBS section, It is observed that With RBS restrained section is slightly ductile than Without RBS restrained section and rotation capacity of With RBS restrained section is high.. In Without RBS restrained section initial stiffness is high.
- From Graph-4 of Minimum rotation value for RBS section, It is observed that With RBS restrained section is ductile and Without RBS restrained has high strength and stiffness and it is highly nonlinear. Rotation capacity of RBS portion With RBS restrained and With RBS without restrained section remain same.
- From Graph-1,3,5 that is graph for for maximum value of full frame, maximum value of RBS section and maximum value for panel zone,it is concluded that graph for panel zone is more ductile and Graph-1 is stiffer than Graph-3and Grap-5.Strength is obtain from Graph-1 that is graph of rotation for all body and ductility is obtained from Graph of panel zone.
- For all length individual behaviour is same.
- There is no need to restrained RBS section as per requirement provide in FEMA when we are considering minimum value of RBS section for length=2m, 3m, 4m, 6m. .
- From graph-4,8,12,16, As length increases, rotation capacity in RBS section reduces.

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**DISSERTATIONS**

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