Study on lateral behavior of corrugated tapered beam and beam to column joint

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Abstract—.This paper present the lateral beahaviour of corrugated tapered section. The numerical analysis is carried out by the software ANSYS 16.1.in these study focused on different parameters like varying tapered ratio(by keeping section and weight is constant) influence of corrugation thickness and effect of double corrugation. The load is applied monotonically to the structure Pushover analysis is used for analyzing the tapered beam. Sinusoidal corrugation is provided to the structure. By tapering the beam it help to reduce the dead weight of the beam and become economical

Index Terms—. corrugated tapered beam, corrugation thickness, double corrugation, ANSYS, pushover analysis, lateral beahaviour, monotonic load

1 INTRODUCTION

This paper mainly focused on the lateral behavior of corrugated tapered beam. By using tapered beam we have so many advantages over the straight beam. In steel structure we have an option for using straight section or tapered section to hold up the structure. By providing corrugation to the structure it help to avoid the use of transvers stiffeners and also help to resist web buckling. The main advantage of using tapered section over the conventional beam is it help to reduce the dead weight and there by save the cost in several ways, superior shear carrying performance particularly in the joints and supports of other element.

There are so many studies occurred on tapered section and about the effect of corrugation profile .R Aydin in (2016) conducted a study on cyclic behavior of diagonally stiffened beam to column connection of a corrugated web I section. in his study there are four specimen is taken for analyzing the structure.1) a thick plate is provided in beam column joint 2) a single stiffener is provided on beam column joint 3) double diagonal stiffener occurred in beam column joint 4) no stiffeners is provided by analyzing the maximum load carrying capacity is showed by the third specimen. Khalid in 2014 in his study he discussed about the bending behavior of corrugated beam. from his study the findings are vertical corrugation is better than horizontal corrugation, the corrugation radius have great influence to increase the load carrying capacity. Taware (2017) his study mainly focused shear capacity of web of large plate girders His Research work involves the finite element analysis of plate girder for different conditions like, i) Tapered Web beams ii) Corrugated Web Beams with Rectangular Trapezoidal, Web Corrugations. The main comparison parameters are i) static behavior, ii) buckling behavior. A study has been carried out to determine the buckling strength and economy of tapered web plate girder with corrugated web by conducting the analysis He observed that tapering the web as per profile there is not much difference in displacement& Buckling behavior, but has the lowest displacement as compared to Corrugated Web. Hence, it is concluded that trapezoidal corrugated web which is better in comparison with rectangular corrugated web. Mohammed Elgay etall conducted a study on shear strength of corrugated web for Beams with corrugated webs were tested to failure under shear; the failure was due to buckling of the web. When the corrugation is coarse the capacity of the panel will be controlled by local buckling of the flat folds of the corrugation, and as the corrugation becomes dense global buckling of the whole panel as an orthotropic plate is in control. Harmut Pasternak(2018) on his studies he says that sinusoidal corrugation, has been increased very much during the last years. the thin web of 1.5 mm to 3 mm corrugated web beams afford a significant weight reduction compared with hot rolled profiles or welded I-sections. From his observation he says that Buckling failure of the web is prevented by the corrugation. The buckling resistance of presently used sinusoidal corrugated webs is comparable with plane webs of 12 mm thickness or more. For those girders do not appear local buckling effects before the web reaches its yielding shear capacity. The buckling curve should be improved

In this paper is focused to the study on lateral behavior of corrugated tapered beam with different tapered ratio like 1.5, and 2 and also the influence of corrugation thickness and the effect of double corrugation also checked ANSYS 16.1 is used.

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2 Models

Non -linear finite element analysis was done on ANSYS 16.1. In order to study the lateral behavior of beam to column joint.

2.1 Properties

Length of beam=2720mm
Length of column=3204mm
Poisson's ratio =0.3
Yield stress of bolt=900MPa
Ultimate strength of 3mm corrugation thickness =440MPa
Ultimate strength of 20mm flange thickness=430MPa
Ultimate strength of 15mm web thickness=460MPa
Elements used=solid186, shell 181

2.2 Corrugated tapered beam

The tapered beam having tapered ratio 1.5, 1.75 and 2 studied here. The analysis was done by two conditions first one is the section of the tapered beam keep constant and the second was the weight of the tapered section keep constant. Pushover method is used to analyze the structure. load is laterally applied to the structure. the supporting condition of column is fixed. By analyzing the structure the maximum load carrying capacity is determined. Fig 1, 2 and 3models were used for analysis

TABLE 1 DIMENSION OF CORRUGATED TAPERED BEAM

Tapered ratio	Keep section constant(mm)		Keep weight constant(mm)	
	Hmax	Hmin	Hmax	Hmin
1.5	363	242	423.5	282.3
1.75	363	207.42	460	257
2	363	181.5	480	240

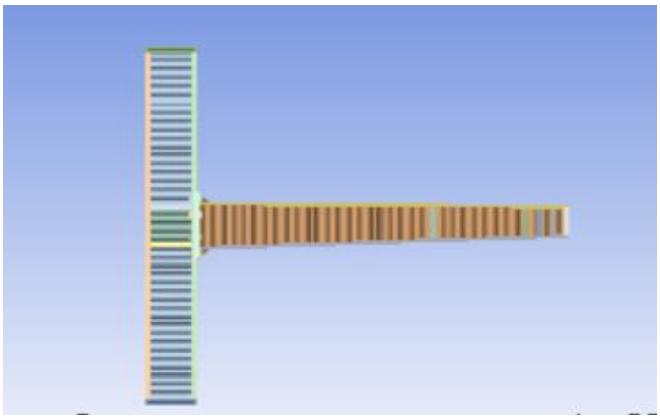

Figure 1 tapered beam having tapered ratio 1.5

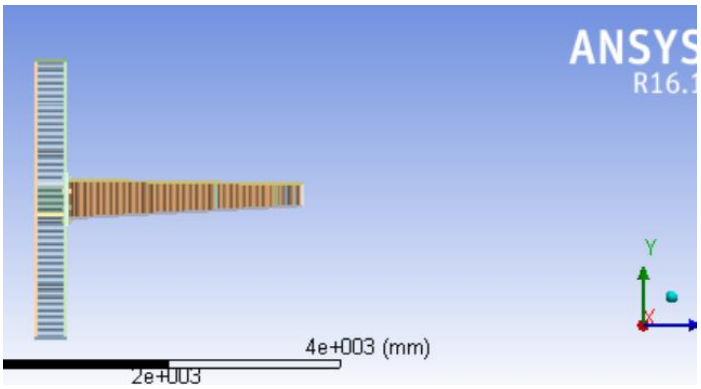

Figure 2 tapered beam having tapered ratio 1.75

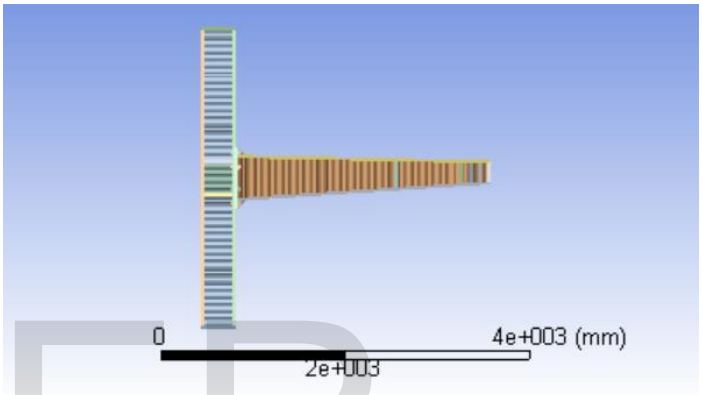

Figure 3 having tapered beam having tapered ratio 2

2.3 Influence of corrugation thickness

Effect of corrugation on load carrying capacity were studied here. Three different models were created having corrugation thickness 1.5.2 and 2.5. Pushover analysis is used load is laterally applied to the structure. fig 4,5and 6 are the models created for analysis.

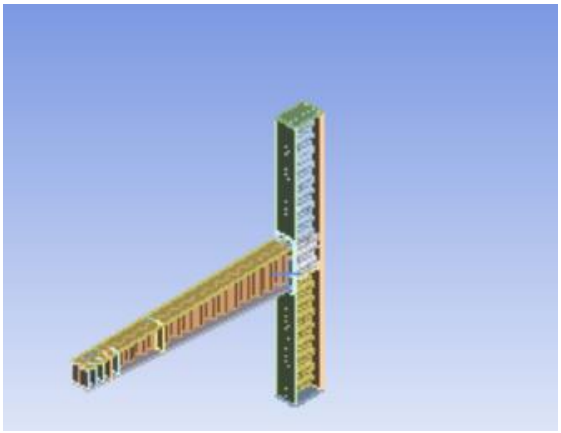

Figure 4 thickness of corrugation -1.5mm

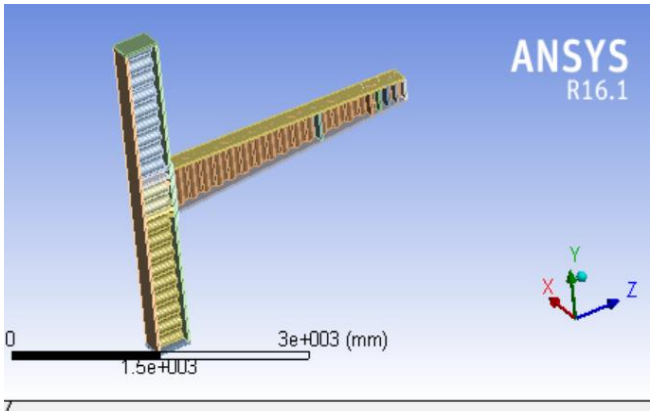

Figure 5 thickness of corrugation -2mm

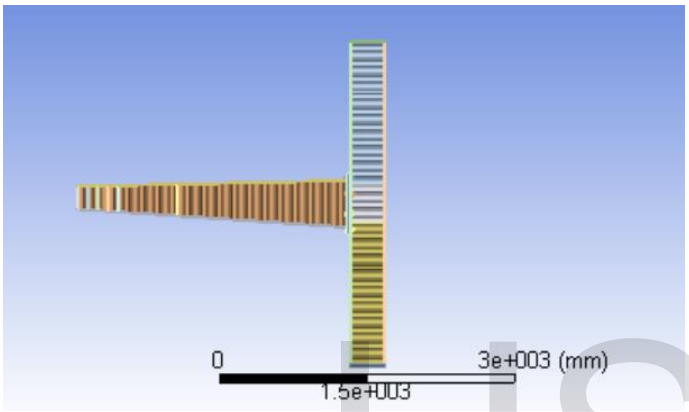

Figure 6 thickness of corrugation-2.5mm

2.4 effect of double corrugation

The maximum stress developed in the area of beam column joint. To reduce the stress development a double corrugation is provided in the portion of beam to column joint. The distance between the panels were also changed. Figure 7 was the model created for the analysis.

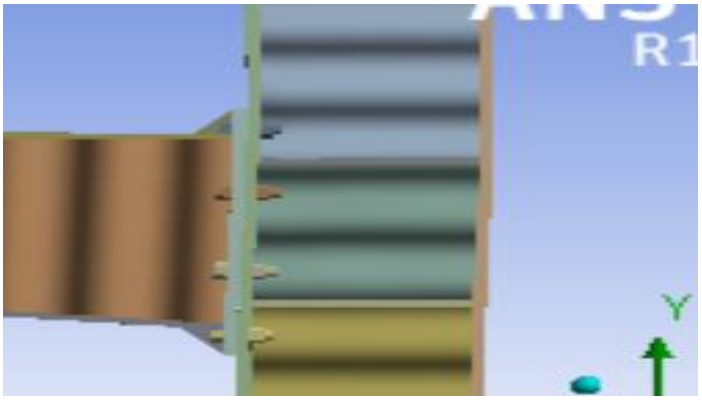

Figure 7 double corrugation

3 RESULT ANALYSIS

TABLE 2 EFFECT OF TAPERED RATIO

Tapered ratio	Section constant		Weight constant	
	Load (kN)	Deformation (mm)	Load (kN)	Deformation (mm)
1	88.67	150.6	88.6	150.6
1.5	86.64	150.2	89.4	150.46
1.75	86.38	150.31	90.2	150.32
2	85.50	150.42	93.6	150.15

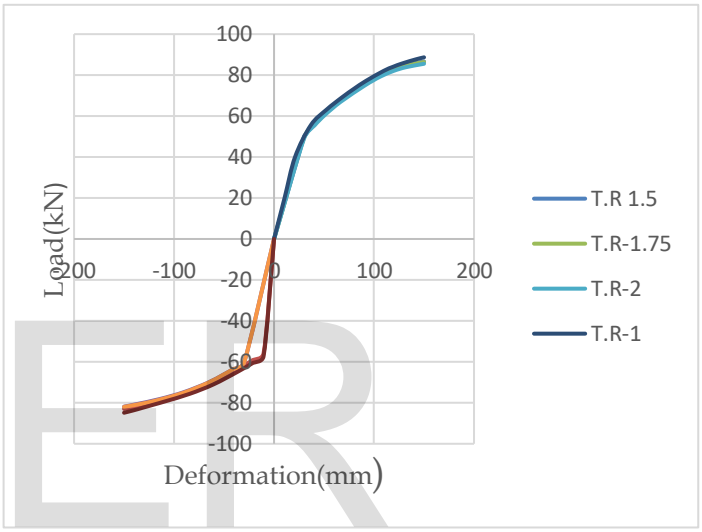

Figure 8 load-deformation graph (keep section constant)

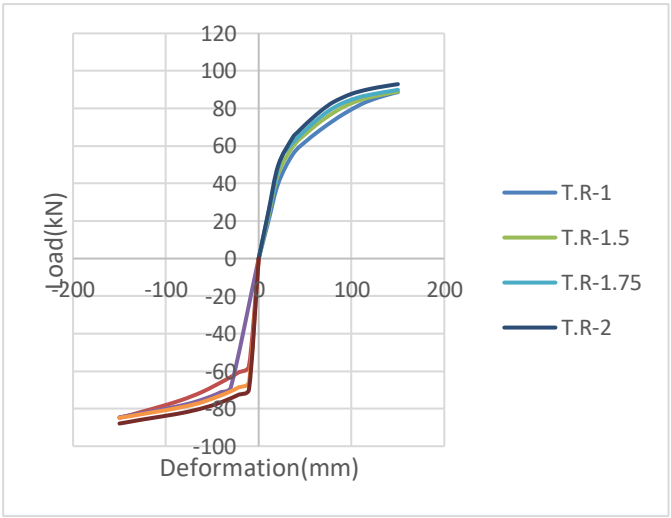

Figure 9 load-deformation graph (keep weight constant)

TABLE 3 INFLUENCE OF CORRUGATION THICKNESS

Corrugation thickness	Load(kN)	Deformation(mm)
1.5	71.932	150.6
2	77.986	150.4
2.5	84.327	150.2

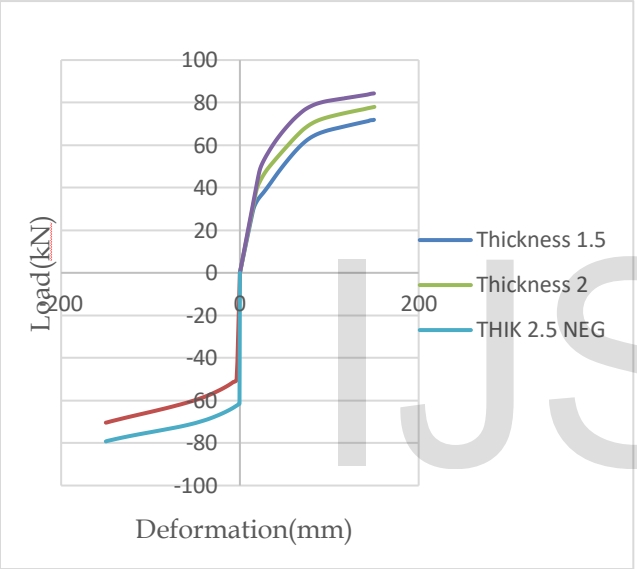

Figure 10 load deformation graph of various corrugation thickness

TABLE 4 EFFECT OF DOUBLE CORRUGATION

Type	Load (kN)	Deformation(mm)
single	86.673	150.6
double	94.83	150.25

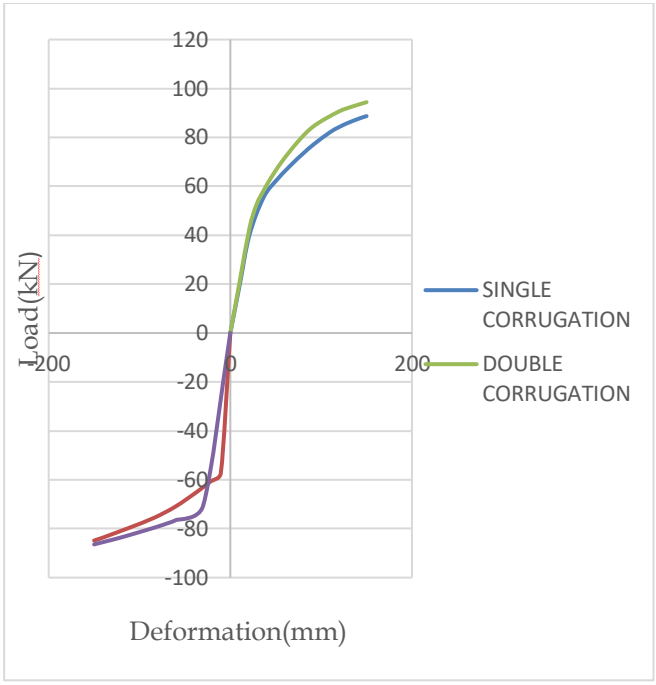

Figure 11 load deformation graph of single corrugation Vs double corrugation

4 DISCUSSION

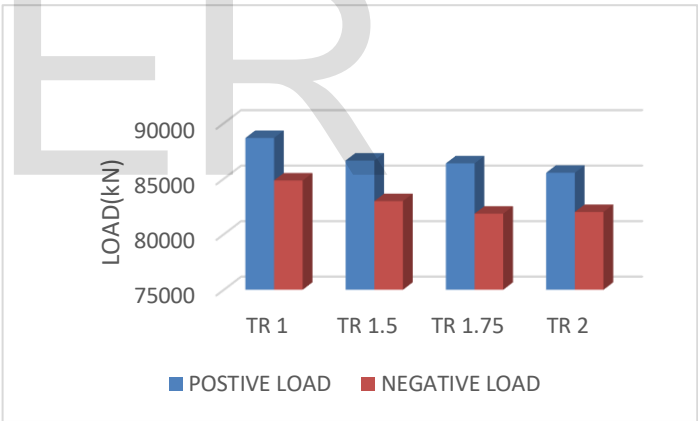

Figure12 comparison of different tapered ratio (keep section constant)

Comparing the load carrying capacity of tapered beam, tapered ratio 1 shows maximum. But there is no great difference occurred when comparing with others. So we have an option to use the tapered beam or straight beam in steel structures. By using the tapered beam there are many advantages the main advantage is help to reduce the self-weight and there by cost of structures in many ways. The dead weight of tapered beam is less its desirable for seismic zone.

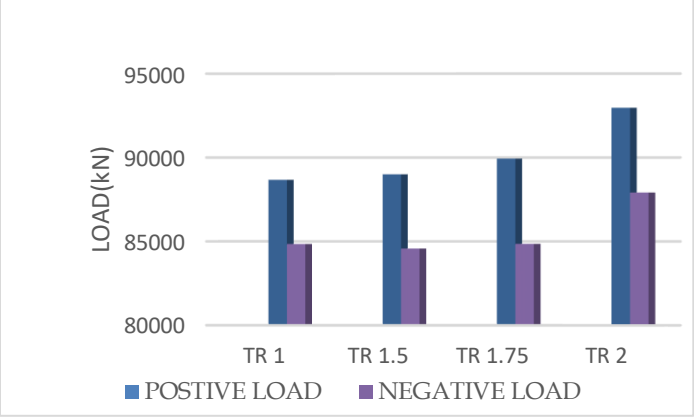

Figure 13 comparison of different tapered ratio

(keep weight constant)

Tapered beam have tapered ratio 2 shows maximum load carrying capacity. It help to increase the ductile behavior of structure. By providing tapering to the beam it help to increase bending behavior of beam. The maximum load carrying capacity of beam with tapered ratio 2 have 93.6 kN with displacement 150mm.

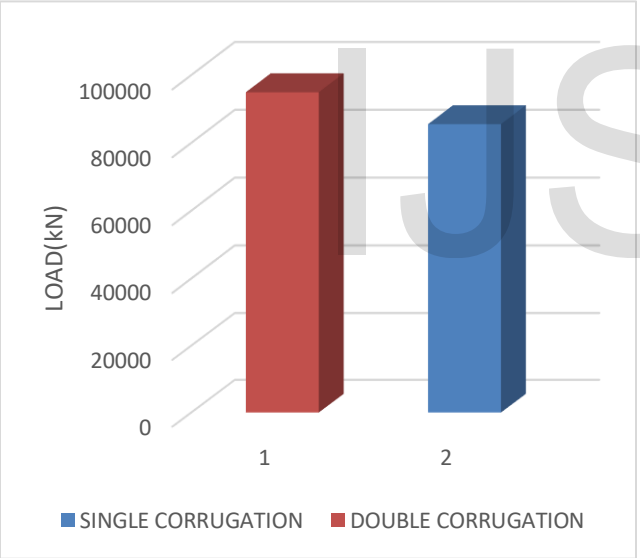

Figure 14 double corrugation Vs single corrugation

The maximum stress is developed in beam to column joint and it's near vicinity. By providing double corrugation in the panel zone its help to reduce the stress developed in the area of beam to column joint and help to enhance the load carrying capacity of the section. The maximum load carrying capacity by providing double corrugation is 94.83Kn with displacement 150mm.there is a significant difference occurred in load carrying capacity by providing double corrugation when compared to single corrugation.

Figure 15 load carrying capacity of different corrugation thickness

The corrugation thickness have great influence on load carrying capacity of the beam. When the thickness of corrugation increases the load carrying capacity also increase. The maximum load carrying capacity is 86kN for corrugation thickness 2.5mm.

5 CONCLUSION

By conducting the finite element analysis on tapered beam, It have more structural efficiency than conventional type. The models were created by varying different parameters Like different tapered ratio, increasing corrugation thickness etc the findings obtained from the study are listed below

I. The beam tapered by keeping section is constant there is no significant difference is observed in load carrying capacity. So in steel structure there is an option to provide tapered section or straight section

II. Using tapered section it help to reduce the self weight and there by cost

III. The tapered ratio two shows maximum load carrying capacity when comparing to others in the cade of keeping weight is constant

IV. The corrugation thickness have great influence on the load carrying capacity of a structure. when corrugation thickness increases load carrying capacity also increases.

V. Double corrugation is a good method to enhance the strength of beam column joint

VI. Tapered beam have desire for seismic area

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