International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 07 | July 2020 www.irjet.net p-ISSN: 2395-0072

Structural Investigation and Strengthening of Plastic Laminates with Coldform Steel Encasements

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Abstract –*Plastic lumber is a plastic form of lumber made of virgin or recycled plastic. In this experiment the performance of plastic lumber blocks that is laminated plastic lumber blocks by bolts and glue is studied .Lamination is the technique of producing a material in multiple layer, so that the composite product shows increased strength, stability, appearance etc. These plastic lumber laminates can be further more strengthen by using cold form steel encasements and can be used as structural members like beam and column. Different models where developed, studied with varying shapes and are analyzed.*

Key Words: Plastic lumber- Lamination-Cold form steel encasement.

1. INTRODUCTION

The increasing generation of plastic waste by industry and in urban areas in recent time has prompted concern in society and efforts to recycle unused plastic materials. Among the alternatives to minimize plastic waste accumulation is using postconsumer plastics to produce plastic lumber as a substitute for natural wood, steel and other materials.

Fig -1: Recycled plastic lumber

Plastic residue or plastic wastes can be convert into plastic lumber a composite materials by adding wood flour, mineral fillers, plant or synthetic fibers ,which is a substitute material for natural wood, concrete and steel.

The composite laminates can be screwed or glued to get various models of lumber blocks. Plastic lumber shows different physical and mechanical properties from natural wood, including lower stiffness and superior weathering resistance.

We can increase the performance of these composite plastic lumber laminates by steel encasements especially cold form steels.

Cold formed steel is the steel products shaped by cold working processes which is nearly at room temperature not at higher temperature, such as rolling, pressing, bending, stamping, etc. Stock bars and sheets of cold rolled steels are used in vast areas of construction.

Light weight, high strength and stiffness, ease of prefabrication, highly recyclable material, etc are the major advantages of cold form steels.

Fig -2: Cold form steel sheets

Different models have been created using ANSYS software with the properties like yield strength, poisson's ratio, etc of plastic lumber and cold form steel. The models are of the dimension of 1400mm x 120mm x 120mm.

2. FINITE ELEMENT MODELLING

2.1 General

To investigate structural performance of plastic laminate beams and columns encased with cold form steel, modeling of structure was done using SOLID186 element of ANSYS 16.1

2.2 Scope

Scope of the work is limited to find the load carrying capacity of plastic laminate beams and columns encased with cold form steel under different configurations of encasements like external encasements and internal encasements and their different section like C section, Rectangular section, I section and HAT section to compare their performance, using nonlinear finite element approach.

2.3 Objectives

To study the behavior of Laminated plastic blocks with external and internal encasements of cold form steel as both beam and column of different sections and find the optimum section.

2.4 Geometry and Material properties

In total there were 8 models, 4 models of external encasements and 4 models of internal encasements. In that 4 models are analysed as beams and 4 models are analysed as column. Laminates are screwed each other and with the encasements.

External encased models are

1. Plastic laminates externally encased with rectangular section as beam
2. Plastic laminates externally encased with rectangular section as column
3. Plastic laminates externally encased with C section as beam
4. Plastic laminates externally encased with C section as column

Internal encased models are

1. Plastic laminates internally encased with I section as beam
2. Plastic laminates internally encased with I section as column
3. Plastic laminates internally encased with HAT section as beam
4. Plastic laminates internally encased with HAT section as column

Table -1: Material properties of plastic lumber

Properties	Description
Density (kg/m^3)	1100
Young's modulus (MPa)	1700
Poisson's ratio	0.2

Table -2: Material properties of cold form steel

Properties	Description
Density (kg/m^3)	7870
Young's modulus (MPa)	210000
Poisson's ratio	0.287

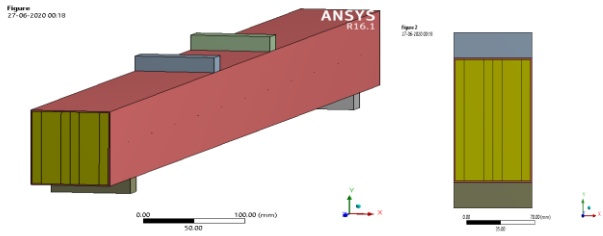

Fig -3: Laminate beam model externally encased with rectangular section

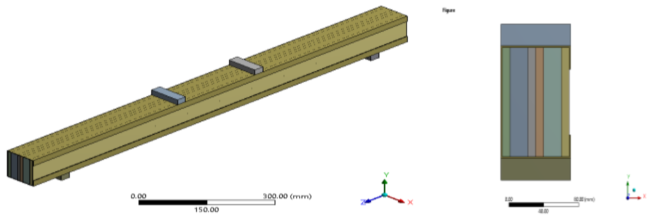

Fig -4: Laminate beam model externally encased with C section

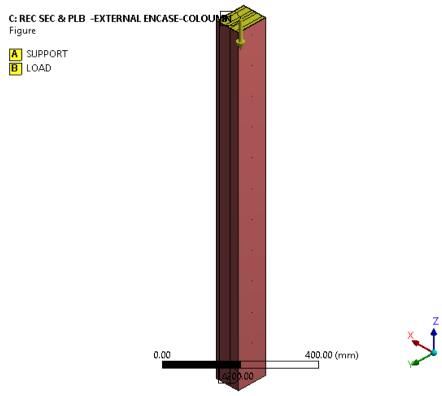

Fig -5: Laminate column model externally encased with rectangular section

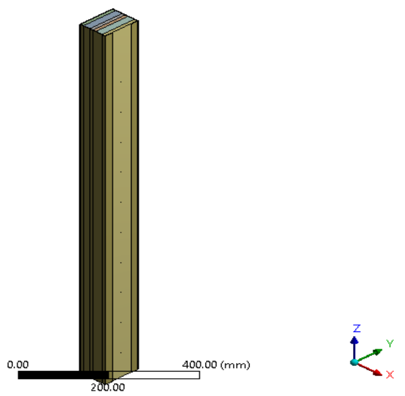

Fig -6: Laminate column model externally encased with C section

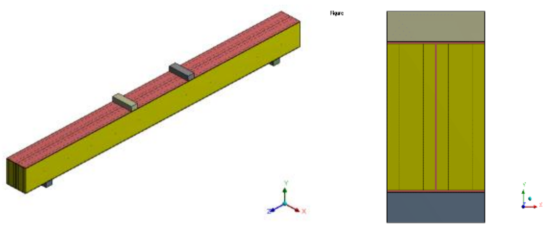

Fig -7: Laminate beam model internally encased with I section

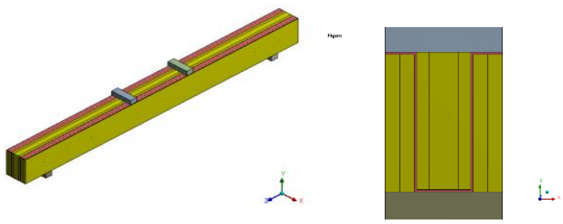

Fig -8: Laminate beam model internally encased with HAT section

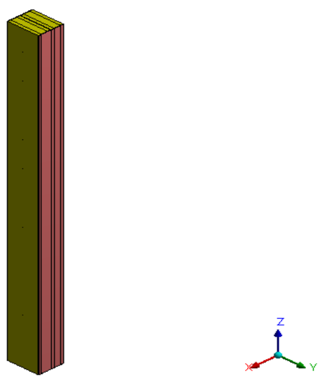

Fig -9: Laminate column model internally encased with I section

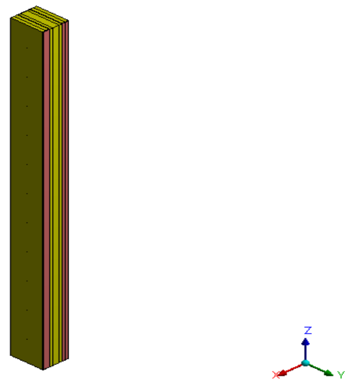

Fig -10: Laminate column model internally encased with HAT section

2.5 Meshing

To understand structural behavior properly solid models were subjected to meshing. Meshing divided whole model into finite elements. After meshing solid models were converted into finite element models.

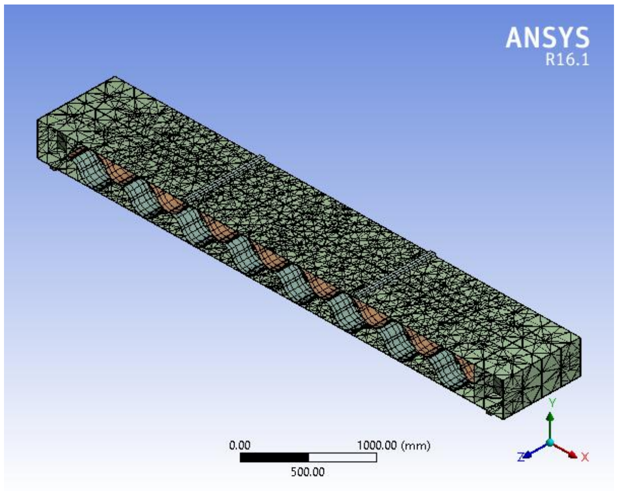

Fig -11: Meshing of 3D model in ANSYS 16.1

2.6 Loading and Boundary conditions

To stimulate real conditions, laminate beams were analyzed with a simply supported system at both ends and load was applied as four-point loading in one direction. The load was placed at a distance of 550mm from both the ends and 300mm distance between them. The bilinear isotropic hardening rule was used for finite element analysis.

And the steel encased laminate columns were analysed as axial loading. Plastic laminate column models are subjected to load at the centroid of column cross section.

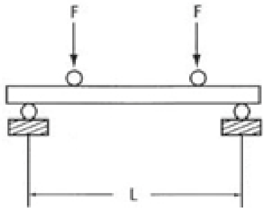

Fig -12: Four-point loading

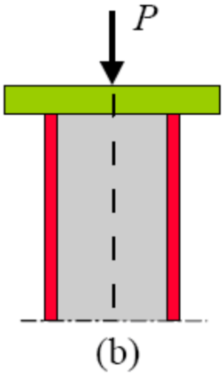

Fig -13: Axial loading

3. RESULTS AND DISCUSSIONS

3.1 Four-point loading test

Plastic laminate beam models were subjected to four-point loading. The models were simply supported at a distance of 100mm from both the ends and loads were applied at a distance of 550mm from both ends of the model. From the load deflection graph, maximum load carrying capacity and total deflection of model was obtained and compared between them.

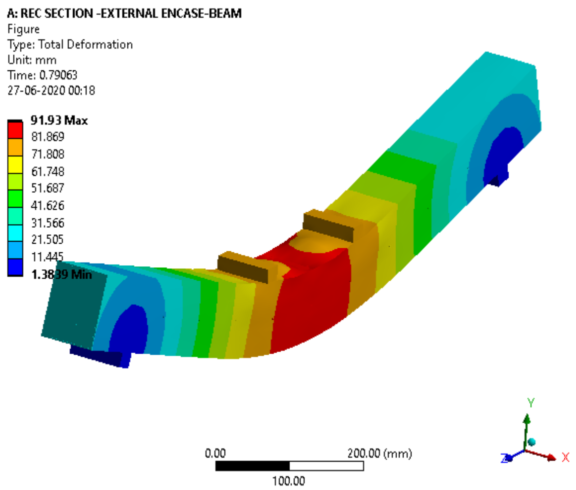

Fig -14: Total deformation of Laminate beam model externally encased with rectangular section

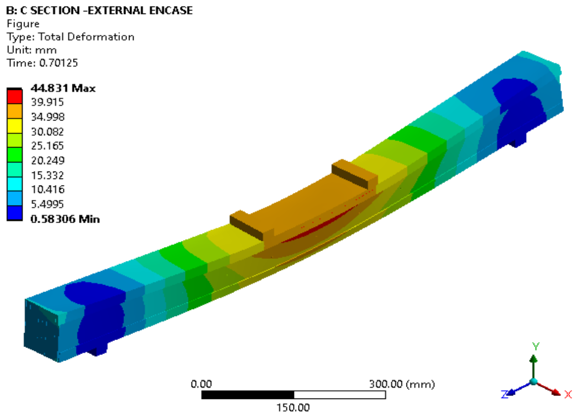

Fig -15: Total deformation of Laminate beam model externally encased with C section

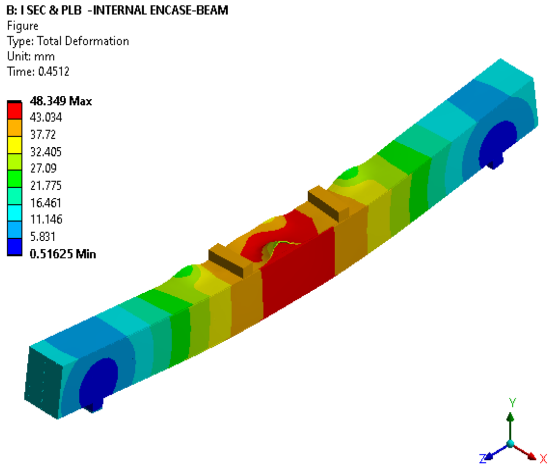

Fig -16: Total deformation of Laminate beam model internally encased with I section

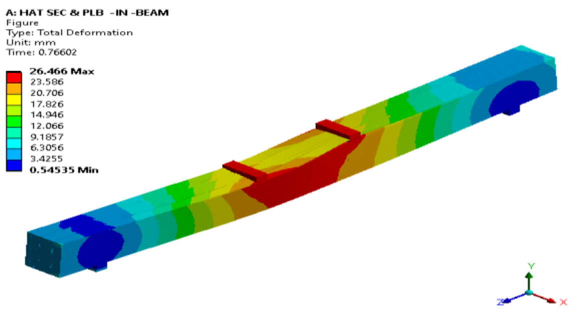

Fig -17: Total deformation of Laminate beam model internally encased with HAT section

Table -3: Ultimate load and Total deformation of beam models with external encasements

No.	External encasements as beam	Ultimate load (kN)	Total deformation (mm)
1	Rectangular sec	68.88	91.93
2	C section	50.76	44.83

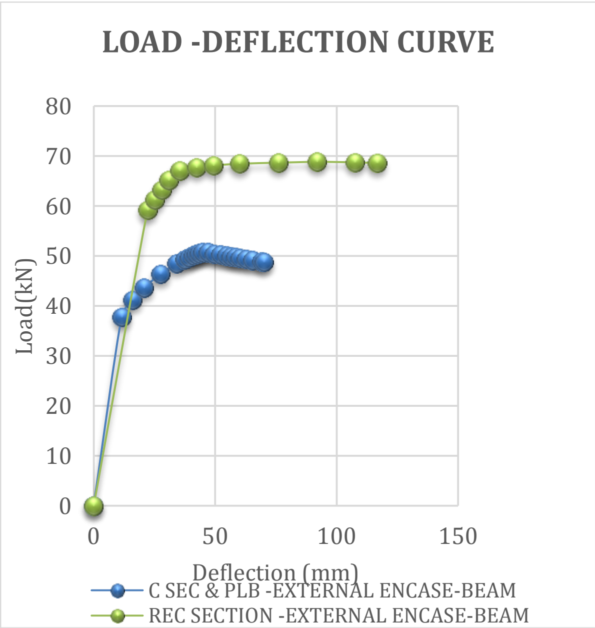

Chart -1: Load deflection graph of laminate beam model with external encasements

Table -4: Ultimate load and Total deformation of beam models with internal encasements

No.	Internal encasements as beam	Ultimate load (kN)	Total deformation (mm)
1	I section	53.71	49.35
2	HAT section	40.96	29.49

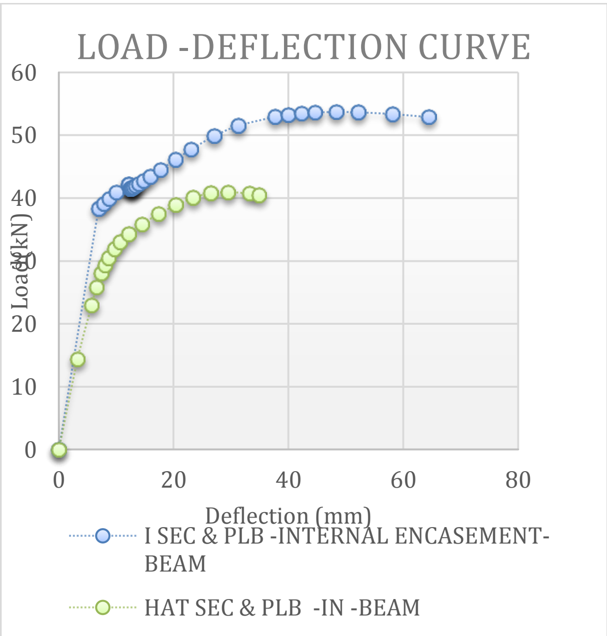

Chart -2: Load deflection graph of laminate beam model with internal encasements

Table -5: Ultimate load and Total deformation of laminate beam models

No.	Type of laminates		Ultimate load (kN)	Total deformation (mm)
1	Rectangular section	External encasement	68.88	91.93
2	C section	External encasement	50.76	44.83
3	I section	Internal encasement	53.71	49.35
4	HAT section	Internal encasement	40.96	29.49

From the data obtained it is clear that in cold form steel externally encased plastic laminate beams, rectangular section models are having more load carrying capacity than C section beam model, precisely rectangular section shows 26% higher strength compare to C section as in beam.

While in case of internally encased beams I section shows 23% higher strength than HAT section. While comparing both internal and external encasements Rectangular sections shows higher strength than all of them as beam.

3.2 Axial loading

Plastic laminate column models are subjected to load at the centroid of column cross section. From the load deflection graph, maximum load carrying capacity and total deflection of model was obtained and compared between them.

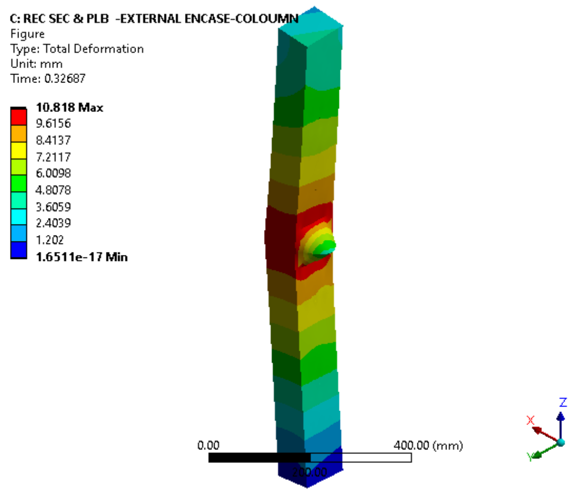

Fig -18: Total deformation of Laminate column model externally encased with Rectangular section

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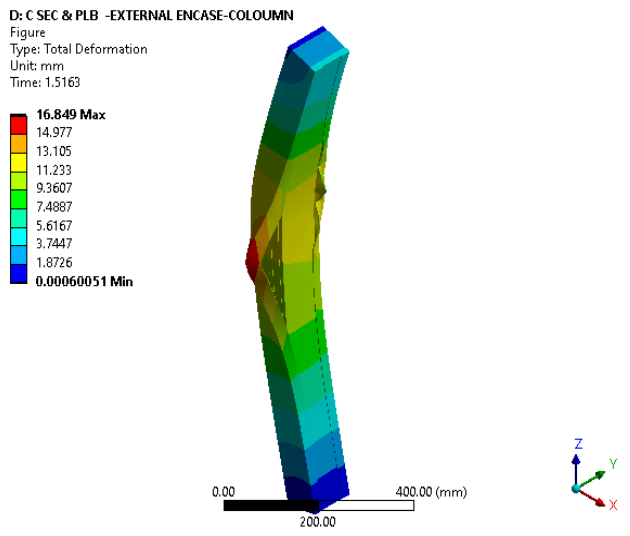

Fig -19: Total deformation of Laminate column model externally encased with C section

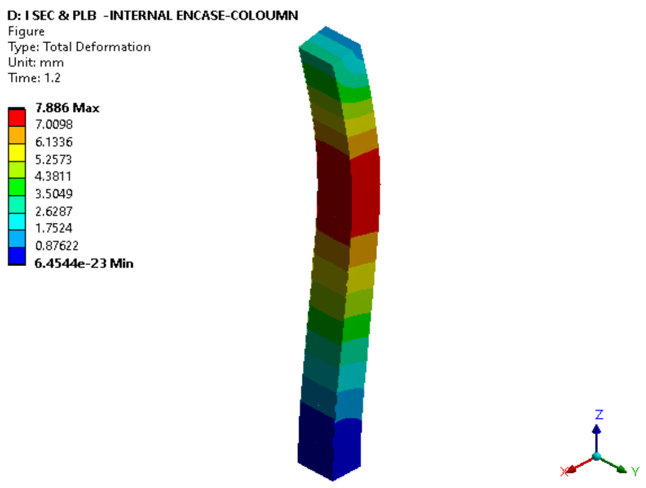

Fig -20: Total deformation of Laminate column model internally encased with I section

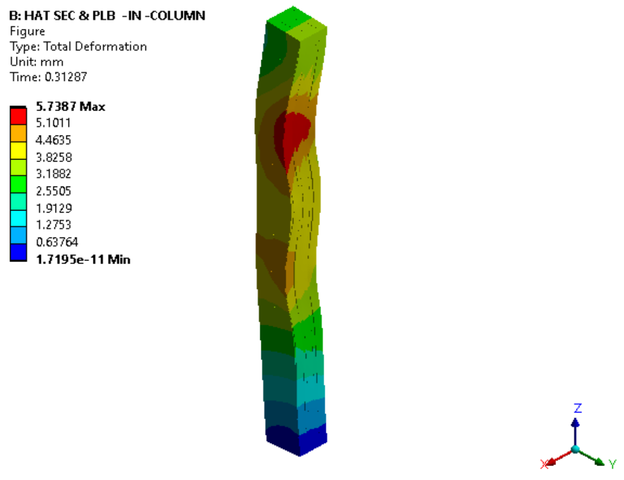

Fig -21: Total deformation of Laminate column model internally encased with HAT section

Table -6: Ultimate load and Total deformation of column models with external encasements

No.	External encasements as column	Ultimate load (kN)	Total deformation (mm)
1	Rectangular sec	222.50	2.75
2	C section	137.38	6.97

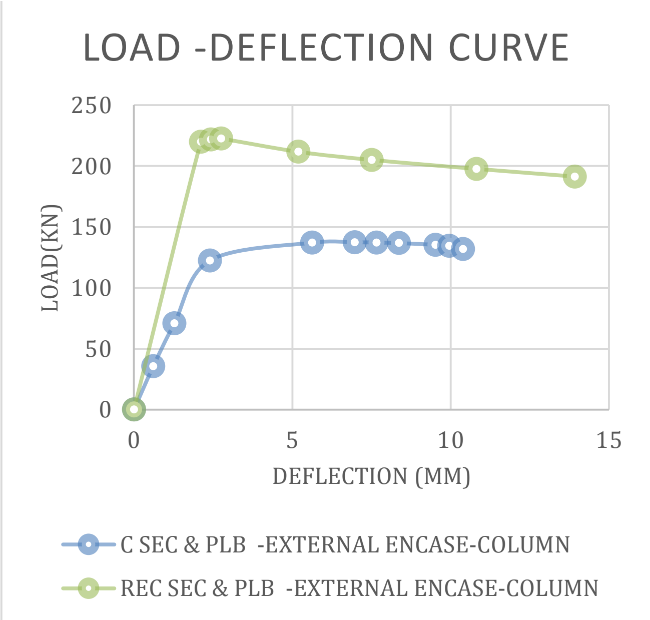

Chart -3: Load deflection graph of laminate column model with external encasements

Table -7: Ultimate load and Total deformation of column models with internal encasements

No.	Internal encasements as column	Ultimate load (kN)	Total deformation (mm)
1	I section	146.46	6.26
2	HAT section	190.65	4.53

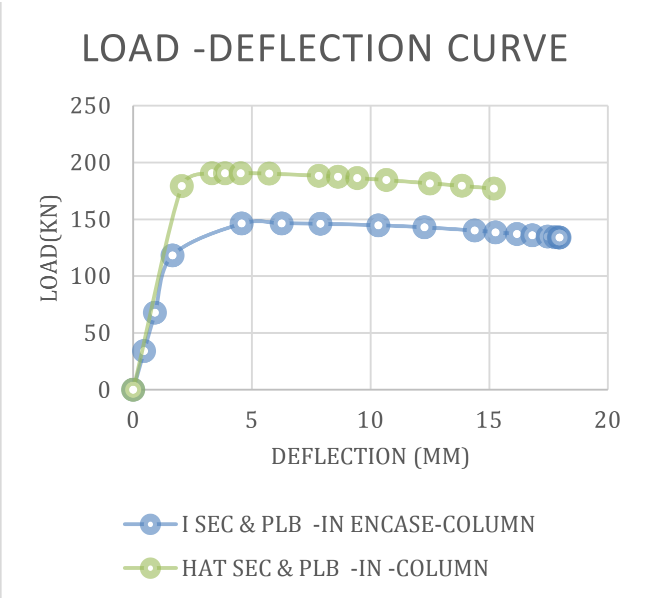

Chart -4: Load deflection graph of laminate column model with internal encasements

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Table -8: Ultimate load and Total deformation of laminate column models

No.	Type of laminates		Ultimate load (kN)	Total deformation (mm)
1	Rectangular section	External encasement	222.50	2.75
2	C section	External encasement	137.38	6.97
3	I section	Internal encasement	146.46	6.26
4	HAT section	Internal encasement	190.65	4.53

From the data obtained it is clear that in coldform steel externally encased plastic laminate column sections, rectangular section models are having more load carrying capacity than C section beam model, precisely rectangular section shows 38% higher strength compare to C section as in column.

While in case of internally encased columns, HAT section shows 23% higher strength than I section. While comparing both internal and external encasements Rectangular sections shows higher strength than all of them as column.

CONCLUSIONS

From the study, following conclusions were arrived at

- In internal encasements, HAT section shows 23% higher strength compare to I section as in column.
- While in case of beam I section shows 23% higher strength than HAT section.
- In external encasements, Rectangular section shows 38% higher strength compare to C section as in column.
- As well as in case of beam Rectangular section shows 26% higher strength than C section.
- While comparing both internal and external encasements Rectangular sections shows higher strength than all of them as both column and beam.
- While comparing with conventional wooden beam rectangular section shows 60% more strength

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