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EXPERIMENTAL STUDY ON COMPRESSION BEHAVIOUR OF FRP ANGLE SECTIONS

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ABSTRACT

FRP is a composite material made of a polymer matrix reinforced with fibres. Pultrusion is one of the ways to manufacture FRP sections. Pultrusion technology has lead to the easy and mass production of larger pultruded parts capable of serving as structural members. FRP is commonly used in various fields such as aerospace, military vehicles, armours, marine structures, car parts and has been used in the construction industry. Angle sections are typically used as truss members in towers and are subjected to axial tension or compression. Steel sections typically used in towers are prone to corrosion and constant maintenance. Globally, significant numbers of steel structures all over the world that are structurally deficient and require maintenance.FRP owing to its light weight and durability can be used as an alternative. Also, FRP is non-conductive material. Hence, it can eliminate or reduce the use of insulators, thereby reducing the cost of the tower. The objective of this project is to study the compression behaviour of FRP angle sections. Theoretical and finite element study on FRP angle section with various slenderness ratio and size is done to study the ultimate load and modes of failures. The results were compared and validated.

1.INTRODUCTION

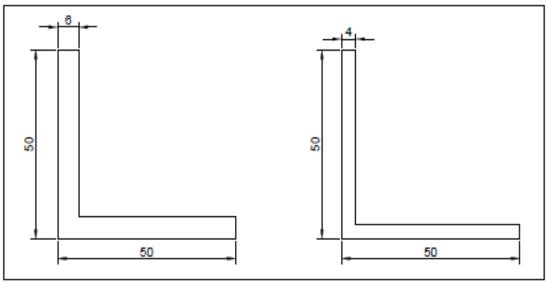
The demand for power consumption in India has dramatically increased over the last decade due to increased use of electrical gadgets by the public. This has created a need for more power generation and consequently the need for construction of new transmission towers. Also, with the increase in mobile phones, there is a increased need for mobile network towers. Angle sections are typically used as truss members in towers and are subjected to axial tension or compression. Steel section typically used in towers are prone to corrosion and constant maintenance. Globally, significant numbers of steel structures all over the world that are structurally deficient and require maintenance.FRP owing to its light weight and better durability can be used as an alternative. Also, FRP is a non-conductive material. Hence, it can eliminate or reduce the use of insulators, thereby reducing the cost of the tower.

2.THEORETICAL DESIGN

Capacity of FRP angle sections is found by using various formulae available in literature. The details of the calculation of capacity is presented.

2.1 SELECTION OF ANGLE SECTION:

Two size of angle sections namely 50x50x4mm and 50x50x6mm are chosen for the study. It is based on availability in the market. Fig gives a cross section of an FRP angle section.



GEOMETRIC PROPERTIES

FRP Size (mm)	Section Area (mm^2)	C_{xx}= C_{yy} (mm)	e_{xx}= e_{yy} (mm)	Radius of Gyration (mm)			Product of Inertia $1x10^4$ (mm^4)			
				r_{xx}= r_{yy}	r_{uu}	r_{vv}	I_{xx}= I_{yy}	I_{uu}	I_{vv}	I_{xy}
50x50x4	384	13.9	36.01	15.5	19.5	9.9	9.26	14.7	3.76	5.5
50x50x6	564	14.7	35.3	15.2	19.2	9.8	13.1	20.8	5.4	7.7

Design Equations

Reference	Mode of buckling / Limit state	Eqation
Euler's (3)	Critical Buckling	$F_{cr}=\frac{\pi^2 EA}{\lambda^2}$
Strong Well Manual(4)	Global Buckling	$\sigma_{cr}=\frac{E_l}{56 \text{ x } \left[\frac{KL}{r}\right]^{0.55}}$
Pecce& Cosenza(4)	Local Buckling	$\sigma_{cr}=\frac{E_l}{27 \text{ x } \left[\frac{b}{t}\right]^{0.95}}$
Pultex (4)	Lateral Torsional Buckling	$\sigma_{cr} = \phi\frac{E_l}{2(1+v)} \text{ x } \left[\frac{t}{b}\right]^2$
Zureick& Steffen (4)	Lateral Torsional Buckling	$F_{cr} = 0.9 \frac{G_{xy}}{\left[\frac{b}{t}\right]^2}$

3.FINITE ELEMENT ANALYSIS

Finite element model of FRP angle section is developed in finite element software ABAQUS 6.14. The developed model is validated with results available in literature. Further a parametric study is done, varying the slenderness ratio. The details of modelling,

Geometry:

These sections are created has 3D modelling space and it has deformable type of element. And base feature is shell shaped and extrusion type.

Element:

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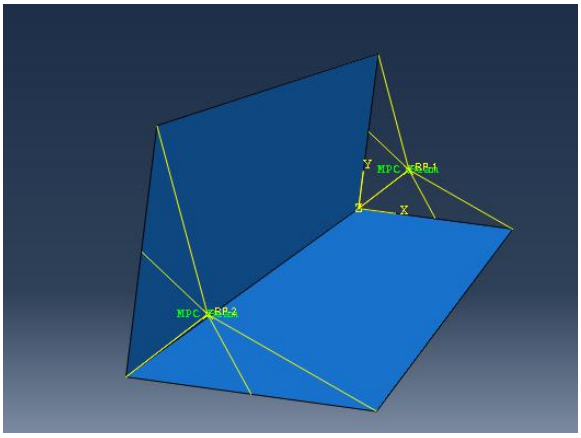
The element has created 4-node shell element is called S4R.



Validated with FEA

shown the global buckling modes with FEA validation and

Member	Length	Slenderness ratio	Buckling Load (kN)	
			Theoretical	FEA
50x50x4	1m	75.75	11.39	8.86
50x50x4	1.5m	113.64	5.06	4.93
50x50x6	1m	76.53	16.39	16.69
50x50x6	1.5m	114.79	7.27	7.02

various parameter studied for FRP angle section

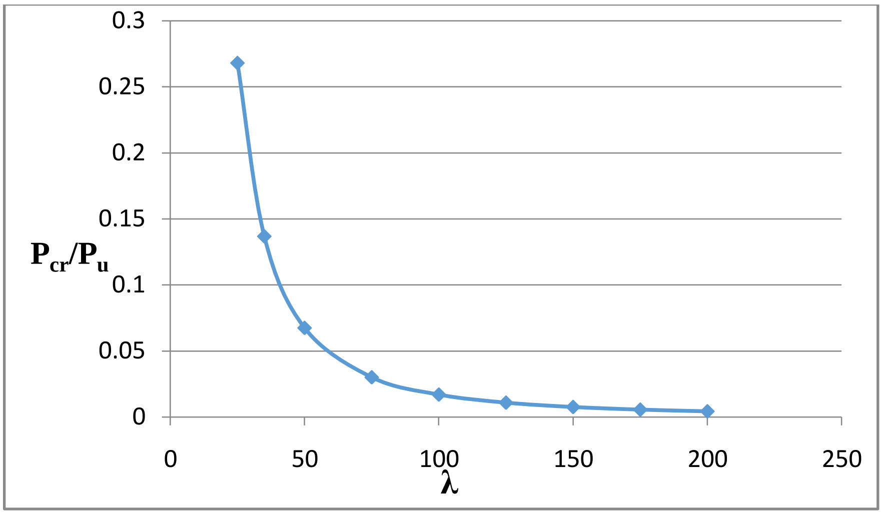
4. PARAMETRIC STUDY

The slenderness ratio is well known one of the important parameters affecting the buckling capacity of FRP pultruded members under axial compression. In this study, the length of the section namely 50x50x6mm is varied. The length chosen are 245mm, 343mm, 490mm, 735mm, 980mm, 1225mm, 1470mm, 1715mm and 1960mm. The corresponding slenderness ratios for 50x50x6mm are 25, 35, 50, 75, 100, 125, 150, 175 and 120 respectively. The FEA buckling load are found for the section which selected for parametric study. Table 6.2 gives the buckling load for FRP angle section of various slenderness ratio.

4.1 VARIOUS OF Pcr/P_u WITH SLENDERNESS RATIO

The ultimate load is calculated based on literature data were used for parametric study.

P_u= σ_ux Area = 800x564 = 451.2kN



Variation of P_{cr}/P_u with slenderness ratio

P_{cr} – Critical Buckling Load **P_u – Ultimate Load** **λ – slenderness ratio =l/r**

5.EXPERIMENTAL STUDY

5.1 MATERIAL PROCUREMENT

It is proposed to test six angle sections of size are 50x50x4mm and 50x50x6mm
of length 0.5m, 0.75m and 1.0m respectively, under uniaxial compression. GFRP pultruded angle sections were procurement from Meena Fiberglass Industries, Pondicherry. GFRP is made up of E-glass and polyester(isotalic) resin.

5.2 DETERMINATION OF MATERIAL PROPERTIES OF FRP.

Basic properties of FRP such as tensile strength, modulus, maximum strain and volume fraction were found by testing in laboratory.

5.3 DIRECT TENSION

The Universal Testing Machine(INSTRON) is type of Model 3369 Table Mounted Materials Testing system, Capacity 50kN available at Advanced material testing Laboratory in Central Workshop Division. Test speed of 1mm/min was considered.

Maximum tensile strength was found to be 487.2 MPa and corresponding ultimate strain was 0.134. Modulus of elasticity in the major direction was found to be 8897MPa.

Percentage Elongation of FRP material

The value obtained from the above results about 15.84%

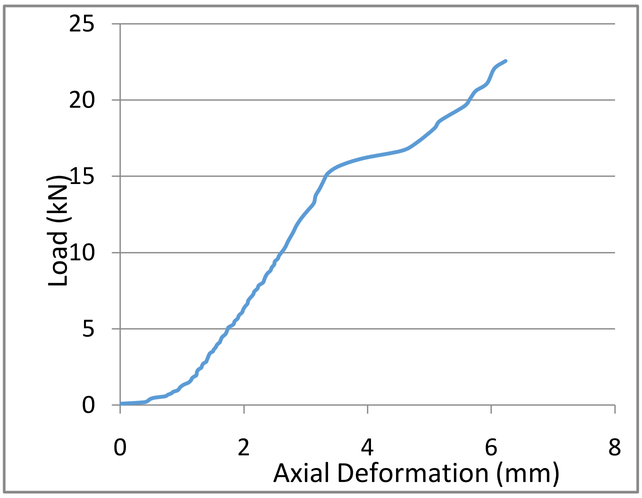
5.4 FABRICATION OF TEST SETUP

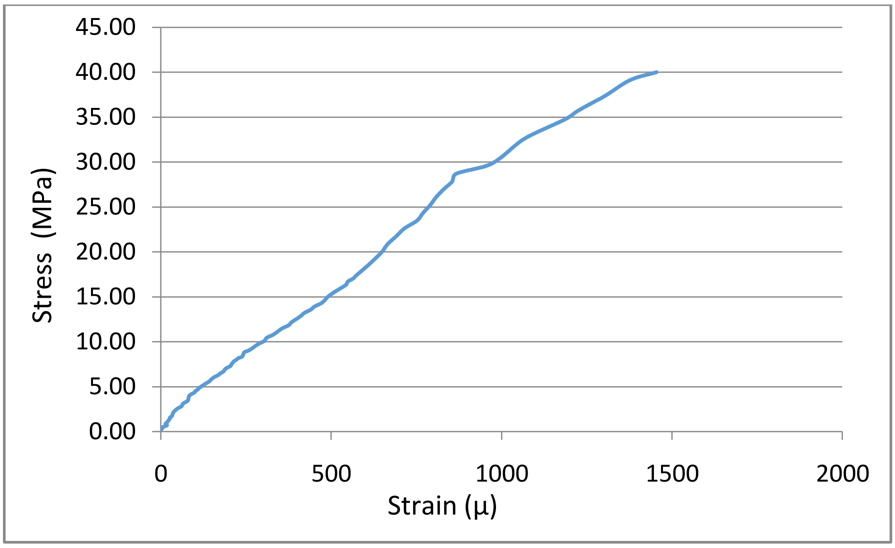
End supports for the specimens consist of grooved plate allowing rotation but arresting lateral motion thus stimulating simply supported boundary condition. Axial load is applied uniformly on the specimen thorough end plate by means of hydraulic jack of capacity 10tons. Arrangements were made to measure strain and axial deformation.

5.5 TESTING OF ANGLE SECTION UNDER COMPRESSION

FRP angle section of size 50x50x6mm and of length 1m was tested under axial compression. Load was applied at 10kg to 50kg intervals. Strain and axial deformation was measured at each interval of loading. The specimen was tested upto failure load of 18.15kN.

Load vs Axial Deformation – 50x50x6mm, l =1mSpecimen at failure





Stress vs strain -50x50x6mm, length=1m

CAMPARISSON OF BUCKLNG LOAD ON FRP ANGLE SECTIONS

SL.NO	ANGLE SECTIONS		CAPACITY (kN)	
		THEORETICAL	EXPERIMENTAL	FEA
1	50x50x4mm, Length 500mm	11.39	11.56	13.92
2	50x50x4mm, Length 750mm	7.06	7.85	8.31
3	50x50x6mm, Length 500mm	25.39	27	28.83
4	50x50x6mm, Length 750mm	20.27	21.56	22.676

5	50x50x6mm, Length 1000mm	18.02	18.15	20.353

6. CONCULSIONS

1. It is observed from the experimental study that the load carrying capacity decrease with the increase in slenderness ratio.

2. Specimens of length 1m and 0.75m failed by buckling at mid height whereas specimen of 0.5m failed by buckling near the supports. All specimen was exhibited warning in the way of noise before failure. The specimens regained their original shape after removal of load.

3. Developed finite element model validates well with the experimental study and also with results from the literature.

REFERENCES

1. Ever Barbero& John Tomblin (1992) "Euler Buckling of Thin-Walled Composite Columns" Thin-Wailed Structures 17 (1993) 237-258 pp
2. Zouheir A. Hashem and Robert L. Yuan (2001) " Short vs. long column behavior of pultruded glass-fiber reinforced polymer composites" Construction and Building Materials vol 15 pp 369-378
3. Selvaraj.M, Kulkarni.S.M, Ramesh Babu.R, (2012) "Behaviour Analysis of built up transmission line tower from FRP pultruded sections", International Journal of Emerging Technology and Advanced Engineering, Vol 2(9) pp 39-47.
4. Ahmed Godat, Frederic Legeron, Vincent Gagne and Benjamin Marmion(2013). "Use of FRP pultruded members for electricity transmission towers", Composite Structures, Vol 105 ,pp 408–421.
5. Ana M. Girao Coelho, J.Toby Mottram, NavroopMatharu (2015) " Virtual Charaterization of delamination failures in pultrded GFRP angles" Composites Part B Vol 90 pp 212-222
6. Alexandre Landesmanna, Carlos Alexandre Serutia, Eduardo de Miranda Batistaa (2015) "Mechanical Properties of Glass Fiber Reinforced Polymers Members for Structural Applications" Vol 18(6) pp
7. Ever Barbero& John Tomblin (1992) "Euler Buckling of Thin-Walled Composite Columns" Thin-Wailed Structures 17 (1993) 237-258 pp
8. Zouheir A. Hashem and Robert L. Yuan (2001) " Short vs. long column behavior of pultruded glass-fiber reinforced polymer composites" Construction and Building Materials vol 15 pp 369-378
9. Selvaraj.M, Kulkarni.S.M, Ramesh Babu.R, (2012) "Behaviour Analysis of built up transmission line tower from FRP pultruded sections", International Journal of Emerging Technology and Advanced Engineering, Vol 2(9) pp 39-47.
10. Ahmed Godat, Frederic Legeron, Vincent Gagne and Benjamin Marmion(2013). "Use of FRP pultruded members for electricity transmission towers", Composite Structures, Vol 105 ,pp 408–421.
11. Ana M. Girao Coelho, J.Toby Mottram, NavroopMatharu (2015) " Virtual Charaterization of delamination failures in pultrded GFRP angles" Composites Part B Vol 90 pp 212-222
12. Alexandre Landesmanna, Carlos Alexandre Serutia, Eduardo de Miranda Batistaa (2015) "Mechanical Properties of Glass Fiber Reinforced Polymers Members for Structural Applications" Vol 18(6) pp