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Analysis of elliptical steel tubular section with frp

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Abstract - *External wrapping of FRP (Fiber reinforced polymer) has become a popular technique in retrofitting of structures, because of light weight, easy handling and fast installation. FRP sheets helps in strengthening of structures, delays the buckling, and they do not corrode. So that they can prevent corrosion of steel structures in marine environment. In this paper Retrofitting and Strengthening of steel tubular section using FRP is studied. Here elliptical steel tubular section is used as the control specimen. FRP is fully wrapped around the steel tubular section. Comparison of different FRP sheets were used in the study, they are CFRP, AFRP, and GFRP. Ansys 2021 software is used for the study. Various analysis was conducted and the performance of the steel tubular section is studied. Specimens wrapped by FRP shows a better result than the specimen without FRP. FRPs will increase the load carrying capacity and delays the buckling action in specimens with FRP wrapping. Among all the FRPs, CFRP shows a better result than AFRP and GFRP. CFRP wrapping has a better compression load, flexural and buckling values than AFRP and GFRP.*

Key Words: *Finite Element Analysis, FRP wrapping, Steel tubular section, Strengthening, Buckling*

1.INTRODUCTION

Several studies were conducted to find out the behavior of FRP - strengthened steel structures, subjected to static axial compression loading, and therefore the results are well documented in many analysis articles [6]. Polymer technology have new developments in fibers and FRP (fiber reinforced polymer) in order to improve the behavior of concrete structures. Since FRP have high durability and light weight it has been widely utilized in construction field [9]. Retrofitting of construction concrete and steel structures from natural calamities like earthquakes, fire, and flood become a necessary activity. So, the introduction of FRP material is a great advantage for structural components. Many previous experimental studies have a good impact on retrofitting structural components using fiber reinforced polymers. [8].

1.1 FRP Sheet

FRP (fiber-reinforced polymer) is a chemical component. It consists of a matrix and fiber. It is generally used in industries like construction, transport, and marine to make structures resistant to deformation. Apart from that it also improves the strength, safety, durability and reduces the formation of cracks. A skilled person will be needed for the installation process of FRP. Installation of FRP sheets around structural components includes the following steps, like site preparation, in which surface should be free from wet condition, because they cause the formation of bubbles. The next step is surface preparation. The surface should be cleaned and roughened to ensure strong bond between resin and FRP. Final step is that epoxy is applied on the surface and then FRP sheet is installed

Fig -1: Different FRP Sheet

1.2 Objective

- To study the effect of FRP on a steel tubular section.
- Several tests were carried out to find compressive behavior, flexural behavior and static buckling.

2. METHODOLOGY

To study the effect of FRP on a steel tubular section. Different frp sheet are used in the study, they are CFRP (carbon fiber polymer), AFRP (aramid fiber polymer), GFRP (glass fiber polymer).

Software used for modelling is Ansys 2021.

Material property of parent specimen

- Cross section : z =203.3mm, y =101.6mm
- Thickness : 2.75mm
- Length : 496.74 mm
- Density : 7850 kg/mm^3
- Poisson's Ratio : 0.3
- Young's modulus : 2 E+05 Mpa
- Yield strength : 350 Mpa

Bilinear isotropic Hardening is given with

Bulk modulus 1.6667e+05 Mpa,

Shear modulus 76923 Mpa and

Tangent modulus 2000 Mpa.

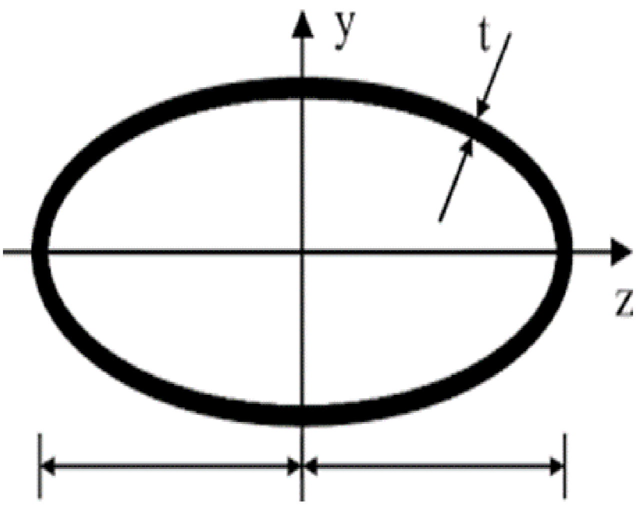

Fig -2: Cross section of specimen

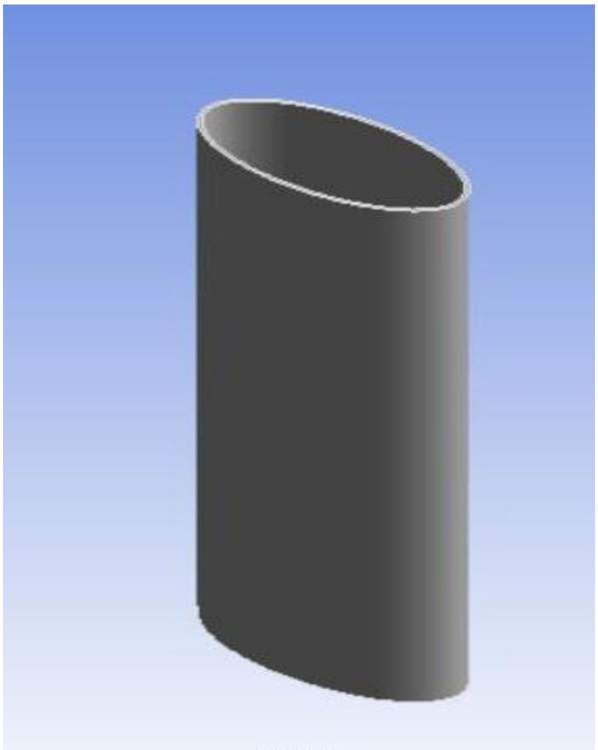

Fig- 3: Modelling of Elliptical steel tubular section

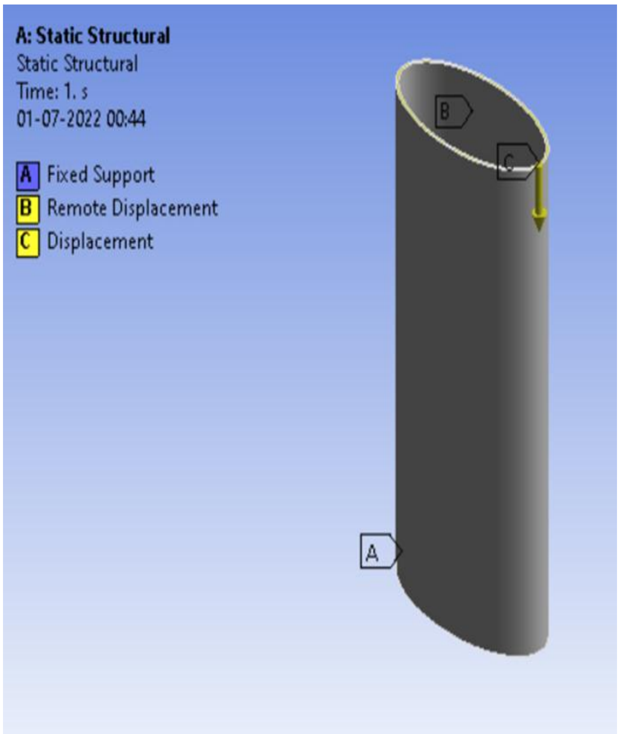

Fig - 4: Boundary condition of Elliptical steel tubular section

Fixed support is given at the bottom face, Remote displacement is given at the top face in which x and z component is 0 mm (ramped) and y component is set free. And its behavior is coupled.

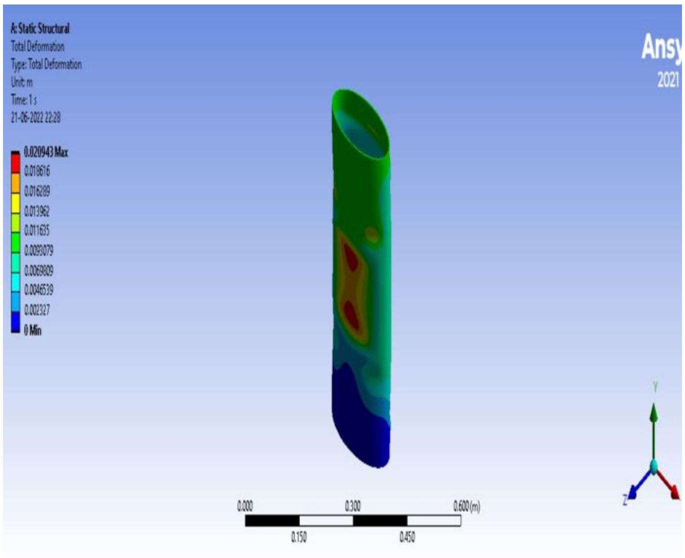

Fig- 5: Total deformation of elliptical steel tubular section

Maximum ultimate load obtained from load vs displacement graph is 467.74 KN and its corresponding displacement is 1 mm.

2.1 Compression analysis

A nonlinear compression analysis was analyzed for different FRP. Here we use CFRP, AFRP and GFRP for wrapping around the steel tubular section. For the analysis we use symmetry model of the steel tubular section for the easy computation in FRP wrapping.

FRP used for the study is orthotropic in nature. And the thickness used for frp sheet is 1mm. FRP is connected to specimen by type bonded.

Ex = Modulus of elasticity in the x direction

Ey = Modulus of elasticity in the y direction

Ez = Modulus of elasticity in the z direction

Vxy= Poisson's ratio in the xy plane

Vxz= Poisson's ratio in the xz plane

Vyz= Poisson's ratio in the yz plane

Gxy = Shear modulus in the xy plane

Gxz = Shear modulus in the xz plane

Gyz = Shear modulus in the yz plane

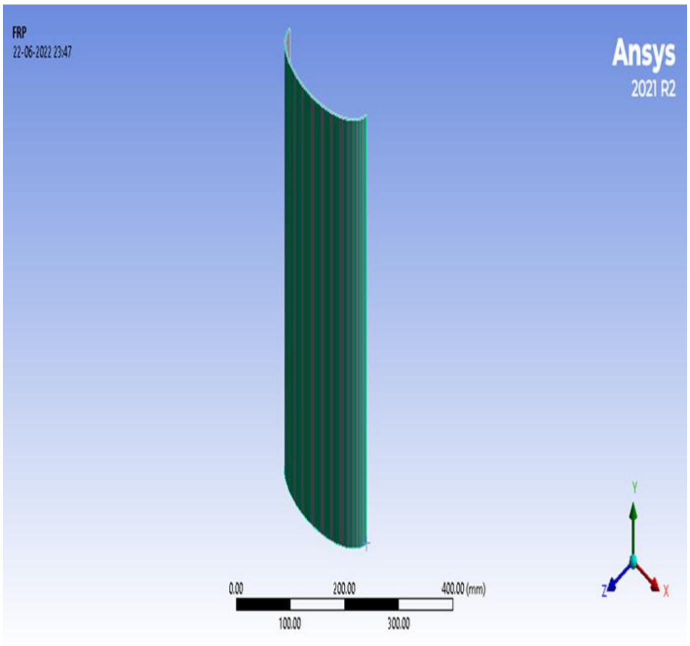

Fig -6: Symmetry model of specimen with frp

Table -1: Properties of frp sheets

PROPERTIES	CFRP	AFRP	GFRP
Ex (Mpa)	165000	13600	21000
Ey (Mpa)	9650	1482.1	7000
Ez (Mpa)	9650	1482.1	7000
Gxy (Mpa)	5200	549.13	1520
Gyz (Mpa)	5200	547	2650
Gzx (Mpa)	3400	549.13	1520
Vxy	0.3	0.32	0.26
Vyz	0.3	0.35	0.3
Vzx	0.45	0.35	0.26

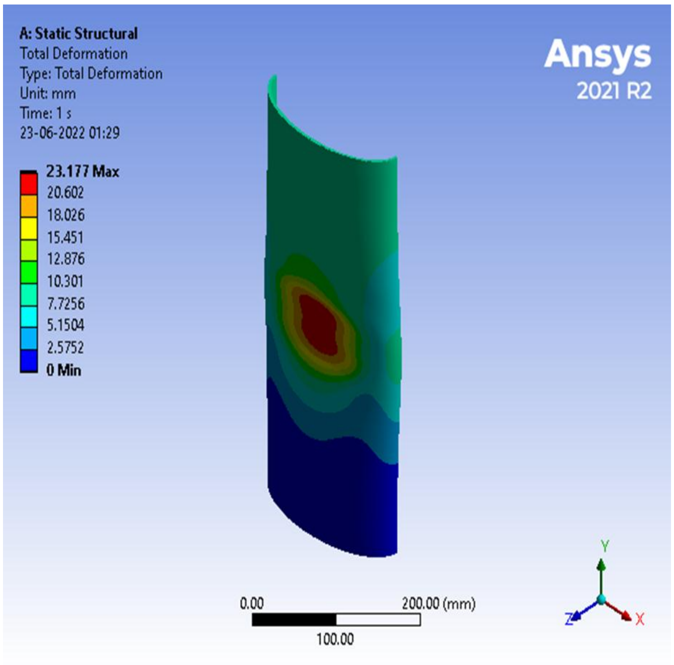

Fig – 7: Total deformation of CFRP

Specimen without FRP has ultimate compression load 467.74 KN and displacement at that corresponding load is 1 mm. Specimen with CFRP has ultimate compression load 598.58 KN and its corresponding displacement is 5.2 mm. Specimen with AFRP has ultimate compression load 473.76 KN. And its corresponding displacement is 1.4 mm. Specimen with GFRP has ultimate compression load 498.98 KN and its corresponding displacement is 4.6 mm. Specimens wrapped with FRP sheet shows improvement in compression load carrying capacity than specimen without FRP sheet wrapping. In which steel tubular specimen wrapped with CFRP has maximum load carrying capacity than other FRPs.

2.2 Flexural analysis

A nonlinear flexural analysis was analyzed for different FRP. Here we use CFRP, AFRP and GFRP for wrapping around the steel tubular section. And compare it with specimen without FRP. Properties used for specimen and frp is same as used in compression analysis. Meshing size 10mm is given.

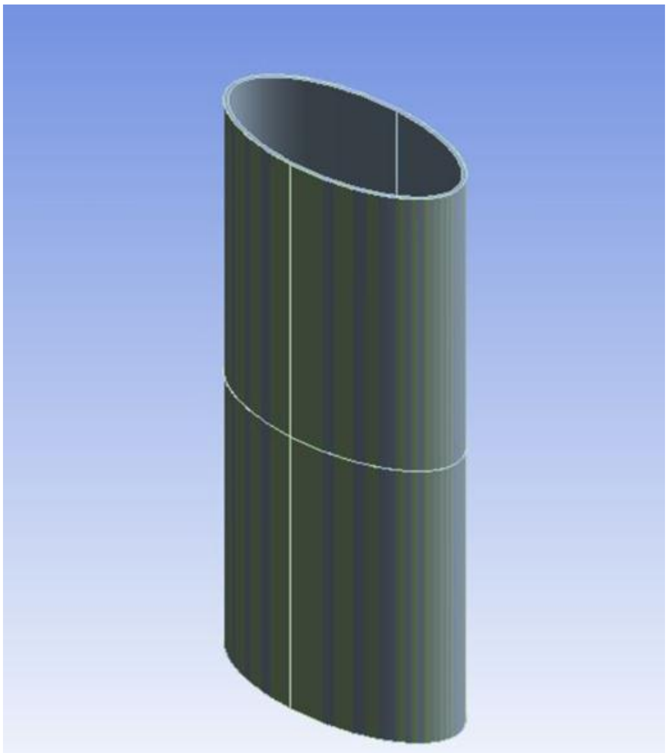

Fig – 8: Model for flexural analysis

Fixed support is given at the top and bottom face of specimen. Displacement load analysis is done. Displacement is given at the center point of the specimen.

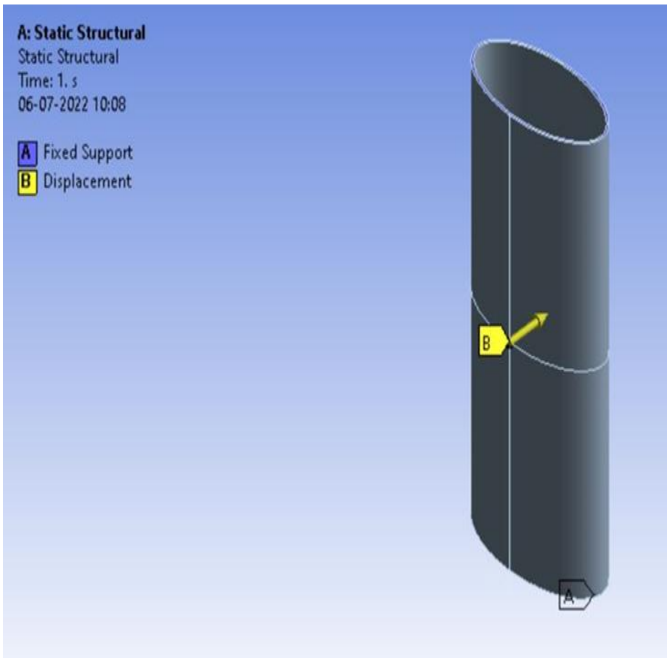

Fig -9: Boundary condition of flexural specimen

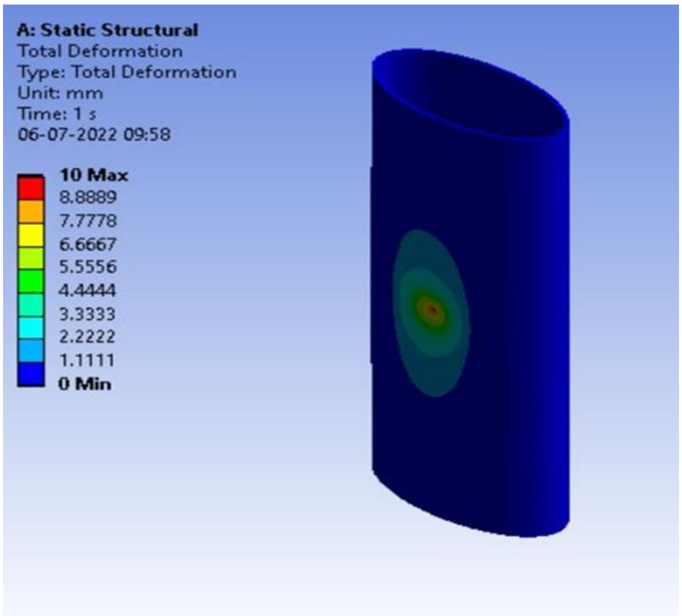

Fig – 10: Total deformation of flexural specimen with GFRP

Graph shown in fig 11 shows the comparison of flexural analysis of specimen with and without FRP wrapping. Specimen without frp wrapping has flexural load of 11.676 KN. CFRP wrapping gives 17.849 KN, AFRP wrapping gives 12.425 KN, GFRP wrapping gives 13.173 KN.

Specimens with FRP wrapping has more flexural load capacity than specimen without FRP wrapping. And CFRP wrapped specimen gives better result than AFRP and GFRP. Displacement is controlled at 10 mm.

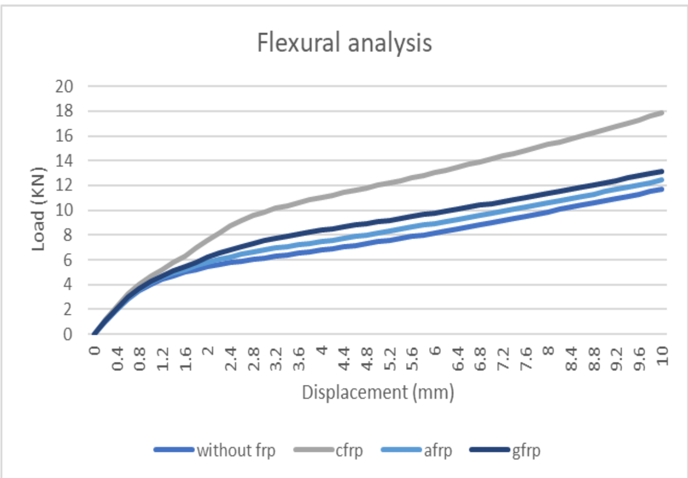

Chart -1: Flexural analysis graph

2.3 Buckling analysis

A linear static buckling analysis was analyzed for different FRP. Here we use different FRP such as CFRP, AFRP and GFRP for wrapping around the steel tubular section. And it is compared with specimen without FRP wrapping.

Boundary conditions-Fixed support is given at the bottom face, Remote displacement is given at the top face in which x and z component is 0 mm (ramped) and y component is set free. A force of 1N is applied at top face of section.

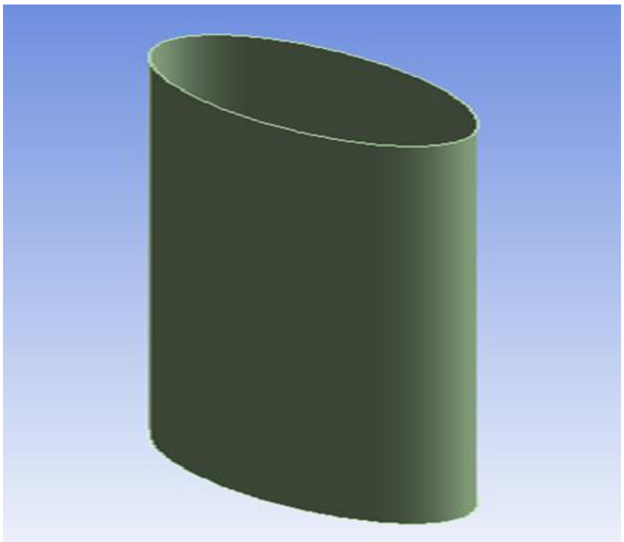

Fig - 11: Model with FRP for static buckling

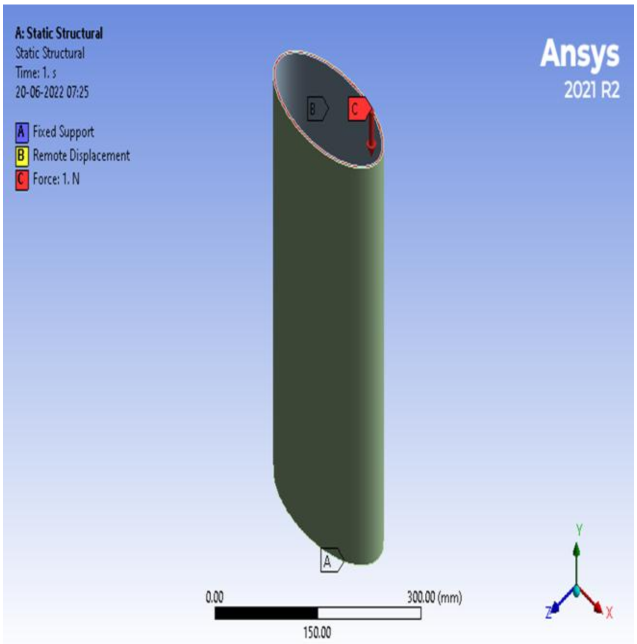

Fig – 12: Boundary condition of linear static buckling

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