Comparitive Study Of Buckling And Bonding Behaviour Of Glass Fiber Reinforced Epoxy Resin Composite Column Under Compressive Loading Mechanism.

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ABSTRACT

Glass Fiber – reinforced polymer (GFPR) has been used as an alternative to steel due to high strength –to-weight ratio, high stiffness- to – weight ratio and corrosion and fatigue resistance. GFRP have been found to be more attractive in Asian region due to their cost competitiveness. Hence effort is required to find the bonding and buckling behaviors of fiber reinforced composite (FRC) column made using epoxy resin and glass fiber sheet with Triethylenetetramine (TETA) as hardener for curing of resin. To achieve the objective, an experimental setup was prepared with, specimen of hollow circular section is casted and compressive loading was applied to specimen. Numerical investigations have also been carried out using finite element analysis software ANSYS 13.0. load vs. Deflectioncurve, failure modes and ultimate load carrying capacity of specimens are presented in this work. This will help in finding the buckling nature of the section.

Keywords—FRC,Epoxy Resin,E-Glass Fiber, polyurathanetetraamine

INTRODUCTION

Composite materials are materials with two or more constituents combined to form a material with different properties than those of the individual constituents. Fiber reinforced composites (FRC) is a composite material that consists of two constituents: a series of fibers surrounded by a solid matrix. FRC is high-performance fiber composite achieved by cross-linking fiber molecules with resins in the FRC material matrix through a proprietary molecular re-engineering process, yielding a product of exceptional structural properties. The main objective of this thesis work is to study the Behavior of FRC circular column under axial compression by Theoretical analysis using eulers equation and an experimental setup was prepared with, specimen of hollow circular section is casted and compressive loading was applied to specimen. Numerical investigations have also been carried out using finite element analysis software ANSYS 13.0

MATERIAL COLLECTION AND TESTING

A. EPOXY RESIN

Epoxy resins are low molecular weight pre-polymers or higher molecular weight polymers which normally contain at least two epoxide groups. The epoxide group is also sometimes referred to as a glycidyl or oxirane group. Epoxy resins may react (cross-linked) either with themselves through catalytic homo polymerization, or with a wide range of co-reactants including poly functional amines, acids (and acid anhydrides), phenols, alcohols and thiols. These co-reactants are often referred to as hardeners or curatives, and the cross-linking reaction is commonly referred to as curing. Reaction of polyepoxides with themselves or with poly functional hardeners forms a thermosetting polymer, often with high mechanical properties, temperature and chemical resistance. Testing and results of epoxy resin are given below in table -1.

Table-1 Chemical Properties of Resin

S.no.	Tests performed	Test method	Specification	Results
1.	Visual appearance	In house	Clear liquid resin	Clear liquid resin
2.	Color Index, Gardner	ISO-4630-2	0 - 1	0.1
3.	Epoxide index (Eq/Kg)	ISO-3001	5.3 – 5.45	5.43

4.	Viscosity dynamic at 250C , mPa.s	ISO-12058	10000 – 12000	10250
5.	Chlorine content (hydrolysable), ppm	AMTM 116	0.0 – 400	240

B. HARDENER

Hardeners are substances that are used for the setting/Curing of the resins. The chemical hardener used here is "polyurathanetetramine". It is primarily used as a cross linker in Epoxy curing..It is soluble in polar solvents and exhibits the reactivity typical for amines. For FRC using epoxy resin, the mix proportion is 150 grams of hardener is mixed with 1000 grams of Epoxy resin as per company recommendation.

C. E-GLASS FIBER

Glass Fibers are among the most versatile industrial materials known today. Fiberglass is much more sustainable than Aluminium, steel or timber. There are no large smoke plumes or other forms of environmental pollution from the manufacture of fiberglass. They exhibit useful properties such as hardness, transparency, resistance to chemical attack, stability, and inertness, as well as desirable fiber properties such as strength, flexibility, and stiffness. This acts as the reinforcing material in FRC. E- glass fiber as reinforcing material in polymer matrix composite is extremely common. Optimal strength is attained when straight and continuous are aligned in single direction. Hence here unidirectional fabrics are used. For promoting strength in other direction , Laminate structures are constructed with continuous fibres aligned in other direction. such type of structures are used in tanks.

Fig-1 E-glass fiber with unidirectional fabrics

SPECIMEN CASTING AND ANALYSIS

A. CASTING PROCEDURE

Two specimens are casted by the process of Hand layup process shown in fig-3. Whose dimensional length is 1000mm, external diameter of 100mm and internal diameter as 70mm, 80mm.Initially the hardener and Epoxy resin was mixed according to the ratio. PVC pipe was used as a mould. The pipe was thoroughly cleaned and it was surrounded by a film for easy removing after curing. Initially the resin mixture was applied to the surface. After that Sheets of fiber matting were laid into the mold, then resin mixture was added using a brush or roller. The material must conform to the mold, and air must not be trapped between the fiber and the mold. The fiber was added layer by layer. Totally 16 layers were added for attaining 15 mm thickness. Four layers were coated per day because during this process enormous amount of energy was released. Finally the casting and curing was done within 4 days.

Fig-2 Casting of specimen

B. THEORETICAL ANALYSIS

The beam is theoretically analyzed by the following formula. $Pcr = \pi^2 EI / le^2$ The sectional properties and loading values of column are given in Table-2

TABLE-2 THEORETICAL ANALYSIS

properties	**Section1**	**Section2**
shape	Hollow circular section	Hollow circular section
Length (mm)	1000	1000
Ext.diameter (mm)	100	100
Int.diameter (mm)	70	80
Young's modulus (GPa)	39	39
Moment of inertia (mm^4)	3.7×10^6	2.9×10^6
End condition	One end fixed;other end hinged	One end fixed;other end hinged
Critical load (KN)	1424	1116.25

C. EXPERIMENTAL ANALYSIS

The section was analyzed using loading frame Capacity of 100 tonne. The values for loads and deflection are tabulated in table-3 below.

Table-3 EXPERIMENTAL ANALYSIS

Load	**Deflection (mm)**
5	0.62
50	2.01
100	2.6
150	2.85
200	2.7
250	2.97

301	2.8
350	2.7
405	2.6
550	2.69

D. NUMERICAL ANALYSIS

Analytical study is carried out by using the Finite Element software ANSYS13.0

Linear and Non-linear analysisis carried out.The properties of the material were determined by coupon test. The value of Young's modulus 'E' is given as 0.13 x 10^5 N/mm^2. The yield stress of the cold formed angle is taken as 64N/mm^2.Load Deflection curve, Load carrying capacity and failure pattern of the specimen is observed.

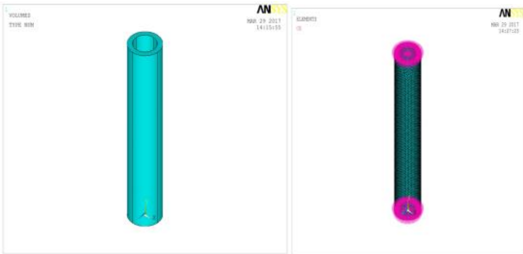


Fig-3 Model of FRC Column

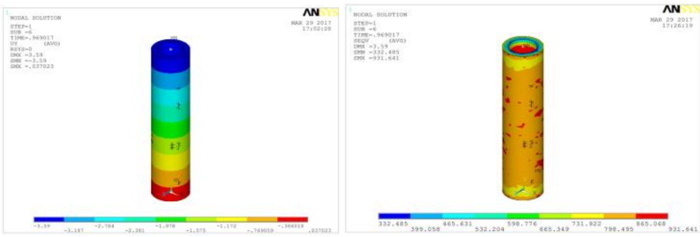
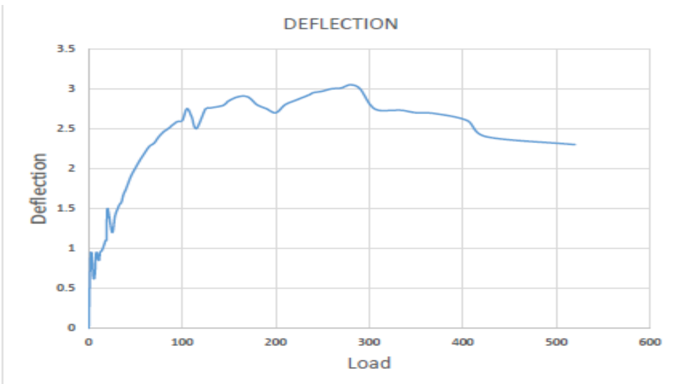


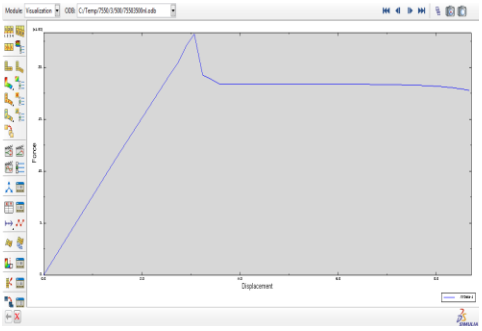
Fig-4 Deformed shape of specimen

RESULTS AND DISCUSSION

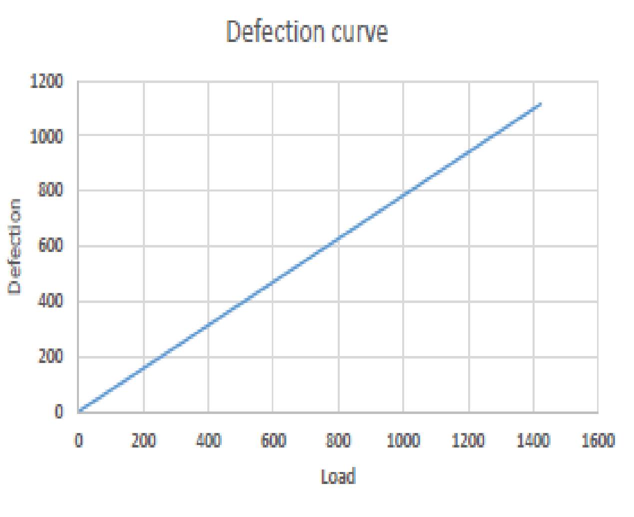
The summary of theoretical and experimental study results of our specimen is discussed in this paper. In the theoretical study, the column will be able to withstand loads around 1500kN,and in the numerical study the column will be able to withstand loads up to 931kN, but due to practical difficulty the experiment was stopped at 540kN, as the loading frame was limited to 50 tonnes. The load deflection curve is shown below in graph - 1 and graph - 2.



Graph 1 Load vs deflection curve for experimental analysis



Graph 2 Load vs deflection curve for Numerical analysis



Graph 3 Load vs deflection curve for theoretical analysis

CONCLUSION

Our FRC Beam is tested experimentally and theoretically, which gives more over similar results. So we convince with our result that our FRC Beam can carry more weight with good elastic nature and restore to its original position when the load is removed. The FRC is also weightless in nature which makes it easier for transportation and hoisting. It is also resistant against corrosion. With these many advantages, FRC can be used at places where conventional steel or concrete cannot be used.

FRC- LIMITATIONS

A. Warping

One notable feature of FRC is that the resins used are subject to contraction during the curing process. For polyester this contraction is often of the order of 5-6%, and for epoxy it can be much lower, about 2%.
When formed as part of FRC, because the fibers don't contract, the differential can create changes in the shape of the part during cure. Distortions will usually appear hours, days or weeks after the resin has set.

B. Health Problems

Inhaling these fibers can reduce lung function and cause inflammation in animals and humans. FRC can cause skin, eye and throat irritation. At higher exposure levels, FRC also has been associated with skin rashes and difficulty in breathing.

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