Experimental Study of Behaviour of Hollow Circular Section under Compression with Wrapping of Basalt Fibre Reinforced Polymer – A Review

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Abstract: *The review paper represents study of the behaviour of HSS (Hollow Steel Section) under compression using basalt fibre reinforced polymer (BFRP) fabrics. Also a review of feasible study on using BFRP in axial strengthening of hollow circular section. The aim of this review paper is to explore the reviews regarding BFRP. Researchers studied that basalt fibres improves tensile strength, flexural strength and toughness of concrete. The adhesion between the Basalt fibre and its composites are better as compared to carbon fibre and its composites. The prominent advantages specified by analyst of this (BFRP) composites include high specific mechano-physico-chemical properties, biodegradability, and non-abrasive qualities. This paper focuses on the practicability of using BFRP as an external confinement of HSS for increment of strength. The results will be verified using different methods.*

Keywords: *Hollow Steel Section (HSS), Hollow circular column, strengthening, Basalt Fibre Reinforced Polymer (BFRP).*

Introduction:

Fibre-reinforced polymer (FRP) is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass , carbon , aramid and basalt. Polymer matrix with different arrangement of fibres efficiently elaborates the strength, stiffness, toughness. FRP also leads to the weight saving and corrosion resistance of section. FRP bars, sheets, and strips are used for strengthening of various structures constructed from concrete, masonry, timber, and even steel.

Basalt Fibre reinforced polymer (BFRP), is an eco-friendly material. As well as inert and naturally occurring material. The FRP composite materials were introduced in the year 1909. But the composite industry began boost in market only after 1930s. It has been used as a fireproof textile. Krishan Pareek studied the Alkali resistance, thermal stability of Basalt fibre as well as flexural strength, temperature variation and adhesive nature. Compared to the synthetic fibres, basalt fibres exhibit high thermal stability. Basalt fibres are inorganic fibres, they do not burn, and the melting point is around 1350–1450°C. Basalt fibres break nimbly under mechanical stress. Thus, it has to be treated carefully in the field.Hu, Y. Liu, (2010) in Technical Textile Yarns, gave the following data;

Table no. 1

Capability	BF
Density, g/cm^3	2.63–2.8
Tensile strength, MPa	3000–4840
Elastic modulus, GPa	79.3–93.1
Temperature of application, °C	− 260– + 650

HSS (Hollow steel sections) are used in structural steel frame buildings. These are mostly used where the structure has to resist loading from multiple directions. Over a past few decades, HSSs use has been evolved due to its vulnerable properties. The numerous advantages such as light weight, high strength, large energy absorption capacity, high torsional rigidity, and adequate ductility to certain extents. HSS of square and circular have uniform geometry along two or more cross sectional axes, and thus have uniform strength characteristics. These properties make relevant choices for column. However, the HSS has superior resistance to lateral torsional buckling.

From the past, the research initiatives observed that external strengthening provides a practical and cost effective solution. The earliest investigators utilized steel plates for external strengthening. The scope of this review is to choose an appropriate method to perform compression testing on HSS using BFRP.

Researches on Basalt fibre:

Basalt fibre composites:

Review on the applicability of basalt fibre as a reinforcing composites has been made [1] over recent years. It mostly emphasised on the effect of using the mineral fibre of different matrices as polymer in metal and concrete. The polymer comprises of thermoset and thermoplastic. The reviews focused on the basalt fibre reinforcing polymer composites behaviour, for example specific mechano-physico-chemical properties, biodegradability, and non-abrasive qualities [2]. It also states some comparison between glass fibre and basalt fibre. Minor discussions were made on the insighting the basalt as a construction material.

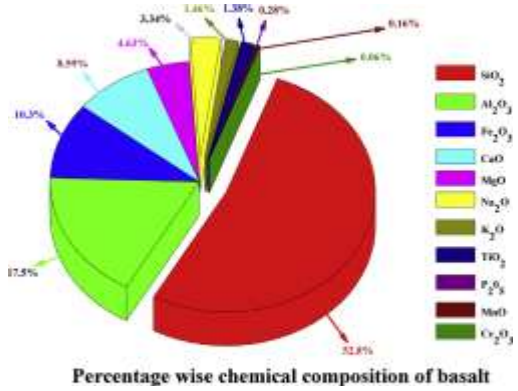

Fig. no 1. Percentage distribution of chemical constituents in basalt.

Some pivotal points indulged in review were its high modulus of elasticity, high elastic strength, corrosion resistance, high-temperature resistance, extended operating temperature range and ease of handling [3]. Along with these, a review has been done on the usage of different basalt products like aggregate, rod, fibre, mesh, etc. in structural applications. The review also tends to identify critical constraints that restrain the implementation of basalt as a global construction material, thereby opening avenues of needed research. Testing was undertaken to measure the magnitude of shrinkage strain that develops in unrestrained specimens [4]. Experimental tests where done to evaluate the potential use of chopped basalt fibres in preventing the cracks. Results indicate that the basalt fibres are effective in preventing cracks by reducing the magnitude of free shrinkage, and by restricting the growth of cracks if they do occur. Furthermore, V.Nasir studied the corrosion behaviour and crack formation mechanism of the basalt fibre when exposed to sulphuric acid [5]. It claims that basalt fibre can be a suitable replacement for E-glass fibre in corrosive media. A study was made on the continuous basalt fibre reinforced polymer as a new fibrous composite.

Continuous Basalt Fibre (CBF):

A review also states that, compared with the carbon fibre reinforced polymer, BFRP has many advantages in ductility, high thermal resistance, corrosion resistance and cost [6]. Therefore, BFRP can replace or mix CFRP in structural strengthening in some cases. The general and the prospective developments of BFRP in structural member strengthening are fully summarized and prospected from development, properties, experimental investigations aspects. Additionally, ZHANG Min, stated that Continuous Basalt fibre (CBF) has excellent mechanical properties, physical properties and lower prices [7]. Many types of CBFRP including sheet, plate and rod can be made by compounding fibre and epoxy resin. Even the Continuous basalt fibres have high tensile strength, elastic modulus, softening point, high chemical resistance and working temperature [8]. Basalt fibre reinforced composites have great improvement in the thermal mechanical and dielectric parameters. Continuous basalt fibres have a wide spectrum of advantages in the field of applications as textile glass fibre or reinforcement for composites.

Basalt fibre as a reinforcing polymer in concrete structure:

Basalt fibres improves tensile strength, flexural strength and toughness of concrete [9]. It can be used to extend the life of important concrete structures such as nuclear power plants, highways, bridges and runways. In addition, basalt fibre is found to be amorphous and hydrophilic in nature. It was observed that basalt fibres are definitely a potential building material having higher thermal stability and higher mechanical properties.

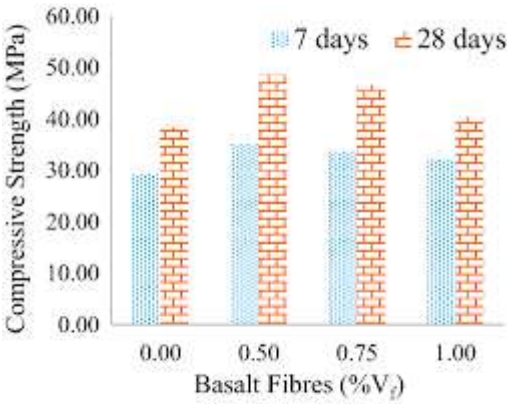

Fig. no. 2 Compressive strengths of BFRC

From [10], review deduced that, externally bonded Basalt Fibre Reinforced Polymer (BFRP) laminates aids in strengthening the rectangular reinforced section of a RC beam. The analysis of influence of BFRP on the ultimate bending moments and also service deflection of the cross-sectional area. It seems to be a cost-effective, durable and fire resistant alternative to traditional fibres. It is corrosion resistant and effective solution due to the high strength as well as the low weight of a composite material. In accordance with the Basalt fibre can also be a good alternative for polypropylene fibre and polyacrylonitrile fibre [11]. With its excellent properties, such as crack resistance, impact resistance, impermeability and shrinkage resistance, basalt fibre is helpful for improving durability and increasing the working life of concrete. The application field of high performance concrete is growing, but the brittle and crack performance of common concrete is more serious. Fibre can hinder early plastic cracking and shrinkage cracking and effectively improves properties of High

Strength Concrete. Further, JohnBranston [12], reckoned the significance of Basalt Fibre Reinforced Concrete (BFRC), in the flexural and impact testing. BFRC increases pre-cracking strength; has little effect under loading. BFRC is made up of basalt bundled fibres and basalt minibars. Bundled fibres failed by rupturing, whereas the minibars failed by pulling out. Interfacial properties were also investigated by scanning electron microscopy. The results indicated both types of fibre increased pre-cracking strength, but only minibars enhanced the post-cracking behaviour, likely due to protection from the polymer.

Basalt fibre as a reinforcing polymer in steel structure:

Experiment done using Carbon Fibre Reinforced Polymer (CFRP) as an external confinement of hollow square section [13]. It enhanced the load carrying capacity and stiffness of the hollow sections and also reduced the axial shortening of columns by providing external confinement against the elastic deformation. The three-dimensional nonlinear finite element modelling of CFRP strengthened hollow square sections is created by using ANSYS 12.0 to validate the results and the numerical results such as failure modes and load deformation behaviour. Apart from that, Kambiz Narmashiri predicted that much longer plates indicated more reduction of strain at the CFRP tip compared to the shorter CFRP plate lengths [14]. The experimental and numerical investigations on the Carbon Fibre Reinforced Polymer (CFRP) failure analysis and structural behaviour of the CFRP flexural strengthened steel I-beams. Understanding the CFRP failure modes is useful to find solutions for preventing or retarding the failures. Moreover, fibre reinforced polymer (FRP) composites increases the strength, stiffness and the ductility of steel beams [15]. The analytical models were then used to demonstrate the effectiveness of the BFRP strengthening. It was found that BFRP could yield significant benefits in terms of increasing the strength and stiffness for the timber sections with defects.

Conclusion:

Basalt fibre has high elastic modulus, which helps in increasing stiffness of section which has been predicted by Smriti Raj[3].This benefits in reducing the buckling of a section of structural steel.

Whereas when the BFRP has been used as a external confinement to the concrete section, its eventually increases the tensile strength, flexural strength, and also increases torsional resistance which was deduced by S.K.Singh[9].

The overview studied by the V.Foire[1], explains that BFRP has a practical, reliable, and economical aspects regarding its usage.

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