EXPERIMENTAL STUDY ON THE BEHAVIOR OF CONCRETE BY USING JUTE FIBER AND GGBS

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***Abstract** - The study presents the experimental investigation carried out to evaluate effects of replacing the cement with Ground Granulated Blast Slag and addition of Jute Fiber on various concrete properties. The basic objective of this study was to replace the cement with GGBS and addition of jute fiber as reinforcement because the natural resources are depleting very fast due to rapid pace of construction activities in India .The replacement of the cement with GGBS and addition of Jute fiber to conventional concrete effects on the various properties i,e the slump values, compressive strength of cubes, split tensile strength of cylinders and flexural strength of beams are evaluated in this study, because jute fiber is cheap and easily available. Use of GGBS as waste industrial by product of iron and steel production provides great opportunity to utilize it to mix with Cement to increase the strength of concrete and makes it sulphate resistance. The test results of concrete were obtained by replacing cement with GGBS in various percentages of 0%, 15%, 25%, 35%, 45% and 55% and also Jute fiber is added in various percentages of 0%, 0.1%, 0.15%, 0.3%, 0.45% and 0.6%. All specimens were cured for 7days, 14days and 28 days before testing. From the study it has been observed that the GGBS could be a good replacement added with cement increases the compression strength at rapid pace and addition of jute fiber as reinforcement increases the tensile strength of concrete at early stages.*

Key words: Jute Fiber, Ground Granulated Blast Slag (GGBS), Slump of mix concrete, Compressive strength, Tensile strength, Flexural strength and comparison of concrete mixes.

1. INTRODUCTION.

The development of civilization and social progress has been greatly influenced by the application of concrete in establishing infrastructural facilities. The unique position that the conventional cement-based concrete widely used construction material is understandable, given its wide spectrum favorable attributes. These include regional produce ability, versatility, wide ranging performance properties and cost effectiveness. The global usage of concrete is second to water. Annual worldwide production of concrete is estimated to be around one cubic meter for every person on earth. The increased demand for concrete calls for increased production of cement, undisputedly the most widely used single binder ingredient of traditional concrete.

A. Benefits of Jute Fiber

- Jute fibre is 100% bio-degradable and recyclable and thus environmentally friendly.
- Jute is a natural fiber with golden and silky shine and hence called The Golden Fibre.
- Jute is the cheapest vegetable fibre procured from the bast or skin of the plant's stem.
- It is the second most important vegetable fibre after cotton, in terms of usage, global consumption, production, and availability.
- It has high tensile strength, low extensibility, and ensures better breathability of fabrics. Therefore, jute is very suitable in agricultural commodity bulk packaging.
- It helps to make best quality industrial yarn, fabric, net, and sacks. It is one of the most versatile natural fibres that has been used in raw materials for packaging, textiles, non-textile, construction, and agricultural sectors. Bulking of yarn results in a reduced breaking tenacity and an increased breaking extensibility when blended as a ternary blend.

B. Benefits of GGBS Concrete.

- Good workability which helps in better placing and compaction.
- Due to the less heat of hydration the temperature rise will be less avoiding the risk of thermal cracking in large volume of concrete.
- High resistance to chloride attack which reduces the risk of corrosion in concrete.
- High resistance to sulphide attack and also other chemicals.
- Good sustainability
- The Physical properties are specific gravity 2.9, Bulk density 1200 Kg/m^3 and fineness 350 m^2/Kg. GGBS is

used along with the ordinary Portland cement or other pozzolanic materials in concrete. Its use is increasing day by day because it improves the durability of concrete which essentially increase the lifespan of concrete structures from fifty to hundred years.

Fig 1: GGBS

Fig 2: Jute fiber

2. LITERATURAL REVIEW

Venu Malagavelli et al. (2014) studied on high performance concrete with GGBS and sand concluded that the percentage increase of compressive strength of concrete is 11.06 and 17.6% at the age of 7 and 28 days by replacing 50% of cement with GGBS and 25% of sand with ROBO sand.

Luo et al. (2015) experimentally studied the chloride diffusion coefficient and the chloride binding capacity of Portland cement or blended cement made of Portland cement and 70 % GGBS replacement with or without 5 % sulphate. They found that (i) chloride diffusion coefficient decreased; (ii) chloride ion binding capacity improved in samples of blended cement.

Clear (2015) concluded that higher the proportion of GGBS, the slower the early age strength development. Oner and Akyuz studied on optimum level of GGBS on compressive strength of concrete and concluded that the optimum level of GGBS content for maximizing strength is at about 55–59% of the total binder content.

Tejas R Patil et.al (2015) represented that Concrete is most widely used construction material in the world. Fiber reinforced concrete (FRC) is a concrete in which small and discontinuous fibers are dispersed uniformly. The fibers used in FRC may be of different materials like steel, G.I., carbon, glass, asbestos, polypropylene, jute etc. The addition of these fibers into concrete mass can dramatically increase the compressive strength, tensile strength, flexural strength and impact strength of concrete. FRC has found many applications in civil engineering field. Based on the laboratory experiment on fiber reinforced concrete (FRC), cube and cylinders specimens have been designed with steel fiber reinforced concrete (SFRC) containing fibers of 0% and 0.5% volume fraction of hook end Steel fibers of 53.85, 50 aspect ratio and alkali resistant glass fibers containing 0% and 0.25% by weight of cement of 12mm cut length were used without admixture. Comparing the result of FRC with plain M20 grade concrete, this paper validated the positive effect of different fibers with percentage increase in compression and splitting improvement of specimen at 7 and 28 days, analyzed the sensitivity of addition of fibers to concrete with different strength.

Akash Tejwani et.al (2016) presented that Concrete is the combination of cement, natural sand or artificial sand and aggregate which are used in civil engineering works such as township project and infrastructure work. The present research work shows the study of cement concrete with varying percentage of fibers which are namely 0.10%, 0.20%, 0.30% ,0.40% & 0.50%. M20 grade concrete was adopted. Sizes of cube (15*15*15 cm) were used for testing. Compressive test of cubes was carried out with different types of fibers namely AFRC and NFRC with natural sand and artificial sand. The aim of this research is to use of different fiber as reinforcement in concrete for a greater durability, workability and reduction in crack. The present work is concerned with the compressive strength of FRC specimens (132 cubes) with 90 days of normal water curing and 90 days curing in sulphate & chloride. The method of mixing plays an important character in FRC in which stress is determined by the fiber orientation. FRC controls micro cracking and deformation under load much better than plain concrete.

Muhammad Azhar Saleem et.al (2016) proposed that this research aims to reinforce the compressed earth brick with jute fibers in order to investigate the effect of these fibers on their compressive strength. Bricks were cast in the laboratory in similar fashion as adopted in an industrial brick fabricating plant; however, compression was applied using a compression machine. Different proportions of water and jute were added in the soil for fabricating the standard size bricks (9×4.5×3 inches). After 28 days of sun drying, the compressive strength tests were performed on the brick specimens. The result showed improved strength behavior due to jute fiber addition. Up to 2.75 times increase in compressive strength was achieved with jute fiber compared to that of bricks without fibers. Moreover, cost comparison between un-burnt fiber-reinforced bricks, un-burnt bricks without fibers and burnt bricks without fibers was also carried out in order to demonstrate the potential applicability of un-burnt fiber-reinforced compressed earth bricks in the remote areas. The results demonstrate that the compressed earth bricks incorporating jute fibers dramatically increased the strength and can prove to be more sustainable than conventional mud homes.

Qian Jueshi and Shi Caijun (2017) studied on high performance cementing materials from industrial slag and reviewed the recent progresses in the activation of latent cementitious properties of different slag. They opined that Alkali activated slag, such as blast furnace slag, steel slag, copper slag and phosphorus slag should be a prime topic for construction materials researchers.

Ganesh Babu and Sree Rama Kumar (2017) studied on efficiency of GGBS in Concrete. Wainwright conducted Bleed tests in accordance with ASTM C232-92 on concretes in which up to 85% of the cement was replaced with ground granulated blast furnace slag (GGBS) obtained from different sources. They observed that delaying the start of the bleed test from 30 to 120 min reduced the bleed capacity of the OPC mix by more than 55% compared with 32% for the slag mixes. The reduction in bleed rate was similar for all mixes at about 45%.

3. NOMINAL MIX DESIGN.

Target mean strength of concrete

For a tolerance factor of 1.65 and using table 1 from IS 10262-2000, the standard deviation S = 5 N/mm^2. So, Target mean strength can be given by, Characteristic cure strength = 35 + (5x1.65) = 43.25 N/mm^2.

Selection of water cement ratio

From IS 456-2000, maximum water cement ratio = 0.45, Adopt water cement ratio as 0.45

Selection of water cement content

From IS 10262-2009, maximum water content is 186 liter (for 100mm) slump range for 20 mm aggregate.
Estimate water content for 100mm slump = 186 kg/m3, required water content = 186 + 11 = 197 kg/m^3

Calculation of cement content

Cement = $\left[\frac{197}{0.45}\right]$= 437.7 kg/m3

Mix calculation

The calculations per unit volume of concrete shall be as follows;

a) Volume of concrete = 1 m^3

b) Volume of cement = $\left[\frac{mass\ of\ cement}{specific\ gravity\ of\ cement}\right] \times \left[\frac{1}{1000}\right] = \left[\frac{437.7}{3.15}\right] \times \left[\frac{1}{1000}\right]$= 0.138 m^3

c) Volume of water = $\left[\frac{mass\ of\ water}{specific\ gravity\ of\ water}\right] \times \left[\frac{1}{1000}\right] = \left[\frac{197}{1000}\right]$= 0.197 m^3

d) Volume of all in aggregate = $[a - [b + c + d]]$ = 1-[0.138 + 0.197]= 0.665 m^3

e) Volume of coarse aggregate = 0.665 x 2.60 x 0.55x 1000= 951 Kg/m^3

f) Mass of fine aggregate = 0.665 x 2.70 x 0.45 x 1000 = 808 kg/m^3

Table 1: Mix Design Proportion for M35 Conventional Concrete

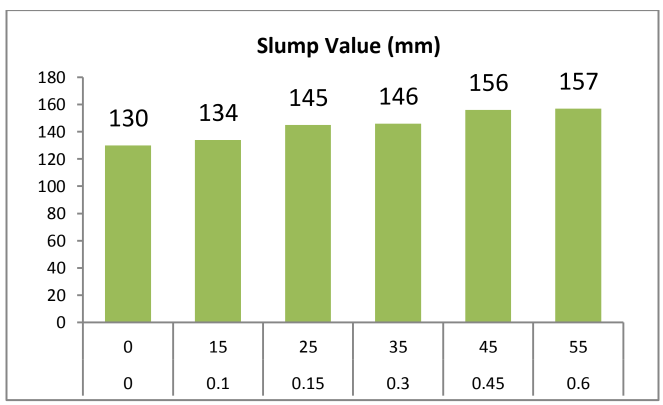
	C	FA	CA	Water
W(kg/m^3)	437	808	951	197 L
Ratio	1	1.84	2.17	0.45

4. RESULTS

A. Slump Test.

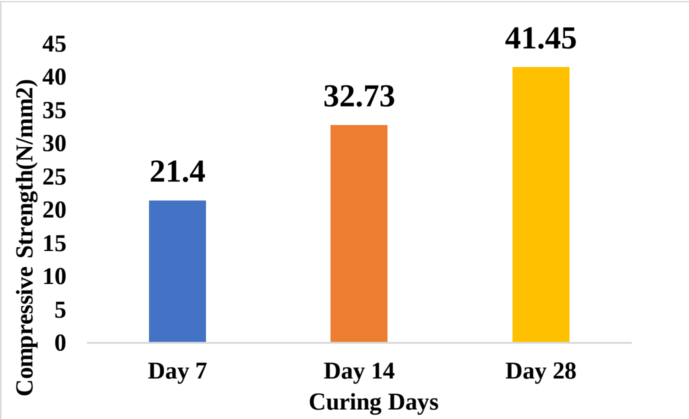
Table 2: Slump Values Obtained.

Concrete Mix		
Jute %	**GGBS %**	**Slump Value**
0	0	130
0.1	15	134
0.15	25	145
0.30	35	146
0.45	45	156
0.60	55	157

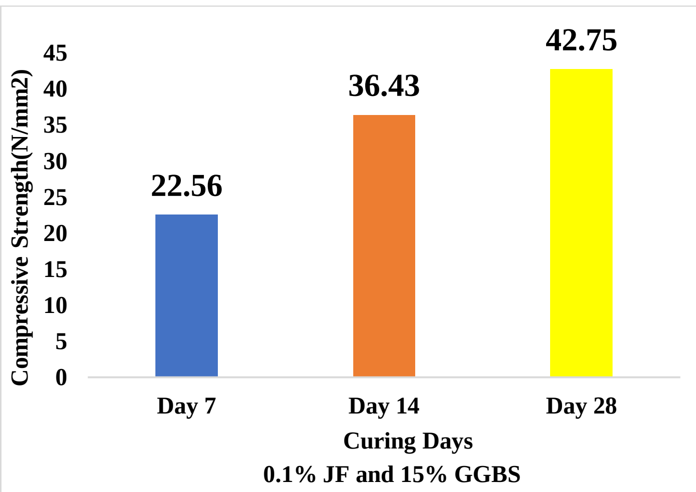


Graph 1: slump values of various mixes.

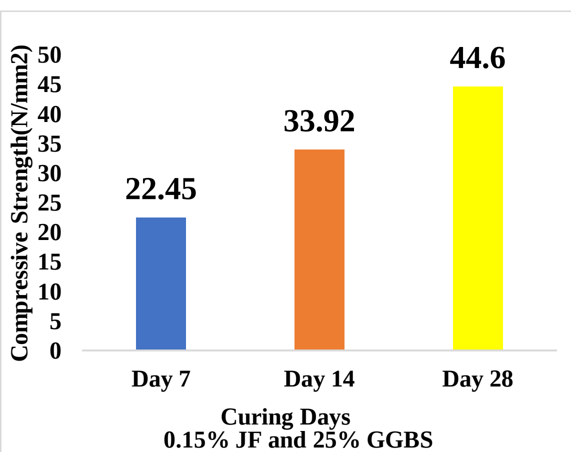
B. Compressive Strength Values.



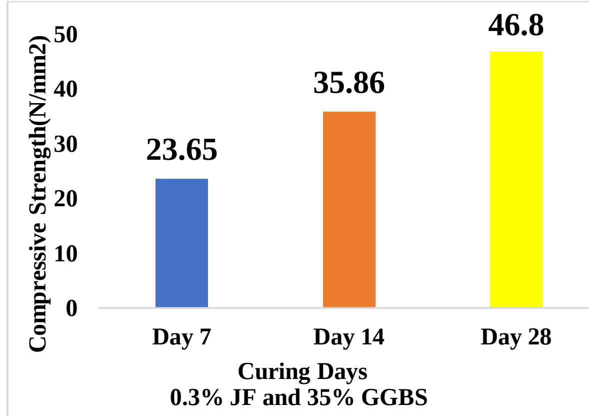
Graph 2: Average Compressive Strength (N/mm²) for cubes of Conventional Concrete



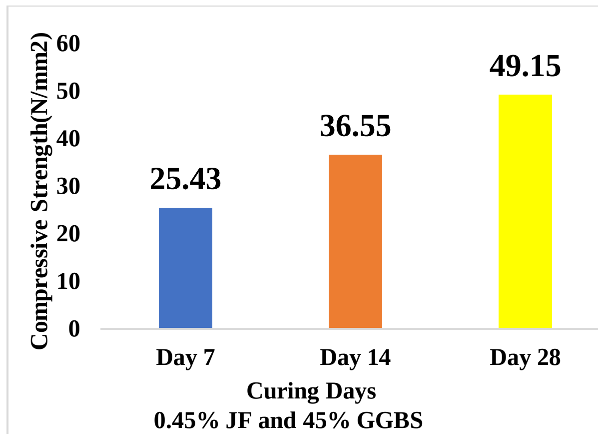
Graph 3: Average Compressive Strength for cubes of concrete with 0.1% jute fiber and 15% GGBS



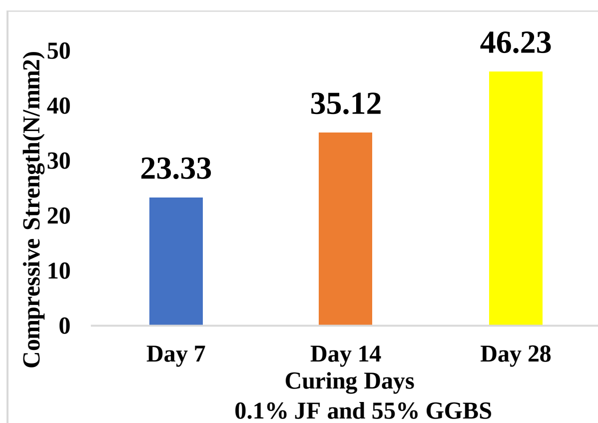
Graph 4: Average Compressive Strength for cubes of concrete with 0.15% jute fiber and 25% GGBS



Graph 5: Average Compressive Strength for cubes of concrete with 0.3% jute fiber and 35% GGBS

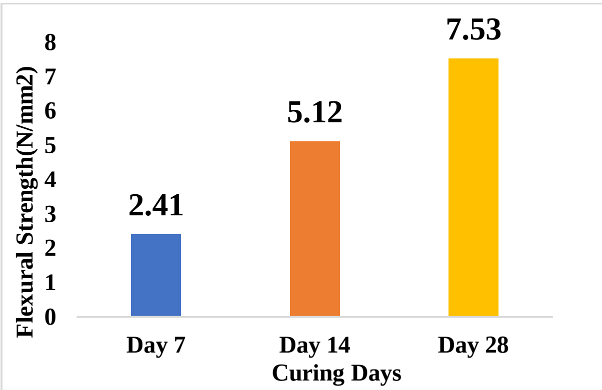


Graph 6: Average Compressive Strength for cubes of concrete with 0.45% jute fiber and 45% GGBS

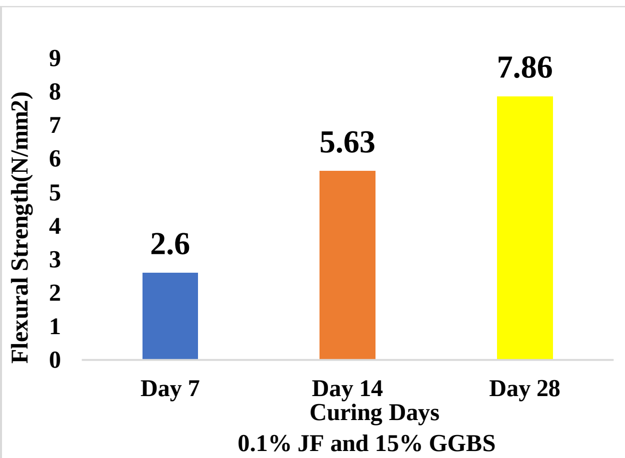


Graph 7: Average Compressive Strength for cubes of concrete with 0.6% jute fiber and 55% GGBS

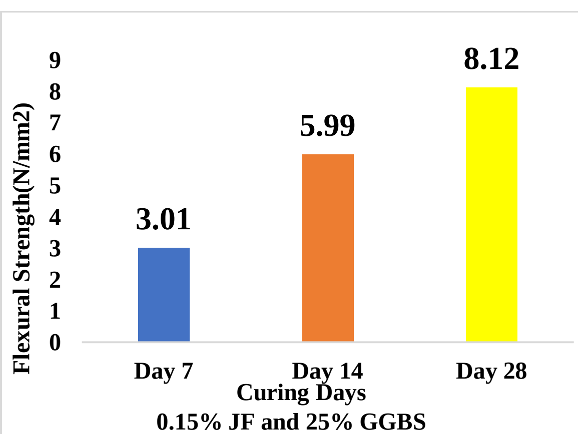
C. Flexural Strength Values.



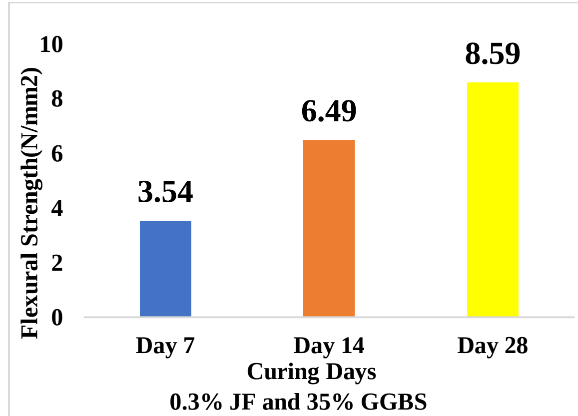
Graph 8: Average Flexural Strength for beams of Conventional concrete



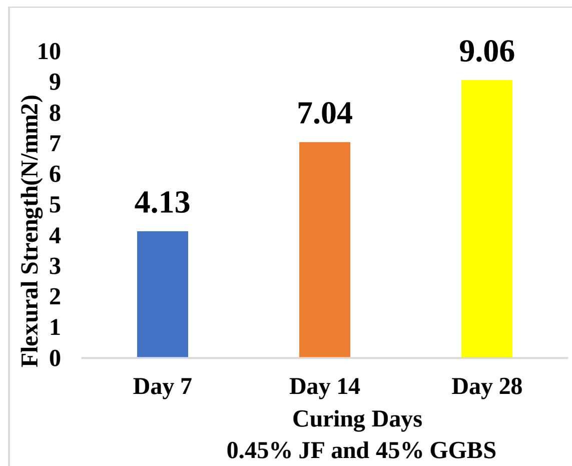
Graph 9: Average Flexural Strength for beams of concrete with 0.1% jute fiber and 15% GGBS



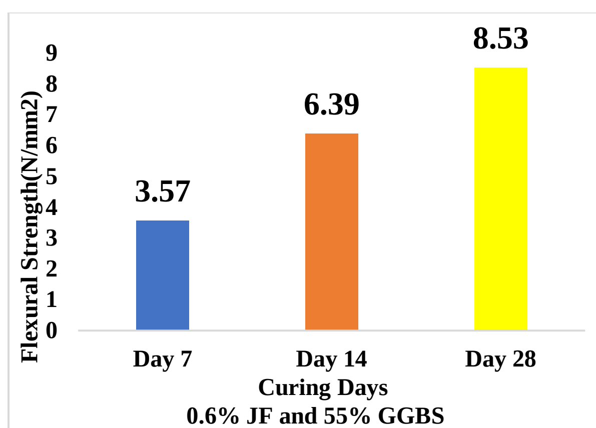
Graph 10: Average Flexural Strength for beams of concrete with 0.15% jute fiber and 25% GGBS



Graph 11: Average Flexural Strength for beams of concrete with 0.3% jute fiber and 35% GGBS

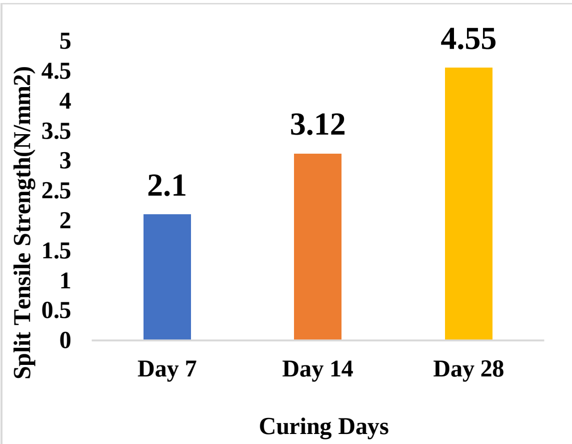


Graph 12: Average Flexural Strength for beams of concrete with 0.45% jute fiber and 45% GGBS

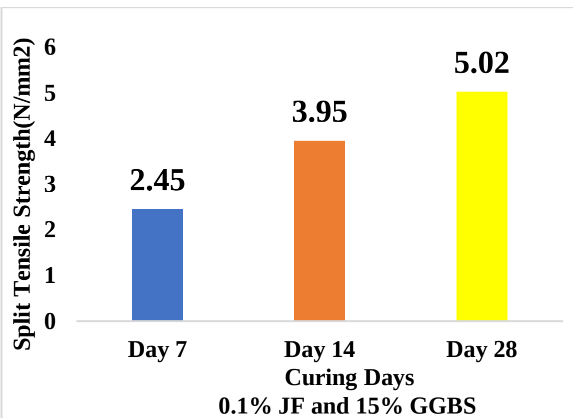


Graph 13: Average Flexural Strength for beams of concrete with 0.6% jute fiber and 55% GGBS

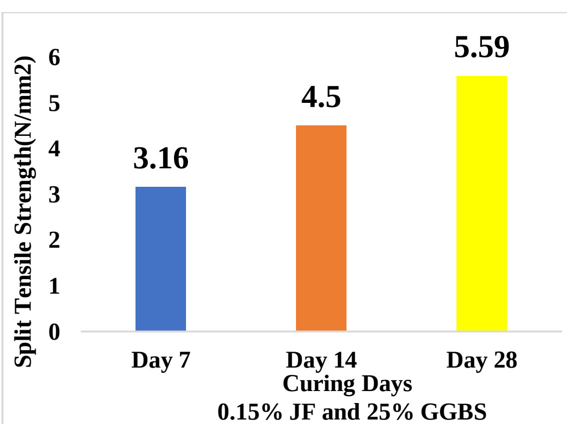
D. Split Tensile Strength Values



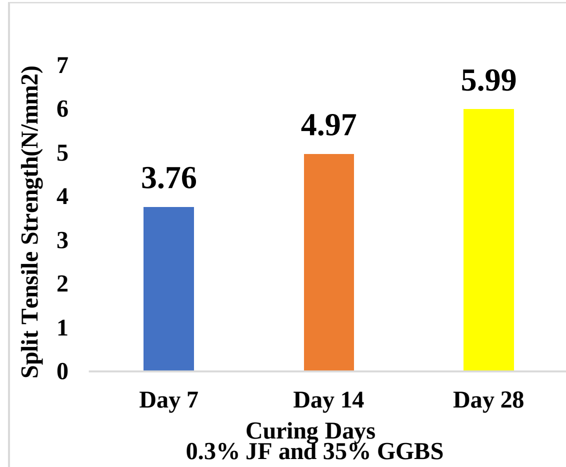
Graph 14: Average Split Tensile Strength for cylinders of Conventional concrete



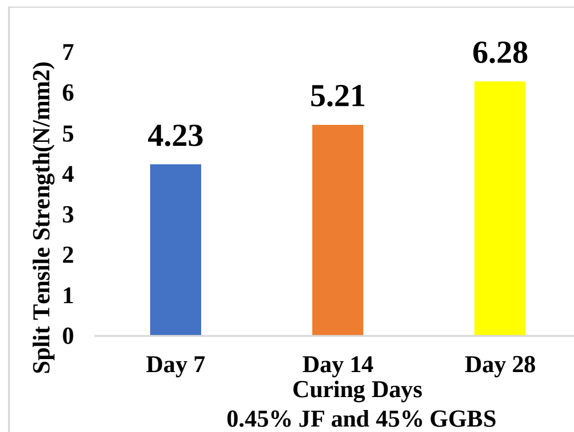
Graph 15: Average Split Tensile Strength for cylinders of concrete with 0.1% jute fiber and 15% GGBS



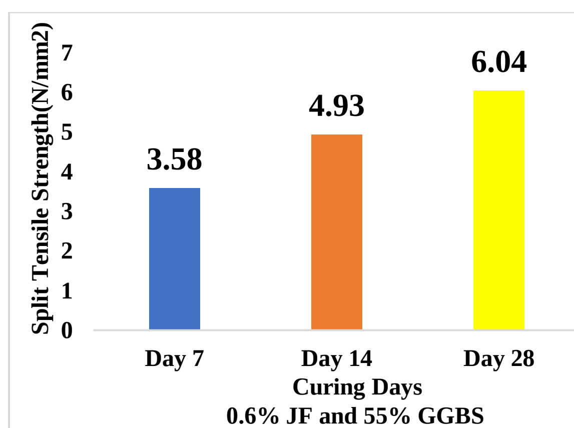
Graph 16: Average Split Tensile Strength for cylinders of concrete with 0.15% jute fiber and 25% GGBS



Graph 17: Average Split Tensile Strength for cylinders of concrete with 0.3% jute fiber and 35% GGBS



Graph 18: Average Split Tensile Strength for cylinders of concrete with 0.45% jute fiber and 45% GGBS



Graph 19: Average Split Tensile Strength for cylinders of concrete with 0.6% jute fiber and 55% GGBS

5. CONCLUSIONS

Concrete is old material. Mainly constituted of cement, sand, coarse aggregate made up of natural stones. In present study, GGBS is replaced instead of cement to concrete mix in proportion of 0%, 15%, 25%, 35%, 45%, and 55%. Jute fiber is also added in the mix proportion of 0%, 0.1%, 0.15%, 0.30%, 0.45% and 0.6%. The various structural characteristics e,g compressive strength, split tensile and flexural strength of concrete mixes has been evaluated in this study. The slump values of different mixes of concrete with different percentages of GGBS and jute fiber are also observed experimentally. The following conclusions has been made from present study.

- The compressive strength of concrete after 7days curing increases gradually by replacement of cement with GGBS percentage and addition of jute fiber become maximum 25.43 N/m2 when 45% GGBS and 0.45% jute fiber.
- The compressive strength of concrete after 14days curing increases gradually by replacement of cement with GGBS percentage and addition of jute fiber become maximum 36.55 N/m2 when 45% GGBS and 0.45% jute fiber.
- The compressive strength of concrete after 28days curing increases gradually by replacement of cement with GGBS percentage and addition of jute fiber become maximum 49.15 N/m2 when 45% GGBS and 0.45% jute fiber.
- The split tensile strength of concrete decreases with increase in percentages of GGBS and increases gradually due to increase in percentage of jute fiber from 0.1% to 0.45%. The split tensile strength achieves maximum position of 4.23 N/m2 when 0.45% of jute fiber is added to concrete mix after curing 7days.
- The split tensile strength achieves maximum position of 5.21 N/m2 when 0.45% of jute fiber is added to concrete mix after curing 14days.
- The split tensile strength achieves maximum position of 6.28 N/m2 when 0.45% of jute fiber is added to concrete mix after curing 28days
- The ultimate flexural strength was observed maximum with 45% GGBS and 0.45% of jute fiber i,e 4.13 N/m2 of mix after curing 7days. It mainly depends upon brittleness of concrete mix. If we increase the percentage of jute fiber in concrete its brittleness decreases hence ultimate bearing capacity of concrete mixes increase as shown in ultimate flexural graph.
- The ultimate flexural strength observed maximum with 45% GGBS and 0.45% of jute fiber i,e 7.04 N/m2 of mix after curing 14days.
- The ultimate flexural strength observed maximum with 45% GGBS and 0.45% of jute fiber i,e 9.06 N/m2 of mix after curing 28days.
- The slump value increases 130 mm to 157 mm due to jute fiber percentage ranging from 0 to 0.6%. Maximum slump 157 mm is observed at 0.6% jute fiber in concrete mix due to the reason that heavy reinforcement of jute is added.

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