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# An Experimental study on Effect of Rice Husk Ash and Glass Fibre on properties of Cement with Partial replacement of Fine Aggregate by Quarry Dust

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***Abstract : Fiber reinforced concrete is a composite material consisting of mixtures of cement, fine aggregate, coarse aggregate and fibers. The fiber reinforced concrete exhibits better fatigue strength and increased static and dynamic tensile strength and compressive strength. In this project, the strength of fiber reinforced concrete was investigated partial replacement of cement with rice husk ash and fine aggregate with quarry dust. Glass fiber was added in the order of 0.25% and 0.5% by weight of cement. Rice husk ash was used to replace Ordinary Portland Cement by 10%, 20% and 30% by weight of cement proportions. Quarry dust was used as partial replacement of fine aggregate by 20%.***

***Keywords – Compressive strength, tensile strength, Rice husk ash, Quarry dust and Glass fiber.***

## 1. INTRODUCTION

Glass fiber reinforced concrete (GRF) is a material made of a cementite's matrix composed of cement, sand, water and admixtures, in which short length glass fiber are dispersed. It has been widely used in the construction industry for many advantages, such as being light weight, fire resistance, good appearance and strength. Various application of GFRC shown in the study of the experimental test results, techno-economic comparison with other types, as well as the financial calculations presented, indicate the tremendous potential of GFRC as an alternative construction material. The need to reduce the high cost of Ordinary Portland Cement in order to provide accommodation for the population has intensified research into the use of some locally available material that could be used as partial replacement for Ordinary Portland Cement (OPC) in Civil Engineering and Building Works. Supplementary cementite's materials have been proven to be effective in meeting most of the requirements of durable concrete and blended cements are now used in many parts of the world (Baker, Putrajaya and Abdulaziz, 2010). Various research work has been carried out on the binary blends of Ordinary Portland Cement with different pozzolans in making cement composites (Adewuyi and Ola, 2005; De Sensale, 2006; Saraswathy and song, 2007; Ettu et al, 2013). Rice Husk Ash (RHA) which is an agricultural by-product has been reported to be a good pozzolans by numerous researchers. Mehta and Pirth (2000) investigated the use of RHA to reduce temperature in high strength mass concrete and got result showing that RHA is very effective in reducing the temperature of mass concrete compared to OPC concrete. Malhotra and Mehta (2004) later reported that ground RHA with finer particle size that OPC improves concrete properties, including that higher substitution amounts results in lower water absorption values and the addition of RHA causes an increment in the compressive strength. Cordeiro, Filho and Fairbarn (2009) carried out elaborate studies of Brazilian RHA and Rice Straw Ash (RSA) and demonstrated that grinding increases the pozzolanic activity of RHA and that high strength of RHA, RSA concrete makes production of blocks with good bearing strength in a rural setting possible. Their study showed that combination of RHA or RSA with lime produces a week cementite's material which could however be used to stabilize laterite and improve the bearing strength of the material. Habeeb and Fayyadh (2009) investigated the influence of RHA average particle size on the properties of concrete and found out that at early ages the strength was comparable, while at the age of 28 days, finer RHA exhibited higher strength than the sample with coarser RHA. Rukzon, Chindaprasirt and Mahachai (2009) further studied the effect of grinding on the chemical and physical properties of rice husk ash and the effect of RHA fineness on properties of mortar and found that pozzolans with finer particles had greater pozzolanic reaction. In this study trail tests for concrete with glass fiber are conducted to indicate the differences in compressive strength and flexural strength by using cubes and prisms of varying sizes.

## 2. NEED FOR PRESENT INVESTIGATION

From the literature study, it appears that a number of researches were concentrated their attention on the study of the influence of fiber addition in concrete mixture on mechanical and durability properties of concrete. Considering partial replacement of cement with Rice Husk Ash (RHA) in glass fiber concrete is an area that needs more study. But limited research work has been carried out concerning the influence of addition in concrete with pozzolans.

## 3. OBJECTS OF THE PRESENT INVESTIGATION

To determine the properties of Rice Husk Ash (RHA), Glass fiber and Quarry Dust. To find the effect of Rice Husk Ash (RHA) on concrete by replacement of cement. To determine the behaviour of concrete produced from cement with combination of Rice Husk Ash (RHA), Fine Aggregate of Quarry Dust and Glass Fiber at different proportions. To determine the mechanical properties of concrete such as compressive strength, split tensile strength and flexural strength.

## 4. LITERATURE REVIEW

**"Utilization of Fly Ash, Rice Husk Ash, and Palm Oil Fuel Ash in Glass Fiber Reinforced Concrete (2011)".** Huchai Sujivorakul Chai Jaturapitakkul, A.M.ASCE, Akkaphol Taotip. *Journal of Materials in Civil Engineering* 23.9 (2011): 1281-1288. To use of widely available Fly Ash (FA), Rice Husk Ash (RHA), and Palm Oil Fuel Ash (POFA) in Thailand to make glass fiber reinforced concrete (GFRC). An external spray mix machine was employed to produce all specimens with 5% by weight of alkaline resistant (AR) glass fiber. The GFRC specimens were investigated for water absorption, bending strength, bending strain and toughness at 7, 28, 56 and 180 days. Test results showed that, for both GFRC panels with and without cement replacement by FA, RHA and POFA, the Limit of Proportionality (LOP) increased with an increase in the age of curing, whereas the Modulus of Rupture (MOR) increased initially and then started to drop gradually.

**"Combine Effect of Rice Husk Ash and Fly Ash on Concrete by 30% Cement Replacement (2013)".** Satish H. Sathawane, Vikrant S. Vairagade and Kavitha S. Kene. *Procedia Engineering* 51 (2013): 35-44. Effect of partial replacement of cement by Fly Ash and Rice Husk Ash in combine proportion started from 30% FA and 0% RHA mix together in concrete by replacement of cement with the gradual increase of RHA by 2.5% and simultaneously gradual decrease of FA by 2.5%. Optimum results was take 15% FA and 15% RHA. The tests on hardened concrete were destructive in nature which includes compressive strength, split tensile strength and flexural strength at 7, 14, 28, 56 and 90 days of curing.

**"Rice Husk Ash as both Pozzolanic admixture and internal curing agent in Ultra-High Performance Concrete (2014)".** Viet Thien An Van, Christiane Robler, Danh Dai Bui, Horst Michael Ludwig. *Cement and Concrete Composites* 53 (2014): 270-278. The addition of RHA strongly mitigates autogenous shrinkage of UHPC. The incorporation of RHA and GGBS improves workability, compressive strength and autogenous shrinkage of UHPC containing RHA. The highly problematic autogenous shrinkage of UHPC containing SF is mainly caused by the high self desiccation during hydration. The addition of RHA significantly delays and slows down the decrease in the internal relative humidity (self-desiccation) of UHPC, and hence strongly mitigates autogenous shrinkage of UHPC. RHA clearly plays as an internal curing agent.

**"Effect of Rice Husk Ash and Fiber on mechanical properties of pervious concrete pavement (2014)".** Saeid Hesami, Saeed Ahmadi and Mahdi Nematzadeh. *Construction and Building Materials* 53 (2014): 680-691. The use of pervious concrete pavement is significantly increasing due to reduction of road runoff and absorption of noise. However, this type of pavement cannot be used for heavy traffic due to a high amount of voids and consequently low strength of previous concrete. Rice Husk Ash (RHA) was used in order to strengthen pozzolanic cement paste and the effect of 0%, 2%, 4%, 6%, 8%, 10% and 12% weight percentage as a cement replacement in concrete mixtures on the mechanical properties was studied. Moreover, 0.2% Vf of glass (where Vf is the proportion of fiber volume to total volume of concrete), 0.5% Vf of steel and 0.3% Vf of Poly-Phenylene sulphide (PPS) fibers were used to improve the mechanical properties of the pervious concrete.

**Rana A. Mtasher et al (2008).** Rana A. Mtasher et al investigated the effect of fibrillated glass fiber on the compressive and flexural strength of normal weight concrete. Four mixes used glass fiber weight with 0.4, 0.8, 1 and 1.5 percentage of cement content. To provide basis for comparison, reference specimens were cast without glass fiber. The increase in the compressive strength for fibrous concrete compared to non-fibrous concrete is 11%, 24.35% and 56.4% for 0.4%, 0.8%, 1% and 1.5% fiber content respectively. The increase in the flexural strength for fibers concrete compared to the non-fibrous concrete is 24.6%, 49.36%, 57% and 85% for 0.4%, 0.8%, 1% and 1.5% fiber weight content respectively. The average ratio of flexural strength is about 11.18%.

**"Effect of Glass Fiber on Ordinary Portland Cement Concrete (2012)".** Deshmukh S.H., Bhusari J.P., Zende A.M. *IOSR Journal of Engineering, June 2012, volume 2(6) pp: 1308-1312.* Concrete is a tension weak building material, which is often crack ridden connected to plastic and hardened states, drying shrinkage, and the like. Moreover, concrete suffers from low tensile strength, limited ductility and little resistance to cracking. In order to improve these properties, and attempt has been made to study the effect of addition of glass fibers in Ordinary Portland Cement concrete (OPC). The result have shown improvement in mechanical and durability properties with addition of glass fibers.

 

**"The Use of Rice Husk Ash as Partial Replacement for Cement in Concrete (2010)".** O.A. Adenuga, A.A. Soyingbe and O.E. Ogunsanmi. *Department of Building, University of Lagos, Akoka, Yaba. The Lagos Journal of Environmental Studies* 7(2), 2010. The study examines the use of Rice Husk Ash (RHA) as partial replacement for cement in concrete by determining various properties of Rice Husk Ash (RHA) through laboratory experiments. The objective of the study includes, determining the specific gravity of RHA, the effect of RHA on compressive strength of concrete and on properties of concrete such as density and workability. The results of the study revealed specific gravity of 2.36 for the RHA used.

**"Experimental Study on Glass Fibers Reinforced Concrete Moderate Deep Beam (2009)".** V.R. Rathi, A.V. Ghogare and S.R. Nawale. In this study, the result of glass fiber reinforced moderate deep beam with and without stirrups have been presented. Six tee beams of constant overall span and depth 150mm, 200mm, 250mm, 300mm with span to depth (L/D) ratios of 4,3,2,4,2 and glass fibers of 12mm cut length and diameter 0.0125mm added at volume fraction of 0%, 0.25%, 0.50%, 0.75% and 1%. The beams were tested under two points loads at mid span. The results showed that the addition of glass fiber significantly improved the compressive strength, split tensile strength, flexural strength, shear stress and ductility of reinforced moderate deep beams without stirrups.

**"Experimental Study on the Effect of Cement and Sand Replacement with Red Mud and Quarry Dust in Cement Concrete Pavements (2006)".** R. Pavankumar, P. Satya Sagar. *International Journal on Recent and Innovation Trends in Computing and Communication ISSN*: 2321-8169 Volume: 4 and Issue: 6. The main objective of the project is experimental study of the possibility of utilizing the waste red mud (bauxite residue) and quarry dust in cement concrete. The quarry dust which is available from local resources can be used as a replacement of river sand in conventional concrete pavements. This study aim at describing such utilization and their effective usage in concrete. Experiments have been conducted under laboratory conditions to assess the compressive strength and flexural strength of the concrete cubes made of red mud and quarry dust. By conducting the model tests we can replace the 15% of cement with red mud and 30% of sand with quarry dust.

**"Experimental Study on Partial Replacement of Cement with Fly Ash and complete Replacement of Sand with M-Sand (2015)".** T. Subramani, K.S. Ramesh. *International Journal of Application or Innovation in Engineering and Management (IJAIEM)*, Volume: 4 and Issue: 5, May 2015. Due to rapid growth in construction activity, the available sources of natural sand are getting exhausted and also, good quality sand may have to be transported from long distance, which adds to the cost of construction. In some cases, natural sand may not be of good quality. Therefore, it is necessary to replace natural sand in concrete by an alternate material partially, without compromising the quality of concrete. Quarry Dust is one such material which can be used to replace sand as fine aggregate.

## 5. PROPERTIES OF MATERIALS

### CEMENT

The cement used for this study is 53-grade Ordinary Portland Cement (OPC). The physical properties are obtained by conducting following tests on cement.

| SI.No | Properties | Value | Standard value |
|---|---|---|---|
| 1 | Specific gravity | 3.14 | 3.10 – 3.20 |
| 2 | Standard consistency | 30% | 25 – 35% |
| 3 | Initial setting time | 53 min | >30 min |
| 4 | Final setting time | 570 min | <600 min |

Table 1: Physical properties of cement

### FINE AGGREGATE

The fine aggregate (sand) used for all the specimens were Natural River sand. It plays a very important role in concrete in both its plastic and hardened state. The physical properties are obtained by conducting following tests on fine aggregate.

| SI.No | Properties | Value |
|---|---|---|
| 1 | Specific gravity | 2.67 |
| 2 | Fineness modulus | 347% |
| 3 | Bulk density | 1621 kg/$m^3$ |
| 4 | Water absorption | 1.20% |

Table 2: Physical properties of fine aggregate

| SI.No | IS Sieve size (mm) | Weight retained | Retained weight in % | Cumulative % of weight retained | % of finer |
|---|---|---|---|---|---|
| 1 | 4.75 | 15 | 0.75 | 0.75 | 99.25 |
| 2 | 2.36 | 25 | 1.25 | 2 | 98 |
| 3 | 1.18 | 320 | 16 | 18 | 82 |
| 4 | 0.6 | 550 | 27.5 | 45.5 | 54.5 |
| 5 | 0.3 | 880 | 44 | 89.5 | 10.5 |
| 6 | 0.15 | 50 | 2.5 | 92 | 8 |
| 7 | PAN | 160 | 8 | 100 | 0 |

Table 3: Sieve analysis for fine aggregate

**COURSE AGGREGATE**

Aggregate have large influence on the properties of the concrete. The coarse aggregate used in this test was obtained from hard broken granite jelly conforming to IS: 2386 (part-3)-1993(Reaffirmed 1997).

For concreting generally 20mm coarse aggregate are used but in our case due to the addition of fibers 12.5mm coarse aggregate adopted in order to avoiding the balling effect.

Table 4: Physical properties of coarse aggregate

| SI.No | Properties | Value1 |
|---|---|---|
| 1 | Specific gravity | 2.64 |
| 2 | Impact value | 15.82 |
| 3 | Bulk density | 1427 kg/m$^3$ |
| 4 | Water absorption | 0.95% |

**GLASS FIBER**

Glass fiber most popular of the synthetics, are chemically inert, hydrophobic and lightweight. They are produced as continuous cylindrical monofilaments that can be chopped to specified length or cut as films and tapes and formed into fine fibrils of rectangular cross section. Used at a rate of at least 0.1% by volume of concrete, glass fibers reduce plastic shrinkage cracking and subsidence cracking over steel reinforcement.

- Type – Alkali resistant glass fiber
- Length – 12mm
- Colour – Brilliant White

**RICE HUSK ASH (RHA)**

The husk contains about 75% of organic volatile matter and the balance 25% of the weight of this husk is converted into ash during the firing process, is known as Rice Husk Ash (RHA).

- RHA contains 90-95% $SiO_2$, 1-3% $K_2O$ and <5% unburnt carbon.
- The pozzolanic and cementious reaction associated with RHA reduces the free lime present in the cement paste.
- Decrease the permeability of the system.
- Improves overall resistance to $CO_2$ attack.
- Enhances resistance to corrosion of steel in concrete.

**QUARRY DUST**

Concrete is the most widely used composite material today. The constitution of concrete is coarse aggregate, fine aggregate, binding material and water. Rapid increase in construction activities leads to acute shortage of conventional construction material. The function of the fine aggregate is to assist in producing workability and uniformity in the mixture. The river deposits are the most common source of fine aggregate. Now-a-days the natural river sand has becomes scarce and very costly.

- Specific gravity – 2.57
- Fineness modulus – 2.41
- Density – 1.85 gm/cc
- Void ratio – 0.42

 

## 6. MIX PROPORTION

The mix ratio of the conventional M40 grade concrete by weight is arrived from IS code method (As per IS 10262:2009).

Table 5: Mix proportion

| | |
|---|---|
| Cement | 431.82 kg/m$^3$ |
| Water | 190 kg/m$^3$ |
| Fine aggregate | 696.8 kg/m$^3$ |
| Coarse aggregate | 1045.2 kg/m$^3$ |
| Water/cement ratio | 0.44 |

Table 6: Mix ratio

| Cement | Fine aggregate | Coarse aggregate | Water/Cement ratio |
|---|---|---|---|
| 1 | 1.61 | 2.42 | 0.44 |

Table 7: Mix proportion for replacement material

| | |
|---|---|
| 100% Cement | 431.8 kg/m$^3$ |
| 10% RHA | 43.2 kg/m$^3$ |
| 20% RHA | 86.3 kg/m$^3$ |
| 30% RHA | 129.5 kg/m$^3$ |
| Water | 190 kg/m$^3$ |
| Remaining 80% Fine aggregate | 557.44 kg/m$^3$ |
| Coarse aggregate | 1045.2 kg/m$^3$ |
| 0.25% Glass fiber | 1.0795 kg/m$^3$ |
| 0.5% Glass fiber | 2.159 kg/m$^3$ |
| | |

## 7. EXPERIMENTAL INVESTIGATION

For any successful investigation, numerous tests have to be performed and the trend of result should be studied carefully before arriving at the final conclusions. To have reliable result from the tests experimental set up and testing procedure are required. The various tests to be performed for the investigations on the present topic are as follows. 1. Compression test on cubes 2. Split Tensile test on cylinders 3. Flexural test on prism.

## 8. TESTING ON SPECIMENS

*COMPRESSIVE STRENGTH TEST*

Specimen used for the test was 150mmx150mmx150mm cubes. Tests were conducted using Compression Testing Machine (CTM) of capacity 400kN. The tests were carried out at a uniform stress of 14 N/mm$^2$/min after the specimen had been centred in the testing machine.

Compressive strength = P/A (N/mm$^2$)

Where, P-maximum applied load in N

A-cross section area of specimen in mm$^2$

*SPLIT TENSILE STRENGTH TEST*

The test is carried out by placing a cylindrical specimen of diameter of 150mm and height of 300mm, horizontally between then loading surface of a Compression Testing Machine (CTM) and the loading is applied until failure of the cylinder, along the vertical diameter.

Split Tensile strength = $P/\pi DL$ (N/mm$^2$)

Where, P-maximum applied load in N

D and L are the diameter and length of cylinder in mm

 

*FLEXURAL STRENGTH TEST*

For each of the different dosage, prism with dimension 500mmx100mmx100mm concrete was prepared. The test specimen are placed in the machine. The load is applied to the uppermost surface as cast in the mould along two lines spaced 20cm or 13.3cm apart. The load is increased until the specimen fails and maximum load applied to the specimen during the test is reduced.

Flexural strength = $3Pa/bd^2$ ($N/mm^2$)

Where, P-maximum applied load in N

## 9. RESULT AND DISCUSSION

*COMPRESSION TEST ON CUBES*

**The compressive strength of cubes for conventional concrete at 7 days is 24.72 $N/mm^2$ and 28 days 46.48 $N/mm^2$.**

Table 8: Compressive strength on cubes

| Specimen | Mean load in kN | 7 days | Mean load in kN | 28 days |
|---|---|---|---|---|
| S1 | 695 | 30.89 | 1117 | 52.37 |
| **S2** | **708** | **31.51** | **1203** | **53.48** |
| S3 | 686 | 30.49 | 1143 | 50.82 |
| S4 | 677 | 30.09 | 1128 | 50.15 |
| S5 | 661 | 29.42 | 1113 | 49.50 |
| S6 | 643 | 28.62 | 1097 | 48.79 |
| S7 | 600 | 26.71 | 1024 | 45.52 |
| S8 | 589 | 26.22 | 969 | 43.07 |
| S9 | 575 | 25.56 | 958 | 42.62 |

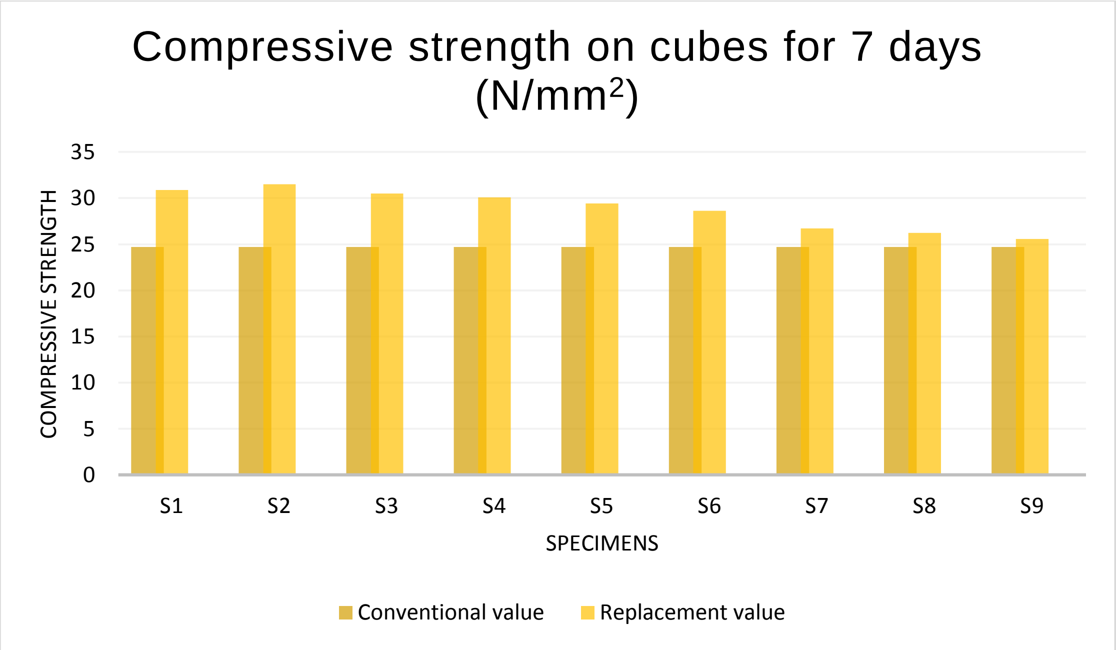


Figure 1: Compressive strength for 7 days

 

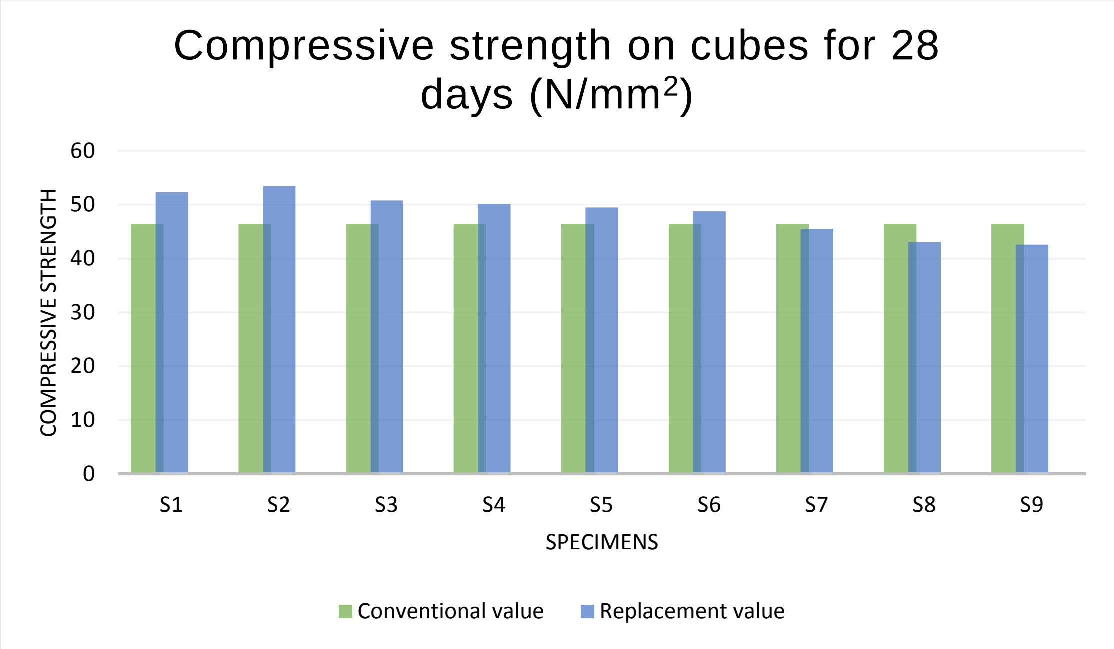


Figure 2: Compressive strength for 28 days

*SPLIT TENSILE TEST ON CYLINDERS*

**The split tensile strength on cylinder for conventional concrete for 7 days is 3.67 N/mm$^2$ and 28 days 5.49 N/mm$^2$.**

| Specimen | Mean load in kN | 7 days | Mean load in kN | 28 days |
|---|---|---|---|---|
| S1 | 498 | 3.52 | 773 | 5.46 |
| **S2** | **522** | **3.69** | **786** | **5.56** |
| S3 | 500 | 3.53 | 752 | 5.32 |
| S4 | 462 | 3.27 | 736 | 5.21 |
| S5 | 444 | 3.15 | 725 | 5.13 |
| S6 | 429 | 3.02 | 713 | 5.04 |
| S7 | 413 | 2.92 | 698 | 4.94 |
| S8 | 397 | 2.80 | 681 | 4.82 |
| S9 | 385 | 2.72 | 672 | 4.75 |

Table 9: Split tensile strength on cylinders

 

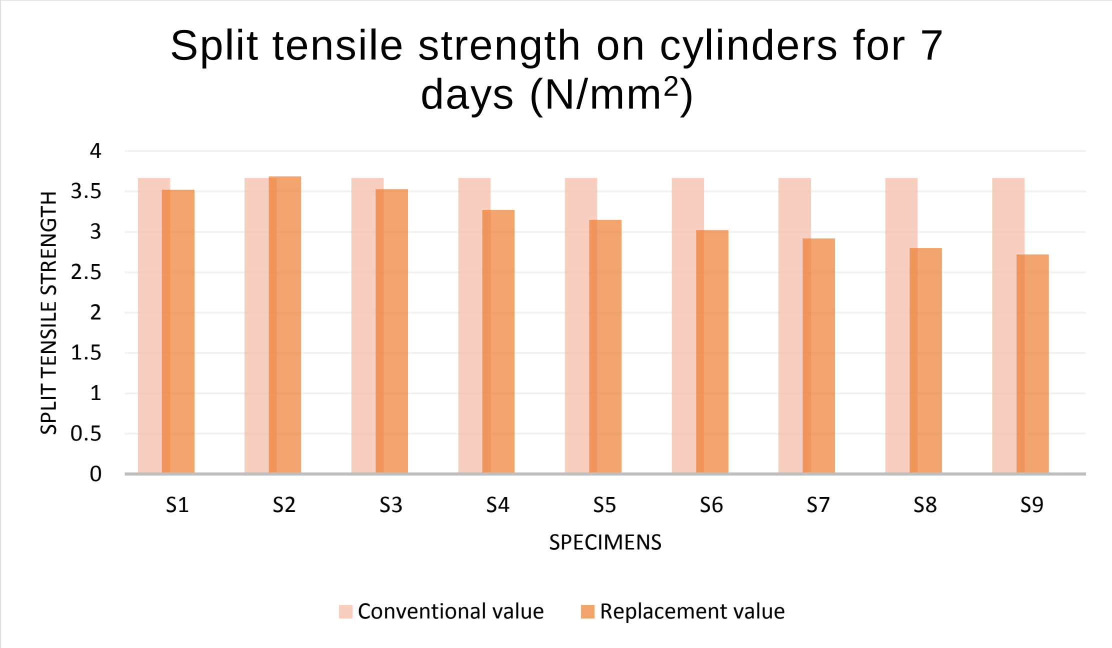


Figure 3: Split tensile strength for 7 days

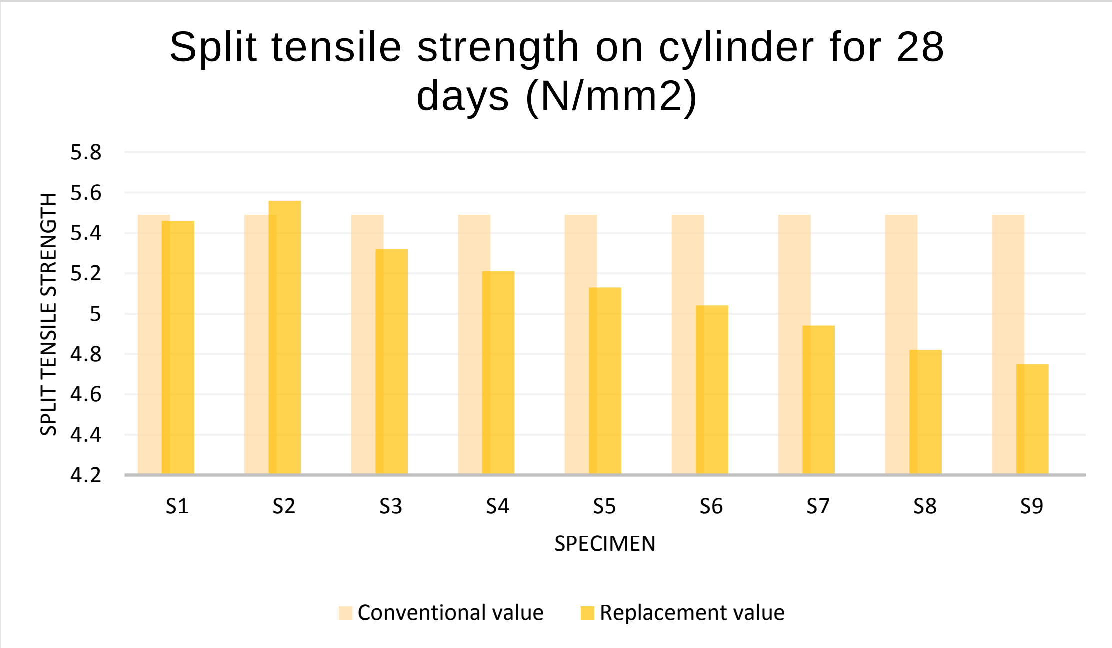


Figure 4: Split tensile strength for 28 days

*FLEXURAL STRENGTH ON PRISM*

**The flexural strength of prism for conventional concrete at 7 days is 3.27 N/mm$^2$ and 28 days is 5.45 N/mm$^2$.**

Table 10: Flexural strength on prism

| Specimen | Mean value in kN | 7 days | Mean value in kN | 28 days |
|---|---|---|---|---|
| S1 | 10.50 | 3.15 | 17.70 | 5.31 |
| **S2** | **11.30** | **3.39** | **18.63** | **5.59** |
| S3 | 10.13 | 3.04 | 17.10 | 5.13 |
| S4 | 9.63 | 2.89 | 16.36 | 4.91 |
| S5 | 9.10 | 2.73 | 15.96 | 4.79 |
| S6 | 8.83 | 2.65 | 15.40 | 4.62 |
| S7 | 8.56 | 2.57 | 14.96 | 4.49 |
| S8 | 8.03 | 2.41 | 14.60 | 4.38 |
| S9 | 7.83 | 2.35 | 14.23 | 4.27 |

 

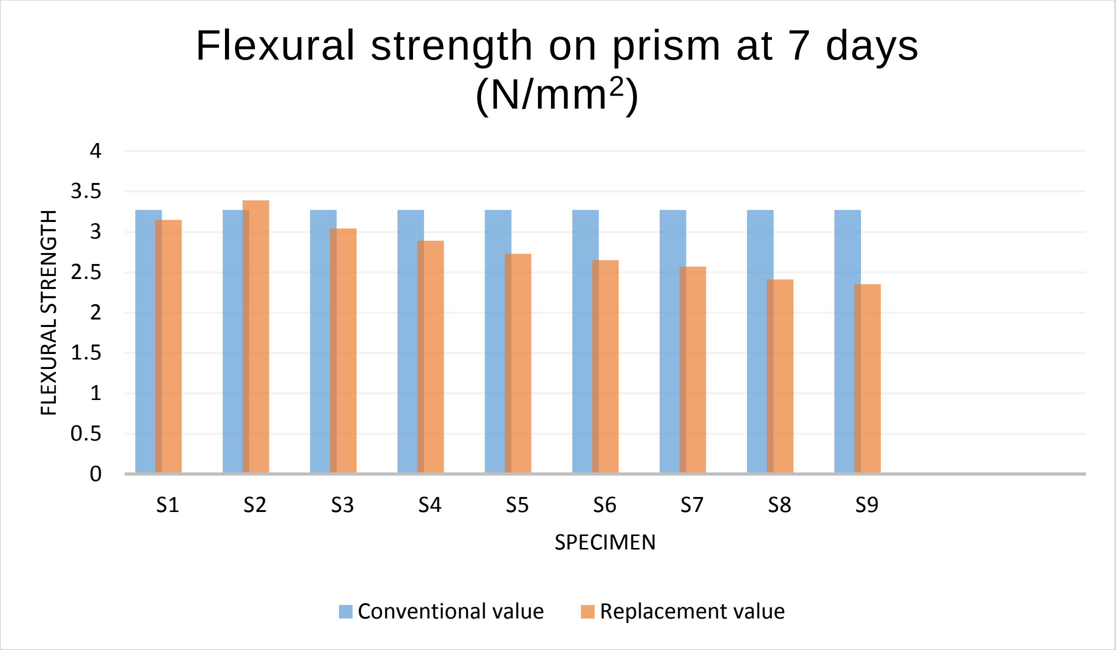


Figure 5: Flexural strength for 7 days

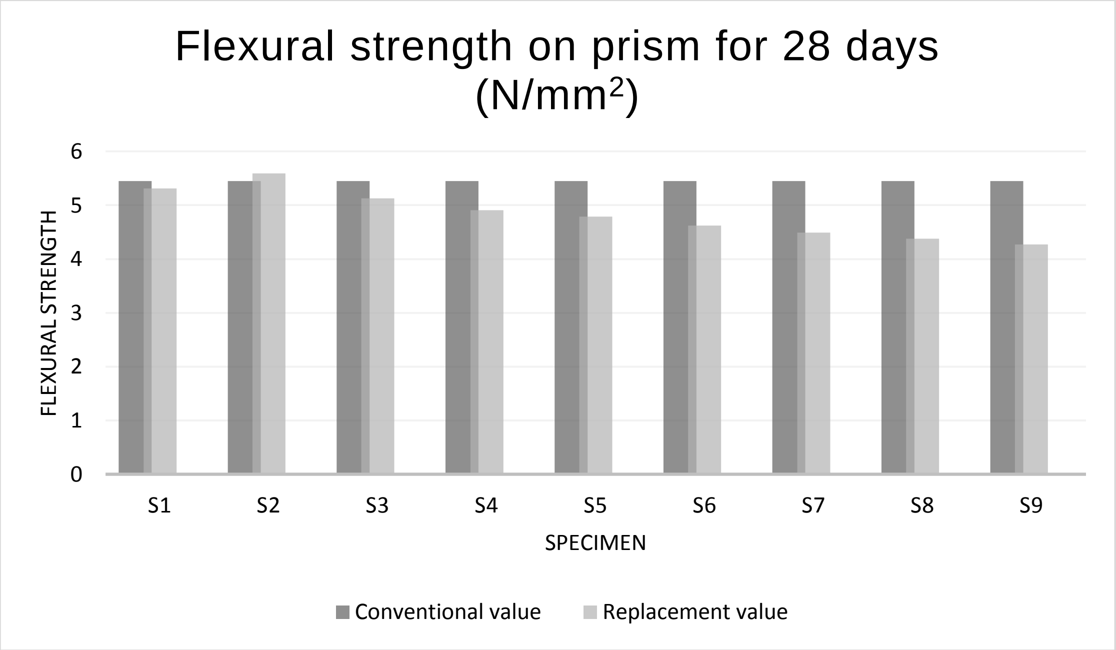


Figure 6: Flexural strength for 28 days

## CONCLUSION

- Fiber reinforced concrete is a composite material consisting of mixtures of cement, fine aggregate, coarse aggregate and fibers. The fiber reinforced concrete exhibits better fatigue strength and increased static and dynamic tensile strength.
- The strength of fiber reinforced concrete was investigated with partial replacement of cement with Rice Husk Ash (RHA) and fine aggregate with Quarry Dust.
- Glass fiber was added in the order of 0%, 0.25% and 0.5% by weight of cement. Rice Husk Ash (RHA) was used to replace Ordinary Portland Cement (OPC) by 10%, 20% and 30% by weight of cement proportions. Quarry Dust was used as partial replacement for fine aggregate by 20%.
- Totally 9 mixers were prepared to test the behaviour of fiber. The specimens were casted and cured at 7 days and 28 days to obtained better results.
- The 10% replacement of Rice Husk Ash (RHA) with cement, 0.25% of Glass Fiber showed higher strength.

 

- Compressive strength of 31.51 N/mm$^2$ at 7 days and 53.48 N/mm$^2$ at 28 days.
- Split Tensile strength of 3.69 N/mm$^2$ at 7 days and 5.56 N/mm$^2$ at 28 days.
- Flexural strength of 3.39 N/mm$^2$ at 7 days and 5.59 N/mm$^2$ at 28 days.

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