SUSTAINABLE PRODUCTION OF CONCRETE USING RICE HUSK ASH AND STEEL FIBERS: MECHANICAL PARAMETERS

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Abstract

Concrete in construction, is a structural material consisting of a hard, chemically inert particulate substance, known as aggregate (usually sand and gravel) that is bonded together by cement and water. Concrete is good in compression but weak in tension, hence new advancements are implemented like using steel fibres (SF) in concrete which will strengthen the tensile zone. For the current study, 5%, 10% and 15% of cement will be replaced with RHA and a constant SF of 1.75% as total volume of concrete will be added. The fresh, mechanical and durability parameters of the modified concrete will be studied to know the combined effect of SF and RHA. Moreover, non-destructive tests will also be performed to know the in-depth hardened concrete properties

1. Introduction

The world at the end of the 20th century that has just been left behind was very different to the world that its people inherited at the beginning of that century. The latter half of the last century saw unprecedented technological changes and innovations in science and engineering in the field of communications, medicine, transportation and information technology, and in the wide range and use of materials. The construction industry has been no exception to these changes when one looks at the exciting achievements in the design and construction of buildings, bridges, offshore structures, dams, and monuments, such as the Channel. Tunnel and the Millennium Wheel. There is no doubt that these dramatic changes to the scientific, engineering and industrial face of the world have brought about great social benefits in terms of wealth, good living and leisure, at least to those living in the industrialized nations of the world. But this process of the evolution of

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the industrial and information technology era has also, however, been followed, particularly during the last four to five decades, by unprecedented social changes, unpredictable upheavals in world economy, uncompromising social attitudes, and unacceptable pollution and damage to our natural environment. In global terms, the social and societal transformations that have occurred can be categorized in terms of technological revolutions, population growth, worldwide urbanization, and uncontrolled pollution and creation of waste.

2. **Literature Review**

Ghassan Abood Habeeb, Hilmi Bin Mahmud, The compressive strength of the blended concrete with 10% RHA has been increased significantly, and for up to 20% replacement could be valuably replaced by cement without adversely affecting the strength. Increasing RHA fineness enhances the strength of blended concrete. **Alireza Naji Givi, Suraya Abdul Rashid, Farah Nora A. Aziz, Mohamad Amran Mohd Salleh,** RHA blended concrete can decrease the temperature effect that occurs during the cement hydration. RHA blended concrete can improve the workability of concrete compared to OPC. **Godwin A. Akeke, Maurice E. Ephraim, Akobo, I.Z.S and Joseph O. Ukpata.** The compressive strength and workability tests suggests that RHA could be substituted for OPC at up to 25% in the production of concrete with no loss in workability or strength. **G.A. Habeeb, M.M. Fayyadh,** The mechanical properties in terms of flexural and tensile strength have been significantly improved with the addition of RHA, with the coarse RHA showing the least improvement. On the other hand, the value of Static modulus was comparable with slight increase in the RHA concrete mixtures. **Yunusa A. Alhassan and Danladi Egbunu,** The concrete incorporating PFA did not show any increase in the compressive strength compared to the RHA and the control Portland cement concrete. The higher strength of the RHA at all the replacement level compared to the PFA is due probably to its reduced porosity, reduced Ca(OH)2 content and the reduced width of the interfacial zone between the paste and the aggregates. **A.M. Shende1 , A.M. Pande2 , M. Gulfam Pathan,** It is observed that compressive strength, split tensile strength and flexural strength are on higher side for 3% fibers as compared to that produced from 0%, 1% and 2% fibers. **Yuanxun Zheng, Xiaolong Wu, Guangxian He, Qingfang Shang, Jianguo Xu and Yikai Sun,** With the increase in steel fiber content, all of these

ISSN- 2394-5125 VOL 09, ISSUE 04, 2022

mechanical properties such as compression strength, flexural strength, and splitting tensile strength improve gradually; especially for flexural strength and splitting tensile strength, the steel fiber reinforcement effect is obvious. At the same fiber content, reinforcement effect of mechanical properties of high-strength concrete is better.

3. Materials:

3.1 Cement:

Ordinary Portland cement of 53 grades was used in this project.

3.2 Coarse Aggregate:

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 are being used. The Flakiness and Elongation Index were maintained well below 15%. Physical property evaluation and gradation of coarse aggregate were carried out and the test results are presented below: Aggregates are the major ingredients of concrete. They constitute 70-80% of the total volume, provide a rigid skeleton structure for concrete, and act as economical space fillers. Because at least threequarters of the volume of the concrete is occupied by aggregate, it is not surprising that its quality is of considerable importance. The properties of aggregate greatly affect the durability and structural performance of concrete..

The following tests have been conducted on coarse aggregates.

- Specific Gravity
- Bulk Density
- Fineness modulus

3.3 Fine Aggregates:

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand and crushed sand is being used in combination as fine aggregate conforming to the requirements of IS: 383. The river sand is wash and screen, to eliminate deleterious materials and over size particles. The fine aggregate shall consist of natural sand or, subject to approval, other inert materials with similar characteristics, or combinations having hard, strong, durable particles. The use of concrete is being constrained by urbanization, zoning regulations, increased cost and environmental concern. The following tests have been conducted on fine aggregates

- Specific Gravity

- Bulk Density
- Sieve Analysis (Fineness Modulus)

3.4 Water [IS: 456-2000]:

Water used for both mixing and curing should be free from injurious amount of deleterious materials such as acids, alkalies, salts, organic materials etc. Potable water is generally considered satisfactory for mixing and curing concrete. In present work potable tap water was used.

3.5 RICE HUSK ASH

1	Silicon Dioxide	86.94%
2	Aluminium Oxide	0.2%
3	Iron Oxide	0.1%
4	Calcium Oxide	0.3 - 2.25%
5	Magnesium Oxide	0.2 - 0.6%
6	Sodium Oxide	0.1 -0.8%
7	Potassium Oxide	2.15 - 2.30%

3.6 Steel Fibre

Steel fibres are low carbon , cold drawn steel wire fibres is one of promising areas of science. The use of steel fibre in concrete is new revolution. Steel fibre like crimped steel fibres and hooked end steel fibres etc.…which are presently used in concrete to modify its flexure strength properties. In the present study strength properties such as Compressive strength, split tensile strength and flexural strength of M35 grade of concrete with the use of steel fibre (1.75%) as additional with cement and sand were studied. It was found from the experimental study that concrete composites with superior properties can be produced using Steel fibre

ISSN- 2394-5125 VOL 09, ISSUE 04, 2022

3.7 Chemical Admixtures

Admixture is defined as materials, other than cement, water and aggregates, that is used as an ingredient of concrete and it is added to the batch immediately before or during mixing.

3.8.1 MasterPolyheed® 8101

MasterPolyheed 8101 from the traditional superplasticisers is a new, unique mechanism of action that greatly improves the effectiveness of cement dispersion.

4. Mix Design

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in two states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.

5. Methodology

5.1 Tests on Fresh Concrete

5.1.1 Slump Cone Test

This is a test used extensively in site work all over the work. The slump test does not measure the workability of concrete although ACI 116R – 90 describes it as a measure of consistency, but the test is very useful in detecting variations in the uniformity of a mix of given nominal proportions. The slump test is prescribed by IS: 456 (2000), ASTM C 143 90A and BS 1881 Part 102:1983. The mould for the slump test is a frustum of a cone, 300mm (12inch) high. It is placed on a smooth surface with the smaller opening at the top and filled with concrete in three layers. Each layer is tamped 25 times with a standard 16mm (5inch) diameter steel rod, rounded at the end, and the top surface struck off by means of a sawing and rolling its base during the entire operation, this is facilitated by handles or foot rests brazed to the mould.

ISSN- 2394-5125 VOL 09, ISSUE 04, 2022

Fig1: slump cone

5.2 Test for Compressive Strength of Concrete (Is: 516-1959):

The compressive strength of concrete is one of the most important Properties of concrete in most structural application concrete is implied primarily to resist compressive stress.

In the investigation, conventional concrete Rice husk ash(RHA), Sugarcane Bagasse Ash (SBA), composite, concrete cubes of 150mm x 150mm x 150mm sizes were used for testing the compressive strength. The cubes are tested in a compression-testing machine of capacity 2000kn. The load has been applied at a rate of 315kn/mm. The load applied in such a way that the two opposite sides of the cubes are compressed. The load at which the control specimen ultimately fail is noted. The average of three cubes is taken as compressive strength.

ISSN- 2394-5125 VOL 09, ISSUE 04, 2022

5.3 Flexural Strength

Flexural strength is an indirect measure of the tensile strength of concrete. It is a measure of the maximum stress on the tension face of an unreinforced concrete beam or slab at the point of failure in bending. It is measured by loading 150 x 150-mm (or (100 x 100-mm) concrete beams with a span length at least three times the depth.

The flexural strength is expressed as Modulus of Rupture (MR) in MPa and is determined by standard test methods ASTM C78 (third-point loading) or ASTM C293 (center-point loading).The specimen size and type of loading doesimpact the measured flexural strength and comparisons or requirements should be based on the same beam size and loading configuration. The MR measured by third-point loading (ASTM C78) is lower than that determined by center-point loading (ASTM C293), sometimes by as much as 15 percent. It is also observed that a lower flexural strength will be measured with larger beam specimens

5.4 Splitting Tensile Strength

The cylinder specimen was placed horizontally in the centering with packing skip (wooden strip)/or loading pieces carefully positioned along the top and bottom of the plane of loading of the specimen. The load was applied without shock and increased continuously at a nominal rate with in the range 1.2 N/mm2 /min to 2.4 N/mm2 /min until failure the specimen. The maximum load applied was recorded at failure. Appearance of concrete and unused features in the type of failure was also observed

Fig16: split tensile strength

ISSN- 2394-5125 VOL 09, ISSUE 04, 2022

5.5 Rebound Hammer

Rebound Hammer test is a Non-destructive testing method of concrete which provide a convenient and rapid indication of the compressive strength of the concrete. The rebound hammer is also called as Schmidt hammer that consist of a spring controlled mass that slides on a plunger within a tubular housing. The operation of rebound hammer is When the plunger of rebound hammer is pressed against the surface of concrete, a spring controlled mass with a constant energy is made to hit concrete surface to rebound back. The extent of rebound, which is a measure of surface hardness, is measured on a graduated scale. This measured value is designated as Rebound Number (rebound index). A concrete with low strength and low stiffness will absorb more energy to yield in a lower rebound value.

Fig17: Rebound hammer

5.6 Ultra Sonic Pulse Velocity Test

The ultrasonic pulse velocity methods involved propagating ultrasonic waves in the concrete which generated by electric current and it measured the time taken for waves to propagate between one to another one point. This method is complied with BS EN 12504-4:2004 [7]. The equipment or generator of pulse wave called PUNDIT Lab which consists of 2 transducers for wave transmission and reception purpose. In figure 1, the direct method was used in this ultrasonic pulse velocity testing. There were 2 parameters, pulse velocity and time passes by pulse wave through the test specimens were obtained.

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ISSN- 2394-5125 VOL 09, ISSUE 04, 2022

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6.Results and Discussion

Fresh Property

6.1 Workability:

The slump of concrete mixed using the M35 mix proportion was found to be a True slump. The value of slump has found to be varying with increase in the percentage of rice husk ash replacement. The steel fibers withhold the wet concrete together and decreases the workability. The height of slump is decreasing gradually with increase in percentage of rice husk ash, thus workability also increases with increase in percentage of rice husk ash.

6.2 Flexural Strength:

The flexural strength of beams is measured on the flexural testing machine. The maximum flexural strength when compared to control concrete is obtained on 7th day test for 5%, 10%, 15% replacement with rice husk ash. There is a decrease in strength on the 28th day and the minimum strength is obtained when replaced with 15% rice husk ash. The steel fibers with hold the beam together, thus increases the flexural strength.

6.3 Split Tensile Strength:

The split tensile strength of cylinders is measured on compressive testing machine. The results when compared with the control concrete minimum strength is obtained at 5% replacement of rice husk ash and the maximum strength is obtained at 10% rice husk ash on 28th day.

6.4 Rebound Hammer Test:

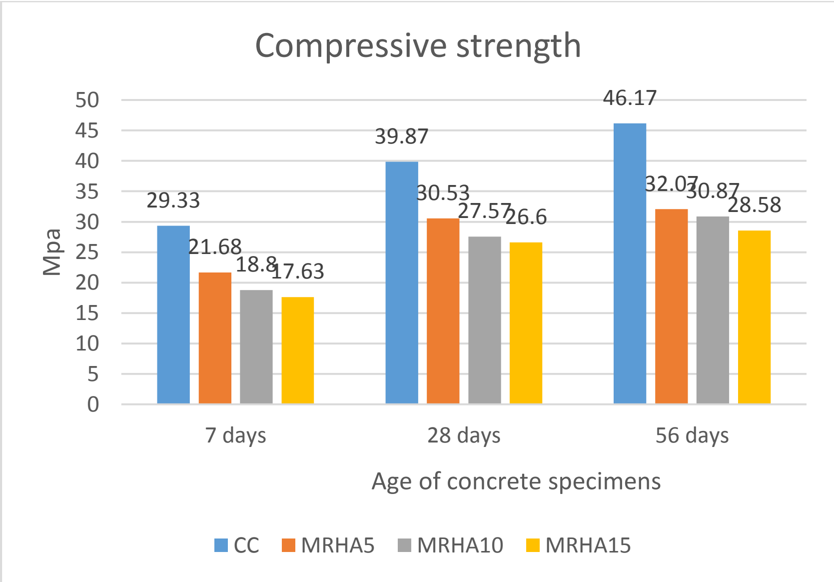
The rebound number is obtained from the rebound hammer test and strength is obtained from the graph present on the rebound hammer. When the test results are compared with the control concrete there is a decrease in strength, the maximum strength is obtained at the 5% replacemnt of rush husk ash and the minimum results are obtained at 10% re

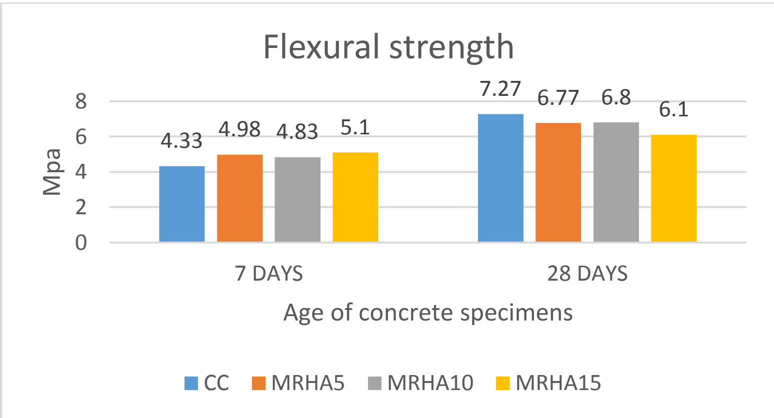
6.5 Ultrasonic Pulse Velocity:

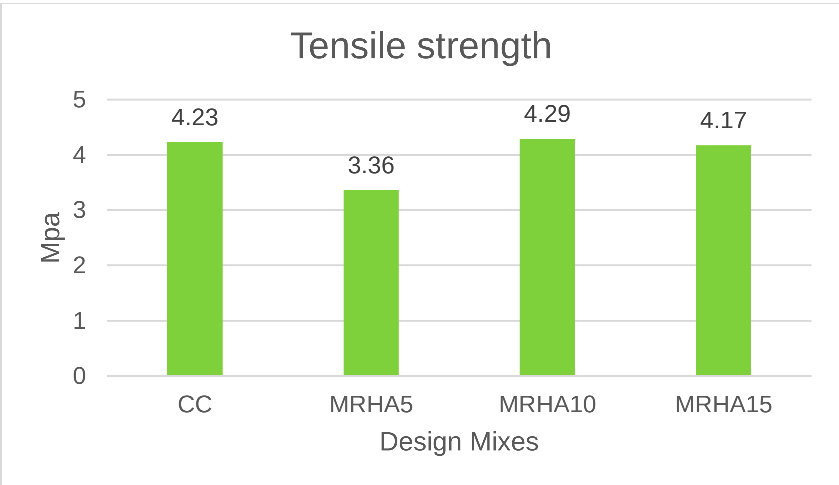
The test results obtained from the UPV test are compared with the control concerete, the

ISSN- 2394-5125 VOL 09, ISSUE 04, 2022

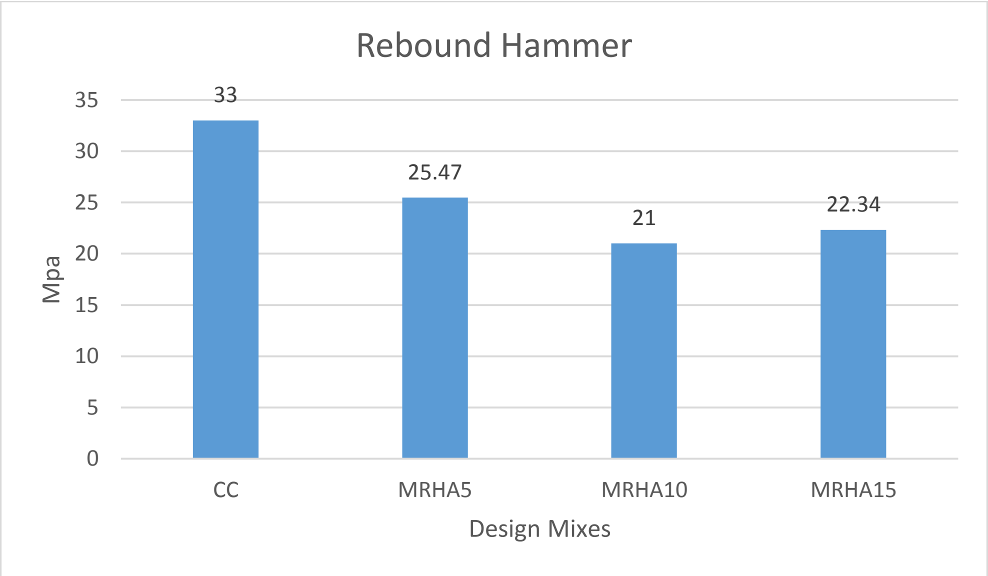
maximum results obtained are at 5% replacement of rice husk ash and minimum results are obtained at 15% replacement of rice husk ash.placement of rice husk ash.

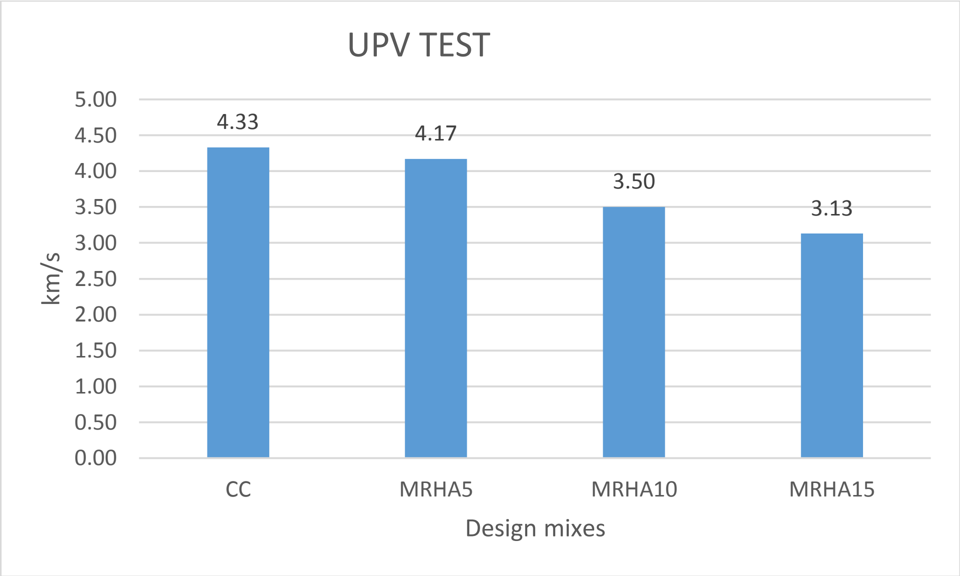






ISSN- 2394-5125 VOL 09, ISSUE 04, 2022





7. Conclusion

The compressive strength of concrete when replaced with rice husk ash in 5%, 10%, 15% percentages the strength gets gradually decreased when compared to the control concrete due to the decrease in workability, because the water absorption of RHA is high. The increase in percentage of RHA proportion there is a decrease in strength parameter. The flexural strength is obtained from testing the beams on the flexural testing machine and the results obtained are fluctuating due to the properties of RHA and the target strength is achieved at early stages and decrease with increase in age.

ISSN- 2394-5125 VOL 09, ISSUE 04, 2022

The tensile strength of concrete is decreased in 5% replacement and the tensile strength obtained from 10% and 15% replacement is almost equal to the control values. The non destructive test results obtained from the concrete cubes are decreased with increase in the percentage replacement of RHA. Control strength target is not reach by the replacement of cement with rice husk ash. Non destructive performed are Rebound hammer and Ultra sonic pulse velocity. RHA is economical, the strength might be less when compared to the control concrete, but can be used for constructions in rural areas to decrease the construction cost. By doing this project we would give a contribution to the society by making the environment more eco-friendly by utilizing the rice husk ash scientifically. Thus by adopting replacement method we can overcome problems such as waste disposal crisis.

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