International Journal For Technological Research In Engineering
Volume 3, Issue 10, June-2016 *ISSN (Online): 2347 - 4718*

STUDIES ON STRENGTH CHARACTERISTICS OF PLASTIC FIBRE REINFORCED CONCRETE WITH RICE HUSK ASH AS AN ADMIXTURE

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ABSTRACT: This paper attempts to bring out the effectiveness of rice husk ash as a versatile concrete admixture and discusses some versatile application of rice husk ash concrete. Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete. In the past, efforts have been made to impart improvement in tensile properties of concrete members by way of using conventional reinforced steel bars and also by applying restraining techniques. Although both these methods provide tensile strength to the concrete members, they however, do not increase the inherent tensile strength of concrete itself. In this direction, an attempt has been made in the present investigation to evaluate the workability, compressive strength, split tensile strength and flexure strength on addition of rice husk ash (0 – 15%) along with plastic fibers (0-3%) in concrete. Though a lot of research is focused in the last decade on use of various admixtures in producing concrete, very little information is available on rice husk ash fiber reinforced concrete. The scope of present research is to study the strength characteristics in terms of compressive, split tensile and flexure strength. Standard cubes of 150 X 150 X 150 mm have been cast and tested for obtaining 7 days and 28 days compressive strength. Standard cylinders of 150mm diameter and 300 mm height were cast and tested for Split tensile strength. Standard Beams of 500mmx100mmx100mm were cast and tested for Flexural strength. M20 concrete has been used as reference mix. Results were analyzed to derive useful conclusions regarding the strength characteristics of rice husk ash fiber reinforced concrete.

Key Words: Fiber Reinforced Concrete, Rice Husk Ash, Admixture, Concrete, Compressive Strength, Durability

I. INTRODUCTION

The use of supplementary cementing materials or mineral admixtures for enhancing durability has gained considerable importance the last decade or so as a key to long service life of concrete structures. There are many mineral admixtures that are used in way throughout the world but rice husk ash stands out as an eco-friendly, sustainable and durable option for concrete. With the advancement of technology and increased field of applications of concrete and mortars, the strength workability, durability and other characters of the ordinary concrete need modifications to make it more suitable by situations. Added to this is the necessity to combat the increasing cost and scarcity of cement. Under these circumstances the use of admixtures is found to be an important alternative solution. The production of superior quality of Ordinary Portland Cement (OPC) in the country was primarily responsible for introducing the grading system in OPC by Bureau of Indian Standard (BIS) during 1986-87. The other varieties of structural cements, such as sulphate resisting Portland cement, Pozzolana cement and blast furnace slag cement found their way in the improve quality of prompted the structural engineers and major consumers to adopt higher grades of concretes in the construction work. This has been marked difference in the quality of concrete during this period primarily due to the availability of superior quality of cements in the market. The trend is continuing more and more varieties of cements are coming to the markets which help to the consumers to make appropriated grade quality of concrete to meet the specific construction requirement. The high performance fiber reinforced, polymer concrete composites and ready mixed concrete have been progressively introduced for specific applications. In the past continuous efforts were made to produce different kinds of cement, suitable for different situations by changing oxide composition and fineness of grinding. With the extensive use of cement, for widely varying conditions, the types of cement that could be made only by varying the relative proportions of the oxide compositions were not found to be sufficient. Recourses have been taken to add one or two more new materials, known as additives, to the clinker at the time of grinding, or to the use of entirely different basic raw materials in the manufacture of cement. The use of additives, changing chemical composition, and use of different raw materials have resulted in the availability of many types of cements to cater to the need of the construction industries for specific purposes. The most important Pozzolana materials are fly ash, silica fume and Metakaolin whose use in cement and concrete is thus likely to be a significant achievement in the development of concrete technology in the coming few decades. The high Performance fiber reinforced, polymer concrete composites and ready mixed concrete have been progressively introduced for specific applications.

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Rice Husk Ash in Concrete

RHA, produced after burning of Rice husks (RH) has high reactivity and pozzolanic property. Indian Standard code of practice for plain and reinforced concrete, IS 456- 2000, recommends use of RHA in concrete but does not specify quantities. Chemical compositions of RHA are affected due to burning process and temperature. Silica content in the ash increases with higher the burning temperature. Under controlled burning condition in industrial furnace, RHA contains silica in amorphous and highly cellular form, with 50-1000 m2/g surface area. So use of RHA with cement improves workability and stability, reduces heat evolution, thermal cracking and plastic shrinkage. This increases strength development, impermeability and durability by strengthening transition zone, modifying the pore-structure, blocking the large voids in the hydrated cement paste through pozzolanic reaction. RHA minimizes alkali-aggregate reaction, reduces expansion, refines pore structure and hinders diffusion of alkali ions to the surface of aggregate by micro porous structure. Portland cement contains 60 to 65% CaO and, upon hydration, a considerable portion of lime is released as free Ca(OH)2, which is primarily responsible for the poor performance of Portland cement concretes in acidic environments. Silica present in the RHA combines with the calcium hydroxide and results excellent resistance of the material to acidic environments. RHA replacing 10% Portland cement resists chloride penetration, improves capillary suction and accelerated chloride diffusivity. Pozzolanic reaction of RHA consumes Ca(OH)2 present in a hydrated Portland cement paste, reduces susceptible to acid attack and improves resistance to chloride penetration. This reduces large pores and porosity resulting very low permeability. The pozzolanic and cementitious reaction associated with RHA reduces the free lime present in the cement paste, decreases the permeability of the system, improves overall resistance to CO2 attack and enhances resistance to corrosion of steel in concrete. Highly micro porous structure RHA mixed concrete provides escape paths for the freezing water inside the concrete, relieving internal stresses, reducing micro cracking and improving freeze-thaw resistance.

Plastic Fibers in Concrete:

A polymer is generally manufactured by step-growth polymerization or addition polymerization. When combined with various agents to enhance or in any way alter the material properties of polymers the result is referred to as a plastic. Composite plastics refer to those types of plastics that result from bonding two or more homogeneous materials with different material properties to derive a final product with certain desired material and mechanical properties. Fibre-reinforced plastics are a category of composite plastics that specifically use fibre materials to mechanically enhance the strength and elasticity of plastics. The original plastic material without fibre reinforcement is known as the matrix. The matrix is a tough but relatively weak plastic that is reinforced by stronger stiffer reinforcing filaments or fibres. The extent that strength and elasticity are enhanced in a fibre-reinforced plastic depends on the mechanical properties of both the fibre and matrix, their volume relative to one another, and the fibre length and orientation within the matrix. Reinforcement of the matrix occurs by definition when the FRP material exhibits increased strength or elasticity relative to the strength and elasticity of the matrix alone. Extensive research work concerning to the various application and methods used for testing of the concrete made by recycled plastics are discussed by many researchers.

Need For Present Investigation

Though a lot of research is focused in the last decade on use of various admixtures in producing concrete, very little information is available on Rice Husk ash Fiber Reinforced Concrete. This new admixture combination has lot of potential for use in concrete. Hence, there is need to study the strength and workability characteristics of RHA-FRC (Rice Husk ash based fiber reinforced concrete).

II. MATERIALS AND METHODS

The scope of present investigation is to study and evaluate the effect of addition of Rice Husk Ash (0, 5, 10 & 15%) and Plastic Fibers (0, 1, 2 & 3 %) in concrete. Cubes of standard size 150mmx150mmx150mm were cast and tested for 28 days compressive strength. Standard cylinders of size 150mm x 300mm were cast and tested for 28days split tensile strength. Also standard beams of size 500mm x100mm x 100mm were cast and were tested for 28 days flexural strength.

Materials Used

Cement: - OPC Cement of 53-grade was used. Coarse Aggregate: - Crushed granite metal with 50% passing 20mm and retained on 12.5mm sieve and 50% passing 12.5mm and retained on 10mm sieve was used. Specific gravity of coarse aggregate was 2.75. Fine aggregate: - River sand from local sources was used as fine aggregate. The specific gravity of sand is 2.68. Water: - Potable fresh water, which is free from concentration of acid and organic substances was used for mixing the concrete.

Fiber: Fibre-reinforced plastic (FRP) (also fibre-reinforced polymer) is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass, carbon, aramid, or basalt. Rarely, other fibres such as paper or wood or asbestos have been used. The polymer is usually an epoxy, vinylester or polyester thermosetting plastic, and phenol formaldehyde resins are still in use. Plastic fibres used in the present work are shown in Figure 1.

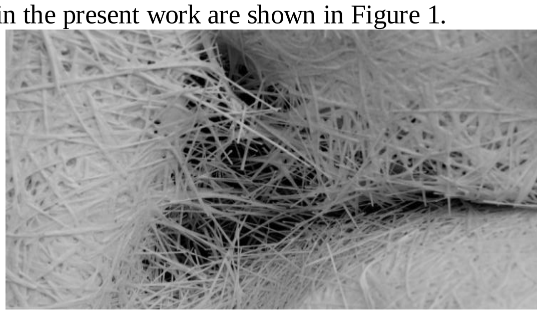

Figure 1. Plastic Fiber

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Rice Husk ash: - The husk surrounds the paddy grain. During milling of paddy about 78 % of weight is received as rice, broken rice and bran. Rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. This husk contains about 75 % 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. This RHA in turn contains around 85 % - 90 % amorphous silica. The moisture content ranged from 8·68 to 10·44%, and the bulk density ranged from 86 to 114 kg/ m3. Rice husk is unusually high in ash, which is 92 to 95% silica, highly porous and lightweight, with a very high external surface area. Its absorbent and insulating properties are useful to many industrial applications, such as acting as a strengthening agent in building materials. Rice husks are processed into rectangular shaped particle boards.Rice husk is the outer cover of paddy and accounts for 20-25 % of its weight. It is removed during rice milling and is used mainly as fuel for heating in Indian homes and industries. Its heating value of 13-15 MJ/kg is lower than most woody biomass fuels. However, it is extensively used in rural India because of its widespread availability and relatively low cost. The annual generation of rice husk in India is 18-22 million tons and this corresponds to a power generation potential of 1200 MW. A few rice husk-based power plants with capacities between I and10 MW are already in operation and these are based either on direct combustion or through fluidized bed combustion. Rice husk is characterized by low bulk density and high ash content (18-22% by weight). The large amount of ash generated during combustion has to be continuously removed for a smooth operation of the system. Silicon oxide forms the main component (90-97%) of the ash with trace amounts of CaO, MgO, K_2O) and Na_2O .

India is a major rice producing country, and the husk generated during milling is mostly used as a fuel in the boilers for processing paddy, producing energy through direct combustion and / or by gasification. About 20 million tones of RHA are produced annually. This RHA is a great environment threat causing damage to the land and the surrounding area in which it is dumped. Lots of ways are being thought of for disposing them by making commercial use of this RHA. RHA used in the present work is shown in Figure 2. below. Physical properties of RHa are given in Table.1 below.

Figure 2. Rice Husk Ash

Table .1 Chemical Composition of Rice Husk Ash

S.No	Parameter	Quantity
1	Loss on ignition	8.71
2	Silica (as SiO_2)	83.60
3	Aluminium (as Al_2O_3)	3.05
4	Iron (as Fe_2O_3)	1.10
5	Titanium (as TiO_2)	Nil
6	Calcium (as CaO)	1.80
7	Magnesium (as MgO)	1.28
8	Sodium (as Na_2O)	0.17
9	Potassium (as K_2O)	0.29

Test Programme

To evaluate the strength characteristics in terms of compressive, split tensile and flexural strengths, a total of 16 mixes were tried with different percentages of Rice Husk ash (0,5,10 & 15%) and different percentages of Plastic fibers (0,1,2 & 3%). In all mixes the same type of aggregate i.e. crushed granite aggregate; river sand and the same proportion of fine aggregate to total aggregate are used. The relative proportions of cement, coarse aggregate, sand and water are obtained by IS - Code method. M30 is considered as the reference mix.

Figure 3. Compressive strength test setup

Figure 4. Split tensile strength test setup

Figure 5. Flexural strength test setup

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III. RESULTS AND DISCUSSION

The results obtained from the experimental procedures were tabulated and presented below. The variations of parameters with respect to the percentage of admixtures are also shown in graphs below.

Compressive strength

Table .2 Compressive strength data at the age of 7 days

PLASTIC FIBRE%	0% RHA	5% RHA	10 % RHA	15 % RHA
0	13.53	15.52	15.98	13.75
1	13.64	15.48	16.12	13.62
2	13.75	14.64	16.98	13.45
3	13.98	14.85	17.09	13.52

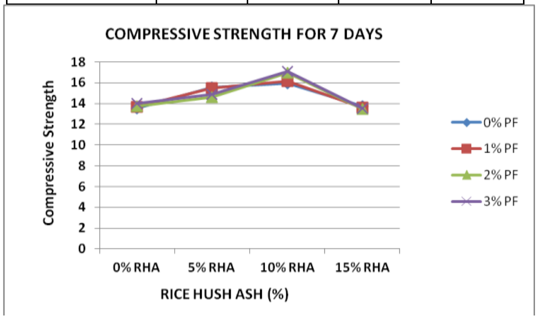

Figure 6 Compressive strength for 7 days

From the above graph it is understood that for all percentages of plastic fibres, at 10% replacement of rice husk ash there is an increase in compressive strength for 7 days. At 3% replacement of plastic fibres there is optimum increase in compressive strength at 7 days. The compressive strength obtained after replacement of 3% plastic fibres and 10% rice husk ash for 7 days is 17.09 Mpa.

Table 3. Compressive strength data at the age of 28 days

PLASTIC FIBRE%	0% RHA	5% RHA	10 % RHA	15 % RHA
0	22.19	21.72	25.75	21.07
1	21.99	21.64	25.64	20.98
2	19.23	23.23	25.46	20.34
3	19.68	23.53	25.53	20.41

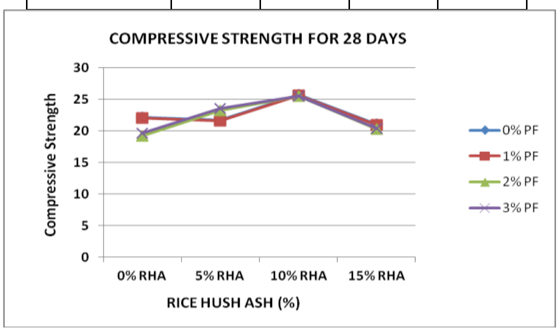

Figure 7. Compressive strength for 28 days

From the above graph it is understood that for all percentages of plastic fibres, at 10% replacement of rice husk ash, there is an increase in compressive strength for 28 days. At 0% replacement of plastic fibres there is optimum increase in compressive strength at 28 days. The compressive strength obtained after replacement of 0% plastic fibres and 10% rice husk ash for 28 days is 25.75 Mpa.

Split Tensile Strength

Table 4. Split Tensile Strength Data at the Age of 7 Days

PLASTIC FIBRE%	0% RHA	5% RHA	10 % RHA	15 % RHA
0	1.68	1.95	2.44	1.75
1	1.54	1.89	2.23	1.64
2	2.06	2.12	2.41	1.86
3	2.10	2.15	2.31	1.95

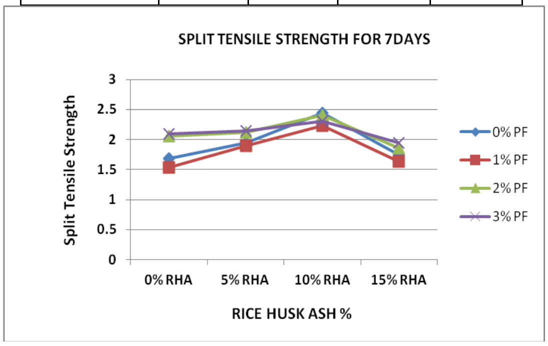

Figure 8. Split tensile strength for 7 days

From the above graph it is understood that for all percentages of plastic fibres, at 10% replacement of rice husk ash, there is a increase in split tensile strength for 7 days. At 0% replacement of plastic fibres there is optimum increase in split tensile strength at 7 days. The split tensile strength obtained after replacement of 0% plastic fibres and 10% rice husk ash for 7 days is 2.44 Mpa.

Table 5. Split Tensile Strength Data at the Age of 28 Days

PLASTIC FIBRE%	0% RHA	5% RHA	10 % RHA	15 % RHA
0	4.21	4.23	4.85	4.28
1	4.20	4.21	4.76	4.19
2	3.78	4.46	4.75	3.98
3	3.98	4.55	4.95	3.78

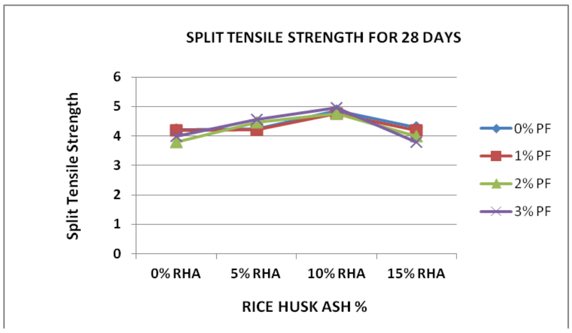

Figure 9. Split Tensile strength for 28 days

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From the above graph it is understood that for all percentages of plastic fibres, at 10% replacement of rice husk ash there is an increase in Split Tensile strength for 28 days. At 3% replacement of plastic fibres there is optimum increase in split tensile strength at 28 days. The Split Tensile strength obtained after replacement of 3% plastic fibres and 10% rice husk ash for 28 days is 4.95 Mpa.

Flexural Strength

Table 6. Flexural Strength Data at the Age of 7 Days

PLASTIC FIBRE%	0% RHA	5% RHA	10 % RHA	15 % RHA
0	1.55	1.75	2.41	1.71
1	1.46	1.64	2.34	1.86
2	1.84	2.06	2.24	1.89
3	1.95	2.11	2.27	1.91

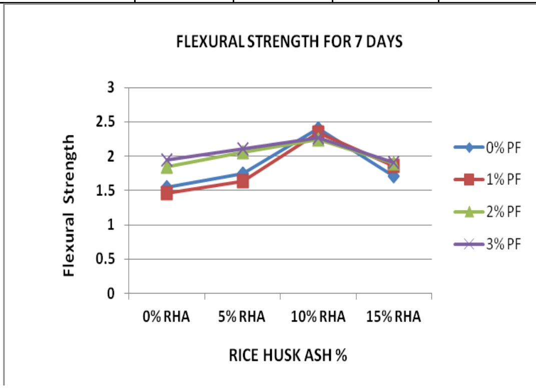

Figure 10. Flexural strength for 7 days

From the above graph it is understood that for all percentages of plastic fibres, at 10% replacement of rice husk ash there is a increase in flexural strength for 7 days. At 0% replacement of plastic fibres there is optimum increase in flexural strength at 7 days. The flexural strength obtained after replacement of 0% plastic fibres and 10% rice husk ash for 7 days is 2.41 Mpa.

Table 7. Flexural Strength Data at the Age of 28 Days

PLASTIC FIBRE%	0% RHA	5% RHA	10 % RHA	15 % RHA
0	4.18	4.17	4.81	4.25
1	4.06	4.13	4.75	4.18
2	3.84	4.45	4.84	3.64
3	3.95	4.51	4.91	3.75

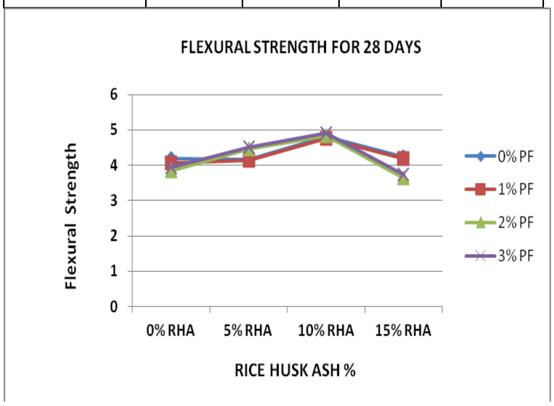

Figure 11. Flexural strength for 28 days

From the above graph it is understood that for all percentages of plastic fibres, at 10% replacement of rice husk ash there is a increase in flexural strength for 28 days. At 3% replacement of plastic fibres there is optimum increase in flexural strength at 28 days. The flexural strength obtained after replacement of 3% plastic fibres and 10% rice husk ash for 28 days is 4.91 Mpa.

IV. CONCLUSIONS

Results were analyzed to derive useful conclusions regarding the strength characteristics of Rice Husk ash fiber reinforced concrete (RHA-FRC). M20 concrete has been used as reference mix. From the experimental results of compressive strength after replacement of rice husk ash and plastic fiber for 7 days and 28 days, the compressive strength is optimum for10% replacement of rice husk ash for both 7 days and 28days, where as in case of plastic fibres 3% replacement is optimum for 7 days and 0% is optimum for 28 days. The results obtained for split tensile strength after replacement of rice husk ash and plastic fiber for 7 days and 28 days, the optimum split tensile strength is obtained at 10% replacement of rice husk ash for both 7 days and 28 days, whereas in case of plastic fiber optimum strength in obtained at 0% replacement for 7 days and 3% replacement for 28days.Optimum flexural strength is achieved after replacement of 10% of rice husk ash for both 7 days and 28 days with 0% and 3% addition of plastic fibres.

SCOPE FOR FUTURE INVESTIGATIONS

Studies on different lengths, proportions and aspect ratios of Plastic fibers may be carried out. Studies on the different proportions of Rice Husk ash may be carried out. Mathematical / Empirical models can be developed for the Stress/Strain behavior of strength characteristics on Rice Husk ash fibre reinforced concrete. Durability studies such as resistance to Sulphate attack, Acid resistance etc., can be carried out on Rice Husk ash fibre reinforced concrete.

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