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EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT AND FINE AGGREGATE WITH RICE HUSK ASH AND WASTE FOUNDRY SAND IN CONCRETE

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Abstract

Cement and fine aggregates are the major materials used in construction. Increase in the demand for these materials lead to the skyrocketing price of the construction. Due to this, the lower and middle income families are not able to build their own houses. There were studies about the research institutions are looking for alternatives can be used for construction to reduce the construction cost. In this regard an attempt has made to know the utilization of waste materials. In this project, Rice Husk Ash and Waste Foundry Sand were used in concrete for the replacement of cement and fine aggregate respectively. The most expensive concrete material is the binder (cement) and if such all-important expensive material is partially replaced with more natural, local and affordable material like RHA will not only take care of waste management but will also reduce the problem of high cost of concrete and housing. In this project, Rice Husk Ash which is taken from a brick kiln was used after grinding in a ball mill. Rice husk ash contains 90-95% SiO2, 1-3% K2O and < 5% un burnt carbon. Foundry sand is high quality silica sand with uniform physical characteristics. It is a By-product of ferrous and nonferrous steel industries, where sand has been used as a molding material. After the multiple usages the foundry sand it is used as land filling material.

This experimental investigation was performed to evaluate the strength properties of concrete in which cement and fine aggregates were partially replaced with Rice Husk Ash and Waste Foundry Sand. Compression test, Split Tensile test, Flexural strength test and workability tests were conducted at the age of 28,56 and 90 days by replacement of river sand with different percentages (0%,10%,20%,30%,40%,50%and 60%) and also with 10% incorporating with rice husk ash. Compressive strength test was carried out on cement mortar cubes to know the optimum percentage of rice husk ash. The results indicate effective use of rice husk ash and waste foundry sand as partial replacement of cement and fine aggregate. However, the percentage of rice husk ash is limited to 10% and waste foundry sand is up to 40%. After these limitations the strength started decreasing. And also the concrete incorporating with rice husk ash showed better workability than plain concrete with inclusion of waste foundry sand.

Keywords: Rice Husk Ash, Waste Foundry Sand, Compressive Strength, Split Tensile Strength, Flexure Strength

I. INTRODUCTION

Concrete, in the broadest sense, is any product or mass made by the use of a cementing medium. Generally, this medium is the product of reaction between hydraulic cement and water. For concrete to be good concrete it has to be satisfactory in its hardened state and also in its fresh state while being transported from the mixer and placed in the formwork. The requirements in the fresh state are that the consistence of the mix is such that the concrete can be compacted and also that the mix is cohesive enough to be transported and placed without segregation. As far as the hardened state is considered, the usual requirement is a satisfactory compressive strength. Many properties of concrete are related to its compressive strength such as density, impermeability, durability, resistance to abrasion, resistance to impact, tensile strength, and resistance to sulphates.

1.1 Waste Foundry Sand

Solid waste management has become one of the global environmental issues, as there is continuous increase in industrial by-products and waste materials. Due to lack of land filling space and its ever increasing cost, utilization of waste material and by-products has become an attractive alternative to disposal. Waste foundry sand (WFS) is one of such industrial by-product. Ferrous and non ferrous metal casting industries produce several million tons of byproduct in the world. In India, approximately 2 million tons of waste foundry sand is produced yearly. WFS is major byproduct of metal casting industry and successfully used as a land filling material for many years. But use of waste foundry sand for land filling is becoming a problem due to rapid increase in disposal cost. Metal foundries use large amounts of sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed "Waste Foundry Sand".

1.2 Rice Husk Ash

India is a major rice producing country. Rice milling generates a byproduct know as husk. This 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 and the husk generated during milling is mostly used as a fuel in the boilers for processing paddy, producing energy through direct combustion or by gasification. Rice husk is an agricultural residue which accounts for 20% of the 700 million tons of rice produced annually worldwide .About 20 million tons of RHA is 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. Rice husk is one of the most widely available agricultural wastes in many rice producing countries around the world. Burning of RH in ambient atmosphere leaves a residue, called rice husk ash. For every 1000 kgs of paddy milled, about 220 kgs (22 %) of husk is produced, and when this husk is burnt in the boilers, about 55 kgs (25 %) of RHA is generated. Rice husk removal during rice refining, creates disposal problem due to less commercial interest.

The produced partially burnt husk from the brick kiln when used as a fuel also contributes to the problem of disposal and efforts are being made to overcome this environmental issue by utilizing this material as a supplementary cementing material. The chemical composition of rice husk ash is found to vary from one sample to another due to the differences in the type of paddy, crop year, climate and geographical conditions.

1.3 Need for the Present Work

Waste foundry sand represents the highest amount of solid wastes generated by foundries. The high cost of land-filling and the potential uses of waste foundry sand in construction purposes have prompted research into their beneficial reuse. Ferrous and nonferrous metal casting industries produce several million tons of byproduct in the world. In India, approximately 2 million tons of waste foundry sand is produced yearly. WFS is major byproduct of metal casting industry and successfully used as a land filling material for many years. But use of waste foundry sand for land filling is becoming a problem due to rapid increase in disposal cost. In an effort to use the WFS in large volume, researches are being carried out for its possible large scale utilization in making concrete as partial replacement of fine aggregate. And also the increased rates of cement dashed all the sectors. By using waste materials like RHA in supplementary to cement will give some relief to the construction. Therefore an attempt has been made in the present study to evaluate the strength properties of concrete mixtures in which fine aggregate (river sand) was partially replaced with Waste Foundry Sand and cement with Rice Husk Ash.

The present experiment is carried out to investigate strength properties of concrete mixes of grade M40 in which fine aggregate (river sand) is to be partially replaced with Waste Foundry Sand. Fine aggregate will be replaced with six percentages (10%, 20%, 30%, 40%, 50% and 60%) of WFS by weight. Some of the strength properties such as Compressive strength, Split tensile strength and Flexural strength of Plain Concrete are to be compared with Binary blended concrete using Rice Husk Ash replacing cement by its optimum percentage.

II. LITERATURE REVIEW

Ghassan Abood Habeeb, **Hilmi Bin Mahmud [1] (2010)** investigated the properties of rice husk ash (RHA) produced by using a Ferro-cement furnace. The effect of grinding on the particle size and the surface area was first investigated, and then the XRD analysis was conducted to verify the presence of amorphous silica in the ash. RHA concrete gave excellent improvement in strength for 10% replacement (30.8% increment compared to the control mix), and up to 20% of cement could be valuably replaced with RHA without adversely affecting the strength. Increasing RHA fineness enhanced the strength of blended concrete compared to coarser RHA and control OPC mixtures.

Gritsada Sua-iam, Natt Makul[2] (2013) investigated the properties of self-compacting concrete (SCC) mixtures comprising ternary combinations of Type 1 Portland cement (OPC), untreated rice husk ash (RHA), and pulverized fuel ash (FA). The SCC mixtures were produced with a controlled slump flow in the range between 67.5 to 72.5 cm diameter with a constant total powder materials content of 550 kg/m^3. RHA and/or FA were used to replace in powder materials with 20 or 40 wt%. The fresh and hardened properties including water requirement, workability, density, compressive strength development and ultrasonic pulse velocity were determined. Self-compacting concrete mixtures formulated using ternary blends exhibited significant improvements in physical properties compared to SCC mixtures containing only RHA or FA.

Rafat Siddique, Geert de Schutter and Albert Noumowec [3] (2008) presented the results of an experimental investigation carried out to evaluate the mechanical properties of concrete mixtures in which fine aggregate (regular sand) was partially replaced with waste foundry sand. Fine aggregate was replaced with three percentages (10%, 20%, and 30%) of WFS by weight. Tests were performed for the properties of fresh concrete. Compressive strength, splitting- tensile strength, flexural strength, and modulus of elasticity were determined at 28, 56, 91, and 365 days. Test results indicated a marginal increase in the strength properties of plain concrete by the inclusion of WFS as partial replacement of fine aggregate (sand) and that can be effectively used in making good quality concrete and construction materials.

Yogesh Aggarwal, Paratibha Aggarwal, Rafat Siddique, El-Hadj Kadri and Rachid Bennacer [4] (2010) presented the design of concrete mixes made with waste foundry sand as partial replacement of fine aggregates up to 40%. Various mechanical properties are evaluated (compressive strength, and split tensile strength). Durability of the concrete regarding resistance to chloride penetration, and carbonation is also evaluated. Test results indicate that industrial by-products can produce concrete with sufficient strength and durability to replace normal concrete. Compressive strength, and split-tensile strength, was determined at 28, 90 and 365 days. Comparative strength development of foundry sand mixes in relation to the control mix i.e. mix without foundry sand was observed. Thereby, indicating effective use of foundry sand as an alternate material, as partial replacement of fine aggregates in concrete.

III. Experimental Materials

Thematerials used in this experimental study were cement, fine aggregate, coarse aggregate, water, waste foundry sand, Rice Husk Ash and super plasticizer.

3.1 Cement

Ordinary Portland cement (Ultra tech cement) of 53 grade confirming to IS: 12269-1987was used. It was tested for its physical properties as per IS 4031 (part II)-1988.

3.2 Aggregate

The size, shape and gradation of the aggregate play an important role in achieving a proper concrete. The flaky and elongated particles will lead to blocking problems in confined zones. The sizes of aggregates will depend upon the size of rebar spacing. The coarse aggregate chosen for Concrete was typically angular in shape, well graded, and smaller than maximum size suited for conventional concrete; typical conventional concrete should have a maximum aggregate size of 20mm. Gradation is an important factor in choosing a coarse aggregate. Gap-graded coarse aggregate promotes segregation to a greater degree than the well graded coarse aggregate.

3.2.1 Fine Aggregate

The locally available river sand was used as fine aggregate in the present investigation. The sand was free from clayey matter, salt and organic impurities. The sand was tested for various properties like specific gravity, bulk density etc., and in accordance with IS 2386-1963. The fine aggregate was conforming to standard specifications.

3.2.2 Coarse Aggregate

Machine crushed angular granite metal of 20mm nominal size from the local source was used as coarse aggregate. It was free from impurities such as dust, clay particles and organic matter etc. The physical properties of coarse aggregate were investigated in accordance with IS 2386 -1963.

3.2.3 Waste Foundry Sand

Waste foundry sand was obtained locally from Agarwal Rolling Mills, Shamshabad,and Hyderabad. WFS were used as a partial replacement of fine aggregate (natural river sand). Metal poured in the foundry is gray iron. The sand was tested for various properties like specific gravity, bulk density etc., and in accordance with IS 2386-1963. The details of test results are given in below table

3.2.3 Water

Locally available water used for mixing and curing which is potable and is free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel.

3.2.4 Rice Husk Ash

Rice Husk Ash is brought from bricks making area at Nandyal near SVR Engineering College used in the present program.

3.2.5 Super Plasticizer

Super plasticizer by trade name Conplast SP 430 manufactured by Fosroc Chemicals (India) limited obtained from S.V Enterprices, Habsiguda, Hyderabad was used as a water reducing agent to achieve the required workability. The dosage of super plasticizer was kept constant throughout the experimental program at 0.5% of the weight of the binder.

3.3 Preparation of Test Specimens

3.3.1 Weighing

The quantities of cement rice husk ash, size of aggregate, and water for each batch were determined by weight, to an accuracy of 0.1 percent of the total weight of the batch.

3.3.2 Concrete Mixing

Mixing of ingredients was done in a rotating pan mixer was adopted.

Fine aggregate and waste foundry sand were thoroughly mixed in a tray using a trowel and similarly the cementitious materials were also thoroughly blended. The drum was loaded with about one-half of the coarse aggregate, then with the fine aggregate, then with the cement and finally with the remaining coarse aggregate on top and the water was added immediately before the rotation of the drum started. The period of mixing was not less than 2 minutes after all the materials were charged in the drum, and the mixing was continued till the resulting concrete was uniform in appearance.

3.3.3 Workability

Each batch of concrete was tested for consistency immediately after mixing, by one of the methods described in IS: 1199-1959. Provided that care was taken to ensure that no water or other material was lost, the concrete used for the consistency tests was remixed with the remainder of batch before making the test specimens. The period of re-mixing was as short as possible yet sufficient to produce a homogeneous mass.

3.3.4 Casting of Specimens

In assembling the mould for use, the joints between the sections of mould were thinly coated with mould oil and a similar coating of mould oil was applied between the contact surfaces of the bottom of the mould and the base plate in order to ensure that no water escapes during the filling. The interior surfaces of the assembled mould were thinly coated with mould oil to prevent adhesion of the concrete. And for cylinders the mould and base plate were coated with a thin film of mould oil before use, in order to prevent adhesion of the concrete.

3.3.5 Compaction

The compaction was done on plane table vibrator and also by using the standard tamping bar for mortar cubes was used and the strokes of the bar were distributed in a uniform manner over the cross-section of the mould.

IV. EXPERIMENTAL RESULTS

4.1 Compressive Strength Test

Table 4.1 Compressive Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand

S.No.	Mix ID	Compressive Strength (MPa)		
		28 days	56 days	90 days
1	WFS0	32.6	42.4	52.07
2	WFS10	33.09	43.4	52.27
3	WFS20	33.32	43.8	53.15
4	WFS30	33.65	44	53.71
5	WFS40	34.22	44.5	54.74
6	WFS50	34.12	44.2	51.18
7	WFS60	32.03	42.1	46.43

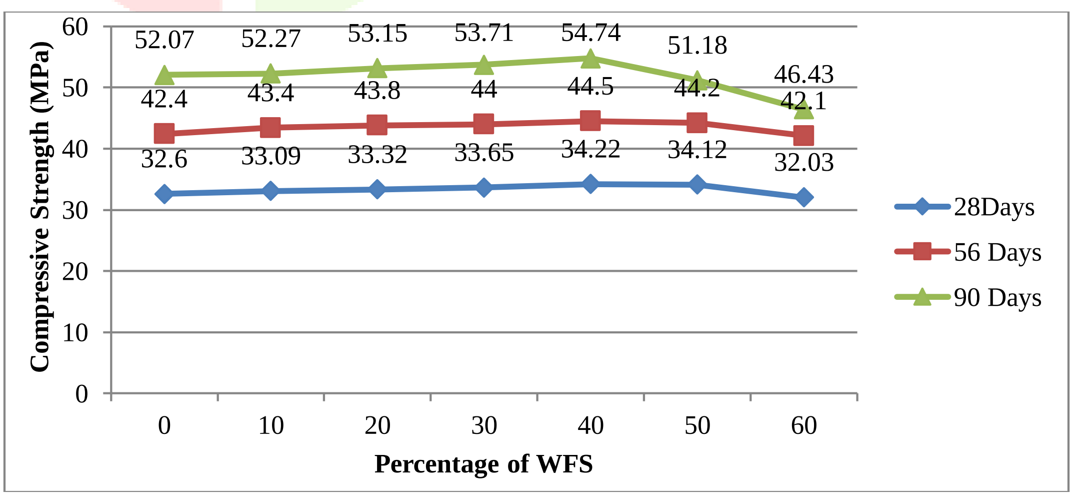

Figure 4.1: Compressive Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand at Different Ages

Table 4.2. Compressive Strength of Various Concrete Mixes with Different Percentage of rice husk ash at Different Ages

S.No.	Mix ID	Compressive Strength (MPa)		
		28 days	56 days	90 days
1	RHA0	28.25	35.10	44.66
2	RHA5	30.56	37.10	45.10
3	RHA10	33.55	38.43	48.22
4	RHA 15	31.5	37.32	47.47

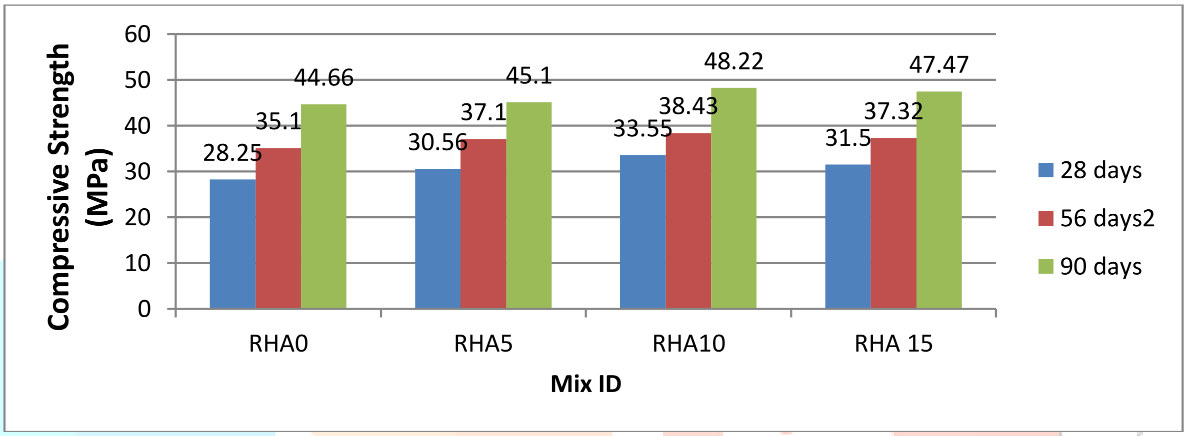

Figure 4.2: Compressive Strength of Various Concrete Mixes with Different Percentage of rice husk ashat Different Ages

4.3.1 Split Tensile Strength Test

Table 4.3 and Figure 4.3 show the graphical representation of variation of split tensile strength of plain concrete at 56 and 90 days.

Table 4.3.1 Split Tensile Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand at Different Ages

S.No.	Mix ID	Split Tensile Strength (MPa)		
		28 days	56 days	90 days
1	WFS0	2.71	3.71	4.58
2	WFS10	2.85	3.85	4.62
3	WFS20	2.93	3.93	4.90
4	WFS30	2.95	3.95	5.00
5	WFS40	3.55	4.55	5.20
6	WFS50	3.05	4.05	4.95
7	WFS60	2.96	3.96	4.70

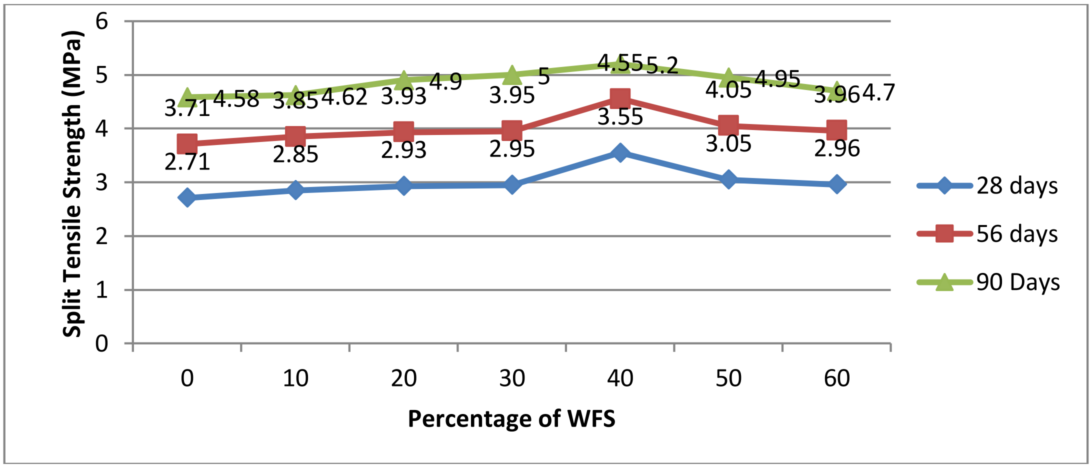

Figure 4.3.1: Split Tensile Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand at Different Ages

Table 4.3.2 Split Tensile Strength of Various Concrete Mixes with rice husk ash and Different Percentages of Waste Foundry Sand

S.No.	Mix ID	Split Tensile Strength (MPa)		
		(28 days)	(56 days)	(90 days)
1	RHA0	2.35	3.28	4.08
2	RHA5	2.48	3.47	4.16
3	RHA10	2.56	3.65	4.45
4	RHA15	2.2	3.2	4.1

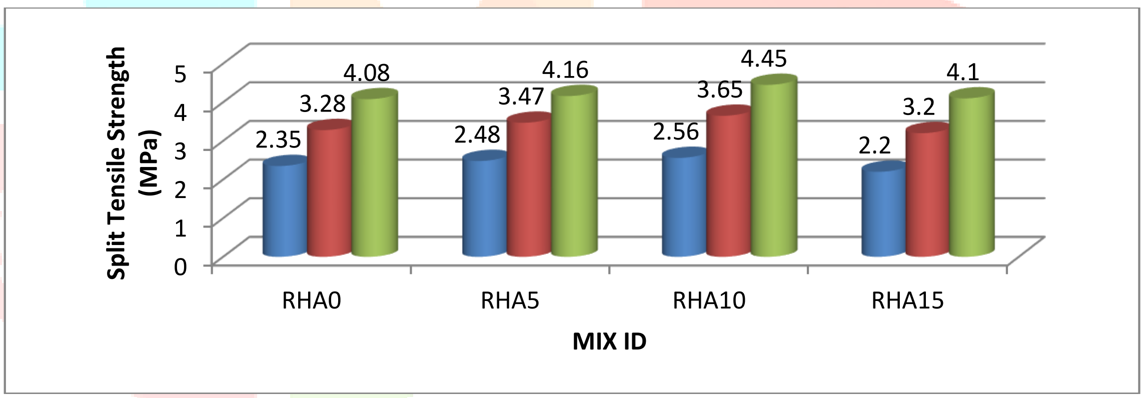

Fig 4.3.2: Split Tensile Strength of Various Concrete Mixes with rice husk

Table 4.3.3: Split Tensile Strength of Various Concrete Mixes with rice husk ash and Different Percentages of Waste Foundry Sand

S.No.	Mix ID	Split Tensile Strength (MPa)		
		(28 days)	(56 days)	(90 days)
1	RHA10WFS0	3.18	4.12	5.08
2	RHA10WFS20	3.45	4.35	5.20
3	RHA10WFS40	3.62	4.45	5.45
4	RHA10WFS60	3.2	4.04	4.9

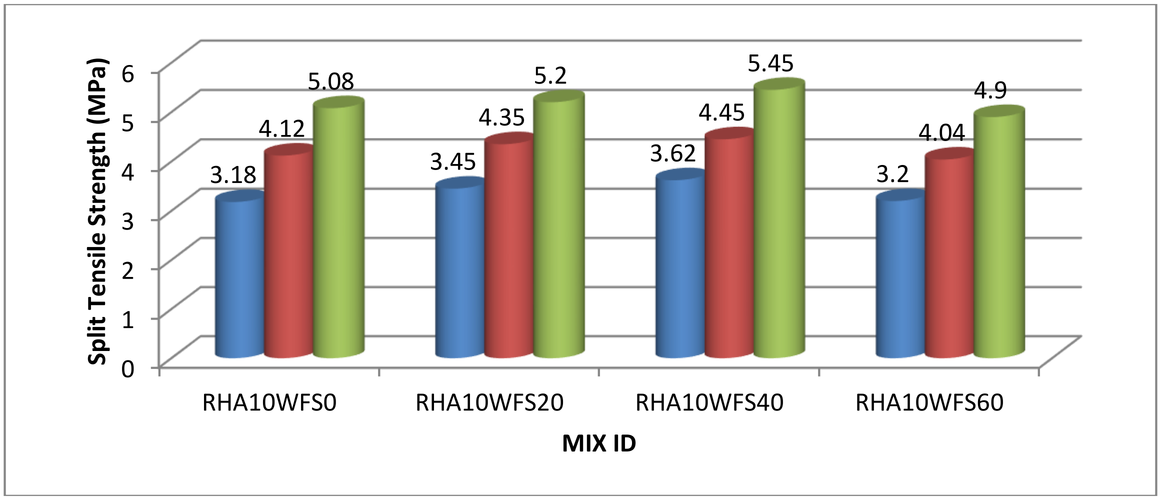

Fig 4.3.3 : Split Tensile Strength of Various Concrete Mixes with rice husk ash and Different Percentages of Waste Foundry Sand at 90 days of curing

4.4 Flexural Strength Test

Table 4.4.1 Flexural Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand

S.No.	Mix ID	Flexural Strength (MPa)		
		28 days	56 days	90 days
1	WFS0	4.9	5.7	6.8
2	WFS10	4.7	5.6	6.5
3	WFS20	4.6	5.4	6.3
4	WFS30	4.3	5.2	6.1
5	WFS40	4.1	5.1	6.0
6	WFS50	4.0	5	5.9
7	WFS60	3.9	4.95	5.5

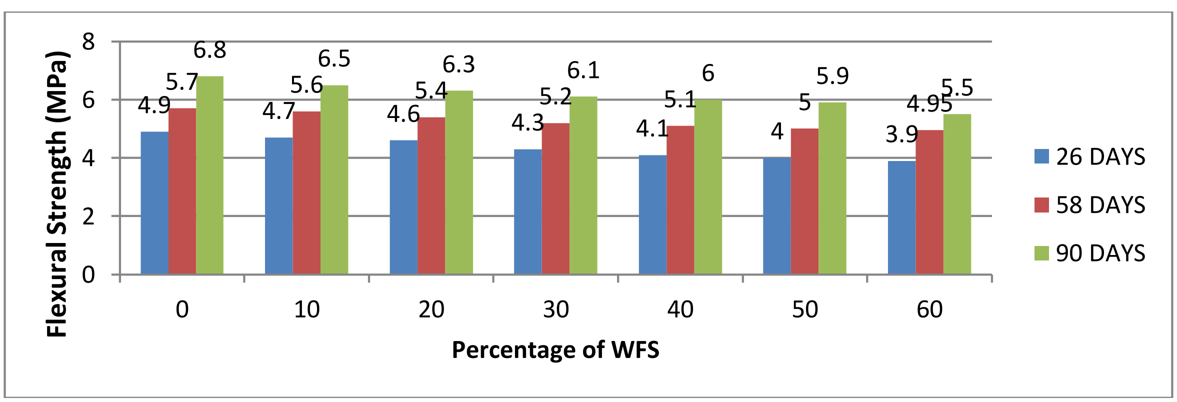

Figure 4: Flexural Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand

4.4.2 Flexural Strength Test

Flexural strength of concrete at 90 days of curing with 10% rice husk ashand various percentage replacement of fine aggregate with waste foundry sand were tested.

Table 4.4.2 Flexural Strength of Various Concrete Mixes with rice husk ash and Different Percentage of Waste Foundry Sand

S.No.	Mix ID	Flexural Strength (MPa)		
		(28 days)	(56 days)	(90 days)
1	RHA10WFS0	3.8	5.5	7.2
2	RHA10WFS20	3.5	5.2	6.5
3	RHA10WFS40	3.2	4.7	6.1
4	RHA10WFS60	3.1	4.6	5.8

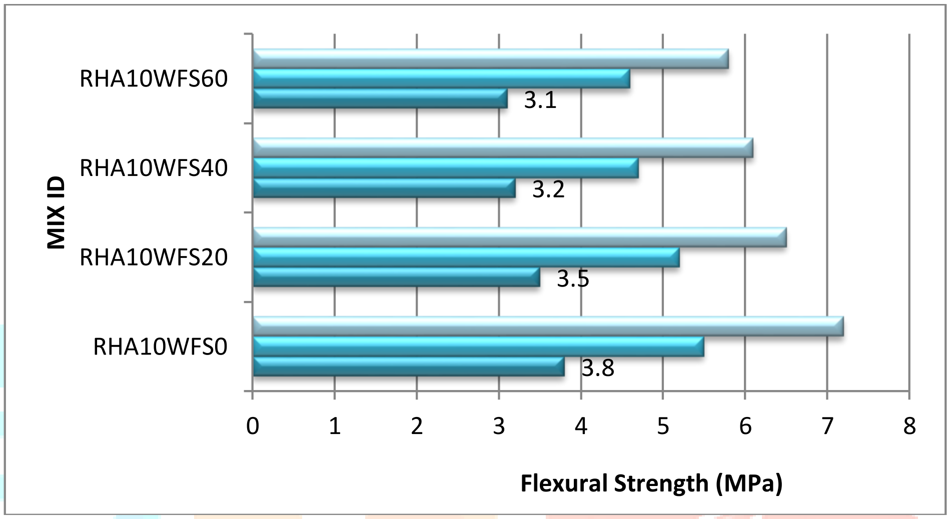

Fig 4.4.2: Flexural Strength of Various Concrete Mixes with rice husk ash and Different Percentage of Waste Foundry Sand at days of curing

V. CONCLUSION

- When percentage of waste foundry sand was increased beyond 40% the mix started losing its workability.
- When cement replaced with rice husk ash for mortar cubes strength increased up to 10 % replacement and then decreased. So, 10 % replacement is optimum here.
- Replacement of fine aggregate with waste foundry sand showed increase in the compressive strength of plain concrete of grade M40 up to 40% and then there was a considerable decrease in the strength. Maximum strength was achieved at 40%.
- For Plain Concrete mix at 60% replacement of fine aggregate strength of 46.43 MPa was achieved at 90 days which is less than the target strength.
- Flexural strength of concrete decreased with the inclusion and increase in the percentage of waste foundry sand for plain concrete.
- 10% replacement of cement with rice husk ashwas found to be optimum for M40 grade of concrete.
- Binary Blended Concrete mix with Rice husk ash as binder replacement containing 60% waste foundry sand was still workable.
- For Binary Blended Concrete mix at 60% replacement of fine aggregate, strength of 52.0 MPa was achieved at 90 days which is more than the target strength.
- Binary Blended Concrete incorporating rice husk ashshowed better performance when compared to plain concrete.
- 12 % increment in the compressive strength was found at 90 days using rice husk ash5% increase in the flexural strength was observed in Binary Blended Concrete mixes when compared to Plain Concrete mixes.
- Rice husk ash which is taken from bricks making kiln can be opted for replacement of cement for a considerable percentage (10 %) only.

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