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Experimental study on properties of concrete using RHA and M Sand

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Abstract— Cement is the most common and expensive binding material used in the field of construction. As the constructions are in numerous and rapid, the use of cement and cost is also increasing. Hence the use of admixtures and by-products are being used as additives to be economical and also to attain the same strength as in the normal concrete. This paper gives the study about the mechanical and durability properties of concrete with the constant replacement of cement with Rice Husk Ash (RHA) and fine aggregate with Manufacture Sand (M -Sand) in different proportions. A total of 6 mixes including control mix were done where 20% RHA has been constantly replaced with cement in all mixes and 0%, 25%, 50%, 75% and 100% replacement of M-Sand with fine aggregate were done for all the mixes. A total of 180 specimens including cubes and cylinders were casted and tested for the compressive strength, split tensile test, water absorption, acid resistance and sorptivity tests. The mixes containing 20% RHA with 50% and 75% M-Sand give economical results in all the mechanical and durability properties compared to control mix.

Keywords— Rice Husk Ash, Manufacture Sand, acid resistance, sorptivity, water absorption.

I. INTRODUCTION

Concrete is most essential and at most used thing in each and every construction work since many centuries. It also one of the oldest construction materials used in industries aswell. But as to meet the modern generation, many modifications are very much necessary in the construction field may it be in terms of strength, expenditure, exposure. In order to meet all these inevitable situations, we as engineers need to make new evolution in the construction field. There are large qualities waste products and by products which can be used effectively in many ways. Some of these products can be used in production of concrete and termed as mineral admixtures. These mineral admixtures can become fillers and can give the similar property as the concrete gives [1-3]. Having the wide spread awareness, environmental friendly and sustainable constructions in the world, the use of natural sand has been limited all over. In order to compensate this, manufactured sand is one thing which could behave similar to the fine aggregate properties. Use of M sand in the concrete can become essential in the use of construction industries and in the outside world as well [4-5]. Manufactured sand crushed from stone or gravel, also called as machine made sand, artificial sand has been used as a substitute of natural sand in concrete [4-6]. It is becoming a trend to safe guard the natural sand by making a good use of M sand in this modern world. Therefore, concrete with M sand has gradually become an essential and green building material [4-7]. Now on the other hand, its RHA which is a by-product obtained from the fields of paddy. RHA contains reactive amorphous silica content when the rice husk is properly burnt at the temperature range lower than 700℃ [8-9]. Many individual studies have been made in the use of RHA and M sand; they were resulted in an economical way and the liable strength. But use RHA and M sand in the replacement of cement and fine aggregate in the same project give less reports and venerable results in the use of both RHA and M sand. Keeping this in mind, the use of RHA in cement has been restricted to 20% and thereby made different proportions of M sand in fine aggregate were done. Use of M sand in this project has been vital and made 100% replacement of fine aggregate with M sand which made us to study a lot of information about the strength and durability of concrete.

Ahmadi et al [10] used different proportions of RHA for their work. The percentages of RHA were kept between 10% to 20% of the weight of total cementitious material. They stated that the use of RHA fetched better results in OPC. Safiuddin et al [11] affirmed that the utilization of RHA certainly has positive effects on the durability properties. Their results indicated towards better resistance to corrosion, freeze thaw cycles and sulphate attack of concrete made with RHA as compared to concrete without RHA. Chopra et al [12] used RHA in their work to replace cement. They used three different proportions of RHA between 10 and 20%. They spotted that the use of RHA had a positive impact on the compressive strength in SCC. They stated that there was about 33% addition in strength at 28 days with RHA content of 15%.

Shen et al [13] studied the characterization of M Sand like particle shape, surface texture and behaviour of concrete. Li et al [14] studied the influence of the M Sand's characteristics on strength and abrasion resistance of pavement cement concrete prepared with M Sand and the effect of lime stone fines content in M Sand on durability of low and high strength concretes. Those studies indicated that M Sand was not necessarily worse than river sand and certain stone powder content in the sand contributes to the strength development, abrasion resistance and durability of the concrete. Menadi et al [15] studied the strength and durability of concrete incorporating crushed lime stone sand. Most research work indicated that the properties of M Sand or crushed sand concretes had equal or even better properties than river sand concrete in some respects.

II. EXPERIMENTAL PROGRAM

Binding material used in this is OPC 53 grade cement and the physical properties are shown in the table I. The binding material which is OPC 53 grade cement is tested according to IS: 8112 and found to be conforming the Indian standards.

TABLE I
PHYSICAL PROPERTIES OF CEMENT

S.NO	Particulars	Results
1	Normal Consistency	32%
2	Fineness Of Cement	6
3	Initial Setting Time	30min
4	Final Setting Time	10 Hours
5	Specific Gravity	3.15
6	Soundness Of Cement	6mm

The fine and coarse aggregates are acquired form locally available places. These aggregates are also tested according to IS: 383-1970 and found conforming the Indian standards and are shown in the table II and III.

TABLE II
PHYSICAL PROPERTIES OF COARSE AGGREGATE

S.NO	PARTICULARS	COARSE AGGREGATE
1	Crushing Value	19.5 %
2	Impact Value	16.2 %
3	Los Angels Abrasion Test on Coarse Aggregate	31.8 %
4	Flakiness Index	10.2%
5	Elongation Index	9.9 %
6	Bulk Density Without Compaction	1.4Kg/lit
7	Bulk Density With Compaction	1.5 Kg/ lit
8	Specific Gravity	2.5
9	Water Absorption	0.3%

TABLE III
PHYSICAL PROPERTIES OF FINE AGGREGATE

S.NO	Particulars	River Sand
1	Specific gravity	2.61
2	Bulk density without compaction	1.618 kg/lit
3	Bulk density with compaction	1.763 kg/lit
4	Water absorption	1.2%
5	Bulking of sand	14%

Now, the mineral admixtures RHA and M-Sand are also acquired from locally available areas. The physical properties of these mineral admixtures are shown in the table IV and V.

TABLE IV
PHYSICAL PROPERTIES OF RICE HUSK ASH

S.NO	Particulars	Results
1	Normal Consistency	32%
2	Fineness Of Cement	6
3	Initial Setting Time	30min
4	Final Setting Time	10 Hours
5	Specific Gravity	3.15
6	Soundness Of Cement	6mm

TABLE V
PHYSICAL PROPERTIES OF M - SAND

S.NO	Particulars	M Sand
1	Specific gravity	2.64
2	Bulk density without compaction	1.709 kg/lit
3	Bulk density with compaction	1.992 kg/lit
4	Water absorption	1.6%
5	Bulking of M - Sand	12%

In total, six mixes were developed. One was control mix (0-0) and other five mixes (20-0, 20-25, 20-50, 20-75, and 20-100) were prepared by 20% constant replacement of cement with RHA and fine aggregate with M-sand in proportions of 0%, 25%, 50%, 75% and 100% from the volume of fine aggregate. The volume of coarse aggregate was fixed with 1034

kg/m^3 and w/c ratio of 0.55 was maintained. For control mix, cement used was 358 kg/m^3; fine aggregate used was 792 kg/m^3. These were suitably replaced for different mixes and the mix proportions are shown in the table VI. For each mix 36 specimens were casted and tested, which consists of 108 cubes of size 150 mm x 150 mm, for compressive strength (7, 14 and 28 days), water absorption (28, 56 and 90 days) and acid resistance (28, 56 and 90 days). And for split tensile strength, 36 specimens were casted and tested having 150 mm x 300 mm dimensions and 36 specimens were casted and tested having 100 mm x 200 mm dimension cylinders for sorptivity tests. Thereby, totally 180 specimens (108 cubes and 72 cylinders) were casted and tested for this project.
The testing moulds were cleaned and greased before filling the concrete. It was allowed to be in moulds for 24 hours and then carefully taken out and kept in curing tank for hardened state. All these specimens were then tested accordingly for various properties.

TABLE VI
TOTAL MIXES AND ITS PROPORTIONS

Mix	RHA & M – Sand (%)	Cement (kg/m^3)	w/c ratio	Coarse Aggregate (kg/m^3)	RHA (kg/m^3)	Fine Aggregate (kg/m^3)	Manufactured Sand (kg/m^3)
Control mix	0-0	358	0.55	1034	Nil	792	Nil
Mix 1	20-0	286	0.55	1034	72	792	Nil
Mix 2	20-25	286	0.55	1034	72	592	198
Mix 3	20-50	286	0.55	1034	72	396	396
Mix 4	20-75	286	0.55	1034	72	198	592
Mix 5	20-100	286	0.55	1034	72	Nil	792

III. RESULTS AND DISCUSSION

This section gives the detailed study about the mechanical and durability properties of mixes done. The study goes with the control mix details first, followed by remaining five mixes having constant RHA replacement and M-Sand to fine aggregate.

A. Mechanical Properties

The mechanical properties here contain compressive strength test and split tensile test. All the mixes casted for this study are tested for 7, 14 and 28 days. 36 cubes were tested for compressive strength and 36 cylinders were tested for split tensile strength. The results are shown in this section contains tabular and graphical format.

1) Compressive Strength: A 2000 kN compression machine is used for testing the cubes of 150 x 150 x 150 mm dimensions. These cubes were tested after the curing time of 7, 14 and 28 days. Table I shows the compressive strength values in N/mm^2 of 7, 14 and 28 days for all the mixes.

TABLE VII
COMPRESSIVE STRENGTH FOR ALL MIXES

S.No	M20 Mix RHA & M-Sand (%)	7 days	14 days	28 days
1	0-0	19.37	20.37	21.26
2	20-0	18.37	19.46	20.18
3	20-25	20.63	22.57	24.44
4	20-50	22.89	23.86	25.73
5	20-75	24.67	25.37	26.45
6	20-100	25.29	26.77	28.47

The graph now shows the way of increasing the compression strength values as the M-Sand replacement increases.

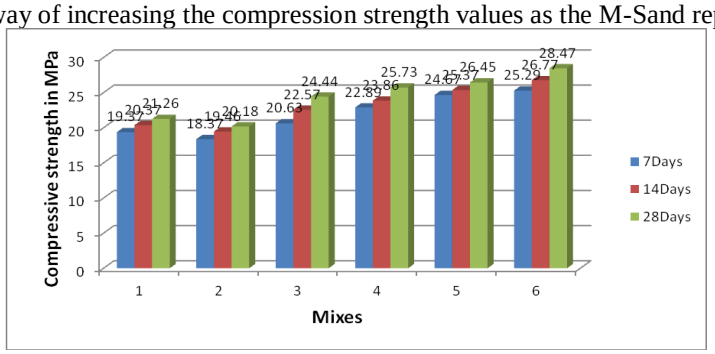

Fig. 1 Compressive strength for all mixes

2) Split Tensile Strength: Cylinders of 0.15 m x 0.30 m dimension were casted and tested for all the mixes after the curing period of 7, 14 and 28 days. Table II shows the mixes and split tensile strength values in N/mm^2.

TABLE VIIII
SPLIT TENSILE STRENGTH FOR ALL MIXES

S.No	M20 Mix RHA & M-Sand (%)	7 days	14 days	28 days
1	0-0	1.844	1.987	2.145
2	20-0	1.687	1.788	1.943
3	20-25	2.016	2.164	2.349
4	20-50	2.184	2.350	2.558
5	20-75	2.210	2.533	2.623
6	20-100	2.461	2.697	2.783

The graph now shows the way of increasing the compression strength values as the M-Sand replacement increases.

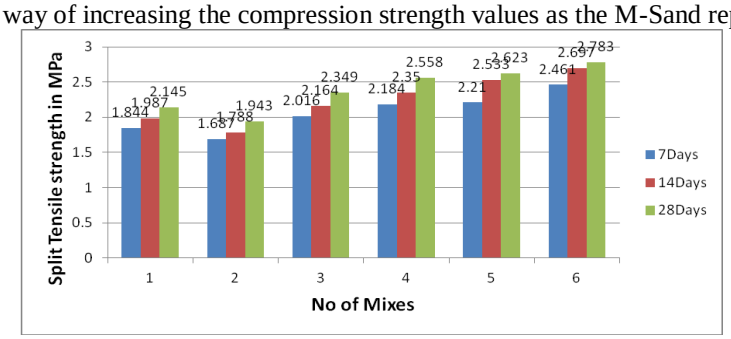

Fig. 2 Split tensile strength for all mixes

B. Durability Properties

The durability properties here in this paper shall be seen which contains water absorption test, acid resistance test and sorptivity. 72 cubes of 150 x 150 x 150 mm dimensions are used for casting and testing water absorption and acid resistance test. 36 cylinders of 0.10 x 0.20 m dimension are used for casting and testing sorptivity test. All these durability properties were conducted for 28, 56 and 90 days. Following tables and graphs can be seen which shows invaluable study on this.

1) Water Absorption: As mentioned, 36 cubes were tested after the curing time of 28, 56 and 90 days. All the values shown in the table for water absorption test are in percentage. The percentage loss of water can be seen decreasing as the days getting increases.

TABLE IIIX
WATER ABSORPTION FOR ALL MIXES

S.No	M20 Mix RHA & M-Sand (%)	28 days	56 days	90 days
1	0-0	0.652	0.523	0.324
2	20-0	0.702	0.572	0.376
3	20-25	0.825	0.680	0.420
4	20-50	0.542	0.398	0.365
5	20-75	0.407	0.377	0.342
6	20-100	0.395	0.360	0.304

The graph now shows the way of decreasing the percentage loss of water values as the M-Sand replacement increases.

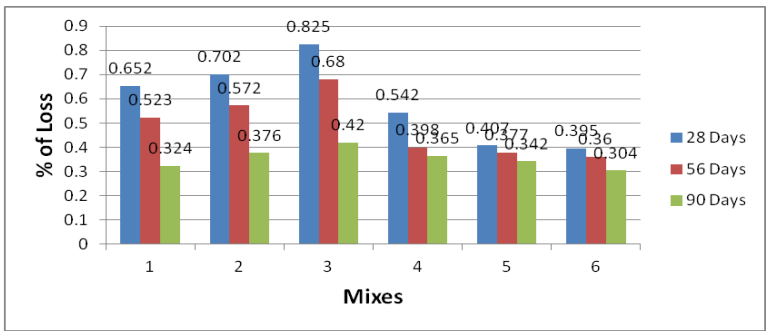

Fig. 3 Water Absorption values for all mixes

2) Acid Resistance: 36 cubes were tested after the curing time of 28, 56 and 90 days. All the values shown in the below table for acid resistance test are in percentage. The percentage loss of weight can be seen decreasing as the days getting increased and also as the replacement of M sand is getting increased.

TABLE X
ACID RESISTNACE FOR ALL MIXES

S.No	M20 Mix RHA & M-Sand (%)	28 days	56 days	90 days
1	0-0	8.35	0.79	0.51
2	20-0	8.17	0.57	0.37
3	20-25	8.58	0.94	0.72
4	20-50	9.12	1.12	0.91
5	20-75	9.48	1.45	1.03
6	20-100	9.73	2.21	1.31

The graph now shows the way of decreasing the percentage weight loss values as the M-Sand replacement increases.

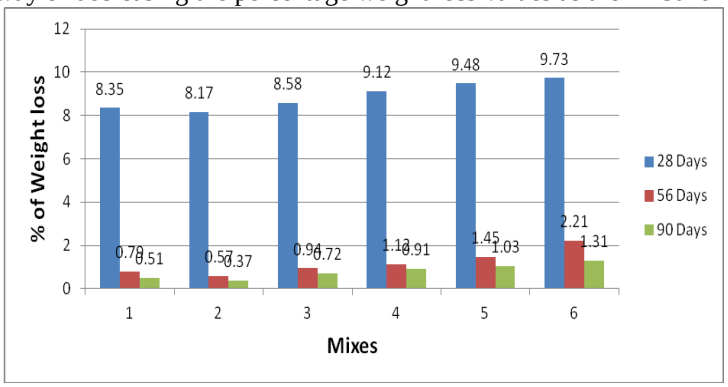

Fig. 4 Acid Resistance values for all mixes

3) Sorptivity: Here we can see the sorptivity values in mm/min for each and every mix. Totally 36 cylinders were casted and tested after the curing time of 28, 56 and 90 days. The sorptivity values are in 10^{-4} with mm/min units. As the values of sorptivity are increased, the strength of the specimen also increased.

TABLE XI
SORPTIVITY FOR ALL MIXES

S.No	M20 Mix RHA & M-Sand (%)	28 days	56 days	90 days
1	0-0	2.57	3.24	3.69
2	20-0	2.21	2.75	3.28
3	20-25	2.92	3.83	4.31
4	20-50	3.28	4.17	4.79
5	20-75	3.72	4.41	5.39
6	20-100	4.01	4.96	5.87

The graph now shows the way of increasing the sorptivity values as the M-Sand replacement increases.

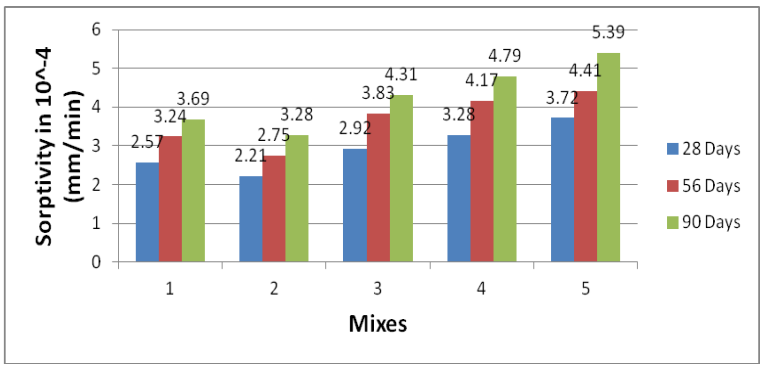

Fig. 5 Sorptivity values for all mixes

So these are the results achieved for all the tests done for the project. With the through study on the results, the following conslusions were made which gives the invaluable information about the usage of M-Sand and RHA in the constructions.

IV. CONCLUSIONS

The utilization of M- Sand and RHA in concrete proves to be advantageous. The use of M – Sand positively affected the compressive strength increasing it by 23%, 34% and 37% at 7, 14 and 28 days respectively. For the split tensile strength, the percentage of increase is 33%, 35% and 36% at 7, 14 and 28 days respectively. There was a decrease in water absorption by 11% to 25% when compared to control mix. There was 93% decrease in weight loss in final mix when compared to control mix. As the use of M-Sand got increased in the mixes, there is increase in percentage weight loss in acid resistance test. The complete replacement of M-Sand with fine aggregate has shown only 7% decrease in percentage weight loss. For sorptivity test, there is 43% increase in final mix when compared to control mix. Having studied and mentioned all these, it can be concluded that the complete replacement of M-sand with fine aggregate has shown a very good strength compared to control mix. Therefore, the use of fine aggregate can be reduced in construction, may not be 100% but to an extent where it can be from 50-75% to achieve good strength and to be economical.

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