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Study on Strength and Durability Characteristics of Concrete Containing Rice Straw ASH and Foundry Sand

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ABSTRACT- The production of raw cement results in carbon emissions into the environment which is a serious agenda that needs to be solved quickly before it's too late for the environment. Almost 8% of total carbon emissions from all over the world come from the cement industry. Billions of tons of carbon dioxide gas are being released into the environment when cement is produced in the manufacturing plants which are damaging the ozone layer of the earth. An alternative solution to the problem may be the use of sustainable concrete prepared by replacing some portion of cement with agro-industrial waste materials such as rice straw ash, foundry sand, rice husk ash etc. In the present study, use of rice straw ash and foundry sand as partial replacement of cement and fine aggregate has been investigated. The sustainable concrete of M35 grade using rice straw ash (5%, 10%, 15% and 20%) and foundry sand (5%, 10%, 15% and 20%) by partial replacement of cement has been prepared and various properties of concrete have been investigated.

KEYWORDS- Sustainable Concrete, Rice Straw Ash, Foundry Sand.

I. INTRODUCTION

Concrete structures, the most common structures, are being constructed with cement, aggregates, water, reinforcing bars (steel bars) with the addition of an external enhancing agent. This material in the fresh stage shows different behavior than the behavior of hardened concrete. millions of raw cements, sand (both coarse and fine), water, and steel bars are being excavated or produced in different parts of the world to meet the high demand of construction industries. The study and investigation of the properties at different stages of concrete and its application comes under the field of concrete technology. all the load-bearing structures are being with concrete as they can easily withstand heavy loads. Different kinds of cement such as OPC, PPC, Rapid hardening cement, etc. are being used in daily constructional work.

Manufacturing of cement results in emission of large amount of carbon dioxide which leads to various environmental problems. To address these problems, various researchers have investigated the utilization of alternate materials in place of cement and aggregate in concrete. Some researchers have investigated the use of foundry sand in concrete as partial replacement of cement at different proportions [1,2,3,5]. Some of the researchers have investigated the utilization of recycled concrete aggregates in structural concrete so that sustainability may be achieved in construction practices [9,10,11]. Rice husk ash and rice straw ash are other agro-industrial waste materials that have been investigated by researchers for potential utilization in structural concrete [4,6,7,8].

The work of construction industry continues even in times of pandemic and becomes essential after calamities. So, manufacturing of construction materials is going on at large scale resulting in depletion of natural resources and other environmental problems. So, alternative waste materials need to be utilized so that environmental issues may be addressed and natural resources may be conserved. In view of addressing the same problems, present study has been undertaken to investigate potential utilization of rice straw ash and foundry sand as partial replacement of cement in structural concrete.

II. MATERIAL USED

Cement: Ordinary Portland cement (grade 43) has been taken confirming to IS: 8112 codes [12]. The various physical properties of cement like consistency, initial and final setting time, specific gravity, etc. have been determined in the laboratory and the results are shown in the Table 1.

Table 1: Physical Properties of OPC 43 grade

S. No.	Properties	OPC 43 Grade	Requirement As Per IS Code
1.	Standard Consistency	28.8%	-
2	Initial Setting Time (min.)	135	>30
3	Final Setting Time (min.)	346	<600
4	Specific Gravity	3.15	3-3.15
5	Specific Surface Area (cm2/g)	2736	>2250

Fine Aggregates: The size of the fine aggregates lies between the 4.75 mm and 75 microns. The determination of physical properties and sieve analysis of fine aggregates has been done in accordance with IS 383: 2016 [13] and the

results are shown in the Table 2.

Table 2: Physical Properties of Fine Aggregates

Test	Result
Specific Gravity	2.64
Fineness Modulus	2.84
Water Absorption	1.16%

Coarse Aggregates: Angular shaped and crushed aggregates have been used as coarse aggregates in the present experimental study. The 10 mm coarse aggregate are selected for the current study. The determination of physical properties and sieve analysis of coarse aggregates has been done confirming to IS 383:2016 [13] and the results are shown in the Table 3.

Table 3: Physical Properties of Graded Coarse Aggregates

Test	Result
Color	Grey
Shape	Angular
Specific Gravity	2.68
Water absorption	0.61%

Rice Straw Ash: Rice straw is the end product of rice production and is obtained after the harvesting of rice. It is separated from the rice grains while harvesting the rice crop and is piled up in the corner through different machines. Straw to paddy ratio normally ranges from 0.7 to 1.4 which is highly dependent on the variety of rice and its growth methodologies. The specific gravity of RSA has been determined in accordance with IS 2720 (Part 3), (2002) and is determined as 2.25 g/cc [14].

Foundry Sand: Foundry sand is high-quality, clean, and uniform-sized silica sand with constant physical features. It is an end product of the ferrous and non-ferrous metal manufacturing companies. The sand is connected to form molds or patterns used for ferrous (iron and steel) and non-ferrous (copper, aluminum, brass) metal castings. In everyday foundry utilization, sand is commonly reclaimed and reused when it is processed through many different cycles. The foundry sand has the capacity to replace the fine aggregates in concrete. The specific gravity of foundry sand has been determined in accordance with IS 2720 (Part 3), (2002) and is determined as 2.65 g/cc [14].

III. CONCRETE MIX PROPORTION

The various concrete mixes i.e., control concrete mix and replacement concrete mixes have been prepared as per the addition of different proportions of replacement materials. The total 5 concrete mixes have been developed in current study as Cm, M1, M2, M3 and M4. Different Concrete Mix Designations undertaken in this study are shown in Table 4.

Table 4: Different Concrete Mix Designations

Mix Design	Rice Straw Ash %	Foundry Sand %
CM	0	0
M1	5	5
M2	10	10
M3	15	15
M4	20	20

IV. RESULTS AND DISCUSSION

Concrete specimens have been prepared in accordance with undertaken mix designations and different properties of prepared concrete mixes such as slump value, compressive strength, split tensile strength etc. have been determined and results are analyzed.

A. Slump Test

Slump test has been conducted on prepared specimens and results are shown in Figure 1. It can be observed that the slump value of control mix (without any replacements) comes out to be 105 mm. whereas, the slump value for concrete mix M1, M2, M3 and M4 comes out to be 96 mm, 89 mm, 75 mm and 71 mm.

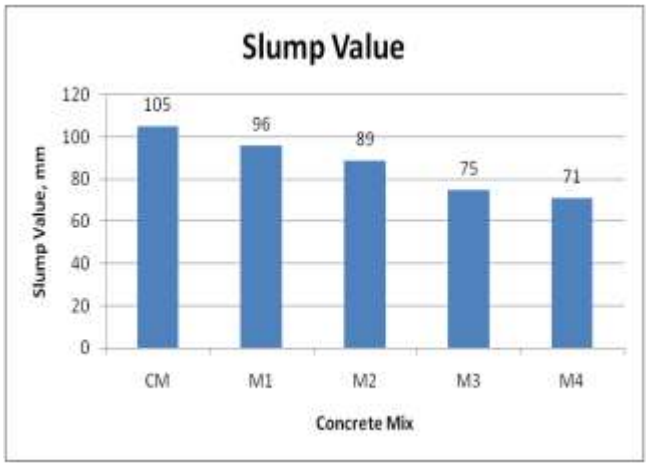

Figure 1: Slump Values for various Concrete Mixes

B. Compressive Strength Test

The compressive strength of control mix (without any replacements) comes out to be 29.02 MPa at 7 days and 44.75 MPa at 28 days. Whereas, the Compressive strength for concrete mix M1, M2, M3 and M4 comes out to be 30.84 MPa at 7 days and 45.98 MPa at 28 days, 32.87 MPa at 7 days and 47.16 MPa at 28 days, 34.11 MPa at 7 days and 48.01 MPa at 28 days, 29.41 MPa at 7 days and 45.17 MPa at 28 days. Test results are given in Figure 2.

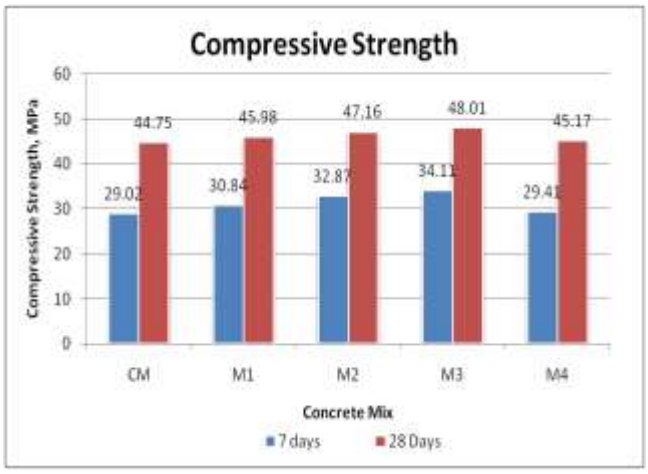

Figure 2: Compressive strength of various Concrete Mixes

C. Split Tensile Strength Test

The Split tensile strength of control mix (without any replacements) comes out to be 2.15 MPa at 7 days and 3.14 MPa at 28 days. Whereas, the Compressive strength for concrete mix M1, M2, M3 and M4 comes out to be 2.49 MPa at 7 days and 3.67 MPa at 28 days, 2.84 MPa at 7 days and 4.09 MPa at 28 days, 3.31 MPa at 7 days and 4.81 MPa at 28 days, 2.24 MPa at 7 days and 3.09 MPa at 28 days. Test results are given in Figure 3.

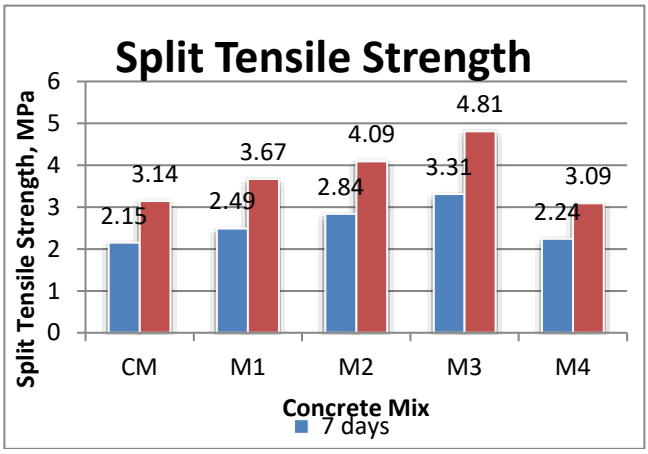

Figure 3: Split Tensile strength of various Concrete Mixes

D. Flexural Strength Test

The Flexural strength of control mix (without any replacements) comes out to be 3.51 MPa at 7 days and 5.04 MPa at 28 days. Whereas, the Compressive strength for concrete mix M1, M2, M3 and M4 comes out to be 3.74 MPa at 7 days and 5.31 MPa at 28 days, 3.99 MPa at 7 days and 5.71 MPa at 28 days, 4.21 MPa at 7 days and 6.01 MPa at 28 days, 3.71 MPa at 7 days and 5.19 MPa at 28 days. Test results are shown in Figure 4.

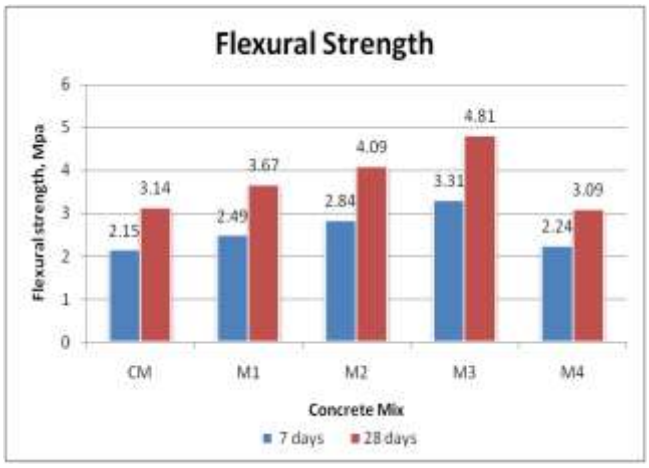

Figure 4: Flexural strength of various Concrete Mixes

E. Water Absorption Test

The % water absorption of control mix (without any replacements) comes out to be 2.72 %. Whereas, the % water absorption for concrete mix M1, M2, M3 and M4 comes out to be 2.55%, 2.48%, 2.43% and 2.39%. Test results are given in Figure 5.

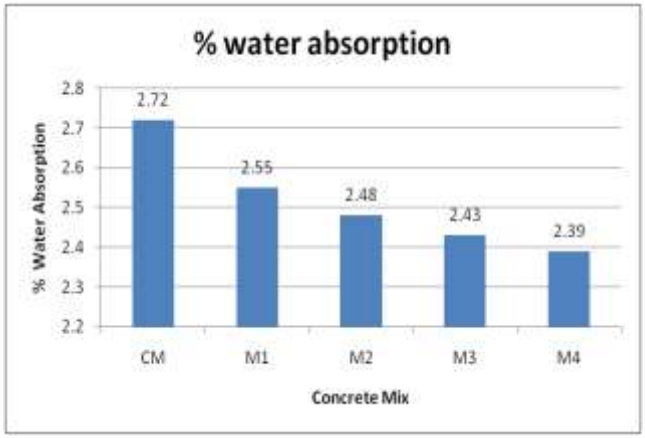

Figure 5: % Water Absorption of various Concrete Mixes

V. CONCLUSION

After scrutinizing the results of all the laboratory results, the conclusions for the current experimental study have been drawn and optimum dosage of the replacement material has been suggested. The conclusions of the study are as follows:

- The slump value of control mix comes out to be 105 mm. From the results, it is concluded that the slump value tends to decrease with the addition of replacement materials i.e., rice straw ash and foundry sand. The percentage decrease in the slump value for concrete mix M1, M2, M3 and M4 is -8.57%, -15.2%, -28.57% and -32.38% respectively.
- The compressive strength of control mix comes out to be 29.02 MPa at 7 days and 44.75 MPa at 28 days. The percentage increase/decrease in the compressive strength value for concrete mix M1, M2, M3 and M4 w.r.t. control

mix at 7 days is +6.27%, +13.2%, +17.54% and +1.34% respectively. Whereas, the percentage increase/decrease in the compressive strength value for concrete mix M1, M2, M3 and M4 w.r.t. control mix at 28 days is +2.75%, +5.39%, +7.28% and +0.94% respectively.

- The Split tensile strength of control mix comes out to be 2.15 MPa at 7 days and 3.14 MPa at 28 days. The percentage increase/decrease in the compressive strength value for concrete mix M1, M2, M3 and M4 w.r.t. control mix at 7 days is +15.81%, +32.09%, +53.95% and +4.19% respectively. Whereas, the percentage increase/decrease in the compressive strength value for concrete mix M1, M2, M3 and M4 w.r.t. control mix at 28 days is +16.88%, +30.25%, +53.18% and -1.59% respectively.
- The Split tensile strength of control mix comes out to be 3.51 MPa at 7 days and 5.04 MPa at 28 days. The percentage increase/decrease in the compressive strength value for concrete mix M1, M2, M3 and M4 w.r.t. control mix at 7 days is +6.55%, +13.68%, +19.94% and +5.70% respectively. Whereas, the percentage increase/decrease in the compressive strength value for concrete mix M1, M2, M3 and M4 w.r.t. control mix at 28 days is +5.26%, +13.29%, +19.25% and -2.98% respectively.
- The % water absorption of control mix comes out to be 2.72 %. The percentage decrease in the % water absorption for concrete mix M1, M2, M3 and M4 w.r.t. control mix at 7 days is -6.25%, -8.82%, -10.66% and -12.13% respectively.
- It can be clearly seen that the strength parameters of concrete mix M3 is maximum. Therefore, it is finally suggested to collectively utilize 15% of Rice Straw Ash and 15% Foundry Sand to obtain optimum strength of concrete.

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