iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VI **Month of publication:** June 2021

DOI: https://doi.org/10.22214/ijraset.2021.36021

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI June 2021- Available at www.ijraset.com

Water Requirement of Concrete with Mineral Admixtures

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Abstract: India is one of the leading producers of sugar and rice, hence agricultural waste is generated in huge quantities in India leading to potential disposal problems without effective management techniques. However, the economic importance of this solid waste has been realised with several applications like adsorbents, filters, ceramics, briquettes, bricks, and blocks and soil amendment activities. Cement is one of the most universally used material. Cement production is an environmental threat as well as the production cost is also very high. Manufacturing of cement and its use is also one of the causes of global warming Environmentalists and Researchers around the world are searching for better options to replace cement As cement replacement materials mineral admixtures are nowadays gaining mileage as they address two problems. First is the waste management of agricultural wastes, which causes air pollution due to open air burning and the second is reducing the demand for cement. Hence in addition to reducing the cost it also reduces the hazardous effect that it has on the environment. In general, the particle size of these admixtures play an important role in making the concrete dense, but low particle size leads to increased surface area and more requirement their surface area increases and workability reduces. Hence to make the concrete workable the water requirement also increase [1].Generally the water requirement or the water cement ratio for normal concrete is between 0.35 to 0.5 , depending on the cement content and the mix design . For high strength concrete where the quantity of cement increases the water cement ratio also increases. But in concrete with mineral admixtures the water cement ratio is more than 0.6. The present paper deals with the water requirement for the concrete with cement replacement with mineral admixtures , The two types of admixtures water requirement of concrete with partial replacement of cement with sugarcane bagasse ash and rice husk ash in different proportions of 5 % , 10%, 15% , 20%, 25% and 30 % , earlier as a binary mix replacing the mineral admixtures individually and later together as a ternary mix using both the mineral admixtures together. The results indicate increase in water content with the increase in cement replacement proportions in both the binary and ternary mix . The increase in water content does not hamper the compressive strength of the binary and ternary mix , but in some cases increases it.
Keywords: binary, ternary, replacement , compressive strength , permeability

I. INTRODUCTION

The present literature involves investigation of two mineral admixtures namely Rice husk Ash (RHA) and Sugarcane baggase ash(SCBA) regarding their water requirement for making a workable mix when used in concrete as a partial replacement to cement , individually or together forming a binary and ternary mix . The specific gravity of mineral admixtures is generally lesser than cement. Therefore the volume of mineral admixtures replacing cement is more as compared to the volume of cement ..Due to the increase in volume the water cement ratio also increases. So in this paper we will investigate the effect of increase in water cement ratio on the mechanical and durability properties of the resultant mix .

II. SIGNIFICANCE OF THE SYSTEM

The paper mainly focuses on the study of the requirement of water for concrete containing mineral admixtures as partial replacement of cement in different percentages of 5,10, 15,20,25,30. The water requirement for normal concrete without any replacements is between 0.35 to 0.5 . But as the mineral admixtures are added to concrete it is observed that the water requirement increases and is up to 0.75. The research till date has proved that as the amount of water in concrete increases the strength of the concrete reduces .

III. LITERATURE SURVEY

N.Samson et.al (2013) carried out a study on the Effect of Water-Cement Ratio on the mechanical properties of gravel crushed over burnt bricks concrete. In this study they have concluded that the compressive strength of concrete reduces with the addition of water[2]. The mineral admixtures like sugarcane bagasse ash and rice husk ash have small particle size and higher specific surface area ,these physical properties are favourable to produce highly dense and impermeable concrete; however, they cause low workability and demand more water [3].The silica content n these mineral admixtures being in the range of 75 to 95 % , the addition of these as a cement replacement increase he strength of the resultant concrete .

Hence even if the water requirement by this concrete being high it effects the compressive strength, but increases it and also makes the concrete dense and impermeable. J. Tangpagasit et.al(2005) investigated the water requirement of neat fine mineral admixture pastes and concluded that an increasing trend towards specific surface area. However, the irregular morphology of particles of some admixtures increases significantly the water requirements[4]. The use of mineral ad mixtures not only produces a denser concrete but also reduces the alkali aggregate reaction due to it low particle size and high specific area [5]

IV. METHODOLOGY

A. Materials used

Portland Cement: Conforming to British Standard specification BS: 12:1996 and IS: 456 2000 fourth revision is used in this study. Artificial sand as per IS: 2386 (Part III) – 1963, is used. The Physical properties of both cement rice husk ash and sugarcane bagasse ash were investigated as per VAT T MC/110, VAT TMC /113 and chemical properties as per FCO 1985 21" Ed standards. Physical parameters of both the cement rice husk ash(RHA) and sugarcane bagasse ash(SCBA) used in this work are shown in Table 1.The rice husk was taken from a paddy field in Gujarat India and sugarcane bagasse from a sugar industry from Maval , District Pune , Maharashtra India .

Table 01 : Physical properties of cement , RHA and SCBA

Sr.No.	Physical property	Cement	Rice husk ash	Sugarcane bagasse ash
01	Colour	Greyish green	Greyish black	Black
02	Particle density	1.15	0.61	0.49
03	Specific gravity	3.15	2.11	1.69
04	Particle size	20	11.3	4.1
05	Fineness passing 45 µm sieve	80	90	100

Aggregates: The aggregates used for the preparation of mortar confirm to IS 2383(I) and (ASTM C33)The aggregates used are hard, strong, dense, durable, and clean and free from veins, adherent coatings and injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances. The aggregates used are cubical. crushed dolomite aggregate, passing through a 12.5- retained on a 4.75 mm sieve with a fineness modulus of 6.26 and a specific gravity of 2.4.

B. Fine Aggregates

The fine aggregate conforming to IS 383 -1970 grading zone II were used. The fine aggregate used is sand with ore than 90% passing through the 4.75 mm IS sieve and less than 10% retained on the 150µ sieve.

C. Water

Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalies, salts, sugar, organic materials that may be deleterious for concrete.

Table 02 : Chemical properties of cement , RHA and SCBA

Sr.No.	Chemical property	Cement	Sugarcane bagasse ash	Rice husk ash
01	Silica as SiO2	21.22	78.39	93.66
02	Aluminium Oxide	5.69	2.23	0.05
03	Iron Oxide	3.39	4.6	0.05
04	Potash	0.55	1.64	1.3
05	Sodium Oxide	0.33	0.28	0.1
06	Sulphite	2.47	1.6	0.01
07	Calcium Oxide	64.25	2.86	1.11
08	Magnesium Oxide	0.85	0.16	0.35
09	LOI	1.85	8.5	3.38

D. *Preparation of Mortar*

Cement Mortar is prepared by replacing cement by rice husk ash and sugarcane bagasse ash individually to form binary mixes and then together to form a ternary mix in different replacement %. The replacement proportions are 5% to 30 percent in intervals of 5 %. The mix is designed for M20 concrete. The water cement ratio for the binary mixes and the ternary mix is given in the table 03 The particle size of RHA is smaller than cement and that of SCBA is smaller than RHA and hence the surface area is also more. Due to higher surface area the water required to make a workable mix is more than that required for a control mix.

V. EXPERIMENTAL RESULTS

A. *W/C ratio*

The casting and curing of specimens is done using potable water free from deleterious materials. Water plays an important role in concrete production. Standard consistency test was performed on each binary and ternary mix to find out the optimum water content required to develop proper workability. The particle size of Rice husk ash and sugarcane bagasse ash is small, and the surface area is large. The water-cement ratio is higher for this binary and ternary mix as compared to the control mix. It is around 0.45 to 1.0 the weight of (cement + Rice husk ash, cement + sugarcane bagasse ash and Cement +Rice husk ash +Sugarcane bagasse ash). Slump cone test is also performed on the mortar of each of the binary mix and ternary mix , and true slump is obtained, indicating good workability of the mix for the water cement ratios mentioned in the table 03. The Compaction factor test is carried out to find out the workability of concrete in association with the slump cone. In the present study, the compaction factor achieved was between 85 to 90 % ,which refers to medium to high workability. Hence using the RHA and SCBA require more water cement ratio to achieve high workability of the mortar.

Table 03 : Water cement ratio for different replacement percentages of RHA, SCBA and RHA+SCBA in concrete

Sr.No	Replacement % of cement	W/C ratio for the binary mix with RHA	W/C ratio for the binary mix with SCBA	W/C ratio for the Ternary mix with RHA+ SCBA
01	0	0.40	0.40	0.42
02	5	0.45	0.46	0.50
03	10	0.49	0.55	0.60
04	15	0.53	0.61	0.70
05	20	0.59	0.70	0.80
06	25	0.65	0.75	0.90
07	30	0.70	0.80	1.0

B. *Compressive Strength Test*

Rice husk ash and Sugarcane bagasse ash are used in different proportions, as mentioned above, ranging from 5% to 30 % by the proportion of the weight of cement. A control mix consisting of only cement without the supplementary cementitious material is also prepared for the comparison of the mechanical properties. The water-cement ratio for the control mix was 0.40 and that for the rice husk ash and bagasse ash concrete was 0.5 to 1.0 for a design cube compressive strength of 20 N/mm2. The control mix was designated as CM 1 and the binary mix proportions were designated as RHA5, RHA10, RHA15, RHA20, RHA25, and RHA30 and SCBA5, SCBA10, SCBA15, SCBA20, SCBA25, and SCBA30 for Rice husk and bagasse ash-concrete proportion as, 5:95, 10: 90, 15: 85, 20: 80, 25:75 and 30: 70 respectively in the binary mix . The ternary mix is prepared by fixing the proportion of Sugarcane bagasse ash to 15 % and varying the proportion of RHA in the ternary mix . The various proportions used are mentioned in the table 06 . The mix proportions are summarized in Table 4 and Table 5 for RHA and SCBA... The concrete was mixed in a laboratory mixer for 2 to 3 minutes, including mixing in dry form. For mixes CM1,RHA5 to RHA30 ,SCBA5 to SCBA30 and the ternary mix , 150 mm cubes were cast from each mix for compressive strength testing. After casting, all specimens were left covered in the casting room for 24 hours. The specimens were then de moulded and transferred to a curing tank with a temperature well maintained at 27+1°C until the testing time. Compressive strength test was performed using ACME Hydraulic Universal Testing Machine (UTM) of 1000 kN capacity as per Indian Standard codes IS: 1608 and IS 432.

Table 4 Preliminary investigation showing the compressive strength of the binary mix containing cement and RHA

Sr No	RHA + Cement	Weight in kg	Density in kg/m^3	3days Comp Strength (Min.8.33 N/mm^2) *	7days Comp Strength (Min.13.29N/mm^2)	14days Comp Strength (Min17.10 N/mm^2)	21days Comp Strength (Min. 18.92N/m^2)	28days Comp Strength Min.20 N/mm^2)
01	05 +95	7.130	2112.59	16.20	16.60	21.30	23.60	26.50
02	10+ 90	7.100	2103.70	16.40	17.50	22.90	24.80	27.15
03	15+85	7.048	2088.29	17.50	18.70	23.50	25.90	28.90
04	20+80	6.910	2047.40	17.70	19.50	25.60	27.70	29.15
05	25+75	6.870	2035.55	16.90	17.70	23.20	25.30	27.80
06	30+70	6.800	2014.82	16.20	17.20	21.40	24.40	26.50

Table 5 Preliminary investigation showing the compressive strength of the binary mix containing cement and SCBA

Sr No	% SCBA	Weight kg	Density (kg/m^3)	3days Comp Strength (Min.8.33 N/mm^2) *	7days Comp Strength (Min.13.29N/mm^2)	14days Comp Strength (Min17.10 N/mm^2)	21days Comp Strength (Min. 18.92N/m^2)	28days Comp Strength Min.20 N/mm^2)
1	05	8.470	2510	23.24	28.2	31.8	35.7	37.8
2	10	8.171	2421	14.6	17.7	19.7	21.7	25.4
3	15	8.071	2400	13.7	18.8	20.2	21.0	23.5
4	20	8.039	2381	10.9	12.8	14.7	18.4	22.4
5	25	7.899	2340	12.7	15.8	17.1	18.4	19.9
6	30	7.625	2331	8.2	9.4	13.5	16.4	18.8

Table 6 Preliminary investigation showing the compressive strength of the binary mix containing cement +RHA+SCBA

Sr No	Cement + RHA +SCBA	Weight in kg	Density in kg/m^3	3days Comp Strength (Min.8.33 N/mm^2) *	7days Comp Strength (Min.13.29N/mm^2)	14days Comp Strength (Min17.10 N/mm^2)	21days Comp Strength (Min. 18.92N/m^2)	28days Comp Strength Min.20 N/mm^2)
01	05 +15+80	6.7735	2112.59	16.20	16.60	21.30	23.60	26.50
02	10 +15+75	7.100	2103.70	16.40	17.50	22.90	24.80	27.15
03	15 +15+70	7.048	2088.29	17.50	18.70	23.50	25.90	28.90
04	20 +15+65	6.910	2047.40	17.70	19.50	25.60	27.70	29.15
05	25 +15+60	6.870	2035.55	16.90	17.70	23.20	25.30	27.80
06	30 +15+55	6.800	2014.82	16.20	17.20	21.40	24.40	26.50

VI. CONCLUSION AND FUTURE WORK

The present study concludes that Rice husk ash and sugarcane bagasse ash (SCBA) can be used as partial replacement materials in concrete structures both as binary mixes or ternary mixes depending on the availability locally. Though the requirement of water increases due to the use of these mineral admixtures , it does not effect the compressive strength of the concrete due to presence of silica in higher percentage . The smaller particle size of the mineral admixtures though increases the specific surface area but also reduces the pores in the concrete and makes the concrete denser and less permeable. The results shows an increase in compressive strength as compared to the control mix. It is found that the 28 days compressive strength of concrete increases with the addition of RHA, SCBA in different replacement percentages varying from 5% to 30% individually as well as when added in combination in the ternary mix. The use of these mineral admixtures not only increase the compressive strength but also reduces the alkali aggregate reaction which is a distress to concrete structures. The fineness of RHA and SCBA allowed it to increase the reaction with Ca(OH)2 to produce more calcium silicate hydrate (C-S-H) resulting in higher compressive strength by acting as a micro filler and enhancing the cement paste pore structure. The use of Rice husk ash and sugarcane bagasse which is otherwise burnt in the fields leading to increase in air pollution is also resulting in reduction in CO_2 emissions and also an ethical and profitable waste disposal method.

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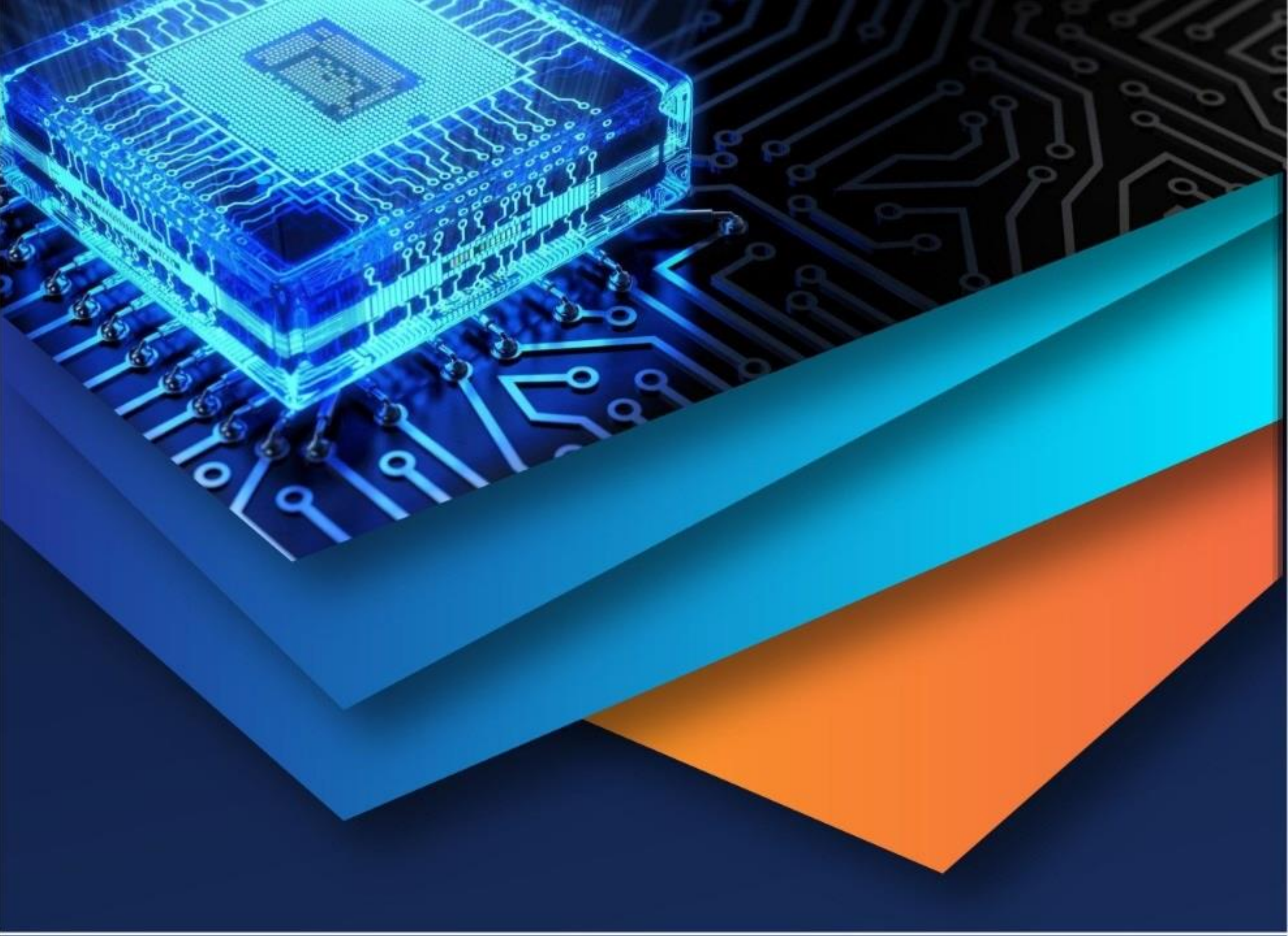

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