International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org Volume 3 Issue 9 ‖ September 2014 ‖ PP.24-31

Experimental Studies on Self Compacting Concrete by Partial Replacement of Sand by quarry dust, Cement by Rice Husk and Bagasse Ash.

[1,]Mr.H.S.Narashimhan , [2,]Dr. Karisiddappa , [3,]Dr. Ramegowda. M.
[1,]Research scholar Associate Professor, Department of Civil Engg.
Malnad College of Engineering, Hassan, Karnataka
[2,]Principal, Government Engineering College Hassan, Karnataka
[3,]Professor, Department of Civil Engg. Adhichunchanagiri Institute of Technology
Chikkamagalur, Karnataka

ABSTRACT: Construction of durable concrete requires skilled labour for placing and compacting concrete. Further durability of concrete structures mainly depends on the quality of concrete and the quality of construction worker. Self-compacting concrete is an innovative concrete that does not require vibration for placing and compaction. Rice husk ash has been used as a highly reactive pozzolanic material to improve the microstructure of the interfacial transition zone between the cement paste and the aggregate in self compacting concrete. The trial mix developed to satisfies the fresh concrete properties as per EFNARC guidelines in the present work. Our main aim is to determine the effect of combination of rice husk ash and bagasse ash as partial substitute of cement on the properties of self-compacting concrete in fresh state and hardened state. In the present study. The results show that the rice husk ash and bagasse ash can be successfully used in place of other mineral admixtures to develop SCC. The fresh concrete properties are determined from slump flow, T_{50} time flow test, J-ring test, V-funnel flow time test, L-box test. The mechanical properties and durability characteristics such as compressive strength, Split tensile test, Acid attack test, Rapid Corrosion test are determined to evaluate the performance of SCC.

KEYWORDS : *Self Compacting Concrete, Rice husk ash, Bagasse ash, Quarry dusty, Filling ability, Passing ability and durability Properties.*

I. INTRODUCTION

Self compacting concrete mixes always contain a powerful superplastizes and often use a large quantity of powder material and or VMA[7]. The superplastizer is necessary for producing a highly fluid concrete mix, while powder materials or viscosity agent are required to maintain sufficient stability/cohesion of the mix, hence reducing bleeding, segregation and settlement. Increase in the cement content leads to a significant rise in material cost and often other negative effect on concrete properties e.g., shrinkage, etc. The utilization of mineral waste dust in the concrete, cost saving. Obliviously the material cost depending upon the source. The cost of the ingredients of normal strength concrete (NSC), high strength concrete (HSC) and self-compacting concrete (SCC) differs marginally.Present scenario of rice husk ash production in India and need for rice husk ash utilization can be explained as below: 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 tons of RHA are produced annually. This rice husk ash is a great environment threat causing damage to the land and the surrounding areas in which it is dumped. Lots of ways are being thought of for disposing them by making commercial use of this rice husk ash. Concrete, an essential building material is widely used in the construction of infrastructures such as buildings, bridges, highways, dams, and many other facilities. One of the ingredients usually used as a binder in the manufacture of concrete is the ordinary Portland cement. The increasing worldwide production of ordinary Portland cement to meet infrastructure developments indicates that concrete will continue to be a chosen material of construction in the future. In order to produce environmentally friendly concrete lot of works are being carried out:

II. REVIEW

Ahmadi, M.A et.al[(1)] studied on the development of Mechanical properties up to 180 days of self compacting and ordinary concretes with rice-husk ash, from a rice paddy milling industry in Rasht (Iran). Two different replacement percentages of cement by RHA, 10%, and 20%, and two different water/cementicious material ratios (0.40 and 0.35), were used for both of self compacting and normal concrete specimens.

Shazim Ali et.al[2] studied on comparison of fresh properties of SCC containing varying amounts of RHA with that containing commercially available viscosity modifying admixture. The comparison is done at different dosages of superplasticizer keeping cement, water, coarse aggregate, and fine aggregate contents constant.a study on the development of Mechanical properties up to 180 days of self compacting and ordinary concretes with rice-husk ash.

Gritsada Sua-iam, Natt Makul [3] examined the effect of adding limestone powder to self-compacting concrete mixtures in which large amounts of bagasse ash were employed as a fine aggregate replacement. A Type 1 Portland cement content of 550 kg/m3 was maintained in all of the mixtures. The fine aggregate was replaced with 10, 20, 40, 60, 80, or 100% bagasse ash and limestone powder by volume. Mixtures were designed to yield a slump flow diameter of 70 ± 2.5 cm. The workability (slump flow, T50cm slump flow time, V-funnel flow time, and J-ring flow) and hardened properties (ultrasonic pulse velocity and compressive strength) of each mixture were measured, and blocking assessments were performed. The volumetric percentage replacement of 20% limestone powder in fine aggregate incorporating 20% bagasse ash effectively enhanced the workability and hardened properties of self-compacting concrete.

Miao Liu et. al[4] studied the Self-compacting concrete with different levels of pulverized fuel ash. The author investigated self-compacting concrete (SCC) with levels of up to 80 % cement replacement by fly ash in mixes adjusted to give constant fresh concrete properties. The hardened concrete and the relationships between hardened properties were then studied. The results show that SCC with up 80 % cement replaced by fly ash is possible. To keep the filling ability constant, replacement of cement with fly ash would require an increase in water / powder (W/P) ratio and a reduction in superplasticiser dosage. They also show fly ash have negative effects on passing ability, consistence retention and hardened concrete properties such as strength. The comparison between SCC and normally vibrated concrete (NVC) shows that their material properties of are similar. The successful completion of this project can lead to the use of higher volume fly ash in SCC.

Prakash Nanthagopalan et al.[5] carried out the fresh and hardened properties of self-compacting concrete produced with manufactured sand, the Self- compacting concrete (SCC) is extensively applied in many construction projects due to its excellent fresh and hardened concrete properties. In recent years, manufactured sand (M- sand) produced by crushing rock deposits is being identified as a suitable alternative source for river sand in concrete. The main objective of this study is to explore the possibility of using M-sand in SCC. In this process, an attempt was made to understand the influence of paste volume and w/p ratio (water to powder ratio) on the properties of self-compacting concrete (SCC) using M-sand. The powder and aggregate combinations were optimized by using the particle packing approach, which involves the selection of combinations having maximum packing density. The chemical admixtures (superplasticisers, viscosity modifying agent) were and J-ring were optimized based on simple empirical tests. Fresh concrete tests such as slump flow, T 500 performed on SCC; hardened concrete tests were limited to compressive strength. From the results, it was observed that relatively higher paste volume is essential to achieve the required flow for SCC using M-sand ,as compared to river sand. Low and medium strength (25–60 MPa) SCCs were achieved by using M-sand based on the approach adopted in the study. Results showed that it is possible to successfully utilize manufactured sand in producing SCC.

Krishna Murthy. et. al[6] focused on the utilization of high reactive Metakaolin and Flyash as an admixtures as an effective pozzolan which causes great improvement in the pore structure, also compatibility is affected by the characteristics of materials and the mix proportions, it becomes necessary to evolve a procedure for mix design of SCC . A simple tool has been designed for self compacting concrete (SCC) mix design with 29% of coarse aggregate, replacement of cement with Metakaolin and class F flyash, combinations of both and controlled SCC mix with 0.36 water/cementitious ratio(by weight) and 388 litre/m3 of cement paste volume. Crushed granite stones of size 16mm and 12.5mm are used with a blending 60:40 by percentage weight of total coarse aggregate. Detailed steps are discussed in this study for the SCC and its mortar.

III. OBJECTIVES OF STUDY

The objective of the study the fresh concrete properties such as filling ability and passing ability and mechanical properties such as compressive strength, split tensile strength and chemical attack such as sulphate attack of self compacting concrete made with up to 20 percent replacement.

IV. MATERIALS

4.1. Cement:

Ordinary Portland cement (43-grade) was used. It is confirming to the requirements of Indian standard Specification IS: 8112–1989 [9]. The physical properties are given Table 1. The tests on cement have been carried out as per IS: 4031–1999.

Table 1: Physical Properties of Ordinary Portland Cement.

Physical test		Results obtained	Requirement IS: 8112-1989
Fineness (retained on 90µm sieve) %		3.33	10 maximum
Normal consistency (%)		31	-
Vicat time of setting (minutes)	Initial setting time	85	30 minimum
	Final setting time	275	600 maximum
Compressive strength (MPa)	3 day	25.40	23.00 minimum
	7 days	33.5	33.00minimum
	28 days	44.05	43.00 minimum
Specific gravity		3.12	-
Soundness, mm		2.00	10 mm maximum

4.2. Rice Husk Ash and Bagasse Ash

The quality of rice husk ash not varies from mill to mill, but also within the same plant itself depending on the type of grain. The rice husk ash had grayish white color. rice husk ash was passed through IS 90 micron sieve and this was used for the present research. Specific gravity of Rice husk ash is 2.11**.** The tests on rice ash carried out as per IS: 1727-1967[10]. Bagasse ash has grayish white colour. Bagasse ash was passed through IS 90 micron sieve has been used for the research. Specific gravity of Bagasse ash is 1.63**.**

4.3. Aggregate

Natural river sand with a 4.75 mm IS sieve maximum size was used as a fine aggregate. It was tested as per Indian Standard Specification IS: 383–1970. Crushed granite aggregate used was 20 mm nominal maximum size, and were tested as per Indian standard Specification. The physical properties of material obtained are and presented has below in Table 2. The particle gradation of fine aggregate are conforming to zone II, the coarse aggregate percentage passing single sized aggregate of nominal 20 mm as per IS: 383-1970[11].

Table 2: Physical Properties of Materials

Property	Materials	
	Fine Aggregate	Coarse Aggregate
Bulk density, Kg/m^3 Loose state Dense state	 1463.30 1508.62	 1395.00 1486.45
Specific gravity	2.61	2.66
Fineness modulus	3.17	7.74
Water absorption, %	1.70	0.45
Surface moisture %	1.5	Nil

4.4. Quarry Screening

Locally available quarry screening (quarry dust) was collected from ‘stone crusher industry. Quarry dust comprises of the smaller aggregate particles, so it was sieved and quarry dust passing from 4.75mm IS sieve and retaining on 150 micron IS sieve is used for the replacement of fine aggregate. The physical properties of material obtained are presented has below in Table 3.

Table 3: Physical Properties Of Materials

Property		Quarry screening
Bulk density, Kg/m^3	Loose state	1580.00
	Dense state	1670.00
Specific gravity		2.55
Fineness modulus		2.96
Water absorption, %		1.52

4.5. Admixtures

Admixtures mainly affect the flow behavior of the Self-compacting concrete. There are water-soluble components added primarily to control setting and hardening of concrete or to reduce its water requirement. Chemical admixtures are grouped according to their functions as accelerators, retarders, water reducing agents and super plasticizers. The admixture used here is Auramix 400, which is a water reducer and viscosity-modifying agent. This admixture is added to increase the workability of concrete and to obtain the self compacting property in concrete.

V. MIX PROPORTIONS

The mix proportions of the concrete mixtures are given in the Table 4. The grade of concrete mixes M30 having characteristics strength of 30 MPa is examined. The mixtures proportioning was carried out by using the guidelines of EFNARC 2002 [8]. A control mixture without rice husk ash and bagasse ash was designed approximately keeping in mind some of the basic concepts. Then the mix was decided proportion based on slump flow test and slump flow T_{50} – sec test. A Four concrete mixture proportions were made by replacing cement with 0%, 10%, 15% and 20% of rice husk ash and bagasse ash and sand replacing 30% of quarry screening.

Preparation and Casting of test specimens : The mixing sequence of SCC consist of first the required amount of all dry material such as coarse aggregate, fine aggregate, cement and fly ash were mixed dry for one minutes, with the mixer running then the 50 percent of water is added slowly and allowed to mix for four minutes. Finally, the remaining water is mixed with superplasticizer an viscosity modifying agent was added and the mixing was continued for two minutes. The test specimens were cast in one layer in steel moulds without any vibration or tamping, the size and shape of the specimens are given in Table 5. delay of setting time, after one day demoulded. The specimen was cured till the day of testing in water under normal temperature and humidity.

Table 4: Mix Proportion For SCC Mixes Using Rice Husk Ash, Bagasse Ash and Quarry screening

Sl. No.	Mix identification Raw materials	MRB-00	MRB-10	MRB-15	MRB-20
1.	Cement (Kg/m^3)	450	405	382.5	360
2.	Rice husk ash(Kg/m^3)	-	33.75	45	56.25
3.	Bagasse ash (Kg/m^3)	-	11.25	22.50	33.75
4.	Fine aggregate(Kg/m^3)	1050	735	735	735
5.	Quarry dust(Kg/m^3)	-	315	315	315
6.	Coarse aggregate(Kg/m^3)	650	650	650	650
7.	Water/cement ratio	0.43	0.43	0.43	0.43
8.	Water content (Kg/m^3)	194	194	194	194
9	Water to powder ratio	0.96	0.96	0.96	0.96
10.	% of C.A content by volume	30.50	30.50	30.50	30.50
11	Fresh Concrete density (Kg/m^3)	2340	2310	2235	2170

Table 5: Test Sample Details

Tests	Sample size	Number
7 days Compressive strength	150 x150 x 150 mm	3
28 days Compressive strength	150 x150 x 150 mm	3
56 days Compressive strength	150 x150 x 150 mm	3
7 days Splitting Tensile strength	150 x300 mm cylinder	3
28 days Splitting Tensile strength	150 x300 mm cylinder	3
56 days Splitting Tensile strength	150 x300 mm cylinder	3
7 days Acid attack in H_2SO4 immersion	100 x100 x 100 mm	3
30 days Acid attack in H_2SO4 immersion	100 x100 x 100 mm	3
45 days Acid attack in H_2SO4 immersion	100 x100 x 100 mm	3
30 days Acid attack in H_2SO4 immersion compressive strength	100 x100 x 100 mm	3
45 days Acid attack in H_2SO4 immersion compressive strength	100 x100 x 100 mm	3

VI. TESTING OF SPECIMENS

The fresh concrete properties such as filling ability such as slump flow, Slumpflow$T_{50\ cm}$, V-funnel and passing ability such as J-ring test and L-box test were carried out according to EFNARC [8]. Hardened concrete properties such as compressive strength, split tensile strength, durability properties such as chemical attack test on were tested as per Indian standard Specification [12].

VII. RESULTS AND DISCUSSION

8.1 Fresh Concrete Properties

For fresh concrete properties such as slump flow, slump flow $T_{50\ cm,}$ J-Ring, L-box, and V-Funnel time are presented has below in Table 6. The various fresh concrete properties of SCC mixtures can be summarized as follows.

Table 6: Properties of Fresh Concrete Using Rice Husk Ash And Bagasse Ash

Mixture	Slump flow, mm	Slump flow$T_{50\ cm}$, seconds	J-Ring difference, mm	J-Ring flow, mm	L-box, percent	V-Funnel, T'0' seconds
MRB-00	620	5	9	465	0,9	13
MRB-10	630	6	10	480	0.8	14
MRB-15	615	7	10	505	0.8	17
MRB-20	600	7	13	535	0.7	19

The viscosity of self-compacting concrete mixtures was evaluated through slump flow test. SCC cannot be developed without any viscosity agent. As the quarry screening, rice husk ash and bagasse dust increase slump flow also decrease. which make the mix workable. The slump flow values of various mixtures were between 620 mm to 600 mm, a slump flow between 650 mm to 800 mm, which are indication of a good deformability. Based on the lump flow and visual observation, SCC property for all mixtures was found to be satisfactory.The viscosity increases and the slump flow value increases with time. It can be seen that an increase in the viscosity of the paste reduces the flowability. The $T_{50\ cm}$ Slump flow time is taken were between 5.0 seconds to 7.0 seconds, the acceptable slump flow $T_{50\ cm}$ values as per the available literatures is 2 to 5 seconds, for SCC mixtures. The difference in level of concrete just inside the bar and that outside bar of J-Ring was found to be acceptable limits except. The acceptable difference as per available literature is 0-10 mm. The V-Funnel flow times were observed to be in the range of 13 to 19 seconds for T_0 seconds. The accepted criteria for V-funnel test results for SCC is 6 to 12 seconds for T_0.

8.2 Hardened Concrete Properties

Comparison of Compressive Strength : The results of compressive strength of cubes for 7 days, 28 days and 56 days curing are given in Table 7. Also results are compared graphically in Fig. 1 It can be seen from Fig. 1 the compressive strength increased with a decrease in the percentage of the rice husk ash and bagasse ash all levels of replacement at 7, 28 and 56 days. The Reductions of compressive strength are 9.93% to 21.86% due to 10% to 20% rice husk ash and bagasse replacement of control mixtures at 7 days. In the early age rice husk ash and bagasse reacts slowly with calcium hydroxide liberated during hydration of cement and does not contribute significantly to the densification of concrete matrix at early ages. The 80% OPC and 20% rice husk ash and bagasse mixtures had the lowest early age compressive strength due to the slower reactivity of rice husk ash and bagasse. Adding a viscosity modifying agent for mixtures and increased superplasticizer dosage, thereby delay of setting. It can be seen from the Figure 1 at the age of 28 days, there was continuing improvement. The control mixture MRB-00 is achieved 39.44 MPa. This can be mainly due to silica and Calcium oxide content The increase in strength from 28 to 56 days was between 23.70 to 45.00 percent. The compressive strength was strongly affected by water cement ratio and filler types.

Table 7: Compressive Strength Results by Adding Both Rice Husk Ash and Bagasse Ash

Mix identification	Cubes at		
	7 days	28 days	56 days
MRB-00	28.22	39.91	57.78
MRB-10	25.42	41.24	59.56
MRB-15	23.11	41.56	50.22
MRB-20	22.05	39.44	48.56

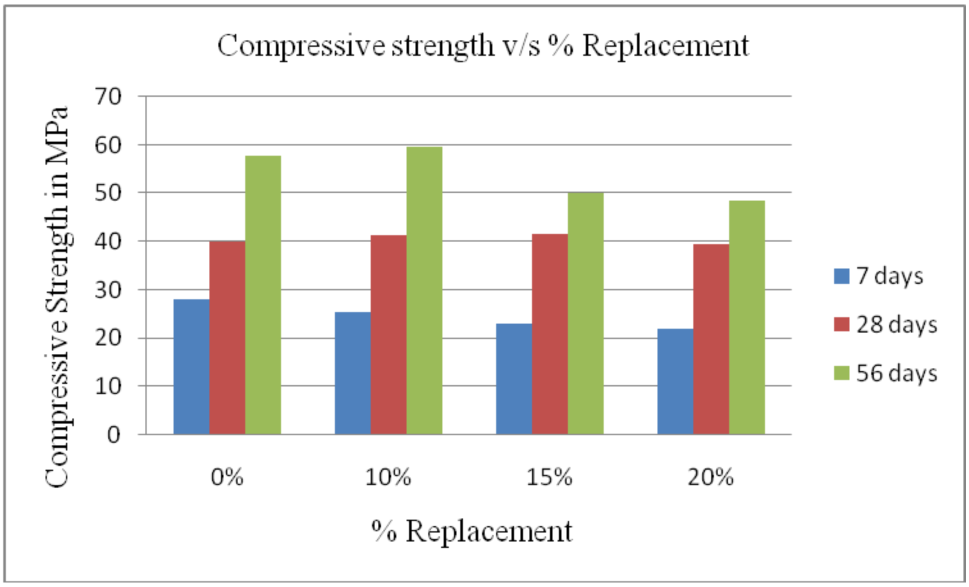

FIG. 1: Comparison of Compressive Strength of SCC With Different Percentage of Replacement of Cement by Rice Husk Ash and Bagasse With Age.

Splitting Tensile Strength : The results of splitting tensile strength of cylinder for 7 days, 28 days and 56 days curing are given in Table 8. Also results are compared graphically in Fig. 2. It can be seen from the Fig. 2, that the split tensile strength at 28 days curing for control mixtures MRB-00 achieved 3.53 MPa. Mixes MRB-nd MRB-20 are showed reduction of 12.00 and 22.71 percent strength respectively, in comparison with the control mixture MRB-00. The increase in strength from 28 to 56 days was between 14.00 to 16.15 percent. The significant increase in strength of rice husk ash and bagasse concrete is due to pozzolanic reaction of rice husk ash and bagasse.

Table 8: Splitting Tensile Strength Results by Adding Both Rice Husk Ash and Bagasse Ash

Mix identification	Splitting Strength in N / mm^2		
	7 days	28 days	56 days
MRB-00	1.98	3.53	4.10
MRB-10	2.69	3.68	4.10
MRB-15	2.54	3.11	3.96
MRB-20	1.84	2.83	3.25

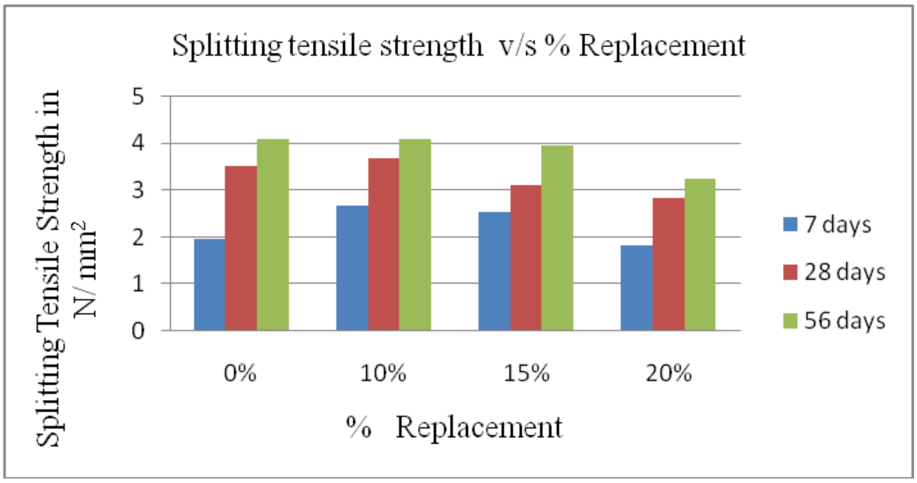

FIG. 2: Comparison of Split Tensile Strength of SCC With Different Percentage of Replacement of Cement By Rice Husk Ash And Bagasse With Age.

Chemical Attack Test. : Percentage of loss of weight of specimen after immersion in 5 % H_2SO_4 solution, the size of specimen are 100 mm x 100 mm x100 mm were used. In the H_2SO_4 solution, The specimens turned into a white pulpy mass in addition to peeling. These reactions resulted from expansive reactions in the concrete binder. In addition, sulfates react with the hydrated calcium-silicate phase present in cements, thereby forming gypsum, which reacts with tricalcium aluminate to form ettringite. These reactions result in a substantial expansion and peeling and lead to an increase in mass loss each week after cleaning and removing the deteriorated layers with a steel-wire brush.

Table 9: Weight of Cubes After Immersion in 5% H_2SO_4 Solution

Sl. No.	Percentage of replacement	Weight of concrete cubes after 28 days of casting and before immersing in 5% H_2SO_4 solution (gms)	Weight of concrete cubes after immersing in 5% H_2SO_4 solution (gms)		
			7 Days	30 Days	45 Days
1	0	2540.50	2498.00	2345.50	2210.00
2	10	2500.00	2465.00	2389.50	2290.00
3	15	2338.50	2320.00	2247.50	2208.00
4	20	2270.00	2259.00	2184.50	2153.00

Table 10: % Loss of Weight After Immersion on 5% H_2SO_4 Solution

Sl. No.	Percentage of replacement	% loss of weight after immersing in 5% H_2SO_4 solution		
		7 Days	30 Days	45 Days
1	0	1.68	7.67	13.01
2	10	1.40	4.47	8.40
3	15	0.79	3.89	5.59
4	20	0.48	3.76	5.15

Table 11: Compressive Strength of Concrete Cubes After Immersion in 5% H_2SO_4 Solution

Sl. No.	Percentage of replacement	28 days Compressive strength of cubes before immersing in 5% H_2SO_4 solution (MPa)	Compressive strength of concrete cubes after immersing in 5% H_2SO_4 solution (MPa)	
			30 Days	45 Days
1	0	38.20	13.05	9.96
2	10	39.85	13.95	10.09
3	15	38.97	14.69	10.02
4	20	37.05	16.73	10.84

VIII. CONCLUSIONS

[1] Percentage of replacement of cement by fly ash increases the slump flow, fill-box flow and J-ring and decreases in T50 and V funnel. The reduction in viscosity of SCC, the time required for slump flow value decreases.

[2] The combined effect of rice husk ash and bagasse on self compacting concrete is a mild decrease in the compressive strength of SCC when replacements are considered with time. Hence it could be adopted as effective replacement of normal SCC.

[3] The SCC with natural pozzolan addition has a better resistance in the acid attack than control mix.

[4] The percentage weight loss of control mix is more when compared to SCC with replacements. This is also true for the acids tried in this investigation.

[5] It is considered as environmental friendly concrete as ashes and quarry dust are efficiently utilized avoiding land pollution.

[6] Rice husk ash and bagasse are used in concrete exhibits good durability characteristics. It can be used as an alternate to cement and also be utilized in cement as a raw material for making blended cement.

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