Study of Self Compacting Concrete by using Marginal Materials-Partial Replacement of Cement with Rice Husk Ash and Partial Replacement of Coarse Aggregate with Demolished Waste

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Abstract: *SCC (Self Compacting Concrete) is a novel form of concrete that can be placed and compacted without the need of vibration. It can flow under its own weight even in crowded reinforcing, totally completing form work and achieving full compaction. The hardened concrete is thick, uniform, and has the same basic properties and durability as regular vibrated concrete. Rice husk ash (RHA) is utilised as a supplemental cementing agent in mortar and concrete because of its pozzolanic reactivity, and it has shown to have substantial economic and technical benefits. The effects of RHA on the strength of mortar and concrete are the main focus of this research. Furthermore, the characteristics and pozzolanic activity of RHA, as well as the benefits and drawbacks of using RHA as a supplement in mortar/concrete, are discussed. Based on the existing documentation, it can be inferred that RHA may be utilised as a supplemental cementing agent up to a particular degree of replacement (about 10% to 40% of the binder) without compromising concrete strength. Proper usage of these RHA leads to the reduction of environmental pollution and the creation of cost-effective concrete; it may also play an important part in the manufacturing of sustainable and economical concrete.*

Keywords—Self Compacting Concrete (SCC), Rice Husk Ash (RHA), Demolished Waste.

1. Introduction

In the field of material science, new technology is quickly developing. Over the last three decades, much research has been conducted across the world to increase the performance of concrete in terms of strength and durability. As a result, concrete has evolved from a simple building material made up of cement, aggregate, and water to an engineering custom-tailored substance made up of numerous additional elements to fulfil the specialized demands of the construction industry. Because of the increasing usage of concrete in unique architectural designs and with tightly spaced reinforcing bars, it is critical to make concrete with acceptable filling ability, structural performance, and longevity. Many studies have been conducted across the world in recent years to enhance the performance of concrete in terms of its most significant attributes, namely strength and durability. Since the 1980s, concrete technology has been studied at all levels, from macro to micro, in order to improve strength and durability. Until 1980, the research study was solely focused on improving the flowability of concrete in order to increase its strength; nevertheless, concrete technologists did not place a high priority on durability. Self-compacting concrete [1] (SCC) was developed as a consequence of this sort of research, which represents a much-needed revolution in the concrete industry. Self-compacting concrete is a highly developed concrete that has a significantly higher fluidity without segregation and can fill every corner of form work using only its own weight (Okamura 1997[2]). As a result, SCC removes the requirement for external or internal vibration for concrete compaction without jeopardizing its technical qualities.

2. Literature

In Minna, Nigeria, the compressive strength of various commercial Sandcrete blocks was studied. Charcoal from burning firewood was used to make Rice Husk Ash (RHA). 150mmx450mm hollow sandcrete blocks were cast, cured, and crushed at 0, 10, 20, 30, 40, and 50 percent replacement levels for 1, 3, 7, 14, 21, and 28 days. The compressive strength of OPC/RHA sandcrete blocks rises with age during curing and falls as the amount of RHA material rises. The study determined that a 20 percent replacement rate is optimal.

In India, over 20 million tonnes of Rice Husk Ash (RHA) are generated each year. The effects of varied quantities of Rice Husk Ash [3] applied to concrete on its physical and mechanical qualities are investigated in this research. Varying percentages of RHA and different w/c ratios were used to replace the cement in bulk in sample cubes. Compressive strength, water absorption, and slump retention were all assessed.

The impact of Rice Husk Ash (RHA) Average Particle Size (APS) on the mechanical characteristics and drying shrinkage of the generated RHA blended concrete is investigated in this work. To replace 20% of the weight of cement, locally made RHA with three different APS (i.e., 31.3, 18.3, and 11. Sum, respectively) was employed. A cement (OPC) combination with a finer RHA yields superior results. Due of the action of micro fine particles, Fine RHA had the highest shrinkage value, which increased its shrinkage values significantly.

The paper describes the use of demolition waste in concrete, conducted laboratory tests and conclusions are drawn.

1. ***Assessment of concrete strength using rice husk ash***

Construction work was largely done with mudstone from the industries throughout the ancient times. Fly ash is a by-product of burned rice husk from a paper mill at a higher temperature. To enhance the qualities of cement concrete, considerable effort is being made globally to totalize natural waste and by-products as extra cementing ingredients. Such materials include rice husk ash (RHA) and fly ash (FA). The paddy business produces rice husk ash as a by-product. Rice Husk Ash is a highly reactive Pozzolanic substance made by burning rice husks under controlled conditions. In this article, I started with a 30 percent FA 0 percent RHA mix in concrete by replacing the cement, and ended with an 090FA 30 percent RHA proportion, with a progressive rise of RHA by 1 percent and a gradual drop of FA by 196. Although the strength of RHA concrete continues to decline following the addition of 15% RHA, the composition of 10% RHA + 20% FA yields the highest strength findings and demonstrates the potential to be utilised as a beneficial material for various construction materials.

3. MATERIALS

1. Cement

Portland Cement concrete is the most often produced material. According to current trends, concrete's failure appears to be brighter since, for the most part, it provides adequate engineering features at cheap cost, as well as energy savings and environmental advantages. Engineers should have a better understanding of construction materials than the general public.

Concrete is derived from the Latin word "CONCRETEUS," which means compact or condensed. Hydration is a chemical process that causes concrete to solidify and harden once it is mixed with water and placed. Water combines with cement, which binds the other components together, resulting in a durable granite-like substance.

Concrete is the most frequently used building material, and it is typically created by combining cement, sand, crushed granites, and water. According to the report, India's per-capital cement consumption is 131 kg, compared to a global average of 348 kg. Humans consume no other substance in such large quantities as water.

Ordinary Portland Cement of Grade 43 with the brand name Zuari cement is utilised in this study. The tests are carried out in compliance with Indian norms, which confirm to IS-8112:2013. Table 1 shows the physical characteristics of the tested cement.

Table-1: Physical Characteristics of Cement.

PHYSICAL PROPERTIES OF CEMENT REFERENCE			
Sl. No.	Test	Results	Requirements as per IS 8112: 2013
1	Specific Gravity	3.10	3.15
2	Fineness of cement	3.50%	Less than 10%
3	Standard Consistency	30%	Not Specified
4	Soundness (Le- chatelier's)	0.5mm	Shall not be more than 10mm
5	Setting time (in minutes)		
	Initial Setting time	90	Shall not be less than 30 minutes
	Final Setting Time	365	Shall not be more than 600 minutes
6	Compressive Strength (MPa) (70.5x70.5x70.5mm cubes)		
	3 Days Strength	24.7 MPa	Shall not be less than 23.0 MPa
	7 Days Strength	35.8 MPa	Shall not be less than 33.0 MPa
	28 Days Strength	46.5 MPa	Shall not be less than 43.0 MPa

2. Fine aggregate

This research employed fine aggregate (M Sand), which was acquired from a local facility and was free of any organic contaminants. The fine aggregate had a specific gravity of 2.73 after passing through a 4.75 mm screen. According to Indian Standard standards, the fine aggregate grading zone was zone II.

To establish specific gravity and fineness modulus, fine aggregate was tested in accordance with IS: 650-1966 and IS: 2386-1968.

Table-2: Physical Characteristics of Fine Aggregate.

Sl. No.	PARTICULAR OF TEST	RESULTS
1	Fineness Modulus	2.36
2	Specific Gravity	2.7
3	Bulk Density (kg/m³)	1650
4	Zone	II

3. Coarse aggregate

Crushed stone is used to make coarse aggregate for concrete. Quarried, crushed, and graded commercial stone Granite, limestone, and trap rock make up a large portion of the crushed stone utilised. Last, basalt, gabbro, diorite, and other dark-colored, fine-grained volcanic rocks are referred to as igneous rocks. Crushed stone that has been graded generally contains only one type of rock and is shattered with sharp edges. Although greater sizes may be utilised for enormous concrete aggregate, the sizes range from 0.25 to 2.5 in (0.64 to 6.35 cm). As coarse aggregate, machine crushed granite broken stone with an angular form was employed.

Table-3: Physical Characteristics of Coarse Aggregate.

Sl. No.	PARTICULAR OF TEST	RESULTS
1	Specific Gravity	2.56
2	Bulk Density (kg/m^3)	1500
3	Water Absorption	0.15%

4. Water

The concrete mix was made with potable water supplied from the water source. The pH of the water is 7.0, and all other physical properties are within Indian guidelines.

Table-4: Analysis of portable water.

SL. No	Type of Test Conducted	Results	Permissible Limits	Relevant BIS codes
1	pH value	7.00	Should not be less than 6	IS: 456-2000
2	Total Acidity	50 mg/l as $CaCO_3$	Should be less than 50 mg/l as $CaCO_3$	
3	Total Alkalinity	110 mg/l as $CaCO_3$	Should be less than 250 mg/l as $CaCO_3$	
4	Total dissolved solids Organic Inorganic	160 mg/l 260 mg/l	Less than 200 mg/l	
5	Chlorides	240 mg/l	Should not be more than 500 mg/l for PCC and not be more than 2000 mg/l for RCC	
6	Suspended Solids	60 mg/l	Should be less than 2000 mg/l	

5. Fly ash

Fly ash is a waste product from coal-fired power plants. The most extensively utilised pozzolanic substance on the planet is fly ash. Fly ash is defined as "the finely divided residue resulting from the combustion of ground or powdered coal, which is transported from the firebox through the boiler by flue gases" in Cement and Concrete Terminology (ACI Committee 116) by "the finely divided residue resulting from the combustion of ground or powdered coal, which is transported from the firebox through the boiler by flue gases."

Table-5: Physical properties of Fly ash.

Sl. No.	PARTICULAR OF TEST	RESULTS
1	Specific Gravity	2.06
From Thermal Power Plant, Raichur		

6. Admixtures

An admixture is a substance that is added to concrete to improve a specific or desired attribute of the material. It is also described as a substance used as an in gradient in concrete that is not made of cement, water, or aggregates. Admixtures are used to change the qualities of the product so that it may be used in a variety of situations. Concrete is now employed for a wide range of purposes in order to make it appropriate for a variety of circumstances. Ordinary concrete may not be able to provide the requisite quality performance or durability in these circumstances. Admixtures are used in these situations to change the qualities of conventional concrete to make it more suited for any setting. The admixture (Super-Plasticizer & VMA) utilised in this study is Auramix 400.

4. EXPERIMENTAL TESTS

It's vital to remember that none of the SCC test techniques have been standardized yet. The methods described here are not completely comprehensive processes, but rather descriptions. They are mostly improvised approaches created expressly for SCC. As a result, these tests have not been evaluated for concrete validation.

a. Slump Flow Test

Although two persons are required to measure the T50 time, this is a simple and quick test technique. It may be utilised on site, albeit the size of the base plate makes it a little awkward to manoeuvre, and flat ground is required. It is the most often used test and provides a decent indication of filling ability. It provides no indication of the concrete's capacity to move through reinforcement without being blocked, although it may indicate resistance to segregation. It might be claimed that the entirely unrestricted flow is not indicative of what happens in practice in concrete construction, but the test can be useful in determining the consistency of ready-mixed concrete delivery to a site from load to load.

b. L Box Test

This is a common test that may be used in the lab or on the job. It evaluates SCC's capacity to fill and pass, and it can detect major lack of stability (segregation). Segregation can also be discovered by cutting and examining parts of the horizontal section of the concrete. Unfortunately, because there is no consensus on materials, size, or reinforcing bar arrangement, comparing test results is challenging. There is no indication that the apparatus's wall, and the resulting 'wall effect,' has any influence on concrete flow, although this setup does, to some extent, imitate what occurs to concrete on the job site when it is restricted within formwork. If times are being measured, two operators are necessary, and there is a degree of operator error.

c. V Funnel Test

Despite the fact that the test is intended to quantify flow ability, the outcome is influenced by concrete qualities other than flow. Because of the inverted cone shape, any potential for concrete to block will be reflected in the final product - for example, if there is too much coarse aggregate. Strong flow time is also linked to limited deformability and high inter-particle friction due to high paste viscosity.

d. J Ring Test

These sets of tests are seen to have a lot of promise, yet there is no consensus on how to interpret the results. There are a variety of choices; for example, comparing the slump-flow/J Ring spread to the unconstrained slump flow may be instructive: to what degree is it reduced?

These combinations, like the slump flow test, have the drawback of being unconfined, and hence do not reflect how concrete is put and moved in actuality. The Orimet option has the benefit of being a dynamic test that also reflects placement in practice, but it has the disadvantage of having two operators.

5. TEST RESULTS

1. Flow test results

The following table gives the flow test results of effect of addition of RHA in various percentages and Demolished Waste in constant percentage on the properties of Self-Compacting Concrete,

1. Overall results of compressive strength after 7 days of curing of M-40.

Table-6: Compressive test results.

SL NO.	% Replacement of DW	Compressive Strength	
		Non-Destructive (N/mm²)	Destructive in ACTM (N/mm²)
1	0	27.00	27.50
2	10	24.00	25.60
3	20	22.50	22.26
4	30	21.56	20.58
5	40	20.02	20.12

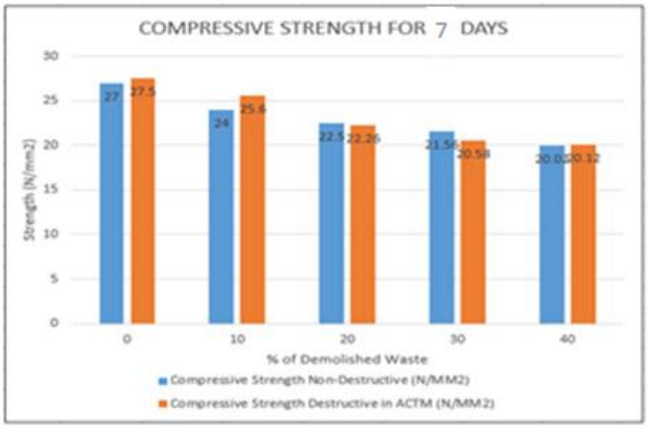

Chart-1: Compressive strength chart for 7 days of curing.

2. Overall results of compressive strength, Split tensile and Flexural strength after 28 days of curing of M-40.

Table-7: Test results.

%RHA	%DW	Compressive Strength (N/mm²)	Split Tensile Strength (N/mm²)	Flexural Strength (N/mm²)
10	10	39.60	5.68	10.6
	20	35.71	5.35	9.75
	30	33.00	5.10	9.25
	40	32.67	4.98	9.05
20	10	32.23	4.89	8.98
	20	32.40	4.65	8.64
	30	30.63	4.42	8.43
	40	28.64	4.24	8.24

30	10	27.89	4.10	8.04
	20	26.89	4.09	7.96
	30	20.50	3.95	7.65
	40	18.54	3.72	7.04

3. Overall results of compressive strength, Split tensile and Flexural strength after 28 days of curing of M-40.

Table-8: Flow Test results.

%RHA	%DW	Slump (mm)	V-Funnel (mm)	J-Ring (mm)	L-Box (mm)
10	10	280.0	9.00	10.00	0.95
	20	273.5	8.75	9.51	0.93
	30	268.2	8.20	9.40	0.98
	40	265.7	8.09	9.15	1.10
20	10	253.5	7.85	8.76	0.84
	20	248.0	7.62	8.42	0.86
	30	244.6	7.40	8.31	0.83
	40	240.0	7.20	8.00	0.78
30	10	235.0	6.85	7.84	0.76
	20	230.1	6.24	7.53	0.75
	30	215.2	6.18	7.00	0.84
	40	198.5	5.80	6.80	0.92

6. CONCLUSIONS

In the present investigation based on above experimental results of concrete mixes, the following conclusions are drawn,

- Mixes show higher compressive rather than normal concrete.
- Replacement of cement with Rice Husk Ash in matrix causes reduction utilization of cement and expenditures. Also, can improve quality of concrete at the age of 28 days.
- According to study, addition of pozzolans like RHA the concrete can improve the mechanical properties of specimens.
- It is seen that Density is directly proportional to strength, as the Density increases, strength increases whereas the Density decreases strength also decreases.
- From the Flow test results the parameters like slump flow, V-funnel flow decreases with increase in the percentage of replacement as the RHA absorb comparatively more water.
- Demolished waste is a waste material from construction site, it is low in cost, so replacement with natural aggregates reduces the cost of constructions.
- RHA can be very good replacement for cement with respect to economy and strength shall be very economical.
- Increases the % Rice Husk Ash there will be a decrease in the Compressive strength.
- As there is an Increase in % demolished waste there will be also decrease in Compressive Strength.
- As there is an increase in % DW there will be slighter decrease in the slump value.

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