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The use of rice husk ash as admixture in producing self-compacting concrete

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Abstract

Admixtures are incorporated into concrete in today's world in order to achieve variety of goals. This research study the use of rice husk ash as an admixture in producing self-compacting concrete. The rice husk ash is varied in different percentages (5, 10, 15, 20, 25 and 30%) as partial replacement for ordinary Portland cement (OPC) to know if it improves the properties of fresh and hardened properties of the self-compacting concrete. The superplasticizer used was conplast SP 430 and the water cement ratio 0.35 was kept constant throughout all mix. Rice husk ash is a good super-pozzolan which is used to make special concrete mixes, in which the slump Flow, T50cm slump, V-funnel and the L-box test was used to test for the workability of the fresh concrete mix and the compressive strength of each mix was tested to know the specific strength of each self-compacting mix with varying percentage of rice husk ash at 7, 14 and 28 days of curing.

Keyword: Conplast SP430, Rice husk ash (RHA), self-compacting concrete, workability, compressive strength.

1. Introduction

Self-compacting concrete was developed when there was a decline in the amount of skilled labour in japan in 1980s, primarily through the work by Okamura. A committee was formed to study the properties of self-compacting concrete, including fundamental investigation on workability of concrete which was carried out in the university of Tokyo by Ozawa et al [1]. the first usable version was completed in 1988 and was name self-compacting High-performance concrete. This concrete was high fluid in nature which made it to flow freely, consolidate under its own weight and was suitable for placing in difficult condition and section with congested reinforcement. It reduces hearing related damage caused by vibration and reduce time required to place large section. Since the development of self-compacting concrete in japan many organizations across the world have carried out research on the properties of the self-compacting concrete which has brought to this research of the properties of rice husk ash in self compacting concrete. The rice husk ash is gotten from or a by-product of rice paddy milling industries, it is used as alternative or supplementary binder for cement in this research study. The rice husk ash consists of cellulose ($C_5H_{10}O_5$), lignin, hemicellulose Sio_2 and holocellulose [2].

Hossian et al. (2011) found that addition of rice husk ash in cement increases its normal consistency and setting times. It has also been found that addition of rice husk ash in brick does not affect its shape and size [3].

M.U Dabai, (2009) investigated that compressive strength test which were carried out on six mortar cubes with cement replaced by rice husk ash (RHA) at five levels (0-50%). After curing age of 3, 7, 14, 28 days. His finding that the compressive strength of the cubes at 10% replacement increased respectively with age or curing but decreased with increase in RHA content for all mix. The chemical analysis revealed high amount of silica, alumina and oxide [4].

Dao Van Dong, (2008) investigated key properties of high strength concrete using husk ash. Rice husk ash obtained from two sources: Vietnam and India were used to partially replace as cement binder in high strength concrete. The properties of concrete including: slump, density, compressive strength, water and chloride permeability resistance were investigated. The experimental result showed reasonable improvement in all the test. His finding presented that the sample in India were much better that the Vietnam RHA [5].
Ramasamy, (2011) investigated on rice husk ash concrete to evaluate the compressive strength and study its durability properties. In this experiment RHA was replace at various percentages of 5-20% of two grade of concrete, M30and M60 and control was also prepared for comparison purpose. It was observed that for M60 grade concrete compressive strength increased with the addition of superplasticizer while M30 concrete replacement at 10% increased in strength was 7.07% at 90 days compared to normal concrete [6].
FENG Qing-ge, (2004) investigated the effect of highly active rice husk ash produced by an industrial furnace on some properties of concrete. The strength, pore volume and pore distribution of concrete and the $Ca\ (OH)_2$ content in concrete were investigated. His finding shows that RHA replacement of cement, the compressive strength of concrete increase and the average pores radius of concrete is greatly decreased, especially the pores greater than 20mm is decreased while the small pores is increased [7].
Ramadhansyah Putra Jaya, (2011) studied the compressive concrete strength and the gas permeability properties over varying fineness of the rice husk ash were experimentally investigated. Their relationships among them were analyzed. The finding showed that RHA3 produced the concrete with good strength and low porosity. Additionally, the strength of the concrete was improved [8].
Tokunbo O. et al (2015), Experimented on the Durability Properties of Palm Oil Fuel Ash Self Compacting concrete, twelve POFA self-compacting concrete of various strength and grade were designed at varying percentages of 0-30%. The concrete with no replacement served as the control. It was observed that the acid resistant test of the SCC with POFA had high value compared with the concrete mix without POFA. When the specimen is immersed in sodium sulphate for 14, 28, 56 and 90 days, the average reduction in weight increased and the weight is decreased when the POFA increase in the concrete [9].
Nan Su et al. (2001) proposed a new mix design method for self-compacting concrete. First, the amount of aggregate required was determined, and the paste of binder was then filled into the void of aggregate to ensure that the concrete thus obtain has flow ability, self-compacting ability and other desired SCC properties. The amount of aggregate, binder and mixing water, as well as type and dosage of superplasticizer to be used for major factor influencing the properties of SCC. Slump flow, V-funnel, L-box, U-box and compressive strength test were carried out to examine the performance of the SCC, it was discovered that the method provided high quality of SCC [10].

Table 1: Chemical Composition of Rice Husk Ash

S/N	Particulars	Proportion
1	Silicon Dioxide	86.94%
2	Aluminum Oxide	0.2%
3	Iron Oxide	0.1%
4	Calcium Oxide	$0.3 - 2.25\%$
5	Magnesium Oxide	$0.2 - 0.6\%$
6	Sodium Oxide	$0.1 - 0.8\%$
7	Potassium Oxide	$2.15 - 2.30\%$

Experimental Study

This describes the materials used, preparation of the test specimens and their corresponding procedures. Also, the mix design procedure and analysis adopted for the control concrete and the Admixture in Self Compacting Concrete, SCC details of the method of casting and testing of specimens are explained.

Ordinary Portland Cement:
The cement used for this research work was Ordinary Portland Cement (OPC) with grade 42.5, manufactured by Dangote Cement Plc in Nigeria. It was purchased in sealed 50Kg bags with its properties checked.

Fine Aggregates (Sand):
The fine aggregate used was sharp sand obtained from Mowe area of Ogun State. Sharp Sand that pass-through sieve size 4.75mm was used as fine Aggregates.

Coarse Aggregate:
The coarse aggregate used was crushed granite. It was of high quality and free of deleterious organic matter, passes through 12.5mm maximum sieve size. Sieve analysis was conducted on the coarse aggregate.

Rice Husk Ash:
The Rice Husk Ash used for the study were sourced from Ogun State and they were calcined using electric furnace at 600^0C for 2 hours at the forgery and molding workshop of Civil Engineering Covenant University Ota Ogun State. These were later made to pass through sieve no 200 table 7 and Figure 3 shows the chemical analysis of Portland cement and Rice Husk Ash.

Conplast SP 430:
It gives high range water reduction up to 25% with loss of workability. It has a specific gravity of 1.20 at 20°C, no chloride content (IS:9103-1999 and BS:5075) and air entrainment of 2% over control was dark brown in colour. It as advantage of increase workability, strength, improved quality, high cohesion and chloride free.

Water:
The water used for this research was obtained locally. The water was clean and free from any visible impurities.



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study, the slump flow test was carried out in accordance to ASTM C 1611. The test was used to determine the flow ability of self-compacting concrete mix. The diameter of each SCC mix after allowing to flow fully was measured and is presented in the table III respectively the higher the slump flow value the greater the ability to fill the form work under its own weight. The V-Funnel is the time taken to empty the funnel is regarded as a measure of the viscosity (segregation resistance) of the mixture. The L-Box test is conducted to measure the passing ability of the SCC mix which was conducted in accordance to ASTM C 1621. It shows the ratio of h2/h1.

Preparation and casting of specimens
Before casting, the entire test equipment was cleaned and oiled properly. The mould were securely tightened and cross checked to correct dimensions before casting. Necessary precautions were taken such that there are no gaps and any possibility of leakage of slurry in the mould. Careful procedure was adopted in the batching, mixing and casting operations of the concrete. The concrete mixture was prepared in pan mixer. Initially, the coarse and fine aggregates were thoroughly mixed (dry mixing) in pan mixer. To this mixture, the cement and admixture (RHA) were added interchangeably to the required proportion and mixed. The water and the super plasticizer were carefully added in a manner that there was no moisture loss during mixing. After proper mixing, concrete is checked for fresh

properties (L-Box, V Funnel, Slump flow test), the concrete mix were then casted for each mix. After required age of curing (7, 14 and 28 days), the specimens were taken out of the curing tank and their surfaces were wiped off while the required laboratory tests were conducted respectively. Besides testing for the workability, Compressive strength test were performed on the self-compacting concrete with varying percentage of rice husk ash.

Table 2: Test properties and method of Evaluating SCC

Characteristic	Test method	Measured Value	Permissible Range Method	
			Min	Max
Flow ability/Filling ability	Slump-flow	Total spread	600	800
Viscosity/flow ability	V-funnel	Flow time	8	12
Passing ability	L – box	Passing ratio	0.8	1

Result and Discussion

Table 3: Result of workability on fresh concrete mix

RHA percentage	Slump flow	V-funnel	L-box
0%	500	14	0.98
5%	575	12	0.92
10%	625	11.5	0.85
15%	700	10	0.82
20%	740	9	0.8
25%	642	12	0.89
30%	550	12.7	0.90

The fresh properties of the self-compacting `concrete mixture are given in the table 3; the table shows the properties such as slump flow, v-funnel and l-box of all mixes. For the mixtures no bleeding or segregation was recorded. The slump of the concrete mix was in range of 500-740, all self-compacting mixture exhibited satisfactory result. Lowest workability was obtained at 30% of rice husk ash. Workability decreases with increase in rice husk ash from 25% replacement of rice husk ash.

Table 4: Showing the compressive result of the varying mix

S/N	RHA %	Compressive Strength (mpa)		
		7 days	14 days	28 days
1	0%	25.5	28.4	31.7
2	5%	28.4	31.5	32.6
3	10%	30.5	32.4	35.2
4	15%	31.1	33.7	36.4
5	20%	32.8	34.5	37.5
6	25%	30.4	33.2	32.6
7	30%	23.7	25.1	30.5

From the above result in the table 4, it was observed that the rice husk ash gave an increase in the strength from 5-20% of replacement with cement. Also compared to the control mix the mix with rice husk ash as replacement had an increase in strength but it was observed from the result that an increase in rice husk ash after 20% gave a decrease in the strength. Similarly, the compressive strength of 20% of rice husk ash replacement gave early strength (32.8, 34.5, 37.5, 48.2 mpa) which increased accordingly with the respective curing age. This increase is due to the rice husk ash which reduces the volume of larger pores in cement paste. While the mix of 25 and 30% showed a decrease in strength, this is due to the presence of high or excessive dosage of RHA to blend with the cement and liberate during the hydration process.

Conclusion

1. The experimental study concluded from the workability test carried out that an increase in amount of rice husk ash above 20% in the mix will result to decrease in workability of the mix. However, the replacement of rice husk ash from 5-20% gave a good workability result.
2. From the result obtained for the compressive strength of each mix, maximum compressive strength was obtained by the mix containing 20% of rice husk ash at all curing age respectively.
3. The present result shows that it is possible to design a self-compacting concrete mix with rice husk ash up to 20% as replacement for cement

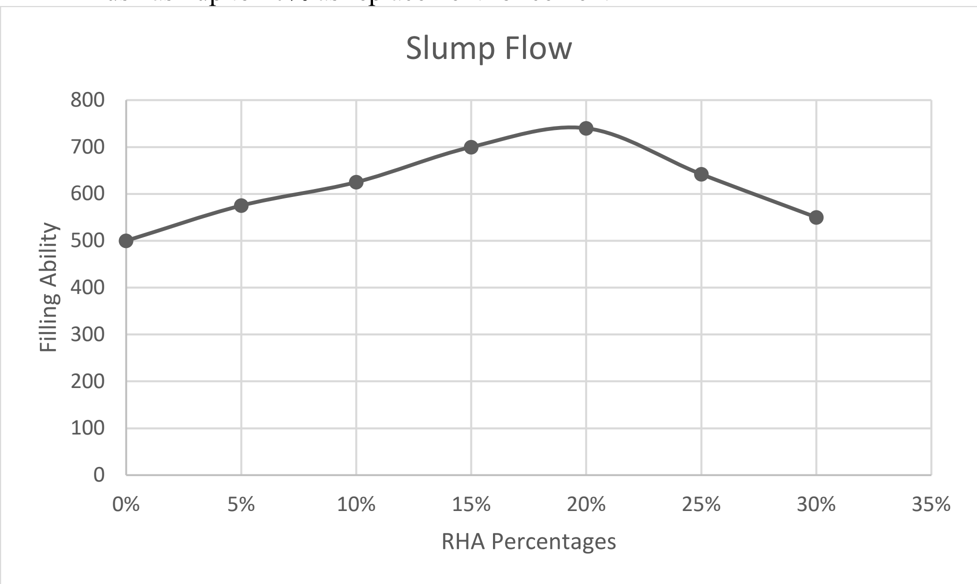

Figure 4. Slump Flow of the varying Concrete Mix

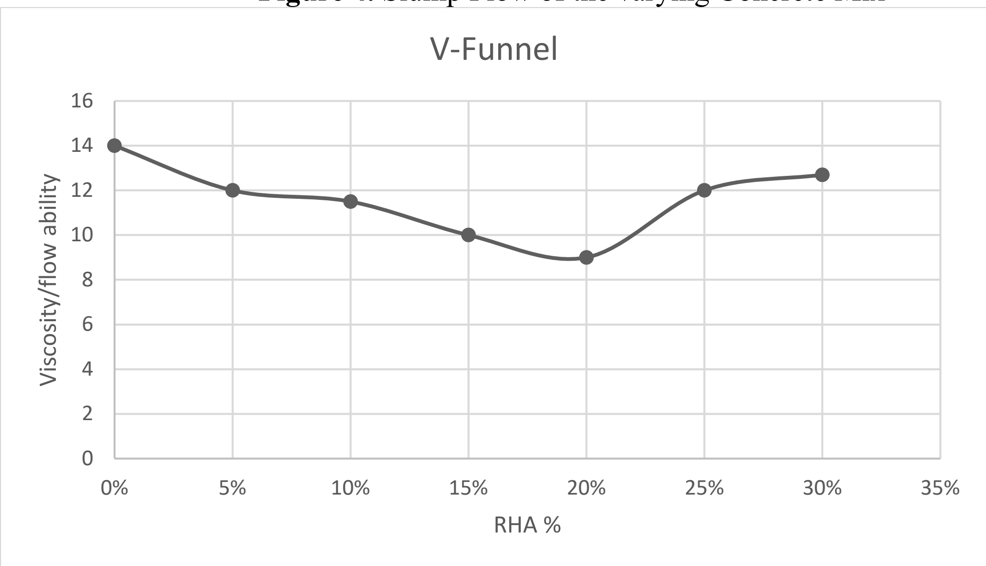

Figure 5: Showing the flow ability of various mix

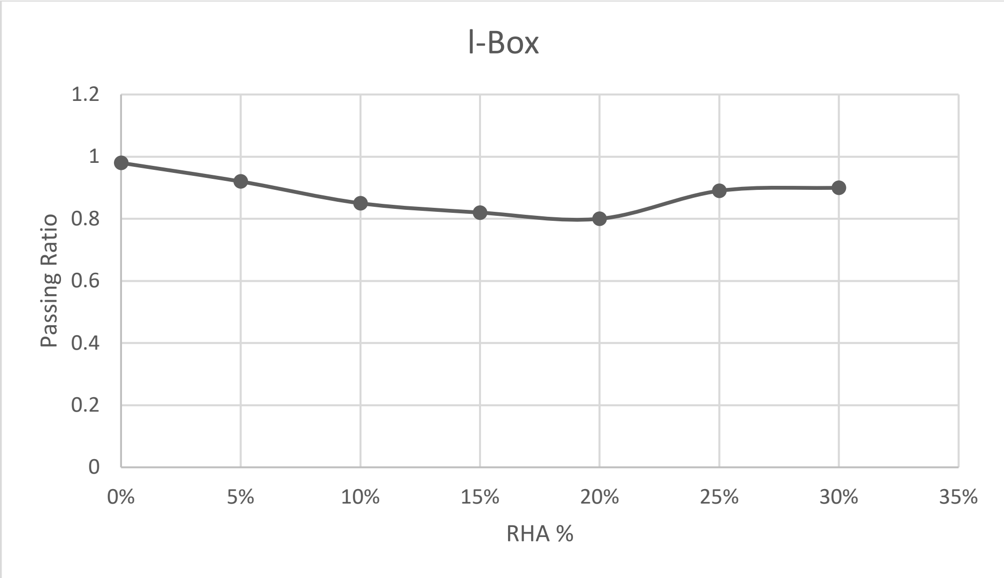

Figure 6: Showing the passing ability of the various mix

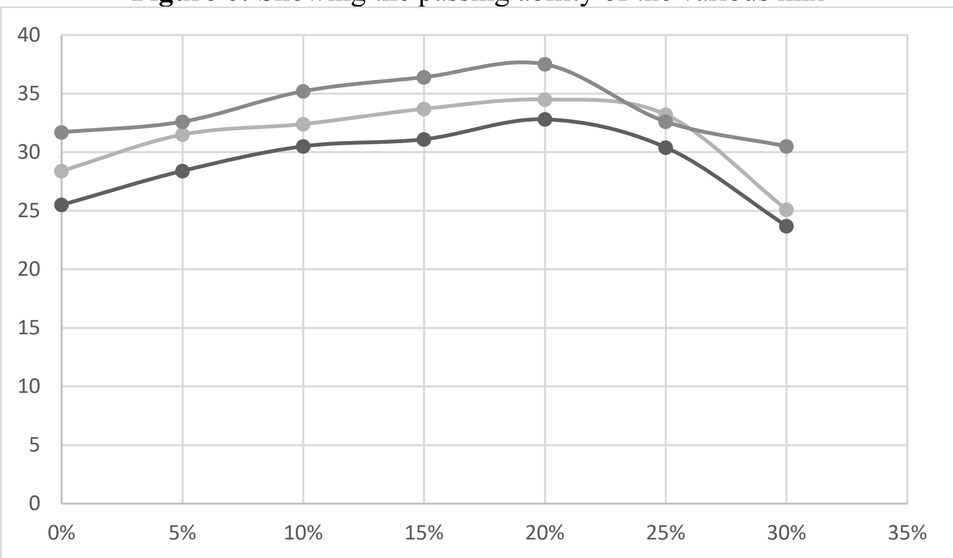

Figure 7: Compressive Strength of rice husk ash mix at varying percentage with respect to curing days

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