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A Review on Self-Compacting Concrete and The Effect of Elevated Temperature on Concrete Produced with Rice Husk Ash.

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ABSTRACT: This paper reviews the use of rice husk ash in the production of self-compacting concrete (SCC). The advantages of using rice husk ash in SCC production over more commonly used materials such as Portland cement are explored. The use of rice husk ash can reduce the environmental impacts of SCC by replacing the primary constituent of cement and allowing for production with significantly lower carbon dioxide emissions and water use. The mechanical properties of SCC produced with rice husk ash are studied, and the results are compared with those of SCC produced with more conventional materials. The influence of various proportions of rice husk ash on the properties of SCC were investigated and discussed. The results of this review suggest that rice husk ash can be easily used in SCC production and offers several advantages when compared to other traditional materials.

KEYWORDS: Pozzolanic Materials, Rice Husk Ash, Elevated Temperature, Compressive Strength, Flexural Strength and Durability.

I. INTRODUCTION

Self-compacting concrete (SCC) is a unique concrete from conventional concrete because it can be laid and compacted due to its weight without causing any vibration or with minimal vibration (EFNARC, 2002). In addition, SCC tends to segregate and bleed due to its enough cohesive nature. The most influential characteristics of SCC are good passing ability, high flow ability, and high segregation resistance (Lalitha, 2020). Concrete is a construction material that can be exposed to high temperatures due to fire outbreaks. Its exposure can lead to damage to concrete structures despite not being a combustible material. Elevated temperature alters physical, chemical and mechanical changes in concrete properties. Also, the environmental impact caused by cement is enormous. The production of cement is costly and also consumes higher energy for its production. It causes an increase in the extraction of natural resources and releases higher CO₂ during cement production. This has given rise to the search for more efficient and environmentally friendly materials that can replace binders in concrete production. The cement industry accounts for 5 – 8% of CO₂ emissions globally and it is regarded as the second largest producer of this greenhouse gas (Scrivener and Kirk, 2007). SO₃ and NO₂ released during the manufacture of Portland cement can cause serious environmental impacts such as the greenhouse effect and acid rain (Dongxu et al, 2000). The cost of cement binder used in concrete works is increasing daily and unaffordable, yet the need for housing and other constructions requiring this material keeps growing with increasing population, thus creating a void to be filled by finding alternative binding materials that can be used solely or in partial replacement of cement.

II. LITERATURE REVIEW

2.1 Pozzolans

Pozzolan is defined as a siliceous or aluminosiliceous material that, in finely divided form and the presence of moisture, chemically reacts at ordinary room temperature with calcium hydroxide, released by the hydration of Portland cement, to form compounds possessing cementitious properties (Canadian Standard Association, 2000). Pozzolans main function in concrete is to enhance the workability, durability and strength (Olawuyi et al., 2017). American Concrete Institute (2000) categorised Pozzolans into two categories, they are natural or artificial, depending on their



source. Natural pozzolans are either raw or calcined natural materials such as ash, shale, or some diatomaceous earth that have pozzolanic properties. Artificial pozzolans are mostly from by-product materials.

2.1.1 Classification of Pozzolans.

Table 1: Requirements of Pozzolana. (ASTM Specification C618-92a, 1994).

Chemical Requirements	Mineral Admixture Class		
	N	F	C
Silicon dioxide, Aluminium dioxide and Iron oxide (SiO ₂ +Al ₂ O ₃ +Fe ₂ O ₃), Minimum %	70	70	50
Sulphur Trioxide (SO ₃), Maximum %			
Moisture content, maximum %	4.0	5.0	5.0
Loss on Ignition, maximum %	3.0	3.0	3.0
Available alkalis as Na ₂ O, maximum%	10.0	6.0	6.0
	1.5	1.5	1.5
PHYSICAL REQUIREMENTS			
Fineness, maximum % retained on 325-Mesh (44µm) sieve.	34	34	34

2.1.2 Benefits of Pozzolans

ACI, (2000) said that Pozzolans did not only strengthen the concrete but have the following benefits as well.

- (i) Concrete produced from pozzolans are less costly than ordinary Portland cement.
- (ii) Concrete produced from pozzolans continues to gain increasing strength with time.
- (iii) Pozzolana decreases the permeability of concrete.
- (iv) Pozzolana concrete can resist the attack by aggressive compounds and hence increases concrete durability.
- (v) Pozzolans have other benefits such as reduction in shrinkage, low heat production, improved workability of concrete etc.

2.2 Self-Compacting Concrete.

Self-compacting concrete (SCC) is unique from traditional concrete because of its property to be laid and compacted due to its weight with minimal vibration or no vibration. In addition, SCC can segregate and bleed due to its enough cohesive nature. The most influential properties of SCC are good passing ability, high flowability, and high segregation resistance (EFNARC, 2002). The addition of pozzolanic materials as a partial replacement to OPC in SCC is an effective way to improve the fresh state and hardening properties of concrete. This is because calcium hydroxide (Ca (OH)₂) produced by cement hydration reacts with pozzolanic materials like rice husk ash (RHA) to produce additional calcium silicate hydrate (C-S-H) gel. The formation of this gel helps to improve the strength and durability of concrete by altering the pore structures of concrete.

2.2.1 Advantages of SCC Over Conventional Concrete.

EFNARC (2002) stated some of the advantages of using self-compacting concrete, they are:

- (i) Improved quality of concrete, faster construction times and overall costs.
- (ii) Facilitation of introduction of automation into concrete construction.
- (iii) Substantial reduction of environmental noise loading on and around a site.
- (iv) Better surface finishes and easier placing.
- (v) Improved durability and reliability of concrete structures.



2.2.2 Workability Properties of SCC

Workability is the ability of a fresh (plastic) concrete mix to fill the form/mould properly with the desired work (vibration) without reducing the concrete's quality. Slump test is used to measure the workability of fresh concrete.

Table 2: Test methods for workability properties of SCC (EFNARC. 2002)

Method	Property
Slump-flow by Abrams cone	Filling ability
T50cm slumpflow	Filling ability
J-ring	Passing ability
V-funnel	Filling ability
V-funnel at T5minutes	Segregation resistance
L-box	Passing ability
U-box	Passing ability
Fill-box	Passing ability
GTM screen stability test	Segregation resistance
Orimet	Filling ability

For the initial mix design of SCC, all three workability parameters (filling ability, passing ability and segregation resistance) need to be assessed to ensure that all aspects are fulfilled. A full-scale test should be used to verify the self-compacting characteristics of the chosen design for a particular application. For site quality control, two test methods are generally sufficient to monitor production quality. Typical combinations are Slump-flow and V-funnel or Slump-flow and J-ring (EFNARC, 2002).

Table 3: Workability Test (EFNARC, 2002)

Workability Tests	Requirements
Slump flow - Abrams	650 – 800 mm
T 50cm slump flow	2 – 5 sec
J Ring	0 – 10 mm
V Funnel	8 – 12 sec
V Funnel- T 5min	+ 3 sec.
L Box	H2 / H1 = 0,8-1,0
U Box	H2-H1 = 30 mm max
Fill Box	90 – 100 %
Screen Stability	0 – 15 %
Orimet test	0 – 5 sec

2.3 Rice Husk Ash

Rice husk Ash is regarded as super-pozzolana because of the large amount of silicon dioxide which is recommended for use in concrete production. Rice husk ash is one of the promising pozzolanic materials that can be blended with Portland cement for the production of durability and forms a calcium silicate hydrate (CSH) around the cement particles which is highly dense and less porous, and may increase the strength of concrete against cracking. Rice husk ash is a suitable source of pozzolanic material among agricultural waste components and is available in large quantities. It improves the durability properties of concrete (Abalaka, 2013).



2.3.1 Chemical Properties of Rice Husk Ash.

Table 4. XRF analysis for rice husk ash.

Compound	Composition (%)	Composition (%)
	RHA @700	RHA @800
Al ₂ O ₃	3.22	3.50
SiO ₂	73.2	72.7
Fe ₂ O ₃	1.77	1.92
Pb ₂ O ₃	8.75	9.60
SO ₃	0.15	0.17
K ₂ O	5.67	5.98
CaO	4.38	4.61
TiO ₂	0.24	0.24
Cr ₂ O ₃	0.003	0.003
MnO	0.67	0.69
CuO	0.02	0.03
ZnO	0.17	0.17
Cl	Nd	Nd

Source: Taku (2016).

2.3.2 Mechanical Properties of Concrete Produced with Rice Husk Ash.

Osama et.al (2021) reported the use of Rice Husk Ash (RHA) in concrete production in the presence and absence of steel fibres. The performance of concrete was examined. A total of nine mixes were designed, one control, four were without steel fibres containing only RHA, and the remaining four mixed RHA with steel fibres from 0.5 to 2%. Tests with 5, 10, 15, and 20% percentages of RHA replacing the concrete were targeted. Results were compared with the reference samples. From the results, it was revealed that about 10% of cement might be replaced with Rice Husk Ash mixed in with steel fibres with almost equal compressive strength. The replacement of cement more than 15% with RHA will produce concrete with a low performance in terms of strength and durability.

Seyed and Mojtaba (2017) revealed the benefits resulting from various ratios of rice husk ash (RHA) on concrete indicators through 5 mixture plans with proportions of 5, 10, 15, 20 and 25%. RHA by weight of cement in addition to 10% micro-silica (MS) to be compared with a reference mixture with 100% Portland cement. The results indicated a positive relationship between a 15% replacement of RHA and with increase in compressive strengths by about 20%. The optimum level of strength and durability properties generally gain with an addition of up to 20%, beyond that is associated with a slight decrease in strength parameters by about 4.5%. The same results obtained for water absorption ratios are likely to be unfavourable. Chloride ions penetration increased with an increase in cement replacement by about 25% relative to the initial values (about less than one-fifth).

Taku (2016) investigated the effect of the calcination temperature of rice husk on the pozzolanic properties of rice husk ash (RHA). Rice husk was collected and washed to remove sand and other impurities using the water beneficiation method and calcined at temperatures of 400, 500, 600, 700 and 800°C respectively for three hours. The result of XRF analysis revealed that RHA calcined at temperatures between 400°C and 800°C contains more than 70% silica as stipulated by ASTM C618 for pozzolanas. The silica content though varies slightly with different calcination temperatures of the rice husk ash. Calcination removed impurities present in the rice husk. As a whole, calcination improves the silica content of rice husk ash for use as a pozzolan and also removes mineral impurities that may affect the pozzolanic properties of the rice husk ash.

An investigation by Obam et.al (2011) confirmed that RHA is a pozzolan and acts as a potential cementitious material. The material was mixed with 45 per cent slaked lime. The resultant product ‘cement’ has a specific gravity of 2.1. The initial and final setting times were found to be 4½ and 76 hours respectively. The pozzolanic Activity Index of the ash was determined. It was found to be highly pozzolanic. The average compressive strength was found to be 3.2 N/mm² (32.6 kg/cm²). The optimum water-cement ratio was found to be 0.86.

Dabai (2009) conducted compressive strength tests on six mortar cubes. Cement was replaced by rice husk ash (RHA) at five levels (0, 10, 20, 30, 40 and 50%). The curing ages of the concrete were 3, 7, 14 and 28 days. The chemical analysis of the rice husk ash showed a high amount of silica (68.12%), alumina (1.01%) and oxides such as calcium oxide (1.01%) and iron oxide (0.78%) responsible for strength, soundness and setting of the concrete. It also



contained a high amount of magnesia (1.31%) which is responsible for the unsoundness. The result of the study indicated that RHA can be used as a cement substitute at 10% and 20% replacement and 14 and 28 days curing age.

2.3.2 Effect of Temperature on RHA-based Concrete.

Concrete can endure high temperatures during fire outbreaks due to its low thermal conductivity and high specific heat capacity but it does mean that the fire as well as the high temperatures does not affect the properties of concrete (Arioza, 2007). Exposure of concrete to fire outbreaks or high temperatures affects the durability of concrete and is regarded as one of the most harmful ways that cause permanent damage to structures. It reduces the service life of the concrete structure, causes casualties and may affect the construction's sustainability (Aydin 2019).

Mohammed et al., (2021) studied the mechanical properties of self-compacting concrete subjected to elevated temperature. The materials used were cement, rice husk ash, metakaolin, and pulverized burnt bricks. Laboratory tests conducted at the hardened stage were compressive strength, weight loss, and ultrasonic pulse velocity of self-compacting concrete subjected to 200°C, 400°C, 600°C, and 800°C elevated temperatures. At 800°C elevated temperature, the result of residual compressive strength shows that SCC produced with the addition of the ternary blend at 10 % had a higher value of residual compressive strength of 27.3 % over the control specimens. Control specimens were found to have the lowest values of weight loss in comparison to the self-compacting concrete produced with the addition of the ternary blend. The result of residual UPV shows that self-compacting concrete produced with the addition of the ternary blend at 10 % had a higher value of 8.6 % over the control specimens.

Wang (2017) conducted a study on the effect of high temperatures on the mechanical properties and microstructure of concrete containing rice husk ash. The result showed an improved strength when concrete was mixed with the appropriate amount of RHA. At 800°C the strength was 50% greater than that of normal concrete. Thus, rice husk ash can improve the strength and temperature resistance of concrete.

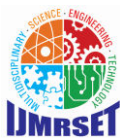
According to Iffat and Bose (2016) revealed that concrete strength, cracking, spalling, moisture content, density of concrete, fire intensity, transverse reinforcement placing, type of aggregates, fibre reinforcement and water-cement ratio can affect the properties of concrete when exposed to fire.

Toumi and Resheidat (2010) identified and quantified surface cracking of concrete heated to different temperatures ranging from 105 to 1250°C was carried out. The initial surface absorption and total porosity were measured. Crack density was determined using a flatbed scanner and images were treated using the Paint Shop program. The total porosity was obtained using the American Society for Testing and Materials (ASTM) methods as reported. The result of the investigation revealed that the mechanical properties of concrete were largely affected by temperatures beyond 500°C and were very feeble when temperatures exceeded 1000°C. The surface cracks' density, initial surface absorption and total porosity by boiling methods revealed a rapid indication of concrete durability from the report.

III. CONCLUSION

The following conclusions were drawn from the review:

- (1) XRF analysis of RHA showed that RHA calcined at temperatures between 400°C and 800°C contains more than 70% silica as contained in the guideline ASTM C618 for pozzolans.
- (2) Concrete containing rice husk ash produced concrete that is economical, durable, workable and effective.
- (3) The use of rice husk ash helps to reduce the cost of production of concrete.
- (4) RHA blend with cement led to a decrease in the workability of concrete but this can be corrected with the additional superplasticizer.
- (5) RHA shows much better performance after 90 days of curing.
- (6) Exposure of concrete to fire outbreak or high temperature affects the durability of concrete and cause permanent damage to structures. It reduces the service life of concrete.
- (7) Self-compacting concrete is unique from traditional concrete, it can be laid and compacted due to its weight without causing any vibration but tends to segregate and bleed due to its cohesive nature.
- (8) The results also showed that the substitution of 20% of the cement content by RHA powder induced higher compressive strength and improved properties related to durability.
- (9) The best possible way of disposal of waste material like RHA powder is to use it in concrete, which will reduce the environmental disposal burden.



REFERENCES

1. Abalaka, A. E. and Ugboime, N. C. (2010). Effects of Rice Husk Ash on the Properties of Cement Sand-Mortar. Nigerian Journal of Construction Technology and Management. 11 (1):7-12.
2. American Concrete Institute (2000): Use Of Raw Or Processed Natural Pozzolana In Concrete. ACI 232. IR-00. Farmington Hills, MI: American Concrete Institute
3. ASTM Specification C618-92a (1994): Chemical And Physical Specification. The American Society For Testing And Materials (ASTM).
4. Aydin, Ertug (2019): Effect of elevated temperature on the marble cement paste products for better sustainable construction. Politeknik Dergisi. 22(2), 259-267
5. Canadian Standards Association, CAN/CSA A3000-98, 'Cementitious Materials Compendium', 2000, 193. Compos. 32 (2); 212-127.
6. Dabai M.U , Muhammad C., Bagudo B.U, and Musa A. (2009): Studies on the Effect of Rice Husk Ash as Cement Admixture. Nigerian Journal of Basic and Applied Science (2009), 17(2)252-256. <http://www.ajol.info/browse-journals> ISSN 0794-5698
7. Dongxu Li, Yimin Chen, Jinlin Shen, Jiaohua Su, Xnequan Wu, (2000), The Influence Of Alkalinity On Activation And Microstructure Of Fly Ash. Cement And Concrete Research, 30, (2000) 881 – 886
8. EFNARC. (2002) "Specification And Guidelines For Self-Compacting Concrete. European Federation Of Producers And Applicators Of Specialist Products For Structures", 2002. www.efnarc.org
9. Iffat S., and Bose B., (2016): A Review on concrete structure in fire. International Journal of Civil , Environmental, Structural, Construction and Architectural Engineering. 2: 123-128
10. Lalitha Surya Tejaswini, G., & Venkateswara Rao, A. (2020). A Detailed Report On Various Behavioral Aspects Of Self-Compacting Concrete. Materials Today: Proceedings, 33, 839-844. <https://doi.org/10.1016/j.matpr.2020.06.273>.
11. Muhammad, A.; Thienel, K.-C.; Sposito, R. (2021): Suitability of Blending Rice Husk Ash and Calcined Clay for the Production of Self-Compacting Concrete: A Review. Materials 2021, 14, 6252. <https://doi.org/10.3390/ma14216252>.
12. Obam, S. And Tyagher, S (2013). Pozzolanicity And Some Engineering Properties Of Rice Husk Ash. Global Journal Of Engineering Research. Vol 12, 2013:45-49
13. Olawuyi, B. J., Joshua, O., Hassan, I. O., Enejiyon, M. O. And Egwuda, C. I. (2017). Exploratory Study On Agro-Waste Ashes Combination With Industrial Waste As Alternative Binders In Concrete. Proceeding Of The International Conference By Nigeria Building And Road Research Institute (NBRI), Abuja. 20th -22nd June
14. Osama Zaid, Jawad Ahmad, Muhammad Shahid Siddique And Fahid Aslam (2021). Effect Of Incorporation Of Rice Husk Ash Instead Of Cement On The Performance Of Steel Fibers Reinforced Concrete. Front. Mater., 30 June 2021 | <https://doi.org/10.3389/fmats.2021.665625>
15. Scrivener K. L. And Kirk Patrick R. J. (2007), Innovation In Use And Research On Cementitious Material. In: 12th International Congress Of Chemistry Of Cement, Montreal, Canada
16. Seyed Alireza And Mojtaba Ahmadi (2017); Rice Husk Ash As A Partial Replacement Of Cement In High Strength Concrete Containing Micro Silica: Evaluating Durability And Mechanical Properties. J.Cscm.2017.05.00. Construction Materials Volume 7, Pages 73-81
17. Shalini, A. Prem,V. and Dahiya, R. P. (2006). Application of a System Dynamics Approach for Assessment and Mitigation of CO2 Emissions From Cement Industry. Journal of Environmental Management, 79:383-398.
18. Taku, J. K, Amartey, Y. D, Kassir T (2016). Comparative Elemental Analysis of Rice Husk Ash Calcined at Different Temperatures Using X-ray Fluorescence (XRF) Technique. American Journal of Civil Engineering and Architecture, 2016, Vol. 4, No. 1, 28-31 Available online at <http://pubs.sciepub.com/ajcea/4/1/4> © Science and Education Publishing DOI:10.12691/ajcea-4-1
19. Toumi Belkacem and Musa Resheidat (2010): Influence of high temperature on surface cracking of concrete studied by image scanning technique. Jordan Journal of Civil Engineering.4(2):155-163.
20. Wang, W.H (2017): Effect of rice husk ash on High-temperature on mechanical properties and temperature resistance. School of civil engineering and hydraulic engineering, Ningxia University, Wencui N St. Yinchuan, China. Pp157-164



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