Direct Research Journal of Engineering and Information Technology
Vol. 8, Pp. 66-69, 2021
ISSN 2354-4155
DOI: https://doi.org/10.26765/DRJEIT14035036
Article Number: DRJEIT14035036
Copyright © 2021
Author(s) retain the copyright of this article
http://directresearchpublisher.org/drjeit/

Full Length Research Paper

The Engineering Assessment of Locally Produced Rice Husk Ash as Cement Partial Replacement in Concrete

Engr. Samaila Muazu Bawa

Department of Civil Engineering, Hassan Usman Katsina Polytechnic Katsina State, Nigeria.
Author E-mail: muazubawaf@gmail.com

Received 18 August 2021; Accepted 26 September 2021; Published 28 September 2021

ABSTRACT: The purpose of this study is to look into the strength contributions of rice husk ash derived from three different species of locally grown rice. The three varieties used are known locally as Jan-Nera, Yar-Yarima, and Jamila, and they differ in texture, yield, and post-harvest behavior. The compressive strength and setting time of concrete with percentages of cement replacement of 0%, 5%, 10%, and 15% for the various rice husk ash were investigated at a constant water to binder (w/b) ratio of 0.6. It is clear that the ashes for all three types of locally produced rice show strength enhancement (28 days) at 5% and 10% but decline at 15%, with Jamila showing strength enhancement throughout the replacement levels. Additional chemical analysis is required to fully understand the actual behaviors of these rice husk ashes in order to cover all of the properties required for concrete soundness in terms of strength and durability.

Keywords: Concrete; rice husk; concrete strength, setting time

INTRODUCTION

Cement has long been used as a binder in the production of concrete (Peter and Lea, 2019; Li, 2011). Concrete, as a major construction material, exhibits different strengths at different stages when the constituents are from different sources and textures, even when the same ratios are maintained. It is governed by its ability to withstand compressive stress, which is why it is good in compression but not so good when tensile stresses are applied to it, which is why it is said to be weak in tension, which is why Rebar is added to concrete to make it reinforced concrete (Li, 2011; Baltakys *et al*., 2018).

Partially replacing binder in concrete production has always been a problem because global cement demand is increasing, necessitating the search for replacement materials (Jian *et al*., 1995). Rice husk ash is abundant in Nigeria, and as rice production increases, so does waste in towns and villages. As a result, more means are required to create the utilization of such end products in the construction site. According to research, there is a significant positive relationship between strength and rice husk ash, which encourages advancement (Li, 2011; Jian *et al*., 1995). The hydration process of concrete mix with rice husk admixture was successful, indicating the need to investigate its potential use as a partial replacement. Jian *et al*. (1995); Scrivener *et al*. (1999); Li *et al*. (2003); Wei *et al*. (2010) The electrical resistivity measurement was used to monitor some early age properties of a concrete mix containing rice husk in order to learn more about its hydration mechanism, which was then compared to its mechanical and compressive strength (Li *et al*., 2003; Wei *et al*., 2010). The objective of this study is to investigate the influence of rice-species in concrete compressive strength and setting time so that best specie and optimum percentage of replacement would be recommended for construction purposes.

MATERIALS AND METHODS

Materials and mixture proportions

An ordinary Portland cement 42.5 was used as the main binder as it is commonly used in engineering activities (Li *et al*., 2003; Wei, *et al*., 2010), locally produced rice was obtained and the husk was extracted to be used under the present investigation. The chemical composition for the different types of rice used has not been explored even though there are some established theories related

Table 1: Mix proportion for the concrete constituents.

Sample	Water/Binder Ratio	Cement (kg/m^3)	Rice Husk Ash (kg/m^3)	Sand (kg/m^3)	Coarse Agg (kg/m^3)
RH0	0.6	455	0	523	1112
RH5	0.6	432.25	22.75	523	1112
RH10	0.6	409.5	45.5	523	1112
RH15	0.6	386.75	68.25	523	1112

Table 2: Initial and final setting time with varying percentage of rice husk ash replacement.

Sample	Jan Nera		Yar-Yarima		Jamila	
	Initial	Final	Initial	Final	Initial	Final
RH0	180	365	180	365	180	365
RH5	176	350	165	328	159	315
RH10	164	330	158	319	145	280
RH15	170	336	165	323	140	265

to this (Jian *et al*., 1995; Li *et al*., 2003; Wei, *et al*., 2010; Taylor, 1997). Concrete grade C30 is targeted with the mix ratio of 1:1$^{1/2}$:3 as shown in the mix proportions for the constituents are shown in (Table 1) with RH used to show that irrespective of the rice type, the proportion remains the same. The replacement of cement by rice husk in mass was 0%, 5%, 10% and 15%, respectively. The samples code was named as RH0J, RH5J, RH10J and RH15J for Jan nera, RH0Y, RH5Y, RH10Y and RH15Y for Yar-Yarima then RH0JM, RH5JM, RH10JM and RH15JM for Jamila. All the concrete samples blended with or without rice husk were prepared with water to binder (w/b) ratio of 0.6. Crushed aggregates sized 10mm as coarse and fine natural sand were used in the experiment (Morshed *et al*., 2014; Adams and Ideker, 2017).

Experimental methods

Setting Time

The setting time of concrete samples was tested by the Vicat Needle. Neat samples with normal consistency were used to measure the setting time of concrete with or without rice husk ash in accordance with the Chinese standard GB/T 1346-2011 and ASTM (Son *et al*., 2018; GB/T, 2011; ISO, 2008; ASTM, 2013), which was non-equivalent with ISO 9597: 2008 (Li *et al*., 2003). For RH0, RH5, RH10, and RH15 for each rice variety, the respective setting times were measured by using a constant w/c ratio of 0.6. During the final setting time test, the specimen mode was not reversed because the w/c ratio is 0.6.

Concrete compressive strength

Concrete cube specimens with the size of 150 ×150 ×150 mm were produced and subjected to test in order to determine compressive strength at 28 days for each rice-specie and for varying percentage of the ash in each mix. All of the specimens were cured in water at 20°C for one day before being demoulded. The testing method follows that of a work presented by (Li 2011; Wei *et al*., 2010; Son *et al*., 2018).

RESULTS AND DISCUSSION

Setting time

Table 2 presents the setting time of samples with varying percentage of rice husk ash replacement. The setting time was shortened with up to 10% replacement for Jan Nera and Yar-Yarima's husk ashes but increased when 15% replacement is used for Jamila specie. The trends continuously show good result enhancement. Setting time predicts compressive strength of concrete according to (Fu *et al*., 2015; Hidalgo *et al*., 2008; Hidalgo *et al*., 2009).

For rice husk replacement RH0, RH5 and RH10% for Jan Nera, the time interval between the initial and final setting time of concrete samples are 185 minutes, 174

Table 3: Tabular presentation of concrete compressive strength with and without rice husk.

Sample	Jan Nera	Yar-Yarima	Jamila
RH0	32	32	32
RH5	33	35	36
RH10	35	36	38
RH15	34	35	39

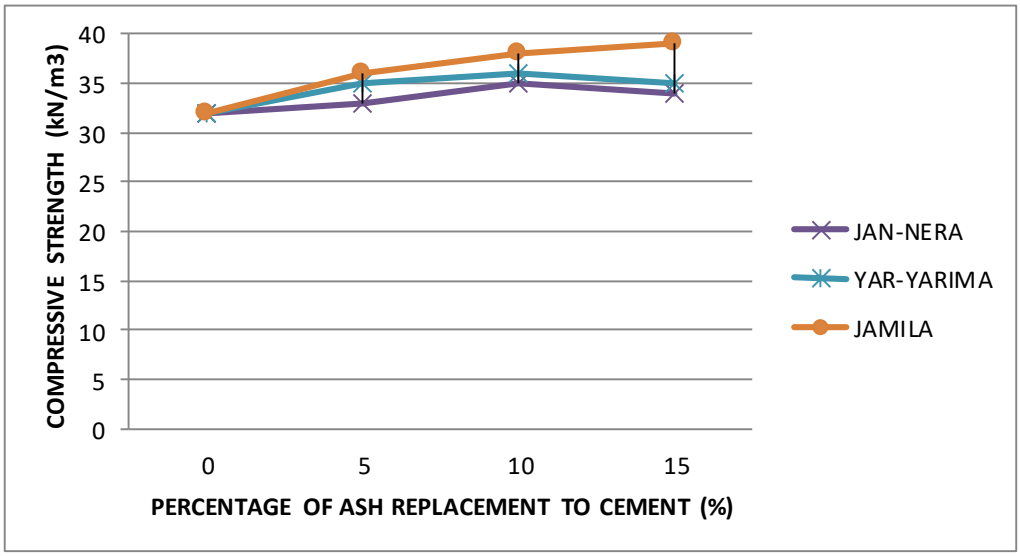

Figure 1: Compressive strength of concrete samples with and without rice husk.

minutes and 166 minutes, respectively but increased at RH15% as 166 minutes while for Yar-Yarima, 185 minutes, 156 minutes, 161 minutes and 158 minutes as at RH0%, RH5%, RH10 and RH15% respectively.

Compressive strength

Figure 1 and Table 3 show the compressive strength of concrete with varying percentage of rice husk as replacement to cement in the concrete. For Jan Nera and Yar-Yarima at RH0%, RH5%, and RH10% with all the samples show reasonable strength at 28 days considering the adopted mix ratio. Though no much strength differences realized with the increase in percentage replacement but it is evident that it can be utilized as partial replacement at a reasonable proportion. It also shows that the husk ash obtained from Jamila rice specie proved to be more suitable to replace cement even at 15%. The results show similarity with the one obtained when another perspective of rice husk application was considered (Jian *et al*., 1995; Collepardi *et al*., 1995; He *et al*., 2019).

DISCUSSION

The result shows shorter setting time with increase in percentage replacement for both Jan Nera and Yar-Yarima specie but became longer at RH15. Similarly, Jamila specie shows uniform trend to those of Jan-Naira at RH5% and RH10% but shorten further at RH15 Thus, the final setting delays uniformly after the initial setting for all the samples.

It has also been noticed that, the concrete samples of Jamila-specie (RHJM) exhibits shortest setting time with RHJM15 sample shows the least time among them which is in line with what has been obtained when rice husk is used as admixture (ISO 9597, 2008; Hidalgo *et al*., 2008; Hidalgo *et al*., 2009).

It can be understood that, the replacement of cement using rice husk ash for the three different rice species examined shows reasonable increment in the strength development at 0, 5 and 10 % for all the species but can

be up to 15% for Jamila-specie. Similar findings have been reported (Jian *et al*., 1995; Wei *et al*., 2010; He *et al*., 2019).

Conclusion

In this paper, it was discovered that replacing the cement binder with rice husk ash at reasonable percentages ranging from 0% to 5% to 10% for all species with up to 15% replacement for Jamila has an effect on setting time and compressive strength. When these types of rice species are used, the results show that the optimum value of replacement percentage is 10%. The long term analysis would be conducted to cover 90 days of specimen testing age in order to examine the long term behaviour of replacing cement with rice husk ash, as well as durability assessment. Further research is recommended to find out the other species so that to know which would be the best to replace ordinary Portland cement and at which percentage.

REFERENCES

Adams MP, Ideker JH (2017). Influence of aggregate type on conversion and strength in calcium aluminate cement concrete, Cem. Concr. Res. 100 (2017): 284–296. doi:10.1016/j.cemconres.2017.07.007.

ASTM C511(2013). Standard specification for mixing rooms, moist cabinets, moist rooms, and water storage tanks used in the testing of hydraulic cements and concretes, ASTM Int. (2013). doi:10.1520/C0511-09.2. (14).

Baltakys K, Sarapajevaite G, Dambrauskas T (2018). The influence of different additives on the early-stage hydration of calcium aluminate cement, J. Therm. Anal. Calorim. 134 (2018) 89–99. doi:10.1007/s10973-018-7153-7.

Collepardi M, Monosi S, Piccioli P (1995). The influence of pozzolanic materials on the mechanical stability of aluminous cement, Cem. Concr. Res. 25 (1995) 961–968. doi:10.1016/0008-8846(96)00024-5.

Fu T, Adams MP, Ideker JH (2015). A preliminary study on a calcium aluminate cement concrete maturity theory in predicting conversion, in: 14th Int. Congr. Chem. Cem., Beijing, 2015. doi:10.13140/RG.2.1.2606.5369.

GB/T 1346 (2011). Test methods for water requirement of normal consistency, setting time and soundness of the Portland cement, (2011).

He R, Ye H, Ma H, Fu C, Jin X, Li Z (2019). Correlating the chloride diffusion coefficient and pore structure of cement-based materials using modified noncontact electrical resistivity measurement, J. Mater. Civ. Eng. 31 (2019) 04019006. doi:10.1061/(asce)mt.1943-5533.0002616.

Hidalgo A, García Calvo JL, Alonso MC, Fernández L, Andrade C (2009). Microstructure development in mixes of calcium aluminate cement with rice huskor fly ash, J. Therm. Anal. Calorim. 96 (2009) 335–345. doi:10.1007/s10973-007-8439-3.

Hidalgo A, López JL, García C, García J, Olmo S, Petit MC (2008). Microstructural evolution of calcium aluminate cements hydration with rice husk and fly ash additions by scanning electron microscopy, and mid and near-infrared spectroscopy, J. Am. Ceram. Soc. 91 (2008) 1258–1265. doi:10.1111/j.1551-2916.2008.02283.x.

ISO 9597(2008). Cements — Test methods — Determination of setting time and soundness, Int. Organ. Stand. (2008).

Jian D, Yan F, Beaudoin JJ (1995). Strätlingite formation in high alumina cement - rice husk systems: Significance of sodium ions, Cem. Concr. Res. 25 (1995) 1311–1319.

Li Z (2011). Advanced Concrete Technology, John Wiley & Sons, Inc., 2011.

Li Z, Wei X, Li W (2003). Preliminary interpretation of portland cement hydration process using resistivity measurements, ACI Mater. J. 100 (2003) 253–257.

Morshed AZ, Azar A, Shao Y (2014) Characte rizing cement carbonation curing using non-contact electrical resistivity measurement, Adv. Cem. Res. 27 (2014) 214–224. doi:10.1680/adcr.13.00083.

Peter H, Lea LMC (2019). Chemistry of Cement and Concrete, 5th ed., Butterworth-Heinemann, Oxford, 2019.

Scrivener KL, Cabiron JL, Letourneux R (1999). High-performance concretes from calcium aluminate cements, Cem. Concr. Res. 29 (1999) 1215–1223. doi:10.1016/S0008-8846(99)00103-9.

Son HM, Park SM, Jang JG, Lee HK (2018). Effect of nano-silica on hydration and conversion of calcium aluminate cement, Constr. Build. Mater. 169 (2018) 819–825. doi:10.1016/j.con buildmat.2018.03.011.

Taylor HFW (1997). Cement Chemistry, 2nd ed., Thomas Telford, London, 1997. doi:10.1016/S0958-9465(98)00023-7.

Wei X, Tian K, Xiao L (2010). Prediction of compressive strength of Portland cement paste based on electrical resistivity measurement, Adv. Cem. Res. 22 (2010) 165–170. doi:10.1680/adcr.2010.22.3.165.