iJETRM
International Journal of Engineering Technology Research & Management

UTILIZATION OF FLY ASH AND RICE HUSK ASH AS A SUPPLEMENT TO CONCRETE MATERIALS - A CRITICAL REVIEW

Mr. Gaurav Shupta , Dr. Ajay Goyal , Er. Akhil Shetty

Department of Civil Engineering, Chitkara University, Himachal Pradesh - 174103, India

ABSTRACT
This paper shows the works in the direction of utilizing fly ash (FA) and rice husk ash (RHA) in concrete which is a construction material made by combining cement and different types of admixtures. Rice husk ash and fly ash are used to improve the mechanical properties of concrete. Rice husk is an agro-based waste product that is obtained from the rice milling industry which is eventually dumped on the environment as a waste to cover a large area of the landfill and causes environmental pollution problems. Fly ash is a combustion-based by-product that is obtained by burning coal in thermal power plants and impacts the environment and poses health problems if not disposed of. These studies presented herein verify the feasibility and potential utilization of these materials for enhancing the properties of concrete on their addition. The purpose of making this review paper is to gather the most relevant study in one place so that further work is done in this direction in the future. Authors of this review paper gather some studied in which concrete is developed by the addition of fly ash and rice husk ash this has gathered after several days of hard work. The results indicated improvement in the durability of concrete by mixing rice husk ash (RHA) and fly ash (FA) apart from the ecological benefits.

KEYWORDS:
Properties, Fly ash (FA), rice husk ash (RHA), and concrete

INTRODUCTION

Concrete is a product that is made from cement, water, a matrix of sand, and mixed with some gravels or crushed stone and primarily used as a raw material in buildings, bridges, etc (Mahalingam et al., 2016). The ingredients used to make concrete is divided into two parts active and inactive. The active group includes-cement and water and the inactive group include -fine and coarse aggregates also known as the inert matrix (Freitas et al., 2020). Concrete is a component that is made by the mixture of two heterogeneous substances that are aggregate and paste which is generally known as a binder. Cement water and aggregate are mixed to prepare the paste used to make the binder (Bahedh & Jaafar, 2018). Admixtures may be used in the concrete but its usage depends on the user. Admixtures are used to enhance the property of concrete. A chemical reaction in which cementitious materials and water are mixed is known as hydration (Bahedh & Jaafar, 2018). In this process, the paste which is formed becomes hard and binds the aggregates. Fly ash, rice husk, and admixtures are used to obtain desired properties in concrete, and the paper by (Sharma & Akhai, 2019) showcase the addition of fly ash with aluminum composite prepared through the casting process showcase the enhancement in the properties. Fly ash is a waste product that we get after burning coal. Fly ash contaminates our environment by mixing in the air (Sharma & Akhai, 2019), so if it is used in concrete to improve its properties the danger that fly ash poses to the environment gets eliminated. Moreover, rice husk ash is also a by-product that is received after burning rice husk in high temperatures at the paper plant industry (Nair et al., 2008). Rice is boiled in the milling process for which heat energy is used in rice mills it is better off installing their boilers than relying on any other energy resources to produce heat energy (Chieng & Kuan, 2020). When energy is to be produced, rice husk is used which is obtained from the milling process which is burned under the controlled temperature inside the boiler itself and is used as fuel through direct combustion or gasification after burning the organic bio-waste that comes out is called rice husk ash. This residual contains silica which highly reactive. Burning temperature and holding time can be some of the properties on which RHS depends (Xu et al., 2015). Nowadays, artificial fiber is commonly used to improve mechanical properties. Throughout the world, experiments are going on to improve cement concrete properties by adding by-products which are fly ash and rice husk ash (Khan et al.,

iJETRM
International Journal of Engineering Technology Research & Management

2015). Rice Husk ash as well as fly ash both is the by-product that is obtained from the paddy industry and the power station after burning coal respectively (Ahmari & Zhang, 2013).

Fig 1: Fly ash

Fig 2: rice husk ash

PHYSICAL AND CHEMICAL PROPERTIES OF FLY ASH AND RICE HUSK ASH (PERCENTAGE)

Fly Ash which is produced after burning the Coal at power generation Industries in result by-product in the form of Fly ash is received (Ali et al., 2020). Moreover, it is utilized as a cementitious and Pozzolonic material in OPC concrete. If ACI 116, the fly ash, which is very close behind the father, is received after the composition of which the call of the ground or powdered call is lit, then it is the firebox transport as the boiler. In the UK it is known as a pulverized - fuel cast. Fly ash is a complex kind of material that is present in the form of a heterogeneous combination of amorphous and crystalline phases (Criado et al., 2010). Fly ash consists of different types of size, chemical, composition, and density. Below is **Table 1** which shows the chemical composition of Fly ash. According to (Arezoumandi et al., 2015) in their paper they have used class- C fly ash which consists of 33.46 % of SiO_2, Al_2O_3 which is 19.53 %, 6.28 % of Fe_2O_3 26.28 % of Cao, 5.54% of MgO, 2.4% of SO_3, 1.43% of Na_2O and 0.34 % of Loss of Ignition (LOI).In this, the specific gravity is 2.73 but the fineness (Blaine) which is not measured. By (Hemalatha & Ramaswamy, 2017) in their paper, they include class F and class C. But both have different chemical composition as follows in class C 11.8 - 46.4% of SiO_2, 2.6 - 20.5 % of Al_2O_3, 1.4 – 15.6 % of Fe_2O_3 ,15.1-54.8 % of Cao, 0.1- 6.7 % of MgO, 1.4-12.9 % of SO_3 ,0.2-2.8 % of Na_2O, 0.3 - 9.3 of K_2O, 0.2-0.4% of P_2O_5,0.6 – 1.0% of TiO_2 and 0.3-11.7 % of Loss of Ignition (LOI).

Vol-05 Issues 01, January-2020 ISSN: 2456-9348
Impact Factor: 4.520

iJETRM
International Journal of Engineering Technology Research & Management

Table 1: Chemical compositions of fly ash (percentage)

Chemical compositions of fly ash														References
SiO_2	Al_2O_3	Fe_2O_3	Cao	MgO	SO_3	Na_2O	K_2O	P_2O_5	TiO_2	MN	LOI	Available alkalis	Types of Fly Ash	
33.46	19.53	6.28	26.28	5.54	2.4	1.43	-	-	-	-	0.34	-	Class -C	(Arezoumandi et al., 2015)
11.8 - 46.4	2.6 - 20.5	1.4-15.6	15.1 - 54.8	0.1 - 6.7	1.4-12.9	0.2 - 2.8	0.3-9.3	0.2 - 0.4	0.6 - 1.0	0.03 - 0.2	0.3 - 11.7	-	Class C	(Hemalatha & Ramaswamy, 2017)
37.0 - 62.1	16.6- 35.6	2.6 - 21.2	0.50 - 14.0	0.3 - 5.2	0.025- 4.7	0.1 - 3.6	0.1 - 4.1	0.1-1.7	0.5 - 2.6	0.03 - 0.1	0.3 - 32.8	-	Class F	
53.1	27.7	9.81	2.4	0.9	0.22	0.11	2.41	-	-	-	-	1.2	Wateree Station wt.%	(Assi et al., 2018)
53.5	28.5	9.41	1.61	1.32	1.01	0.16	0.4	-	-	-	-	1.92	Ordinary McMeekin wt.%	
52.9	28.6	6.6	2.9	1.01	0.1	0.21	2.81	-	-	-	-	2.01	McMeekin Spherix 50 wt.%	
51	29.3	6.52	4.1	1.21	0.22	0.41	2.9	-	-	-	-	2.3	McMeekin Spherix 15 wt.%	
52.32	26.29	5.96	5.83	1.57	0.15	0.04	0.81	-	1.66	-	4.48	-	Geopolymer Fly ash Sand	(Agrawal et al., 2019)

In class F 37.0-62.1 % of SiO_2, 16.6-35.6 % of Al_2O_3, 2.6-21.2 % of Fe_2O_3 ,0.50-14.0 % of Cao, 0.3-5.2% of MgO, 0.025 - 4.7 % of SO_3 ,0.1-3.6 % of Na_2O, 0.1-4.1% of K_2O, 0.1-1.7% of P_2O_5,0.5-2.6% of TiO_2 and 0.3-32.8% of Loss of Ignition (LOI). By (Agrawal et al., 2019) in their Paper Geopolymer Fly ash Sand was used in which 52.32 % of SiO_2, 26.29 % of Al_2O_3, 5.96 % of Fe_2O_3, 5.83% of Cao, 1.57% of MgO, 0.15 % of SO_3, 0.04 % of Na_2O, 0.81% of K_2O, 1.66% of TiO_2 and 4.48% of Loss of Ignition (LOI). In this the specific gravity which was 1.89 and fineness (Blaine) was 2.56.

Table 2: Physical Properties of Fly ash

Specific Gravity	Fineness (Blaine)	References
2.73	Not measured	(Arezoumandi et al., 2015)
22.12	9.027 m^2/kg	(Mahalingam et al., 2016)
1.89	2.56	(Agrawal et al., 2019)
2.18	4350 cm^2/g	(Nawaz et al., 2020)

Rice husk is an agricultural remain that is obtained from various agro-based biomass industries. It is procured from the outer covering of rice grain in the route to obtain white rice kernel during the milling process (Jiang et al., 2018). Thus they all have some chemical composition which has listed in **Table 3.** According to (Vigneshwari et al., 2018) in their paper they have mentioned were 89.9% of SiO_2, CaO that was 2.5%, 3.8% of K_2O, 1.3% of P_2O_5, 0.7% of MnO, and Loss of Ignition (LOI) of 1.80%. where the specific gravity was 2.00.

Table 3: Chemical Composition of Rice husk ash (percentage)

Chemical Composition of Rice husk ash

iJETRM
International Journal of Engineering Technology Research & Management

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	P_2O_5	TiO_2	MnO	LOI	References
89.9	-	-	2.5	-	-	-	3.8	1.3	-	0.7	1.80	(Vigneshwari et al., 2018)
93.5	0.2	0.4	0.9	0.4	0.2	-	3.3	-	-	-	8.7	(Rattanachu et al., 2020)

According to (Rattanachu et al., 2020) in their paper they have mentioned were 93.5% % of SiO_2, 0.2% of Al_2O_3,0.9% of Fe_2O_3, CaO that was 0.9%, 3.3% of K_2O,0.7% of MnO, and Loss of Ignition (LOI) of 8.7%. where the specific gravity was 2.24.

Table 4: Physical Properties of Rice husk ash

Specific Gravity	Fineness (Blaine)	References
2.00	-	(Vigneshwari et al., 2018)
2.24	-	(Rattanachu et al., 2020)

LITERATURE REVIEW

The research so far in flying ash and rice husks is shown in **Table 5**, **Table 6**, below. **Table 7** includes scholarly articles employing rice husk ash and fly ash and presenting the fundamental findings of these approaches.

Table 5: Usage of fly ash in concrete

Author	Materials	Country	Findings/Outcomes
(Arezoumandi et al., 2015)	Class C Fly ash	USA	According to the study, as the substitute level of the fly ash increases, the bond strength of the reinforced steel in the concrete gets a rise.
(Mahalingam et al., 2016)	Fly ash	India	For manufacture, self-compacting concrete raw fly ash was collected and uses it directly. The compressive strength in concrete in which the substitution level of fly ash is slightly below, which is made by mixing 30% raw fly ash with SCC concrete. Raw Fly Ash's pozzolanic performance has been monitored for the additional strength gain for the further curing stages.
(Hemalatha & Ramaswamy, 2017)	Fly ash	India	The study showed that cement can be effectively substituted until 60 % of fly ash by using scientific methods instead of trying and get failed.
(Assi et al., 2018)	Fly ash	USA	The average particle size distribution affects compressive strength according to the outcomes of the investigation. When the smaller particle size is used, the compressive strength of the concrete is increased. When the fly ash grade is revised as of McMeekin to McMeekin Spherix, the compression strengths increase by 210 percent.
(Agrawal et al., 2019)	Fly ash	India	This paper depicts as the river sand concrete can be replaced and increase in durability by geopolymer fly ash concrete. Thus, for building activities, Geopolymer fly ash may be used.
(Nawaz et al., 2020)	Fly ash + sodium sulfate	Pakistan	according to the findings, Sulfate activation leads to a rise in the strength of the fly ash at an initial age. The concrete mixture with 20 % and 40% demonstrates

iJETRM
International Journal of Engineering Technology Research & Management

			greater strength than standard concrete until the activation is completed.

Table 6: Usage of rice husk ash in concrete

Author	Materials	Country	Findings/Outcomes
(Le et al., 2015)	Rice husk ash	Germany	The study shows that RHA (rice husk ash) increases the enlargement of mortar. The mortar in which the coarse rice husk ash subsists becomes disrupted after the 28 and 56 days of immersion. If the minute rice husk ash is incremented, due to this the mortar content decrease.
(Gursel et al., 2016)	Rice husk ash	USA	As per the result of the study, ternary and quaternary concrete combined with RHA along with fly ash. Through this, we get lower GWP while the ability to mix without compromising design strength.
(Fapohunda et al., 2017)	Rice husk ash	Nigeria	The utilization of rice husks in concrete increases water demand. And the cement can be a substitute from the rice husk ash by 10%, which makes the strength development comparable to the controlled specimen. The utilization of rice husk ash in concrete will improve the microstructure as well as avoids degradation due to sulphate attack, chloride ingress, etc and there is a good durable concrete that also contains good shrinkage properties.
(Vigneshwari et al., 2018)	Rice husk ash	India	As per the results, the concrete including rice husk ash depicting the mechanical and durability performance at normal curing and the steam curing has come to satisfactory, at last, rice husk ash can be utilized as an alternative of silica fumes in concrete.
(Sua-iam et al., 2019)	Rice husk ash	Thailand	According to the result of this paper, it is revealed that as the foundry sand waste increases, its effect on the self-consolidating concrete as well as rice husk ash because of this, the amount of superplasticizer is also increased, and the density was decrees and the slump flow loss will occur. Rice husk ash along with foundry sand waste decreases the filling and passing capability of self-consolidating concrete.
(Rattanachu et al., 2020)	Rice husk ash	Thailand	Paper depicts that if the ordinary Portland cement is replaced by 20% from ground rice husk ash, the compressive strength gets enhanced as compared to the recycled aggregate concrete which is not including ground rice husk ash for 60days.

Table 7: Usage of fly ash along with rice husk ash in concrete

Author	Materials	Country	Findings/Outcomes
(Hwang & Huynh, 2015)	Class-F fly ash + Residual Rice Husk Ash	Taiwan	The bricks discussed in this paper have been developed after studying the properties of the brick and its conformity with the relevant Vietnamese standards. The special mention for their increase in durability is due to the utilization of fly ash and rice husk ash, which are used for eco-friendly construction of geo-polymerization bricks.

iJETRM
International Journal of Engineering Technology Research & Management

(Van Tang et al., 2018)	Fly ash (FA) + Rice husk ash (RHA)	Russia	One thing is clear from this paper that it has a significant inflow on the concrete mixtures mobility due to the use of a few quantities of fly ash and rice husk ash. Mathematical modeling has been used by the authors to find out in the high mobility concrete mixture which will get better response for using the appropriate amount of rice husk and flash
(Sam, 2020)	Fly ash (FA) + Rice husk ash (RHA)	China	According to this paper, a concrete has been prepared by mixing fly ash and rice husk adding in various percentage 0%, 10%, 20%, 30%, 40%, 50% and 0%, 5%, 7.5%.10%, 12.5%, and 15% respectively. The compressive strength has been analyzed for at least **7**days and at most, for 28 days, and because of that analyzation it has come out that if the strong compressive concrete strength is to be achieved, the fly ash and rice husk ash had to be used in some percentage now, 30% fly ash and 7.5% of rice husk ash is to use in such way so that they can enhance the strength. We have made it clear that if the fly ash and rice husk ash is taken into the right amount of psoriasis, it makes the compressive strength of concrete rises.
(Das et al., 2020)	Rice husk ash + fly ash from Blast Furnace slag	India	The result of this paper is the rise in the percentage of RHA in geopolymer concrete, which ultimately plays a leading role in a downfall in workability and compressive strength.

CONCLUSION

It is seen that various endeavors have been undertaken for utilizing fly ash with rice husk ash in concrete effectively. The followings points can thus be concluded in this review paper:

1. It has been seen from this review work that, if it worked in that direction, it would improve the mechanical properties, i.e., it is possible to amplify the durability of concrete by mixing rice husk ash and fly ash in concrete. Various researchers have observed in many different countries that the desired strength can be achieved by replacing around 40% of cement with fly ash, rice husk ash, etc.

2. This review study has also highlighted that the strength of the concrete has come's out better when fly ash is used on the other hand the results with rice husk ash concrete are not that much appreciating.

3. The industry produces a lot of the by-products like fly ash, Rice husk ash which have a terrible impact on the environment, so if this material mixed in concrete makes a better construction material and also if fly ash and rice husk ash are mined in cement, there can be cost reduction ranging from 33 to 40%.

FUTURE SCOPE

There are still some possibilities which can be explored through further research:

- In the future, rice husk ash and fly ash can be combined into concrete and can be replaced by fine aggregate. There is still a lot of research required here because there may be a lot of ratios in which they have not been mixed.
- The utilization of RHA in concrete can raise the requirement of water, but if the rice husk ash, fly ash is mixed with some amount of steel fiber, the strength of the concrete can be a boost, which can allow us to replace the aggregate with this mixture. Hence this concrete can be used as a normal concrete in the future.
- There is still a lot of work to be done in this direction to make an economical construction material as well as durability is also high so that people can be benefitted more from it.

iJETRM
International Journal of Engineering Technology Research & Management

REFERENCES

[1] Agrawal, U. S., Wanjari, S. P., & Naresh, D. N. (2019). Impact of replacement of natural river sand with geopolymer fly ash sand on hardened properties of concrete. Construction and Building Materials, 209, 499-507.

[2] Agrawal, U. S., Wanjari, S. P., & Naresh, D. N. (2019). Impact of replacement of natural river sand with geopolymer fly ash sand on hardened properties of concrete. Construction and Building Materials, 209, 499–507. https://doi.org/10.1016/j.conbuildmat.2019.03.134

[3] Ahmari, S., & Zhang, L. (2013). Utilization of cement kiln dust (CKD) to enhance mine tailings-based geopolymer bricks. Construction and Building Materials, 40, 1002-1011.

[4] Ali, B., Qureshi, L. A., Shah, S. H. A., Rehman, S. U., Hussain, I., & Iqbal, M. (2020). A step towards durable, ductile and sustainable concrete: Simultaneous incorporation of recycled aggregates, glass fiber and fly ash. Construction and Building Materials, 251. https://doi.org/10.1016/j.conbuildmat.2020.118980

[5] Arezoumandi, M., Looney, T. J., & Volz, J. S. (2015). Effect of fly ash replacement level on the bond strength of reinforcing steel in concrete beams. Journal of Cleaner Production, 87(1), 745–751. https://doi.org/10.1016/j.jclepro.2014.10.078

[6] Arezoumandi, M., Looney, T. J., & Volz, J. S. (2015). Effect of fly ash replacement level on the bond strength of reinforcing steel in concrete beams. Journal of Cleaner Production, 87(1), 745–751. https://doi.org/10.1016/j.jclepro.2014.10.078

[7] Assi, L. N., Eddie Deaver, E., & Ziehl, P. (2018). Effect of source and particle size distribution on the mechanical and microstructural properties of fly Ash-Based geopolymer concrete. Construction and Building Materials, 167, 372–380. https://doi.org/10.1016/j.conbuildmat.2018.01.193

[8] Assi, L. N., Eddie Deaver, E., & Ziehl, P. (2018). Effect of source and particle size distribution on the mechanical and microstructural properties of fly Ash-Based geopolymer concrete. Construction and Building Materials, 167, 372–380. https://doi.org/10.1016/j.conbuildmat.2018.01.193

[9] Bahedh, M. A., & Jaafar, M. S. (2018). Ultra high-performance concrete utilizing fly ash as cement replacement under autoclaving technique. Case Studies in Construction Materials, 9. https://doi.org/10.1016/j.cscm.2018.e00202

[10] Chieng, S., & Kuan, S. H. (2020). Harnessing bioenergy and high value–added products from rice residues: a review. In Biomass Conversion and Biorefinery. Springer. https://doi.org/10.1007/s13399-020-00891-y

[11] Criado, M., Jiménez, A. F., & Palomo, A. (2010). Effect of sodium sulfate on the alkali activation of fly ash. Cement and Concrete Composites, 32(8), 589–594. https://doi.org/10.1016/j.cemconcomp.2010.05.002

[12] Das, S. K., Mishra, J., Singh, S. K., Mustakim, S. M., Patel, A., Das, S. K., & Behera, U. (2020). Characterization and utilization of rice husk ash (RHA) in fly ash – Blast furnace slag based geopolymer concrete for sustainable future. Materials Today: Proceedings. https://doi.org/10.1016/j.matpr.2020.02.870

[13] Das, S. K., Mishra, J., Singh, S. K., Mustakim, S. M., Patel, A., Das, S. K., & Behera, U. (2020). Characterization and utilization of rice husk ash (RHA) in fly ash – Blast furnace slag based geopolymer concrete for sustainable future. Materials Today: Proceedings. https://doi.org/10.1016/j.matpr.2020.02.870

[14] Fapohunda, C., Akinbile, B., & Shittu, A. (2017). Structure and properties of mortar and concrete with rice husk ash as partial replacement of ordinary Portland cement – A review. In International Journal of Sustainable Built Environment (Vol. 6, Issue 2, pp. 675–692). Elsevier B.V. https://doi.org/10.1016/j.ijsbe.2017.07.004

[15] Fapohunda, C., Akinbile, B., & Shittu, A. (2017). Structure and properties of mortar and concrete with rice husk ash as partial replacement of ordinary Portland cement – A review. In International Journal of Sustainable Built Environment (Vol. 6, Issue 2, pp. 675–692). Elsevier B.V. https://doi.org/10.1016/j.ijsbe.2017.07.004

iJETRM
International Journal of Engineering Technology Research & Management

[16] Freitas, E., Louro, A. S., Costa, H., Cavaco, E. S., Júlio, E., & Pipa, M. (2020). Bond behaviour between steel / stainless-steel reinforcing bars and low binder concrete (LBC). Engineering Structures, 221. https://doi.org/10.1016/j.engstruct.2020.111072

[17] Gursel, A. P., Maryman, H., & Ostertag, C. (2016). A life-cycle approach to environmental, mechanical, and durability properties of "green" concrete mixes with rice husk ash. Journal of Cleaner Production, 112, 823–836. https://doi.org/10.1016/j.jclepro.2015.06.029

[18] Gursel, A. P., Maryman, H., & Ostertag, C. (2016). A life-cycle approach to environmental, mechanical, and durability properties of "green" concrete mixes with rice husk ash. Journal of Cleaner Production, 112, 823–836. https://doi.org/10.1016/j.jclepro.2015.06.029

[19] Hemalatha, T., & Ramaswamy, A. (2017). A review on fly ash characteristics – Towards promoting high volume utilization in developing sustainable concrete. In Journal of Cleaner Production (Vol. 147, pp. 546–559). https://doi.org/10.1016/j.jclepro.2017.01.114

[20] Hemalatha, T., & Ramaswamy, A. (2017). A review on fly ash characteristics – Towards promoting high volume utilization in developing sustainable concrete. In Journal of Cleaner Production (Vol.147, pp. 546–559). Elsevier Ltd. https://doi.org/10.1016/j.jclepro.2017.01.114

[21] Hwang, C. L., & Huynh, T. P. (2015). Evaluation of the Performance and Microstructure of Ecofriendly Construction Bricks Made with Fly Ash and Residual Rice Husk Ash. Advances in Materials Science and Engineering, 2015. https://doi.org/10.1155/2015/891412

[22] Hwang, C. L., & Huynh, T. P. (2015). Evaluation of the Performance and Microstructure of Ecofriendly Construction Bricks Made with Fly Ash and Residual Rice Husk Ash. Advances in Materials Science and Engineering, 2015. https://doi.org/10.1155/2015/891412

[23] Jiang, Y., Ling, T. C., Shi, C., & Pan, S. Y. (2018). Characteristics of steel slags and their use in cement and concrete—A review. In Resources, Conservation and Recycling (Vol. 136, pp. 187–197). Elsevier B.V. https://doi.org/10.1016/j.resconrec.2018.04.023

[24] Jung, S. H., Saraswathy, V., Karthick, S., Kathirvel, P., & Kwon, S. J. (2018). Microstructure Characteristics of Fly Ash Concrete with Rice Husk Ash and Lime Stone Powder. International Journal of Concrete Structures and Materials, 12(1), 17. https://doi.org/10.1186/s40069-018-0257-4

[25] Khan, M. N. N., Jamil, M., Karim, M. R., Zain, M. F. M., & Kaish, A. B. M. A. (2015). Utilization of rice husk ash for sustainable construction: A review. In Research Journal of Applied Sciences, Engineering and Technology (Vol. 9, Issue 12, pp. 1119–1127). Maxwell Science Publications. https://doi.org/10.19026/rjaset.9.2606

[26] Le, H. T., Müller, M., Siewert, K., & Ludwig, H. M. (2015). The mix design for self-compacting high performance concrete containing various mineral admixtures. Materials and Design, 72, 51–62. https://doi.org/10.1016/j.matdes.2015.01.006

[27] Le, H. T., Siewert, K., & Ludwig, H. M. (2015). Alkali silica reaction in mortar formulated from self-compacting high performance concrete containing rice husk ash. Construction and Building Materials, 88, 10–19. https://doi.org/10.1016/j.conbuildmat.2015.04.005

[28] Mahalingam, B., Nagamani, K., Kannan, L. S., Mohammed Haneefa, K., & Bahurudeen, A. (2016). Assessment of hardened characteristics of raw fly ash blended self-compacting concrete. Perspectives in Science, 8, 709–711. https://doi.org/10.1016/j.pisc.2016.06.066

[29] Mahalingam, B., Nagamani, K., Kannan, L. S., Mohammed Haneefa, K., & Bahurudeen, A. (2016). Assessment of hardened characteristics of raw fly ash blended self-compacting concrete. Perspectives in Science, 8, 709–711. https://doi.org/10.1016/j.pisc.2016.06.066

[30] Nair, D. G., Fraaij, A., Klaassen, A. A. K., & Kentgens, A. P. M. (2008). A structural investigation relating to the pozzolanic activity of rice husk ashes. Cement and Concrete Research, 38(6), 861–869. https://doi.org/10.1016/j.cemconres.2007.10.004

[31] Nawaz, M. A., Ali, B., Qureshi, L. A., Usman Aslam, H. M., Hussain, I., Masood, B., & Raza, S. S. (2020). Effect of sulfate activator on mechanical and durability properties of concrete incorporating low calcium fly ash. Case Studies in Construction Materials, 13, e00407. https://doi.org/10.1016/j.cscm.2020.e00407

iJETRM
International Journal of Engineering Technology Research & Management

[32] Nawaz, M. A., Qureshi, L. A., Ali, B., & Raza, A. (2020). Mechanical, durability and economic performance of concrete incorporating fly ash and recycled aggregates. SN Applied Sciences, 2(2). https://doi.org/10.1007/s42452-020-1960-8

[33] Rattanachu, P., Toolkasikorn, P., Tangchirapat, W., Chindaprasirt, P., & Jaturapitakkul, C. (2020). Performance of recycled aggregate concrete with rice husk ash as cement binder. Cement and Concrete Composites, 108, 103533. https://doi.org/10.1016/j.cemconcomp.2020.103533

[34] Rattanachu, P., Toolkasikorn, P., Tangchirapat, W., Chindaprasirt, P., & Jaturapitakkul, C. (2020). Performance of recycled aggregate concrete with rice husk ash as cement binder. Cement and Concrete Composites, 108, 103533. https://doi.org/10.1016/j.cemconcomp.2020.103533

[35] Sam, J. (2020). Compressive Strength of Concrete using Fly Ash and Rice Husk Ash: A Review. Civil Engineering Journal, 6(7), 1400–1410. https://doi.org/10.28991/cej-2020-03091556

[36] Sam, J. (2020). Compressive Strength of Concrete using Fly Ash and Rice Husk Ash: A Review. Civil Engineering Journal, 6(7), 1400–1410. https://doi.org/10.28991/cej-2020-03091556

[37] Sharma, V., & Akhai, S. (2019). Mechanical Behaviour of Fly Ash Reinforced Aluminum Composite Prepared by Casting.

[38] Sharma, V., & Akhai, S. (2019). Trends in Utilization of Coal Fly Ash in India: A Review. Journal of Engineering Design & Analysis, 2(1), 12–16. https://orcid.org/0000-0002-4598-4643

[39] Sua-iam, G., Makul, N., Cheng, S., & Sokrai, P. (2019). Workability and compressive strength development of self-consolidating concrete incorporating rice husk ash and foundry sand waste – A preliminary experimental study. Construction and Building Materials, 228, 116813. https://doi.org/10.1016/j.conbuildmat.2019.116813

[40] Sua-iam, G., Makul, N., Cheng, S., & Sokrai, P. (2019). Workability and compressive strength development of self-consolidating concrete incorporating rice husk ash and foundry sand waste – A preliminary experimental study. Construction and Building Materials, 228, 116813. https://doi.org/10.1016/j.conbuildmat.2019.116813

[41] Van Tang, L., Bulgakov, B., Bazhenova, S., Aleksandrova, O., Ngoc Pham, A., & Dinh Vu, T. (2018). Effect of Rice Husk Ash and Fly Ash on the workability of concrete mixture in the High-Rise Construction. E3S Web of Conferences, 33. https://doi.org/10.1051/e3sconf/20183302029

[42] Vigneshwari, M., Arunachalam, K., & Angayarkanni, A. (2018). Replacement of silica fume with thermally treated rice husk ash in Reactive Powder Concrete. Journal of Cleaner Production, 188, 264–277. https://doi.org/10.1016/j.jclepro.2018.04.008

[43] Vigneshwari, M., Arunachalam, K., & Angayarkanni, A. (2018). Replacement of silica fume with thermally treated rice husk ash in Reactive Powder Concrete. Journal of Cleaner Production, 188, 264–277. https://doi.org/10.1016/j.jclepro.2018.04.008

[44] Xu, W., Lo, Y. T., Ouyang, D., Memon, S. A., Xing, F., Wang, W., & Yuan, X. (2015). Erratum: Effect of rice husk ash fineness on porosity and hydration reaction of blended cement (Construction and Building Materials (2015) 89 (90-101)). In Construction and Building Materials (Vol. 93, p. 1249). Elsevier Ltd. https://doi.org/10.1016/j.conbuildmat.2015.06.048