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WORKABILITY OF RICE HUSK REINFORCED CONCRETE FOR EASY POURING

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Abstract- In the construction industry, the universally used material is reinforced concrete, because of its best durability and cost effectiveness compared to others. The fibre reinforced concrete is also produced by adding fibres and different kinds of fibre in concrete gets importance nowadays. The factor of strength and the quality of the concrete directly depend on the workability property. In this work, in addition to the workability, the compressive strength of the rice husk fibre reinforced concrete is investigated experimentally. The properties of plain cement concrete used as a reference to evaluate the effect of rice husk fibre. It is noted that the workability of the rice husk fibre reinforced concrete is reduced by 8% and the compressive strength is also reduced as compared to the plain cement concrete. Furthermore, the concrete handling becomes harder when the mix is less workable.

Keywords- Rice Husk (RH), Fibres, Concrete Workability, Fibre Reinforced Concrete

1 Introduction

In the construction industry utmost universally used material is reinforced concrete, because of its best durability and cost effectiveness compared to others [1]. Globes world faces very serious environmental and sustainability issues just because of concrete use. The concrete is best in compression but weak in tension. Due to the weak tensile behavior of concrete, its application is limited. The fibre reinforced concrete is produced by adding the different kinds of fibre in concrete to overcome this drawback and to improve the durability and impact resistance of concrete [2]. The addition of natural and artificial fibres in the concrete is developed by the researchers for the structural application [3]. Workability is a very significant property of concrete, which mainly discourses properties such as consistency, flow-ability and compaction of the green concrete [4]. The size of the course aggregate is also effected the workability of fresh concrete. Kronlof et al. [5] Reported that the water requirement reduced with the fine aggregate powder and observed that the better workability achieved by consistent mixing. By adding the fibre, slump value reduced and reported that more water is required if the fibre particles are short [6]. Mehran Khan and Majid Ali, reported that the workability of different fly ash-SPC and fly ash-SCFRC mixes are reduced up to 66%-100% as to that of a PC and CFRC, respectively [7].

Thomas A. Bier et al. [8] Studied that the course aggregate having lower weight and round in shape helped to minimize the workability issue, which is a more common problem in FRC (fibre reinforced concrete). In order to increase the workability of the fibre reinforced concrete the volume of course aggregate should be reduced [9]. As, in the conventional reinforced structures, steel fibre are used, nowadays many researchers used plant fibre as a substitute of steel fibre. There are number of natural fibre used by researchers such as sisal, coconut fibre, jute fibre, hibiscus cannabinus fibre, eucalyptus grandis pulp fibre, Malva fibre, ramie bast fibre, pineapple leaf fibre, kenaf bast fibre, abaca leaf fibre, vakka, date fibre, bamboo fibre, palm fibre, banana fibre, hemp fibre, flax fibre, cotton and sugarcane fibres etc. Natural fibres are locally available in many countries due to which it is very cheap as well. Fibres are used in the construction industry will reduce the overall cost of the project. Handling of the natural fibres are very easy due to their flexibility properties when compared with the steel [10]. The workability of the concrete mix may reduce by adding the fibre and in the FRC use lesser amount of water to avoid honeycombing and bleeding [11]. As, the ration or the content of the fibre increased the workability of the FRC gets reduced significantly [12]. In spite of the fact that whatever the fibre type, workability of concrete reduce significantly by adding the fibre [13].

The applications of agriculture waste like sugarcane bagasse and rice husk ash (RHA) were investigated by many researchers [14] and the utilization of RHA into the concrete are encourages in the construction industry [15].A Million tons of rice are harvested every year in all over the world and approximately 160 tons of rice husk are produced every year, that causes environmental pollution problems and cover a large area of land fill [16]. The quantities of production of rice for the top rice producing country's production in metric ton (Mt) in the years of 2002, 2009, 2010, 2013 and in 2017 are shown in Table 1 [17] and for the year of 2018, 2019, 2020 and for 2021 are shown in Table 2 [18].The Rice husk ash produced by combusting the rice husk and the utilization of rice husk ash in the construction industry provides great advantages by addressing both environmental and commercial concerns. Paddy rice seed is carved with the hard shell of the rice husk, which protects the seeds from the attack of insects, pests, physical damages and delivers nutrient throughout the development of grain [19]. The RH structural layer divided into four parts that are (1) concentration of silica is high, on the rough outer skin with surface hairs, (2) sclerenchyma, (3) spongy parenchyma cells and (4) inner skin. The composition of the rice husk organic compound and chemical composition of the rice, shown in the Table 3 [20].

Table 1: Quantities of rice paddy production[17]

Country	**Rice Production (Mt)**				
	2002	**2009**	**2010**	**2013**	**2017**
China	**177.6**	196.70	197.2	200	210
India	**123**	133.75	120.6	160	163
Indonesia	**48.7**	64.45	66.4	90	74
Bangladesh	**39**	47.7	49.4	45	53
Vietnam	**31.3**	40	40	40	44
West Africa	**10.7**	-	-	13.54	-
Brazil	**10.5**	-	-	12.3	11.9
Pakistan	**5.8**	-	-	9	10.3

Table 2: Quantities of rice paddy production [18]

Country	Rice Production (1000 MT)			
	2018	**2019**	**2020**	**2021**
China	**148490**	146730	148300	149000
India	**116480**	118870	122000	121000
Indonesia	**34200**	34700	35200	35300
Bangladesh	**34909**	35850	34600	35330
Vietnam	**27344**	27100	27100	26900
West Africa	**-**	-	-	-
Brazil	**7140**	7602	7899	7820
Pakistan	**7202**	7414	8184	8200

Table 3-The composition of rice husk organic compound [20]

Content (%)				
	C	**H**	**O**	**N**
	36.74	5.51	42.55	0.28

An ample literature is available on concrete with different types of fibre like coconut fibre, bagasse fibre, sugar cane fibre etc. as a substitute of steel reinforcement. The applications of agriculture waste like sugarcane bagasse and RHA were investigated [14]. But, very limited literature is available in which Rice husk used as a fibre in the concrete mix, numerous researchers used rice husk for the removal of heavy metal [21] and in most of the cases, rice husk ash used as partial replacement of cement [22,23,24,25,26]. RH has been utilized in several sectors as construction material in a concrete production and as fuel in power plants [27].

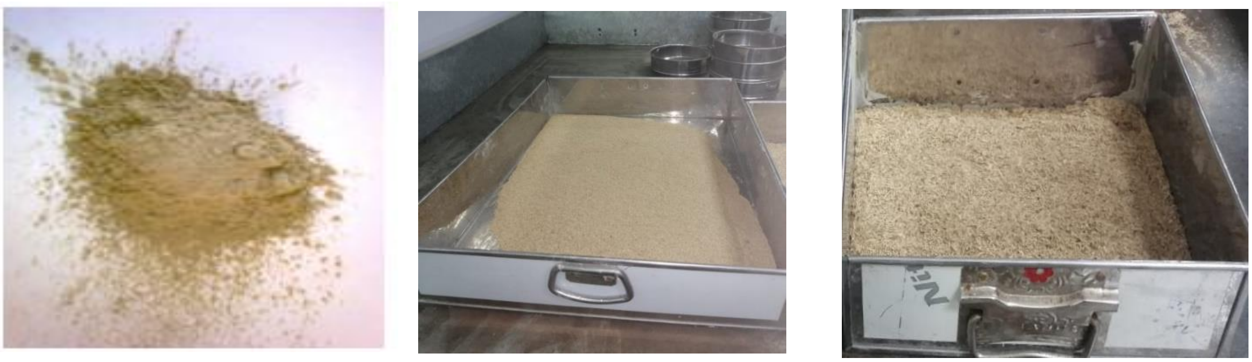
The objective of the present study is to investigate the properties of fresh concrete and hardened concrete experimentally. For this purpose the rise husk fibre having length 0.5cm to 1cm was added in the concrete mix and then slump core test was performed to evaluate the workability of fresh RHFRC. Compressive tests performed to check the properties of hardened concrete and then compared with the value of plain cement concrete to evaluate the effect of fibre. Hence, the addition of rice husk fibre reduced the workability and compressive strength of the concrete.

2 Experimental Procedure

This part of the research shows properties of used material and experimental procedure in this study.

2.1 Raw Materials

The rice husk fibre used in this research was brought from the Sialkot region, where more than 280 tons rice produced every year. In the beginning the rice husk fibres particle size varied in the range of 0.01cm to 3cm. The particles were passed through the sieve number 10, 40, and 100 to remove the dust and small particles and then select the rice husk particle having length 0.5cm to 1cm as shown in Figure 1a, 1b and 1c respectively. The experimental procedure consists the test parameter, preparation of specimens and testing as well. In this research, slump test and compressive test was performed to check the workability and compressive strength of RHFRC respectively.



a) b) c)

Figure 1: a. Dust remove from the rice husk, b. small particles, c. selected rice husk particles for test

Ordinary Portland cement, Margalla crush and the locally available sand were used, the sand passed through the sieve number 4 to remove the larger particles of stone. The size of the aggregate varied from 20mm to 30 mm, were used for the preparation of both types of concrete, rice husk fibre reinforced concrete (RHFRC) and plain cement concrete (PCC). Drinkable tap water used and water temperature was normal. Water cement (W/C) ratio was constant for the production of both types of concrete that was 0.5.

2.2 Concrete Mix Design

For the manufacturing of the rice husk fibre reinforced the mix design ratio is 1:2:4 in which 1 part of cement, 2 part of sand and 4 parts of aggregate are used and same mix design is used for the manufacturing of the plain concrete. While 200 grams rice husk having the length 0.5cm to 1cm added into the RHFRC mix and the water cement W/C ratio is 0.5 as shown in Figure 2a.Table 4 represents mix design of rice husk fibre reinforced concrete (RHFRC) and plain cement concrete (PCC).

Table 4- Mix design of RHFRC and PCC

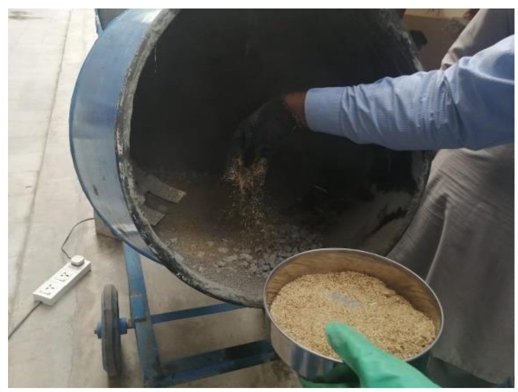
		Content (%)					
Samples	**W/C ratio**	**Cement (Kg)**	**Water (Kg)**	**Sand (Kg)**	**Aggregate (Kg)**	**RH(g)**	**Cylinders**
RHFRC	**0.5**	**4**	**1.4**	**8**	**16**	**200**	**2**
PCC	**0.5**	**4**	**1.4**	**8**	**16**	**00**	**1**

2.3 Casting of Sample

The procedures which were adopted during the casting of the 3 cylinders in which 2 is for RHFRC and 1 for PCC for the given study is given as under.

To ensure the uniformity in the material and greatest possible blending, cement is mixed thoroughly by dry hand. Aggregate is air dried for each batch before using in the mix. Portable water having room temperature is used. Electronic weight balance is used for proportioning of the material and the weight of material done by the weight per cubic foot concrete. The sequence of the material placed in the mixer machine is followed by the standards. First of all ¼ of the aggregated placed in the mixer machine, then ¼ sand, ¼ fibre and then ¼ cement placed respectively, and repeats this for four times as shown in figure 2b. Then the mixed machine on for 1 minute without adding the water so that fibre mixed uniformly into the material. Water is added in three portions to avoid the bleeding phenomenon and mixed the material for 3 minutes. For RHFRC and PCC, 3 cylinders of 150x300mm (6 x 12 inches) was poured in which 2 cylinders are for RHFRC and 1 is for PCC. The average strength of RHFRC specimens is taken. The concrete filled into the mold in layers having an approximate height equal to 5cm and given 25 strokes per layers with the tamping rod of 10x300mm. After initial setting time, all the sample of PCC and RHFRC are labeled for identification.

a)



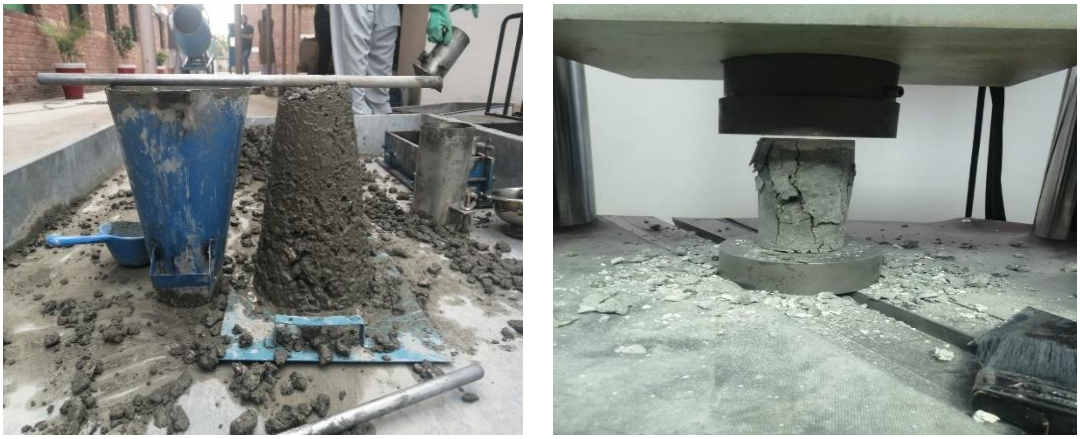
b)

Figure 2: a. Material used in the RHFRC, b. placement of material in the mixer machine by parts

3 Testing Methods

3.1 Slump core test

The workability of the manufactured RHFRC and RHFRC investigated by using the slump core test. As, according to the best knowledge of the author there is no specific method of mixing of fibre reinforced concrete is available, so the methodology for filling of slump core by layers is adopted. A slump core test is performed to check the workability of the fresh concrete, as per the ASTM standards C143/C143M-15a [28]. The slump core is open at the both ends and have handles to carry and the slump cone typically has an internal diameter of 100 mm, at the top and 200mm at the bottom, with the height of 305mm is used to perform the slump test. The cone is placed on the cleaned surface. The cone is filled in three stages with the fresh concrete. Each layer, each time is tamped for 25 times with the metal rod which have standard dimensions. The extra concrete is cleaned out from the molds at the end of the third layer as well. The mold is vertically lifted upward carefully, so as not to disturb the concrete's cone, then the concrete will slump as shown in Figure 3a. The cone is placed upside down near the concrete cone. The tamping rod is placed over the slump cone in such way that the rod other edge reaches the concrete cone. Then the slump value measured by measuring the distance from the top level of the slump cone to the slump concrete top. The slump test is significantly suitable and acceptable, having a slump of median to low workability. The suitable slump range varied from 5mm to 260 mm.



a) b)

Figure 3: a .Measuring the slump value of the RHFRC, b. Compressive test of the RHFRC

3.2 Compressive Strength Test

The 14 days compressive strength of the RHFRC and PCC samples was determined by using ASTM C-39 [29] procedures. Cylinders having dimensions 150mmx300mm were placed in water at normal temperature for 7 days, and then the samples were placed in a room for 7 days, where the temperature was maintained at 27 Celsius and the relative humidity at 50%. The 0.25 MPa/sec pressure rate was maintained throughout the test.

4 Results and discussion

4.1 Workability of fresh concrete

The slump values of RHFRC and PCC are 15mm and 40mm respectively. It is observed that the slump value is significantly reduced by adding the rice husk fibre in the concrete. Although the concentration of the RH has been just 200 grams. Hence the water absorbed by the fibre is greater which disturbed the water cement ratio (W/C), so to maintain the workability free water is not available. Figure 3a represents the slump value of the rice husk fibre reinforced concrete and it is observed that too much variation is noted by adding just 5% rice husk fibre in the concrete when compared with the plain cement concrete. The overall drop in the slump value of the plain cement concrete is about 25 mm which has significant value. If the length and the ratio of the fibre increases the slump value will also decreases.

4.2 Compressive strength of hardener concrete

It is observed that the compressive strength of the rice husk fibre reinforced concrete is 4.8MPa while the compressive strength of the plain cement concrete is 5.231MPa. Although, the concentration of the rice husk fibre is very low, but it is observed that by the addition of the rice husk fibre into the concrete mix decreased the compressive strength, when compared with the plain cement concrete. It can be noted that in case of PCC spalling of concrete were observed while only cracks were developed in case of RHFRC. The crushed RHFRC cylinder specimen which consists fibre content as shown in Figure 3b.

4.2 Ease with concrete handling.

Easy to transport and place of the concrete means easy to handle the concrete and it depends on the workability and consistency of concrete. The size of the aggregate and water cement ratio (W/C) play a vital role in the easy handling of the concrete. Plain cement concrete (PCC) is easy to handle and transport when compared with the rice husk fibre reinforced concrete (RHFRC). This is just because the slump value is reduced and effected by adding the rice husk fibre in the concrete mix and observed that the placing of the RHFRC is little bit harder as compared to the PCC. Moreover, the handling with the RHFRC become difficult when the time passed compared with the PCC. This difficulty is observed due to water absorption capacity of the fibre. This observation shown that the addition of the fibre into the mix made it harder to transport, place and handle.

5 Conclusion

An experiment was conducted to investigate, inspect and evaluate the workability and the compressive strength of the rice husk fibre reinforced concrete and the plain cement concrete. For the manufacturing of RHFRC and the PCC the mix design ratio is constant. While 200 grams rice husk fiber having length 0.5cm to 1cm added into the RHFRC mix and the water cement W/C ratio is 0.5. Slump test performed to evaluate the workability. It is noted that the workability of the rice husk fibre reinforced concrete is reduced by 8% when compared with the plain cement concrete. The compressive strength of the RHFRC is 4.78MPa which is less than the compressive strength of the plain cement concrete that is 5.23MPa. So, the addition of the fibre will reduce the compressive strength of concrete as compared to the plain concrete. Concrete handling become harder, as much as the mix is less workable. The handling and placement of the PCC is easier as compared to RHFRC.As, the workability helps in the proper placement of the concrete as well.

From the results, it is observed that the addition of the natural fibre in the concrete mix imposes significant effect in the reduction of the compressive strength and the workability. The handling of the concrete, highly affects from the workability. The use of rice husk fiber resultantly decreases the workability, and difficult to handle and place as well. So, a greater water cement (W/C) ratio is required to get high workability while incorporating rice husk (RH) fibre into the concrete mix.

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References

[1] Lingling Hu, Zhen He and Shping Zhang, " Sustainable use of rice husk ash in cement-based materials: Environmental evaluation and performance improvement," *Journal of Cleaner Production*", Vol. 264, pp. 121744, 2020.

[2] F. Liu, W. Ding, Y. Qiao and Yafei Qiao, " Experimental investigation on the flexural behavior of hybrid steel-PVA fibre reinforced concrete containing fly ash and slag powder," *Construction and Building Materials*", Vol. 228, pp. 116706, 2019.

[3] Kene, K. S., Vairagade, V. S., & Sathawane, S. (2012). Experimental study on behavior of steel and glass fibre reinforced concrete composites. *Bonfring international journal of industrial engineering and management science*, *2*(4), 125-130.

[4] Choudhary, Harish, A. M. Siddique, and Dauji Saha. "Effect of clay fines on strength and workability of concrete." In *Proceedings of International Conference on Architecture, Civil and Environmental Engineering (ACEE2019), Jawaharlal Nehru University, New Delhi, India*. 2019.

[5] Kronlöf, Anna. (1994). "Effect of very fine aggregate on concrete strength". Materials and Structures, 27, 15-25.
[6] ACI Committee 544, 1999, Measurements of Properties of Fibre Reinforced Concrete, ACI 544-2R-89.
[7] Khan, Mehran, and Majid Ali. "Improvement in concrete behavior with fly ash, silica-fume and coconut fibres." *Construction and Building Materials* 203 (2019): 174-187.
[8] Ali, Ahsan, Shahid Iqbal, Klaus Holschemacher, and Thomas A. Bier. "Effect of fibres on bond performance of lightweight reinforced concrete." *Periodica Polytechnica Civil Engineering* 60, no. 1 (2016): 97-102.
[9] Khayat, Kamal H., Fodhil Kassimi, and Parviz Ghoddousi. "Mixture design and testing of fibre-reinforced self-consolidating concrete." *ACI Materials Journal* 111, no. 2 (2014): 143.
[10] Ali, Majid, Anthony Liu, Hou Sou, and Nawawi Chouw. "Mechanical and dynamic properties of coconut fibre reinforced concrete." *Construction and Building Materials* 30 (2012): 814-825.
[11] Mohod, Milind V. "Performance of steel fibre reinforced concrete." *International Journal of Engineering and Science* 1, no. 12 (2012): 1-4.
[12] Mohod, Milind V. "Performance of steel fibre reinforced concrete." *International Journal of Engineering and Science* 1, no. 12 (2012): 1-4.
[13] Vafaei, Davoud, Reza Hassanli, Xing Ma, Jinming Duan, and Yan Zhuge. "Sorptivity and mechanical properties of fibre-reinforced concrete made with seawater and dredged sea-sand." *Construction and Building Materials* 270 (2021): 121436.
[14] A. A. Dayo, "Use of sugarcane bagasse ash as a fine aggregate in cement concrete", Engineering Science and Technology International Research Journal, Vol. 3, No. 3, pp. 8-11, 2019.
[15] Naraindas Bheel, Muneer Ali Jokhio and Javed Ahmed Abbasi, "Rice Husk Ash and Fly Ash Effects on the Mechanical Properties of Concrete," *Engineering, Technology & Applied Science Research*", Vol. 10, pp.5402-5405, 2020.
[16] Cristina Barris, Pau Sala, Javier Gómez and Lluís Torres, "Flexural behaviour of FRP reinforced concrete beams strengthened with NSM CFRP strips",*Composite Structures*",Vol. 241, pp.11205,2020.
[17] Mohammad A. Mosaberpanaha and Sadiq A. UMAR, "Utilizing Rice Husk Ash as Supplement to Cementitious Materials on Performance of Ultra High Performance Concrete – A review", *Materials Today Sustainability*",Vol. 7–8, pp. 100030, 2020.
[19] Yanping Zou and Tiankui Yang, "Rice Husk, Rice Husk Ash and Their Applications", *Rice Bran and Rice Bran Oil, Chemistry, Processing and Utilization*, pp. 207-246, 2019.
[20] Mohiuddin, Obaidullah, Abdullah Mohiuddin, Madina Obaidullah, Humayun Ahmed, and Samuel Asumadu-Sarkodie, "Electricity production potential and social benefits from rice husk, a case study in Pakistan." *Cogent Engineering* 3,2016.
[21] Zou, Yanping, and Tiankui Yang. "Rice husk, Rice husk ash and their applications." In *Rice Bran and Rice Bran Oil*, pp. 207-246. AOCS Press, 2019.
[22] Muthukrishnan, Souradeep Gupta and Harn Wei Kua,"School of Design and Environment Architecture," *Department of Building,National University of Singapore*", 2019.
[23] Pokpong Rattanachu, Prajak Toolkasikorn, Weerachart Tangchirapat, Prinya Chindaprasirt and Chai Jaturapitakkul," Performance of recycled aggregate concrete with rice husk ash as cement binder," *Cement and Concrete Composites*",Vol. 108, pp. 103533, 2020.
[24] Farshad Ameri, Parham Shoae, Nasrollah BahramLi, *et al.*,"Optimum rice husk ash content and bacterial concentration in self-compacting concrete," *Construction and Building Materials*",Vol. 222, pp. 796-813, 2019.
[25] Peter A. Adesinaa and FestesA.," Structural properties of sustainable concrete developed using rice husk ash and hydrated lime," *Journal of Building Engineering*",Vol. 25, 2019.
[26] Sung-Hoon Kanga, Sung-Gul Honga and Juhyuk Moonc," The use of rice husk ash as reactive filler in ultra-high performance concrete," *Cement and Concrete Research*",Vol.115, pp. 389-400, 2019.
[27] Azat, S., A. V. Korobeinyk, K. Moustakas, and V. J. Inglezakis. "Sustainable production of pure silica from rice husk waste in Kazakhstan." *Journal of cleaner production* 217 (2019): 352-359.
[28] Standard, A. S. T. M. "Standard test method for slump of hydraulic-cement concrete." *ASTM Annual Book of ASTM Standards*, 2015.
[29] Standard, A. S. T. M. "Standard test method for compressive strength of cylindrical concrete specimens." *ASTM C39*, 2010.