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The Impact of Using Rice Husk Ash (RHA) as a Partial Replacement of Cement in Concrete Containing Micro Silica

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ABSTRACT: Rice husk ash (RHA) is a promising pozzolanic alternative material for partial replacement of ordinary Portland cement to increase the durability and strength of concrete and, at the same time, to decrease the corrosion effect caused by the harsh environment conditions. In this study, the impact of adding RHA in ratios (5%) as a replacement of ordinary Portland cement with different Ratio of micro silica (0%, 5%, 10%, 15%) water–cement ratios (1.0) and cured in water for different periods (7, 14, and 28 days) both on the durability and strength of the concrete and on its corrosion was investigated. The prepared specimens were tested by split tensile, compressive, and slump test to determine the suitability of the partial replacement of ordinary Portland cement by RHA in concrete. The most important findings of this work, which is considered novel in this field, are that adding fine (instead of more extensive) RHA particles enhances the flexural, compressive, and tensile strength values with time. An adverse impact was found to increase the water–cement ratio, which is assigned to the effect of water on RHA and as a result on the porosity of the concrete.

KEYWORDS: Rice husk ash, High strength concrete, micro-silica, compressive strength, cement replacement.

I. INTRODUCTION

Rice husk is a by-product of rice milling, produced every year in millions of tons. Rice husk wastes are disposed of largely by burning to minimize their vast volumes. The rice husk ash (RHA) that results from the combustion of the husk is considered a severe pollutant to the environment. It is essential to find a solution to minimize its release to the environment. Thus, researchers have suggested utilizing it in concrete as an alternative ingredient. The utilization of RHA comes with two tangible benefits: it helps mitigate its pollution impact and minimize the cost of concrete structures. Minimizing the use of cement, which is an essential ingredient of concrete, would also help mitigate the environment pollution caused by the cement industry that contributes up to 8–10% of the global emissions of RHA contains amorphous silicon oxide (SiO₂), or silica, and it is a highly pozzolanic material which makes it a suitable material for a partial replacement of Portland cement in concrete mixtures. RHA has been successfully applied in commercial manufacturing as a pozzolanic material in several countries such as Thailand, Columbia, and India. It has been reported that using RHA as a cement replacement can lower the hydration temperature of concrete mass more effectively than the Portland cement concrete. In addition, RHA improves the properties of the concrete mixture in terms of strength, shrinkage, and durability as compared to using pure Portland cement as a bonding agent. Specifically, replacing Portland cement by RHA up to 50% by weight showed better mechanical strength than the regular concrete mixture with pure Portland cement after 3 to 7 days of aging. Although rice husk can be burned in open fields, this increases the number of crystalline particles, which is not suitable for concrete mixtures. Thus, it is performed using special combustion conditions to control combustion temperature. In addition, the open burning of rice husk results in increasing the carbon content, which negatively impacts the properties of the final concrete mixture. Scientists use different combustion operations to increase amorphous particles, which is crucial for the making of a quality structural concrete. It has been reported that the highest amorphous percentage with a high surface area could be achieved by performing the combustion process at temperatures ranging from 500 to 700C

Although researchers in this field have investigated some critical aspects, such as mechanical strength, durability, and physical properties, there is still a lack of exploring the impact of water percentage and aging time on mechanical properties of the concrete mixture as well as chloride ion penetration test, which reveals the ability of the concrete to resist the harsh environment conditions that cause corrosion. In addition, a previous study reported that using RHA lowers the strength of the resulted mixture due to the bigger particles used.

For this reason, there is need to investigate the impact of fine particles of RHA on the properties of the resulting concrete mixture. Thus, in this work, the mechanical properties of the concrete mixture prepared by using RHA and cement in different water–cement ratios were studied experimentally and compared with ordinary concrete at different stages. The objective of this study is to determine the strength of concrete formed by using RHA (7% and 14% by weight), which is ground for a long time (30 min) without any other processing. In addition, the physical properties of the materials used in this experiment were characterized to correlate them with the RHA efficiency as a partial replacement material. Thus, this work provides a more in-depth analysis of this topic and helps fill the void in this field.

II. LITERATURE SURVEY

[1] **Asad A. Khedheyer Al-Alwan a, (2022)** Rice husk ash (RHA) is a promising pozzolanic alternative material for partial replacement of ordinary Portland cement to increase the durability and strength of concrete and, at the same time, to decrease the corrosion effect caused by the harsh environment conditions. In this study, the impact of adding RHA in different ratios (0%, 7%, and 14%) as a replacement of ordinary Portland cement with different water–cement ratios (0.3, 0.5, and 0.7) and cured in water for different periods (10, 20, and 30 days) both on the durability and strength of the concrete and on its corrosion was investigated. The prepared specimens were tested by flexural, compressive, and tensile strength tests, slump test, and Rapid Chloride Ion Penetration test to determine the suitability of the partial replacement of ordinary Portland cement by RHA in concrete.

[2] **Mehdi Maghfouri a, Vahid Alimohammadi b(2022)** Expanded polystyrene (EPS) is currently being utilized in sustainable materials owing to its ultra low density and superior thermal performance. It can be incorporated in concrete mixtures to replace coarse aggregate to produce lightweight aggregate concrete (LWAC). Concerning the high shrinkage development in LWAC, the present study reviews the available published articles regarding the drying shrinkage of lightweight concretes containing expanded polystyrene. According to the previous studies, the drying shrinkage development in expanded polystyrene concrete (EPSC) has been reported to be greater than that in conventional concrete, which must be considered for its application in the construction industry.

[3] **Ar Razi Alvee a, Rizka Malinda a,(2021)** This study explored the influence of nano-silica and Crystalline Admixture (CAs) on the mechanical properties and microstructure of geopolymer pastes. Nano-silica and CAs was added to the mixture at 3%, 4% and 5% respectively by weight of fly ash. The bulk density, the yield stress of geopolymer paste, compressive strength, and flexural bending tests were carried out to evaluate the effect of nano-silica and CAs effect on the geopolymer paste.

[4] **Bikila Meko a, Joshua O. Ighalo b(2021)** The main characteristics of self - compating concrete (SCC) are its ability to flow into every corner of the form work and even in congested reinforcement arrangements under its weight and without segregation. This paper reviews the recent progress in the enhancement of the self - compatibility of SCC in a fresh state

[5] **Edem Chabia, Valery Dokob,(2020)** This work is part of the dynamic of sustainable development and the protection of the environment, by the valorization of agricultural waste in the construction. In this study, rice husks were used as plant aggregates in a cement matrix to produce lightweight concretes used in building materials. For this purpose, studies of compatibility of the cement with rice husk were carried out, as well as the physical, mechanical and thermal behavior of the concretes obtained.

[6] **Seyed Alireza Zareeia,Farshad Amerib(2017)** The preliminary and inevitable interest in the use of partial replacements or by – products as complementary pozzolanic materials was mostly induced by enforcement of air pollution control resulted from cement production industry. Rise husk is by- product taken from rice mill process.

[7] **Siti Asmahani Saada,b, Muhd Fadhil Nuruddina (2016)** One of the important criteria of supplementary cementing material (SCM) in concrete is to possess high content of reactive silica that is essential in concrete strength development. Indeed, it is proven that rice husk ash (RHA) contains high amount of amorphous silica that is vital in the reaction of SCM in concrete.

III. METHODOLOGY

In order to improve the durability and strength of concrete and, at the same time, lessen the corrosion effect brought on by the harsh environmental circumstances, rice husk ash (RHA) is a viable pozzolanic alternative material. In this study, the effects of adding RHA in ratios of 5% as a replacement for regular Portland cement with various ratios of



microsilica (0%, 5%, 10%, 15%) and water-cement ratios (1.0) Super-plasticizer Pozzocreat 60, with 2.2 specific gravity was used. The super-plasticizer MasterSAP INFRA -SSL49 was used and curing in water for various periods (7, 14, and 28 days) were investigated. To assess whether regular Portland cement could be partially replaced by RHA, split tensile, compressive, and slump tests were performed on the produced specimens. RHA and common Portland cement (53 grade, which complies with IS: 10262-2019 criteria) were purchased from Misan Paper Factory and Al-Kufa Cement Factory, respectively. A controlled combustion process carried out at 550 C was used to produce the provided RHA. As a fine aggregate, an excellent grade sand (free of contaminants) was purchased from the Karbala Sand Factory. To ascertain the Portland cement and RHA's chemical composition, X-ray fluorescence (XRF) was used. In our lab, the weight of a specified volume of Portland cement, sand, and RHA was compared to the weight of a corresponding volume of water to calculate each material's specific gravity. RHA was ground in a mechanical grinder (Gidding and Lewis T-Bed HBMs) and used for specimen preparation as received (unprocessed) RHA in concrete. The most important findings of this work, which is considered novel in this field, are that adding fine (instead of more extensive) RHA particles enhances the flexural, compressive, and tensile strength values with time. An adverse impact was found to increase the water-cement ratio, which is assigned to the effect of water on RHA and as a result on the porosity of the concrete. As a result, Portland cement can be partially replaced with RHA with fine particles. The durability, strength, and resistance to extreme environmental conditions of the concrete can all be improved by its addition. In comparison to utilising regular Portland cement, it offers economic and ecological benefits. The statistical analysis demonstrates the significance of the increase in the strength measurements. It is advised to conduct more research on the effects of w/c ratio adjustment on the RHA replacement concrete mix.

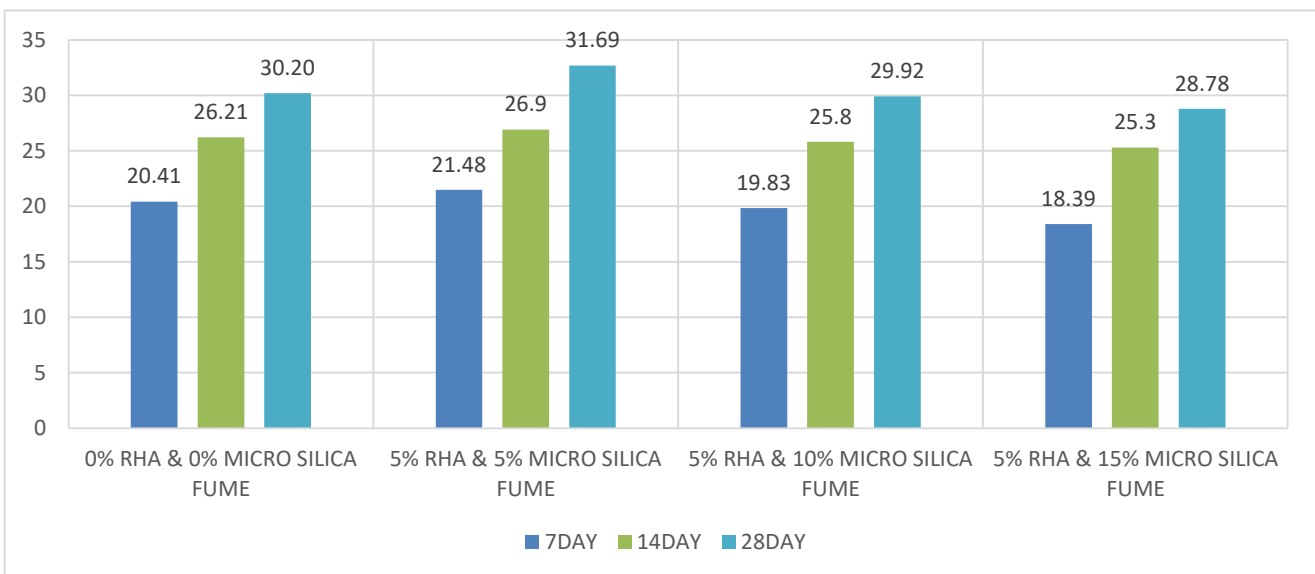
IV. RESULT & DISCUSSION

• COMPRESSIVE STRENGTH TEST:

The experimental and statistical analysis results of the compressive strength (in MPa) after 28 days of curing concrete samples.

(Table No:1)

Sr no.	Percentages of RHA	Percentage of micro silica fume (%)	7 DAY	14DAY	28DAY
1.	0%	0%	20.41 MPa	26.21 MPa	30.20 MPa
2.	5%	5%	21.48 MPa	26.90 MPa	31.69 MPa
3.	5%	10%	19.83 MPa	25.08 MPa	29.92 MPa
4.	5%	15%	18.39 MPa	25.30 MPa	28.78 MPa





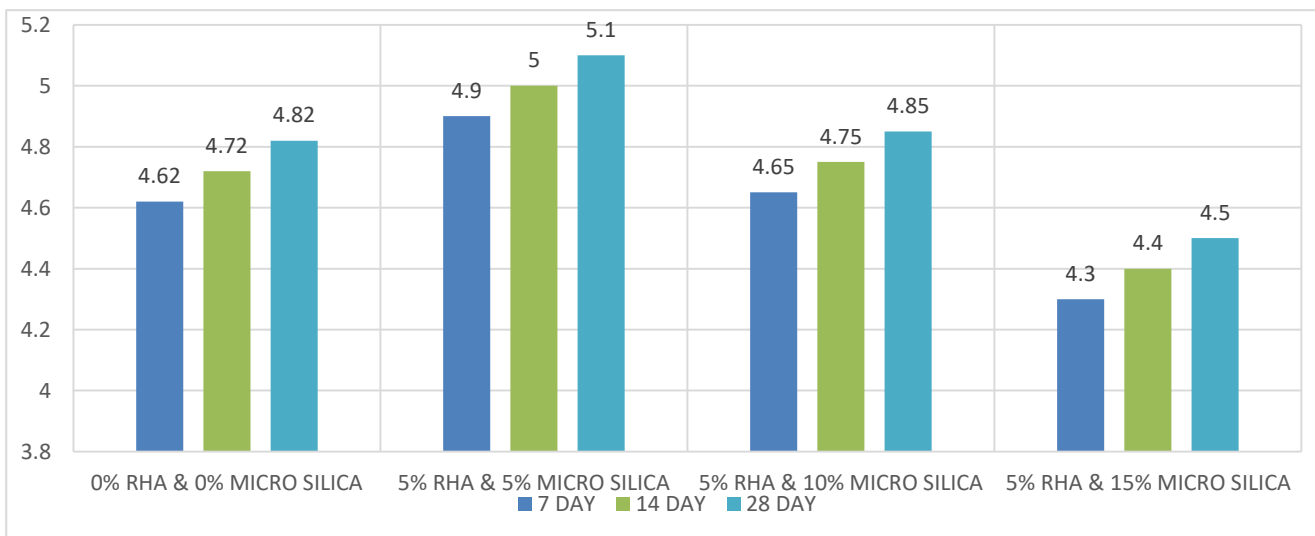
The high variance of the compressive strength data (Table 1) concerning their standards indicates the more spread of the data with the increase in the replacement percentage of RHA. This reflects the high impact the change in the w/c ratio has on the compressive strength. The high variance of the compressive strength data (Table 1) concerning their standards indicates the more spread of the data with the increase in the replacement percentage of RHA. This reflects the high impact the change in the w/c ratio has on the compressive strength.

• **SPLITTING TENSILE STRENGTH TEST:**

(Table no.2)

Experimental and statistical analysis results of the split tensile strength tests (in MPa) after 28days of curing concrete samples.

Sr no.	Percentages of RHA	Percentage of micro silica fume (%)	7 DAY	14DAY	28DAY
1.	0%	0%	4.62 MPa	4.72 MPa	4.82 MPa
2.	5%	5%	4.90 MPa	5.0 MPa	5.10 MPa
3.	5%	10%	4.65 MPa	4.75 MPa	4.85 MPa
4.	5%	15%	4.30 MPa	4.40 MPa	4.5 MPa



To extend the statistical inspection beyond the average values of the results settings and to investigate the significance of the increase in strength measures observed in the sets of data before and after RHA replacement

V. CONCLUSION

The experiment results showed that increasing the RHA content increases the compressive, and tensile strength values with time and decreases the slump value and the chloride ion penetration rate. However, an increase in the w/c ratio has an adverse impact, as it decreases the values of all strength tests and increases the slump value and the chloride ion penetration rate. These behaviors were assigned to the change in the pore structure of the concrete mix thus produced due to the addition of RHA or an increase in the w/c ratio. Increasing the pore structure in the concrete resulted in decreasing the strength and increasing the chloride ion penetration rate. Increasing the w/c ratio leads to an increase in the later dehydration rate which, in turn, increases the pores in the concrete and decreases its strength and resistance to harsh environment conditions. On the other hand, adding RHA may increase or decrease the strength of the resulting concrete based on the properties of RHA used. This experiment used fine particles of RHA, which decreased the pore structure of the resulting concrete and increased its bulk density. Using the fine particles was the main reason behind enhancing the concrete properties after adding RHA in contrast to some other results, which are reported in the literature. Thus, RHA with fine particles is a promising partial replacement for Portland cement. Its addition can enhance the concrete durability, strength, and resistance to harsh environment conditions. It also provides economic and ecological advantages over using ordinary Portland cement. The statistical analysis shows that the increase in the strength measures is significant. However, further investigation on the impact of w/c ratio change on the RHA replaced concrete mix is recommended.

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