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Experimental Investigation on Strength and Workability Properties of Concrete with Partial Replacement of Cement by Metakaolin and Rice Husk Ash

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Abstract:
Concrete is the most extensively used construction material around the world and its properties have been undergoing changes through technological advancements. Varieties of concrete have been developed to enhance the different properties of concrete. An investigation into the potential use of partial replacement of mineral admixture in high-strength concrete has been carried out. The engineering properties of fresh and hardened concrete are obtained by conducting tests on the slump, and compressive strength at 3,7 and 28 days of the curing period, in this research partial replacement of cement by metakaolin and rice husk ash been used for varying replacement of 0%,5%,10%,15%, and 20% with MK(Metakaolin) and 0%,5%,10%(constant) with Rice husk ash (RHA) for high strength, workability and also an eco-friendly by less emission of CO_2. The compressive strength of concrete made with MK-RHA has been compared with High-strength concrete i.e; M60 grade of concrete. It has been concluded that the strength development of concrete blended with metakaolin and rice hush ash was enhanced. It was found that a 10% replacement of metakaolin and a 10% replacement of rice husk ash appeared to be the optimum replacement which exhibited more strength. This investigation has proved that the 10%MK and 10%RHA concrete can be used as structural concrete at a suitable replacement.

Key Words: Rice Husk Ash, Metakaolin, workability, Compressive Strength.

1. Introduction

1.1 General:

In the last decade, the use of supplementary cementing materials has become an integral part of high-strength and high-performance concrete. These can be natural materials, by-products or industrial wastes, or the ones that require less energy and time to produce. The utilization of fine pozzolanic materials in high-strength concrete leads to a reduction of the crystalline compounds, particularly, calcium hydroxide; consequently, there is a reduction of the thickness of the interfacial transition zone in high-strength concrete. The densification of the interfacial transition zone allows for efficient load transfer between the cement mortar and the coarse aggregate contributing to the strength of the concrete, for ultra-high strength concrete where the matrix is extremely dense, a weak aggregate may become the weak link in concrete strength. In recent years, high-strength concrete has been developed with pozzolanic materials like Ground Granulated Blast Furnace Slag, Silica Fume, Fly ash, metakaolin, and rice hush ash. The HSC can be enhanced with workability, and strength, and results in the decrement of permeability. In this work, we used Metakiolin (MK) and Rice Husk Ash (RHA) as pozzolanic material, by using a combination of MK and RHA the mechanical properties of concrete were increased.

1.2 Objectives of Research:

The following are the key goals of this investigation:

1. To investigate the Compressive Strength acquired by the mix at 3 days,7 days, and 28 days respectively.
2. To reduce environmental pollution by utilizing solid wastes.
3. To make an ecologically sustainable concrete mix.
4. To know the optimum replacement percentage corresponding to which strength has increased

2. Review of Literature

Vineeth Kumar, Akash Prakash, objective was to find the compressive and split tensile strength at 7,14,28 Days by partially replacing cement with Metakaolin and marble powder First M30 mix was prepared, and then in each successive trail Metakaolin and marble dust were replaced. The proportions are replaced 5%MK+5%MP,10%MK+10%MP,12.5%MK+12.5%MP, and 15%MK+15%MP. Results showed that the compressive strength and split tensile strength of concrete is higher at 10%MP+10%MK.

M Praneeth Kumar,B Ajitha(2021), Reported that they had tested the strength of the concrete by substituting metakaolin for cement in a range of 0% to 20% and that they had completely replaced the fine aggregate with steel slag sand. It was an M60 mix. The replacement studies were conducted with standard 150 mm x 150 mm x 150 mm cubic specimens. The outcomes demonstrated that superior outcomes were obtained when 15% Metakaolin was substituted for cement and 100% steel slag sand was used in place of fine aggregate. The strength of the concrete decreases when the percentage of Metakaolin exceeds 15%. In addition to producing green concrete, the use of metakaolin protects the environment.

Ch. Jyothi Nikhila, J.D Chaitanya Kumar, The goal was to assess the strength of the cement mix while being substituted with Metakaolin with cement. The concrete mix grade used was M70. The percentages of replacement-induced replacement were 0%, 5%, 10%, 15%, 20%, and 25%.

A.N.Swaminathen, S.Robert Ravi, their work " Strength Characteristics of Concrete with Indian Mettakaolin and Rice Husk Ash." In this research, MK and RHA are studied as a replacement for cement in the following proportions: 0+0%, 5+105, 7.5+10%,10+10%,5+12.5%, 10+12.5%, 5+15%, 7.5+15%, and 10+15%for high strength. It was found that 7.5% replacement of metakaolin and 12.5% replacement of rice husk ash appear to be the optimum replacement which exhibited more strength.

Khawaja Adeel Tariq, Muhammad Sohaib, and Mirza Awais Baig(2021), conducted research on the subject of "Effect of partial replacement of cement with rice husk ash on concrete properties".Cement was substituted for Rica Husk ash at percentages 6%, 12%, and 18%. The optimum results are achieved with a 6% replacement of cement with rice husk ash.

3. Experimental Work

3.1 Materials:

A. Cement: In this research work, the cement used was Ordinary Portland Cement (OPC) 53-grade Sri chakra cement with specific gravity 3.11 which is easily available in the market. The properties of cement were determined in accordance with IS – 8112:1989 were: Fineness – 5% (≤10%); Consistency – 29%; Initial setting time -65minutes (≥30 minutes); Final setting time 550minutes (≤600 minutes).

B. Fine Aggregate: A better quality of river sand was used as fine aggregate by sieving through a 4.75mm sieve. The tests such as specific gravity, bulk density, and fineness modulus, water absorption were obtained as 2.64, 1890.81kg/m3, and 2.52, 1% respectively.

C. Coarse Aggregate: The coarse materials utilized in this research are 20 mm natural stone coarse aggregates that are locally available. Laboratory tests on coarse aggregate were performed as per IS: 2386 (part III)- 1963 to determine different characteristics like specific gravity, and water absorption were obtained as 2.77, and 0.5% respectively.

D. Water: Concrete must be mixed with clean water that has no dangerous quantities of oils. acids, alkalis, organic compounds, or other deleterious chemicals. In this investigation, we used portable tap water from the college campus water plant that met the IS456-2000 standards for casting concrete and curing the specimens.

3.2 Mineral admixtures

A. Rice husk ash: Commercially available rice husk ash which was supplied by NK Enterprises Orissa was used in this research work, physical and chemical properties of the rice husk ash were studied.

B. Metakaolin: Mettakaolin for the present research work was obtained from Astra Chemicals Chennai, the metakaolin was sieved and a fraction passing 100µ sieve was used in the experiments. The chemical and physical properties of MK, RHA, and OPC are presented in the table.

Table 1: Physical and Chemical Properties of MK and RHA

Properties	OPC 53grade	MK	RHA
Physical			
Specific gravity	3.11	2.6	2.22
Average particle size	20µm	2.5µm	7µm
Specific area m^2/kg	325	13000	11250
Color	Grey	Off- white	Grey
PH	12	5.5	8
Chemical Composition %			
SiO2	21.54	52	85
Al2O3	4.68	46	0.50
Fe2O3	2.46	0.60	0.26
TiO2	-	0.65	0.01
CaO	62.58	0.09	1.45
MgO	1.08	0.03	0.6
Na2O	0.24	0.10	1.8
K2O	0.87	0.03	3.21
Loss on ignition	2.58	1.00	4%

3.3 Mix proportions: To attain M60 grade strength, the concrete was designed in accordance with IS 10262-2009, and a water-to-cement ratio of 0.38 was employed. Distinct mixes of cement by varying proportions of 0%,5%,10%,15%, and 20% with MK(Metakaolin) and 0%,5%,10%(constant) with Rice husk ash were tested to analyze the strength characteristics in terms of Compressive. Six cubes are cast for each mix and tested for hardened properties.

3.4 Testing methods

3.4.1. Workability test: The workability of the concrete is checked through slump value. A slump test was performed for all mixes.

3.4.2. Compression test: The specimens of size 150x150x150 mm were tested. The compression test was performed for curing ages of 3,7 and 28 days by a 1000 KN capacity machine. The purpose of these tests was to determine the compressional behavior of the test specimens at specified ages.

4. Test Result and Discussions

4.1. Workability:

The workability of the control mix and MK-RHA mixed concrete was measured according to IS Standards. At different levels of replacement of MK-RHA, the workability of concrete is illustrated in Fig. 1. It is clearly depicted from the results that the control mix has a higher slump value as compared to MK-RHA concrete blends.

4.2 Casting of specimens:

The moulds that were used to cast cubes, cylinders, and beams were carefully cleaned. A thin layer of oil was applied to the interior surface of the moulds to prevent concrete adherence and leakage. Then, using a tamping rod, the concrete was poured into the greased moulds (cubes, beams, and cylinders). Tests were conducted at 3,7 and 28 days of age.

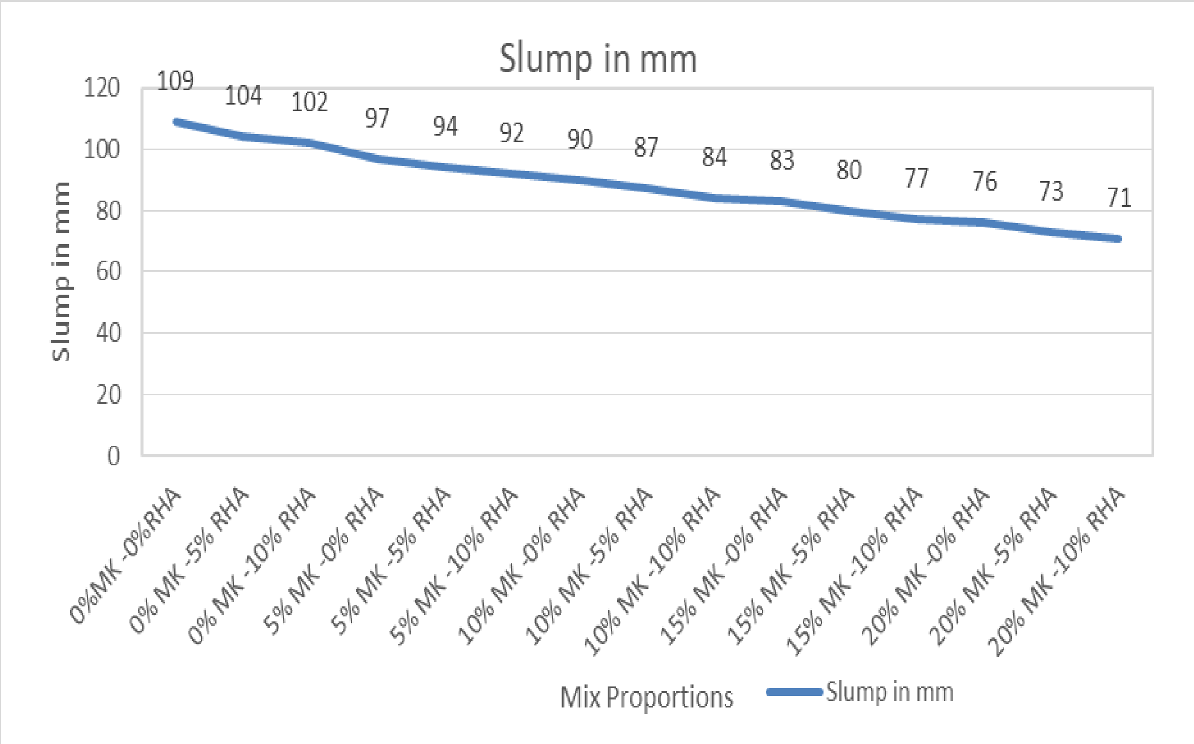

Figure 1: Slump with different mixed proportions of MK-RHA.

4.3 Curing:

Curing is the process of creating an atmosphere conducive to the setting and hardening of concrete. From the time the specimens leave their moulds until they are shipped to the testing laboratory, the specimens are completely immersed in a pond of water with 50 mm of water over them. If possible, keep the temperature between 10°C and 25°C.

4.4 Compressive strength: The uniaxial compressive test results are depicted in Fig.2. In comparison to the control mix, the compressive strength of MK and RHA steadily increased up to 9.44% and subsequently dropped. This study determined that 10%MK+10%RHA was the best combination.

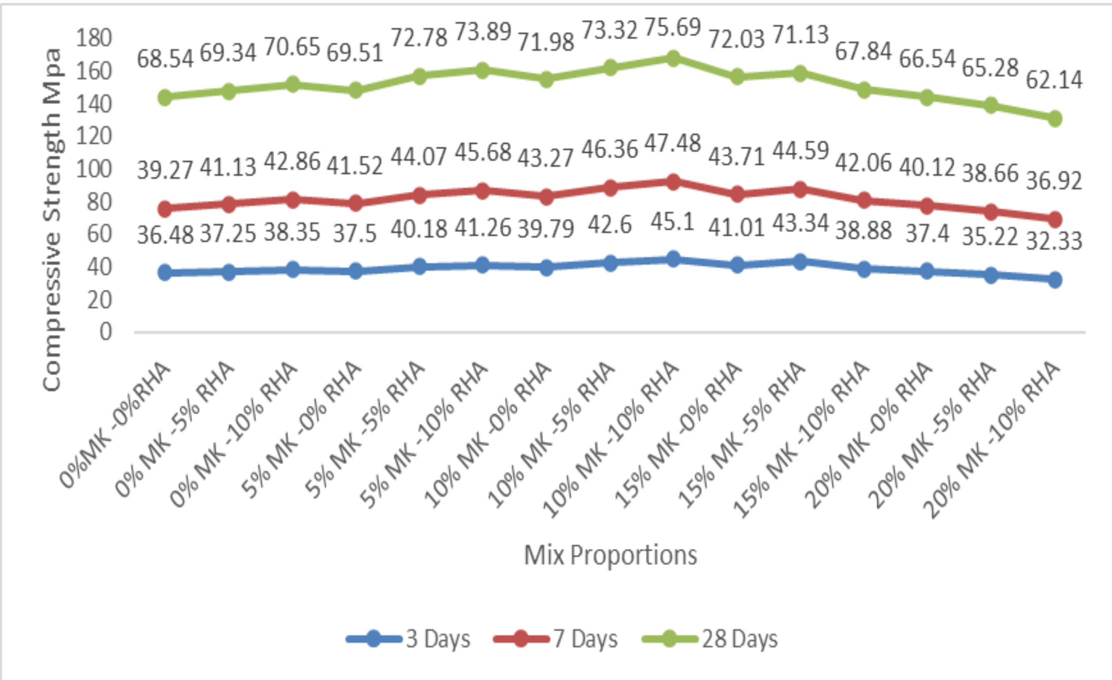

Figure 2: compressive strength with different mixed proportions of MK-RHA.

5. Conclusion

In this research work M60 grade concrete was designed. About 135 cubes were casted for testing the compressive strength of concrete. On the arrival of results, the following conclusions were obtained.

1. The workability of the concrete as measured by the slump reveals that as MK and RHA replacement increases, the slump decreases, and the findings are within the typical range of concrete.
2. Metakaolin and Rice husk Ash concrete gain strength over a period of time, the compressive strength of MK and RHA Concrete is more than conventional concrete.
3. The optimum replacement of cement with MK and RHA is 10% and 10%.
4. The addition of MK and RHA shows an increased water absorption comparing with OPC concrete.
5. As per the experimental results it is concluded that the optimum concrete mixes can be arrived at by blending cement With MK and RHA.

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