Use of Rice Husk Ash as Cementitious Material in Concrete

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Abstract—**In this research, rice husk ash (RHA) was used as a partial substitute for cement in concrete to reduce its cost, and alternative processing methods using agricultural/industrial waste were found. The main objective of this study was to determine the fresh (flowability) and hardened (splitting tensile strength and compressive strength) concrete properties using RHA at 0%, 5%, 10%, 15% and 20% by weight. A total of 90 concrete samples (45 cubes and 45 cylinders) were prepared and cured on 7, 14, and 28 days to the design of target strength 28N/mm^2, and ultimately, these concrete specimens were tested on UTM. Three concrete specimens were cast for each proportion and ultimately the average of the three concrete samples was taken as the final result. The flowability of fresh concrete decreases with increasing content of RHA in concrete. The results showed that the compressive and tensile strength of the concrete specimens increased by 11.8% and 7.31%, respectively by using 10% RHA at 28 days curing.**

Keywords-rice husk ash; cement replacement material; improved strength; reduced construction cost; utilizing disposal waste

I. INTRODUCTION

Concrete is widely and globally used throughout the history of humankind [1]. Concrete is a mixture of sand and crushed rock combined together by a hardened paste of hydraulic cement and water [2]. The increased use of concrete is going to grow the demand for its ingredients' resources (cement, sand, and gravel). The high rate of concrete constituents is increasing rapidly and hence there is a requirement for an unconventional material that is low-cost and readily presented that will also give a similar or greater strength when used for concrete [3]. Cement is one of the constituents of concrete which is costly and its production releases large amounts of CO_2 during its manufacturing [4-8]. Manufacturing one tonne of cement releases about one tonne of CO_2 in the atmosphere while 1.6 tonnes of natural resources are required to produce about one tonne of cement [9-11]. In many studies the cement is partially replaced by agricultural/industrial waste such as glass powder, sugar cane bagasse ash, rice husk ash (RHA), blast furnace slag, maize cob ash, millet husk ash, fly ash etc. in order to reduce cost, waste and CO_2 emissions while these resources are easily available [9, 12]. RHA is the by-product of agricultural waste [13-15], it is considered unwanted and is mostly air burned [16, 17]. Currently disposing of agro/industrial waste is a serious problem. One of these agro wastes is rice husk. Rice husk annual produced quantity is about 120 million tonnes per year in the paddy field [17-19]. The husk manufactured from rice processing is either burnt or dumped. Rice husk is burnt at a certain temperature under atmosphere. RHA possess 85% of silica content that is known as non-crystalline silica and it could be utilized as partial cement replacement material [20-24]. RHA is measured as a highly pozzolanic material [25-29] and it can be used as an additional material in concrete decreasing the environmental problem.

A research study of the hardening properties of concrete was carried out in [30] using 10% RHA. In this study, concrete samples were cured and tested after 7, 14, 28, and 56 days, using a mixing ratio of 1:2:4 with water-cement ratio 0.45, 0.50, and 0.60. The results showed that the compressive and tensile strengths increased by 14.51% and 10.71%, respectively, at 0.45 water-cement ratio when 10% RHA was used in concrete with a curing time of 56 days. Authors in [31] reported that RHA is beneficial to reduce the temperature of concrete as compared to plain cement concrete. Authors in [32] carried out researched on the hardened properties of concrete blended with cement by 5%, 10%, 15% and 20% weight. The concrete samples were designed for target strength of 25N/mm^2 and were cured for 7 and 28 days. The result was that the crushing strength improved by 15.74% when using 10% of RHA in concrete at 28 days [32]. RHA plays an essential role in the characteristics of cementitious materials [33]. The size of

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the RHA particles is finer than OPC, which augments concrete properties [34]. The size of RHA particles is around 25 microns which makes RHA capable of playing a vital role as filler in cement [35]. In this experimental study, RHA was blended in concrete by weight in proportions up to 20%.

II. RESEARCH METHODOLOGY

Research was conducted on the fresh and hardened properties of concrete by using 0%, 5%, 10%, 15% and 20% of RHA as cement substituent material in concrete. A total of 90 concrete samples (45 cubes and 45 cylinders) were prepared and cured at 7, 14, and 28 days to the design of target strength of 28N/mm^2. To get an optimum mix, a number of trail mixes are completed using variable cement (binder), coarse aggregates, fine aggregates, and water. While getting the desirable mix, RHA was used as cement substituent material to determine the characteristics strength of concrete specimens and ultimately, these concrete specimens were tested on UTM while obeying the British Standard (BS) code. In this study, the concrete cubes were cast for compressive strength and cylinders were cast for splitting tensile strength. Three concrete specimens were cast for each proportion and finally, an average value of the three specimens was taken as the final result. This research work was completed in the concrete laboratory of the Department of Civil Engineering, College of Science and Technology, Hyderabad, Sindh, Pakistan.

III. MATERIALS USED

A. Cement

The cement that was used is available locally in the market under the brand name Pak land.

B. Fine Aggregates

Hilly sand was used as fine aggregates of Zone-II which passed through Sieve No. 4 (4.75mm). The fineness modulus, water absorption and specific gravity of fine aggregates are 2.61, 1.8% and 2.60 respectively.

C. Coarse Aggregates

The coarse aggregates used were 20mm in size and were available in the local market. The water absorption and the specific gravity of coarse aggregates were 1.4% and 2.73 respectively.

D. Rice Husk Ash

Rice husk was collected from the region of Sakrand and it was air-dried. RHA was acquired by using uncontrolled temperature burning method. The desired ash was sieved through #30 sieves.

E. Water

Drinking water, available in the lab, was used.

IV. RESULTS AND DISCUSSION

A. Fresh Concrete Workability

The flow of fresh concrete was conducted by slump cone having the dimensions of 10cm top diameter, 20cm bottom diameter and 30cm height. The maximum flow of fresh concrete was 65mm while using 0% RHA as cement substituent material in concrete and the minimum value of workability was 25mm at 20% RHA by weight. It was concluded that the flow of fresh concrete decreases with an increase in the amount of RHA in concrete. The experimental results are shown in Figure1.

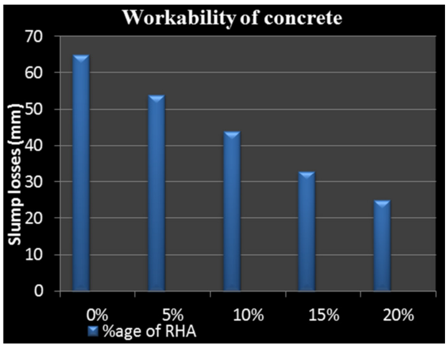

Fig. 1. Workability of fresh concrete

B. Compressive Strength

Compressive strength test were conducted on cubes (100mm×100mm×100mm) by using different RHA percentages. Three specimens were cast for each proportion and ultimately, an average value of these three concrete specimens was taken as the final result. The compressive strength was maximum at 10% of RHA used as cement substituent material in concrete and minimum at 20% of RHA, at 7, 14, and 28 days. The results are shown in Figure 2.

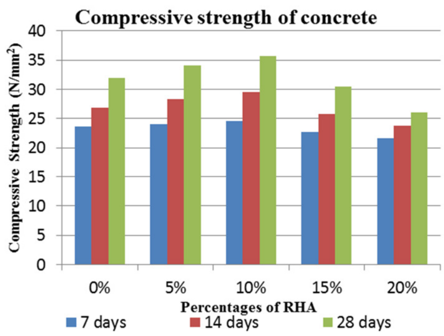

Fig. 2. Compressive strength of concrete at 7, 14, and 28 days

C. Splitting Tensile Strength

Splitting tensile strength tests were conducted on cylinders (200mm×100mm) of various RHA percentages which were cured at 7, 14, and 28 days. Three concrete samples were cast for each proportion and an average was taken as the final result. The maximum splitting tensile strength of concrete was noted at 10% RHA specimens and the minimum splitting strength of concrete was recorded at 20%. The cylinders were tested on UTM. The experimental work results are shown in Figure 3.

V. CONCLUSIONS

- The flow of fresh concrete was noted maximum while using 0% RHA as cement substituent material in concrete. The minimum value of workability was recorded at 20% RHA.

- It was concluded that the flow of fresh concrete decreases with an increase in the amount of RHA in concrete.
- The compressive strength was maximum at 10% RHA concrete and minimum at 20% RHA concrete at 7, 14, and 28 days.
- The maximum splitting tensile strength of concrete was noted at 10% RHA concrete and the minimum splitting strength was recorded at 20% RHA concrete at 7, 14, and 28 days.

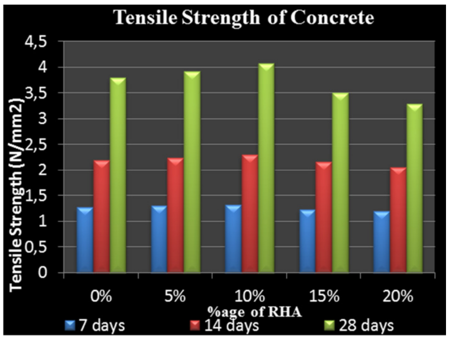

Fig. 3. Split tensile strength at 7, 14, and 28 days

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