Effects of Rice Husk Ash and Recycled Aggregates on Mechanical Properties of Concrete

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Abstract— This study investigates the possible replacement of naturally obtained coarse aggregates with recycled concrete for production of concrete where also the cement is partially replaced with rice husk ash. To achieve this objective, aggregates achieved from demolition of column, beams, lintels and culverts were collected from the old structures in Larkana city, whereas rice husk ash, which is a waste material and is usually dumped, was collected from brick kilns. Controlled concrete mixture and modified concrete mixture using 100% recycled aggregates and replacement of cement with 10% rice husk ash with 1:2:4 ratio and water/cement (w/c) ratio of 0.5, were prepared. 30 cubes and 30 cylinders were cast to check the compressive and tensile strengths of normal and modified concretes at 7, 14 and 28 days. The results revealed that modified mixture prepared with 10% of rice husk ash and 100% of recycled aggregates has significant improvement in compressive and tensile strengths at all three curing periods of 7, 14 and 28 days.

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Index Terms— Rice husk ash, recycled aggregates, mechanical properties, compressive strength, tensile strength

1 INTRODUCTION

IN many big Pakistani cities there is a rush in Construction and Demolition Waste (CDW) quantities which is really harmful and posing an adverse effect to the environment. Utilization of such waste as recycled aggregates in concrete could be helpful both for environmental and economic aspects in the construction industry. The rice husk being used as a source of fuel for kilns. The use of rice husk as a fuel generates huge amount of ash. The Rice Husk Ash (RHA) has no particular use and is generally dumped in the fields in open area, which also causes environmental pollution.

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Effective use of Construction and demolition waste has many benefits. For example, the Environment Agency of the US (EPA, 2002) states that the incineration of 10,000 tons of waste can mean the creation of 1 job, landfill can create 6 jobs, but recycling the same amount of waste can create 36 jobs. During past two decades, researches in the field of CDW have mainly focused on three major topics: generation, reduction and recycling. This is guided by the '3Rs' principle.

Utilization of non-renewable resources, like virgin aggregates, desires to be reduced by recycling debris from demolished structures, practiced in such a way that it could be used to replace virgin fine and coarse aggregate in cement concrete. These substitutions also lessen natural resource consumption and allows for decreasing of the overall volume of materials disposed in landfills, so causing adverse effects to the environment [1-6].Various studies reported that Construction and Demolition Waste corresponds to almost 50% of all municipal waste generated in Brazilian cities [5]. The waste is huge in other countries too, such as in the Hong Kong SAR, Canada and the UK, that currently takes up 33% to 65% of the existing landfill space [6]. The major difference between recycled and traditional aggregates is the adhered mortar of the original concrete. This is the cause of the main differences between the physical properties of recycled aggregates and those of traditional aggregates, where the higher absorption of recycled aggregates should be noted. Both this and the moisture state have pronounced impact on water-to-cement ratio, which finally influences the properties of hardened and freshly made concrete [8, 9].World rice utilization in 2014/15 is currently projected at 500.5 million tones [10]. The RHA has no useful application and it is usually dumped in the fields in open area that causes environmental pollution. All out efforts are being made to minimize this environmental problem by using this one as a supplementary cementing material [11]. The rice husk ash is being considered as mineral

admixture for concrete. The source of rice husk ash is considered important in the variation characteristics of cementitious material [12]. When rice husk burnt under controlled temperature below 800 °C the silica to be produced will be in amorphous form [13, 14].
Keeping all these aspects, this research work is carried out to study the mechanical properties of concrete using rice husk ash as supplementary material with recycled aggregates in concrete in order to minimize the considered environmental problem due to construction and demolition waste and rice husk ash generated in brick kiln and to improve the properties of concrete.

2 MATERIALS AND METHODS

About materials, Ordinary Portland cement under the brand name Lafarge obtained from the local market of Larkana city was used during the experimental work. Manufacture date of cement was checked before purchasing and in this way the cement obtained was recently made. The fine aggregates used during this experimental activity was also bought from the local market. It was clean natural hill sand passing from 4.75 mm sieve. Coarse aggregates were brought from the market of Larkana city. The maximum size obtained was 19 mm. Care was taken while purchasing coarse aggregate to be free from dust and other ingredients. As recycled coarse aggregates, demolished waste from beams, columns and lintels of buildings was collected from the city of Larkana. Before carrying them to the area of research, they were dismantled and split into small pieces to be carried in easy way. Furthermore, these pieces were brought to the college and were broken into small pieces by hammering to split them apart. It took a lot of effort and hardworking to get rid of the cement coating present over the recycled aggregates that cement coating is hindrance to have a strong bond of cement when it is mixed as recycled material following the decrease in the compressive and tensile strengths of hardened concrete. Sieve sizes of 1'', 3/4'' and 1/2"were used to get required size. Rice husk ash was collected from the brick kilns in the vicinity of Larkana city shown in Figure 1. Usually it is a waste material after being used in baking bricks. Clean Rice Hush Ash free from other ingredients and impurities was brought to the structural laboratory. RHA used in concrete was the one passing from 325 number sieve.

Drinkable water available at the structural laboratory was used for preparing all concrete mixtures. Water was also tested for pH value before using it in the mix. The water sample gave pH value equal to 7.2, which is a generally suitable value.

Figure 1. The kiln where Rice Husk is used for baking bricks and the obtained ash.

In the framework of the experimental work and mix proportioning, control concrete mixture and modified concrete mixture using 100% recycled aggregates and replacement of cement with 10% rice husk ash with 1:2:4 ratio and w/c ratio of 0.5 were prepared. In total 30 cubes of 150mm x 150mm x 150mm were cast to check the compressive strength of concrete at the curing ages of 7, 14and 28 days. These specimens were obtained by preparing for each mixture 15 cubes, of which 5 for each curing age. Similarly for each mixture 15 cylinders, obtained by using 5 cylinders for each age, were manufactured. So, in total 30 cylinders with diameter of 150 mm and height of 300 mm were cast to check the spilt tensile strength of concrete at the same curing age of 7, 14 and 28 days. The specimens were cast and taken-out from moulds after 24 hours and kept in a totally wet environment for almost 7, 14 and 28 days of curing.

3 RESULTS AND DISCUSSIONS

3.1 Workability

Slump cone test was carried out to check the workability of all the concrete mix design prepared both from traditional and modified cement concrete. Workability test was done both for plain and Rice Husk Ash modified concrete in order to see the difference. The slump cone values obtained are presented in Table 1.

Table 1: Slump cone values of all concrete mix designs prepared.

S. No.	W/c Ratio	Concrete Mix Design Ratio	Slump of Plain Cement Concrete (mm)	Slump of RHA and RA Concrete (mm)
1	0.50	1:2:4	93	88

It is clear from table 1 that the workability of modified mix prepared with 100% replacement of aggregate with recycled aggregate and 10% replacement of cement with rice husk ash is slightly less as compared to control mix.

3.2 Compressive strength

Results of compressive strength tests at 7, 14 and 28 days of curing ages on cubes of ordinary concrete and modified mixture with 10 % replacement of cement with rice husk ash and 100% replacement of aggregates with recycled aggregates are given in Table 2 and Figure 2.

Table2. Results of compressive strength tests on ordinary concrete and modified concrete with RHA and RA

Curing days	Compressive Strength of plain concrete (psi)	Compressive Strength of RHA with RA concrete (psi)	Increase of compressive strength than ordinary concrete (%)
7 Days	2965	2980	0.51
14 days	3833	3940	2.79
28 days	4495	4590	2.11

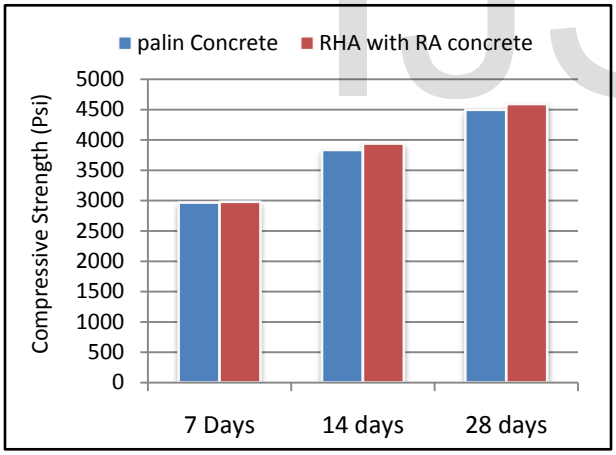

Figure 2. Compressive strength results of ordinary concrete and RHA with RA concrete

It is clear from tale 2 and figure 2 that the modified mixture prepared with replacement of cement with 10% by rice husk ash and 100% replacement of aggregates with recycled aggregates has more compressive strength over ordinary concrete in all three ages of 7, 14 and 28 days. At 28 days age of curing modified mixture prepared with replacement of cement with 10% by rice husk ash and 100% replacement of aggregates with recycled aggregates gave 2.11% more compressive strength than that of control concrete.

3.3 Tensile Strength

Results of tensile strength tests at 7,14 and 28 days of curing ages on cylinders of ordinary concrete and modified concrete mixture with 10% replacement of cement with rice husk ash and 100% replacement of aggregates with recycled aggregates are given in Table 3 and Figure 3.

Table 3. Results of Tensile strength tests on ordinary concrete and modified concrete with RHA and RA.

No of days of curing	Tensile Strength of plain concrete (psi)	Tensile Strength of RHA with RA concrete (psi)	Increase of Tensile strength than ordinary concrete (%)
7 Days	288	295	2.43
14 days	371	389	4.85
28 days	438	455	3.88

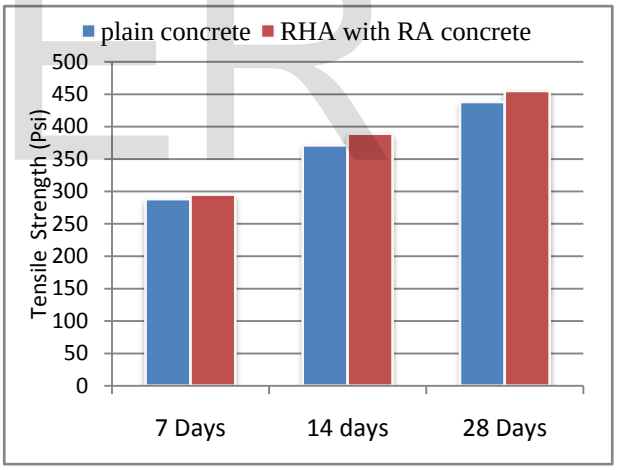

Figure 3. Results of Tensile strength of ordinary concrete and RHA with RA concrete.

It is clear from table 3 and figure 3 that the modified mixture prepared with replacement of cement with 10% by rice husk ash and 100% replacement of aggregates with recycled aggregates has more tensile strength as compared to ordinary concrete in all three ages of 7, 14 and 28 days. At 28 days age of curing, modified mixture prepared with replacement of cement with 10% by rice husk ash and 100% replacement of aggregates with recycled aggregates gave 3.88% more tensile strength than that of control concrete.

4. CONCLUSIONS

Workability of modified mix prepared with 100% replacement of aggregate with recycled aggregate and 10% replacement of cement with rice husk ash is slightly less as compared to control mix.

At 28 days age of curing modified mixture prepared with replacement of cement with 10% by rice husk ash and 100% replacement of aggregates with recycled aggregates gave 2.11% more compressive strength than that of control concrete.

At 28 days age of curing, modified mixture prepared with replacement of cement with 10% by rice husk ash and 100% replacement of aggregates with recycled aggregates gave 3.88% more tensile strength than that of control concrete.

It is concluded from the conducted research that at 100% replacement of aggregate with recycled aggregate and 10% replacement of cement with rice husk ash has significant improvement in mechanical properties of concrete.

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