Usage of Brick Kiln Ash as a Supplementary Cementing Material

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Abstract

Researchers are endeavoring to extract supplementary cementing materials from different agarin product. Different types of agarin by-products are being used as a source of fuel for brick kiln. The generated ash from brick kiln is usually dumped in open fields that creates a myraid of health and environmental issues. In this paper, an experimental study is conducted to utilize the dumped ash as a supplementary cementing material in concrete. In order to find out the optimum proportion of cement replacement, we replace cement with brick kiln ash at the ratio of 0 to 12.5% with an increment of 2.5%. Subsequently, the tests of compressive strength, tensile strength and water penetration are conducted. It is found that the cement replaced at 5% is optimum. The compressive and tensile strength are increased up to 5% and 5%, respectively. Moreover, concrete impermeability is found to be improved by 50% at 5% replacement.

Keywords—Brick kiln ash, compressive, tensile and impermeability.

1 Introduction

Researchers all over the world are endeavoring to utilize waste materials produced from different sources in the construction industry so as to get rid of the waste which is detrimental to the environment. Researchers [1][2] utilized the extracted Malaysian rice husk ash as a supplementary cementing material for construction industries and made use of the waste as a partial replacement for the most expensive cement employed for improving engineering properties of Malaysian soil. The high binder efficiencies were observed and the physical-mechanical performances indicated the effectiveness of the proposal, expanding the concept of low-cost supplementary cementing materials and broadening the range of residual materials suitable for use in cement-based composites [3]. There is a rapidly growing trend in the production of rice in Pakistan, therefore, it is considered to be the most important crop. In Pakistan, it is being used as an alternative of food and, in some cases, the byproduct of rice husk as a source of energy for kilns. The use of rice husk as energy generates enormous amount of ash and the generated ash has no valuable application, but usually deposits in the fields in open areas that causes environmental pollution. Researchers all around the world are striving to minimize this environmental problem by using ash as a supplementary cementing material [4]. RHA is deemed to be a concrete mineral admixture. SiO_2 of RHA normally ranges between 90 to 95%, which is analogous to that of silica fume [5][6]. The source of RHA is considered to be important in the varying characteristics of cementitious material [7]. Researchers conducted the experiment on cement replaced mortar in terms of compressive strength and pore refinement. The optimum level of replacement is totally dependent on the level of fineness of cementitious material [8]. A research was conducted [9] used different cementitious material to form a sustainable concrete. They replaced cement with Silica Fume, Fly Ash and ground granulated blast furnace slag. The result revealed that the suitable concrete could be made with 40% GGBFS replacement, 5% S.F replacement and 20% FA replacement with cement. Amorphous silica is produced at 500°C–800°C and at a higher temperature, i.e. usually above 900°C, silica starts to exist in crystalline state [10]. Researchers in [11] conducted an experimental study on mix blended with RHA as a binder and replaced cement with RHA up to 40% without any noteworthy changing trend in the compressive strength with reference to control mix. A high strength concrete (HSC) was developed in [12] by in-corporating RHA as a partial supplementary cementing material. It was found that the strength

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of HSC containing RHA decreased as compared to control mix. Researchers in [13] focused on the fundamental properties of RHA blended concrete. They made concrete with replacement dosages of 5% to 20% (an increment of 5%) with RHA size of $5\,\mu m$ and $95\,\mu m$. The maximum level of replacement of cement with RHA was 15% for the ash having size of $95\,\mu m$ and 20% for the ash having size of $5\,\mu m$, respectively. They concluded that the modified concrete was improved in strength at 10% replacement with ultra-fine RHA particles. However, ultra-pulse velocity and water absorption of concrete drastically decreased at 10% replacement of cement with $5\,\mu m$ sized RHA. Workability, particularly in case of coarser sized RHA, of fresh concrete increased substantially by adding more quantity rice husk ash. The researchers [2][14] concluded that with the addition of RHA as a cement replacement material in concrete, a significant enhancement in durability characteristics had been obtained in RHA blended concrete which otherwise was hard to achieve by the use of OPC.

The prime aim of the experimental investigation carried out in this paper is to analyze the efficacy of brick kiln ash as a supplementary cementing material in concrete and its effects on various properties of concrete while blending.

2 Experimental Programme

We used ordinary portland cement and the hill sand passing from 4.75 mm sieve and crushed stone, as coarse aggregate, with maximum size of 19 mm. Brick kiln ash was collected from the outskirts of district Shaheed Benazir Abad, Sindh, Pakistan. The ash was grounded in Loss Angels Abrasion machine for 2 hours, and was sieved from 200 sieve. An arbitrary ratio of 1:2:4 with w/c 0.55 was used and the cement was replaced by brick kiln ash at ratio of 0 to 12.5% with an increment of 2.5%, as shown in Table 1. The experimental setup was aimed at finding the optimum proportion of cement replacement with brick kiln ash.

3 RESULTS AND DISCUSSION

This section discusses the experimental results.

3.1 Compressive Strength

28-days compressive strength of all concrete mixes are shown in Table 2. It is evident that the compressive strength of concrete kept on increasing up to 5% replacement of cement with brick kiln ash. Further addition of ash as a supplementary cementing material causes a reduction in the strength. This is because of less availability of silica in the ash to form more Calcium-Silica-Hydrated (CSH) gel which is deemed to be a strengthening component in cement. At 5% replacement of the cement with the brick kiln ash, concrete strength was observed to be 0.53% more as compared to no replacement of concrete. This increase in strength has also been reported in [15][16].

3.2 Tensile Strength

28-days tensile strength of all concrete mixes are shown in Table 3. It can be seen that the tensile strength of concrete kept on increasing up to 5% replacement of cement with brick kiln ash. Further addition of the ash as a supplementary cementing material causes a reduction in the strength. This is because of less availability of silica in the ash to form more calcium-silica-hydrated (CSH) gel which is deemed to be a strengthening component in cement [16].

3.3 Permeabilty

Water penetration of concrete was determined at the age of 28-days curing. From Table 3 and Table 4, it is evident that the impermeability of concrete increases with the increase of cement replacement with brick kiln ash. The water penetration depth at 5% replacement is 35 mm which is 5% more impermeable as compared to normal concrete. This is because brick kiln ash plays a very effective role in pore refinement of the concrete mix. Such increasing and decreasing behavior was also reported in [17].

A comparison of compressive strength, tensile strength and water penetration depth is shown in Figure 1.

From the results, an increasing and decreasing trend can be observed. At 5% replacement of brick Kiln ash as a supplementary cementing material in concrete is found to be the optimum one. Such trend in supplementary cementing materials in concrete has also been reported in [15][17].

4 Conclusion

The compressive strength as well as tensile strength increases up to 5% replacement of the cement with brick kin ash. Permeability of concrete is measured as water penetration depth of concrete. At 5% replacement of cement, concrete becomes more impermeable as compared to the normal concrete mix. Brick kiln ash can be substituted for cement in concrete up to 5% replacement.

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S.No	Concrete	Cement (kg/m3)	%age Replacement	Brick Kiln Ash (kg/m3)	W/C	W/B	Water (kg/m3)	F.A (kg/m3)	C.A (kg/m3)
1	CM	3	0	0	0.55	0.55	1.65	6	12
2	BKAC1	2.925	2.5	0.075	0.55	0.56	1.68	6	12
3	BKAC2	2.85	5	0.15	0.55	0.57	1.72	6	12
4	BKAC3	2.775	7.5	0.225	0.55	0.58	1.75	6	12
5	BKAC4	2.7	10	0.3	0.55	0.6	1.79	6	12
6	BKAC5	2.625	12.5	0.375	0.55	0.61	0.82	6	12

TABLE 1: Concrete mix proportion

S.No	Concrete Mix	Percentage Replacement	Compressive Strength (psi)	(%age) Increase/ Decrease
1	CM	0	2676.7	-
2	BKAC1	2.5	2681.8	0.19
3	BKAC2	5	2691	0.53
4	BKAC3	7.5	2644.8	-1.2
5	BKAC4	10	1969.1	-26.4
6	BKAC5	12.5	1964.75	-26.6

TABLE 2: Compressive strength of concrete

S.No	Concrete	Percentage Replacement	Tensile	(%age) Increase/ Decrease
1	CM	0	275	-
2	BKAC1	2.5	280.33	1.9
3	BKAC2	5	284.7	3.5
4	BKAC3	7.5	270	-1.8
5	BKAC4	10	200	-27.27
6	BKAC5	12.5	190	-30.9

TABLE 3: Tensile strength of concrete

S.No	Concrete	Percentage Replacement	Water Penetration Depth (mm)	(%age) Increase/ Decrease
1	CM	0	50	-
2	BKAC1	2.5	40	20
3	BKAC2	5	35	30
4	BKAC3	7.5	25	50
5	BKAC4	10	35	30
6	BKAC5	12.5	55	-10

TABLE 4: Permeability of concrete

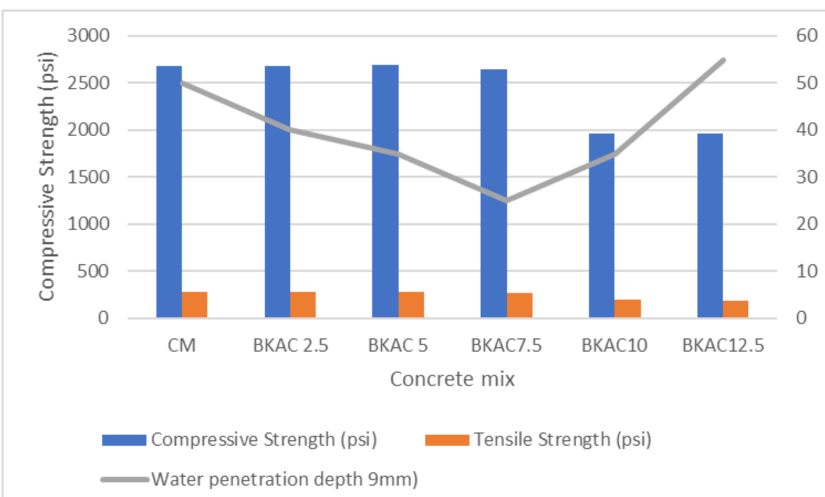

Fig. 1: Compressive, tensile strength and water penetration behavior

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