Utilization of Rice Husk Ash to Mitigate Alkali Silica Reaction in Concrete

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Abstract—*This study focuses on the utilization of rice husk ash (RHA) in replacement of cement to reduce expansion due to alkali silica reaction. Mortar bar specimens were prepared incorporating RHA in various dosages (10%, 20%, 30% and 40% by weight in replacement of cement) and examined in accordance with American standard ASTM C1260. Strength activity index of RHA was also determined. The results showed that the RHA fulfills the strength activity requirements of ASTM. In addition, RHA replacement (10-40% by cement weight) was found to be effective in suppressing the alkali–silica reaction expansion.*

Keywords-concrete; alkali silica reaction; rice husk ash

I. INTRODUCTION

Alkali Silica Reaction (ASR) is considered as the cancer of concrete [1]. Presence of alkalies in concrete results into higher amount of hydroxyl ions. These hydroxyl ions react with reactive siliceous aggregates and form alkali silica gel. Alkali silica gel expands with time and develops stresses in concrete structures. Formation of cracks leading to displacement of concrete member occurs as a result of ASR [2].

In Pakistan, problem of ASR was observed in Tarbela dam and Warsak dam. Presence of cracks along with differential settlement of concrete members was observed in the structures [2]. Reaction can be controlled by utilizing pozzolanic materials such as fly ash, slag, silica fume and other pozzolans in concrete. Formation of silica rich hydration products and entrapment of alkalis are considered responsible for controlling expansion due to ASR [3].

Pakistan is a rice producing country with annual generation of 1.15 million tons of husk [4-5]. Rice husk is used for burning purposes in brick kilns and as a result rice husk ash (RHA) is obtained. In this study, RHA in different replacements of cement (10%, 20% 30% and 40%) was utilized to reduce expansion due to ASR.

II. MATERIALS

Aggregates from Kamser source, Muzaffarabad were used as reactive aggregates during the study. Rice husk ash (RHA) was acquired from a local brick kiln and passed through sieve #200. Local Ordinary Portland cement was used during the study.

III. METHODOLOGY

A. Raw Materials

X-ray fluorescence (XRF) was used to determine the chemical composition of cement and RHA. Petrographic examination was performed in order to determine the mineralogical composition of Kamser source.

B. Mortar Bar Expansion

Mortar bar specimens were prepared following ASTM C1260 (Standard test method for potential alkali reactivity of aggregates (mortar-bar method)). Expansion was measured after 14 and 28 days using ASTM C490 (Standard practice for use of apparatus for the determination of length change of hardened cement paste, mortar, and concrete).

C. Strength Activity Index

Strength activity index of RHA was evaluated in accordance with ASTM C311 (Standard test methods for sampling and testing fly ash or natural pozzolans for use in portland-cement concrete).

IV. RESULTS AND DISCUSSIONS

A. Chemical Analysis

Chemical composition of cement is presented in Table 1. It was observed that alkalies were present in higher amount (i.e., 0.83%). To avoid ASR, alkalies should be present less than 0.6% in cement [6]. Therefore, utilization of such type of cement with reactive aggregates can lead towards ASR. Moreover, silica was observed as the main constituent of RHA. Combined amount of silica, alumina and iron oxide was found to be 85%. Therefore, RHA can be refereed as waste material having pozzolanic properties [6].

B. Petrographic Examination

Petrographic studies revealed that the aggregate source was comprised of limestone-dolomite minerals. Such type of source is considered as reactive for ASR [7].

C. Mortar Bar Expansion

Results of mortar bar expansion test are presented in Fig. 1. Control specimens showed an expansion of 0.13% (i.e., greator than 0.1%) after 14 days and 0.23% (i.e., greator than 0.2%) after 28 days. Therefore, aggregate source can be refereed as reactive for ASR in accordance with ASTM C1260.

TABLE I. CHEMICAL COMPOSITIONS OF RAW MATERIALS

Components	Raw Materials	
	Cement	***RHA***
SiO_2	20.8	75.12
Al_2O_3	5.37	6.06
Fe_2O_3	3.41	4.21
CaO	62.3	3.12
MgO	2.68	1.16
Free Lime	1.05	-
SO_3	1.81	0.31
Na_2O	0.42	1.25
K_2O	0.63	2.31
Na_2O_e	0.83	2.77
LOI	2.02	4.12
IR	0.59	-

Moreover, reduction in expansion was observed with increasing RHA replacement. Expansion decreased approximately 20% and 32% after 28 days, when cement was replaced with 10% and 40% RHA, respectively. Similar reduction in expansion was observed in a previous study with ground-granulated blast furnace slag having pozzolanic properties [8]. Reduction in expansion may be attributed to pozzolanic reaction of RHA. Pozzolanic materials bind alkali ions during the formation of hydration products, which leads to the decreased expansion [9]. Therefore, RHA replacement (10-40% by cement weight) was found to be effective in restricting the alkali–silica reaction expansion.

D. Strength Activity Index

Results of strength activity index of RHA (20% replacement) are presented in Fig. 2. It was observed that strength activity index was higher than 75% for all ages of mortar specimens. RHA can be referred as pozzolanic material having activity index greator than 75% in accordance with ASTM C311. As already observed, RHA can be useful in suppressing ASR expansion due to its pozzolanic behaviour.

V. CONCLUSIONS

Based on the results, RHA can be referred as a waste material having pozzolanic properties. Reduction in ASR expansion is possible after replacing cement with RHA due to its pozzolanic properties. Therefore, RHA replacement (10-40% by cement weight) can be effective in suppressing the ASR expansion.

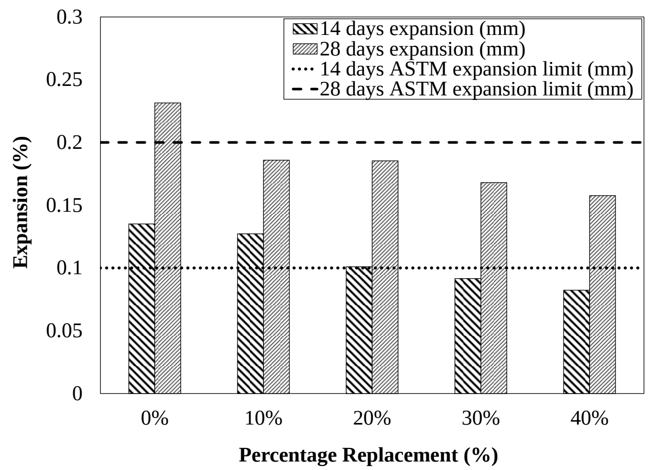

Figure 1. Results of mortar bar expanison test.

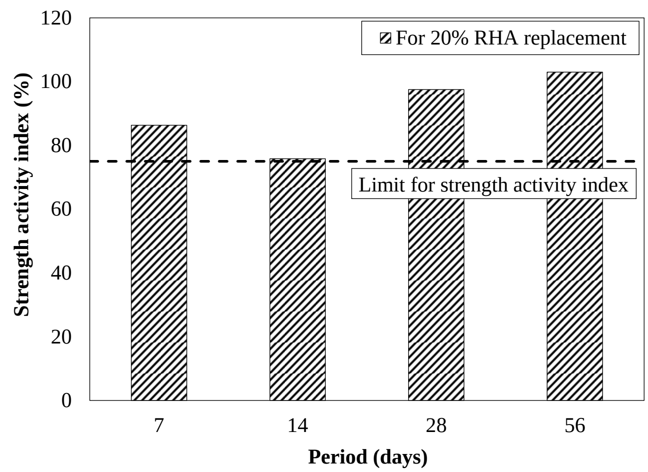

Figure 2. Strength activity index of RHA.

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