Improving the Bond Strength of Rice Husk Ash Concrete by Incorporating Polymer

A New Approach

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***Abstract*—This paper gives an insight of how to improve the bond strength of cement in which concrete is replaced with rice husk ash. A concrete mix was prepared and was used in different types of mixes i.e. Control Mix, 10% cement substituted concrete with rice husk ash and polymer modified concrete by incorporation different dosages of polymer in the 10% cement substituted concrete. A bar of 12mm diameter, 300mm in length was placed in the center of the cylindrical specimens for pull out test. It was observed that the bond strength between concrete and steel decreases with the replacement of cement with ash, conversely the bond strength improves with the addition of polymer dosages.**

Keywords-polymer; bond strength; RHA; cement replacement

I. Introduction

Several pozzolanic materials are used for cement replacement and rice husk ash (RHA) is one of them. Various concrete properties are affected when cement is substituted. Authors in [1] made various cement replacements with RHA starting from 5 to 30% replacement and concluded that bond strength increased up to an optimum level of cement replacement beyond which it started decreasing. A good repair system is supposed to provide a satisfactory bond between the repair material and old concrete. Ideally the bond between the composite concretes behaves as a monolithic. The most notably factors that have an adverse effect on bond strength are the characteristics of original concrete, surface conditions, preparation and characteristics of repair system, workmanship and environmental circumstances [2]. Importance of interfacial bond and surface preparation of concrete substrate prior to embarking on actual repair will be the single most important factor in repair viability as it is well documented in [3, 4]. The inclusion of the latexes to mortars and concretes improves their adhesion or bond strength to various substrates like pastes, mortars, concretes, tiles, bricks, steel, wood and stone in comparison to the un-modified mortars and concretes [2]. The higher adhesion of the latex-modified mortars and concretes is due to higher adhesion of polymers present in them. The adhesion is usually affected by the polymer-cement ratio, and the properties of substrates used. Adhesion or bond between latex-modified mortars and reinforcement has been investigated in [5] in which bond strength kept on increasing with an increase of polymer to cement ratio of 10 to 15%.

Authors in [6] developed an economical polymer-based repair material by blending epoxy acrylate, methyl methacrylate and polyurethane prepolymer. They utilized interpenetrate polymer network technology and conducted a chain of experiments on the bonding response of the developed material to be used for concrete structure crack repairing. The experimental outcomes revealed that the developed repairing material possessed a long lasting ability to repair concrete cracks with wanting operability, bonding agent strength and cracking resistance. Authors in [7] conducted different tests on concrete latex based polymer-modified concrete in green as well as in hardened stage. The dosage of polymer to cement was 2.5, 5 and 7.5%. The utmost effects of polymer modification are on the enhancement of concrete tensile strength, ductility, bond between reinforcement and concrete, and on improvement of properties contributing to the durability of reinforced structures.

II. METHODOLOGY

A laboratory pan mixer for concrete preparation was used. The moulds were lightly coated with mineral oil before use [8]. RHA, EVA powder and aggregates were dry-mixed for 2 minutes, followed by the addition of water and then mixed for 1 minute as per JIS A 1171 (Method of Making Test Samples of Polymer-Modified Mortar in Laboratory). Five specimens of each of the control mix and the 5 different mix types were cast making the total number of 30 cylindrical, sized 100 mm x 200 mm, specimens, by using the mix design shown in Table I.

TABLE I. SPECIMEN MIXES

S. No	Concrete Mix	Cement kg/m^3	RHA kg/m^3	RPP kg/m^3	T.Binder kg/m^3	Plasticizer kg/m^3	Water kg/m^3	F.A kg/m^3	C.A kg/m^3	Slump mm
1	CM	346	0	0.0	346.0	0.0	190.3	692	1038	25- 50
2	RHAMM	311.4	34.6	0.0	346.0	0.0	205.8	692	1038	
3	RHAPMM1	311.4	34.6	3.1	349.1	2.79	205.8	692	1038	
4	RHAPMM2.5	311.4	34.6	7.8	353.8	2.83	205.8	692	1038	
5	RHAPMM5	311.4	34.6	15.6	361.6	2.89	205.8	692	1038	
6	RHAPMM7.5	311.4	34.6	23.4	369.4	2.95	205.8	f692	1038	

A bar of 12 mm diameter, 300 mm length, was placed in the specimens' center for pull out test, as shown in Figure 1. After 24 hours the samples were de-moulded and were kept for curing. The control mix (un-modified) and RHA modified concrete mix samples were cured for 28-days in moist curing as per ASTM C 192 and polymer-modified concrete mix samples were first kept in wet curing for 7-days and then kept in the air for 21-days for air dry curing as per JIS A 1171-2000. At the end of the curing period, the reinforcing bar was pulled with the help of a Universal Load Testing Machine (UTM) until failure and the force was recorded as pull out strength [1]. The bond stress τ was calculated by (1):

$$\tau = \frac{P}{\pi l d} \quad (1)$$

where P is the required force to pull the embedded bar out of concrete specimen, L is the anchorage length of the bar in concrete specimen and d is the bar diameter. The average value of the five samples was recorded as concrete bond strength.

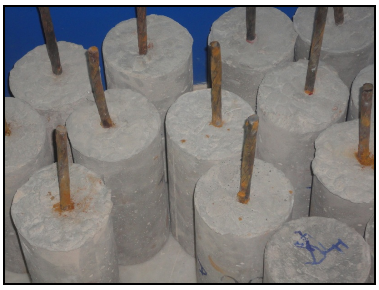

Fig. 1. Samples for pull out test

III. RESULTS AND DISCUSSION

A. Workability

Workability is one of the most important factors governing concrete strength. Results in Figure 2 show the workability of control mix, optimum RHA-modified mix and RHA polymer-modified mixes. From the figure, the addition of RHA as a supplementary cementing material causes a reduction in slump and a stiffer mix compared to control mix. For enhancing workability, keeping the water to cement ratio constant, 0.8 percent of super plasticizer is added. Furthermore, it was noticed that with polymer addition into the mix the slump increased, because the polymer has air entrapping quality. Such findings are lined up with [9, 10].

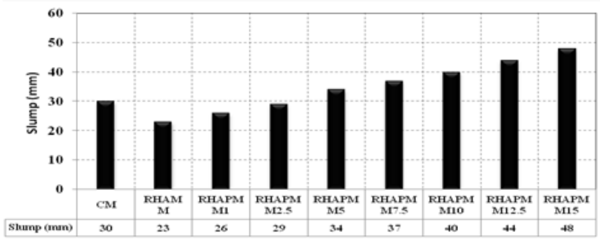

Fig. 2. Workability

B. Bond Strength

Results in Figure 3 show the behavior of bond/adhesion between the tensile reinforcement and concrete in control mix, 10% cement replaced with RHA concrete and RHA polymer-modified concrete (RHAPMC). Upon the cement replacement with RHA a weak bond is observed compared to control mix. Bond strength between reinforcement and RHA modified concrete decreases from 4.47MPa to 4.45MPa (i.e. 0.447% less) compared to the bonding behavior of control mix. This is because the cement substitute, i.e. RHA, is not so dense as cement. However adhesion characteristic significantly increases with the addition of RPP from 1 to 7.5% dosages when compared to control mix. At 5% dosages of RPP in the RHA modified concrete maximum bond strength is 4.49MPa (0.89% increase) compared to RHA modified concrete. The increase in the adhesion is primarily due to the increase in the tensile property. The constituents in polymer-modified concrete are compactly joined with each other due to the presence of interweaving polymer films [11]. Such findings are validated by the researchers in [2, 6, 12, 13].

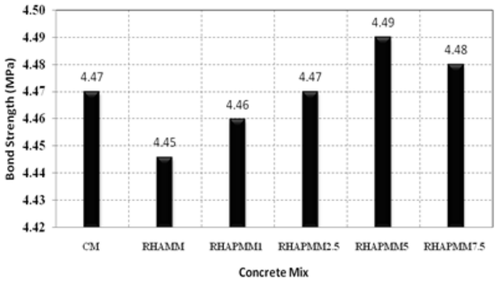

Fig. 3. Bond strength of CM, RHAMM and RHAPMM with steel bar

IV. CONCLUSIONS

On the basis of the experiment results the following conclusions can be drawn:

- The fluidity of the concrete with substituted cement with RHA is increased with the addition of polymer dosages.
- The bond strength between the reinforcement and RHA modified concrete decreases by 0.447% when compared to the bonding behavior of control mix. However adhesion characteristic significantly increases with the addition of RPP from 1 to 7.5% dosages compared to control mix. At 5% dosage of RPP in the RHA modified concrete, maximum bond strength is increased by 0.89% when compared to RHA modified concrete.

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