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EFFECT OF RICE HUSK ASH ON BOND STRESS

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ABSTRACT

The paper presents the effect of Rice husk ash on bond strength between unconfined concrete and HYSD bar. The main parameter considered in this is varying content of Rice husk Ash. The necessary experimentation is carriedout to meet aim of this paper; the experimental results are compared with bond stress equations developed by research scholars. On comparison it is found that the bond strength can be expressed in terms of compressive strength of concrete

Keywords: Pull-out, Bond stress, Admixture, Concrete, Rice Husk Ash

I. INTRODUCTION

Traditional materials used for concrete making are cement, fine aggregate, coarse aggregate and water. Such concrete is strong in compression and weak in tension, reinforcements are added to make it a composite material called Reinforced Concrete (RC), which can resist both compressive and tensile stresses. The behavior of RC structures depends up on the bond stress developed between the steel reinforcement and the surrounding concrete. To ensure the integrity of various constituent or composite action of concrete and steel reinforcement, sufficient bond should be developed by the surrounding concrete with the reinforcement. Proper bond between the steel reinforcement and the surrounding concrete is also crucial for the overall strength and serviceability of RC members [1, 2]. The failure of RC structures may be due primarily to the deterioration of the bond. In IS: 456-2000 [8], design bond stress is documented for different grades of concrete. Mineral Admixtures like Ground Granulated Blast Furnace Slag, Fly Ash, Silica Fume and Rice Husk Ash (RHA) have been using as additional ingredients of concrete to improve strength and durability properties of concrete [3]. Literature is available on effect of mineral admixtures on bond stress is too little. The simplest method to evaluate the bond strength is pullout bond test. Hence an experimental work is taken up to study variation of bond stress with RHA. The experimental data compared with other bond stress equations developed by Orangun et al. [4], AS3600 [5], Md.N.S. Hadi [6], M.V.Reddy[7] and IS:456-2000 [8]

II. PREPARATION OF TEST SPECIMEN

The experimental investigations are carried on a mix which was designed as per Indian standard method [9]. The proportion adopted for casting of test specimens are 1:2.4:3.6 with w/c ratio 0.5. In this mix proportions cement was replaced with RHA in 0%, 2.5% 5.0%, 7.5%, 10.0%, and 12.50%. A mixer was used to mix pre-determined quantities. The RHA, cement, fine and coarse aggregates were first mixed in dry state and calculated amount of water obtained from workability test was added and the whole concrete was mixed for five minutes in wet state. The standard moulds used for this investigation are 150mm*150mm*150mm for cubes and 150mm dia.*300mm height for cylinders. The concrete after mixing was poured into moulds in three layers by poking with a tamping rod. A total of 18 cubes and 18 cylinders with 16mm HYSD bar of 300mm embedded length were cast. Next day specimens were removed from moulds. Then the specimens are kept in water for 28 days. Figure-1shows sample specimen after removing from moulds and before keeping in curing tank. After curing period removed from water and allowed to dry under shade. The cubes are tested under compression, using 200T capacity Compression Testing Machine [10], Figure-2 shows testing of cubes. The cylindrical specimens with embedded bar are used to carry pullout test using 40T capacity UTM [11]. Figure-3 shows the experimental test set up for pullout test. During testing required experimental data for all the specimens [12] is noted. The bond stress is calculated using equation-1 given below.

$$\text{Bond Stress (u)} = \frac{P}{\pi d_b L_d} ------(1)$$

III. EXPERIMENTAL RESULTS AND ANALYSIS

The Experimental results are presented in Table-1, contains average cube compressive strength of concrete due to replacement of cement with RHA and corresponding average bond stress values. From the Table-1, it is observed that due to replacement of cement with RHA the strength is increasing up to 5% and thereafter decreasing. The failure pattern of specimens is shown inFigure-4. From this figure it is clear that the failed specimens crack pattern is radial. And during testing most of the specimens are failed in splitting.

Table-1 The Experimental Results

S.No	RHA Replacement %	Average strength (Mpa)	
		Compressive	Bond
1	0.00	25.28	6.58
2	2.50	29.64	7.93
3	5.00	41.85	7.80
4	7.50	34.00	7.15
5	10.00	26.16	7.02
6	12.50	26.16	5.85

The Bond stress equation developed by Orangun et al. [4] is given below as equation-2, using this equation bond stresses are calculated and presented in column-8 in Table-2

$$u = 0.083045\sqrt{f_c'}\left(1.2 + 3\frac{C}{d_b} + 50\frac{d_b}{L_d}\right) ------(2)$$

Australian Standard 3600 [5] recommends the following Equation-3 for bond stress between concrete and reinforcing steel. The Bond stress is calculated using this equation-3 and presented in column 9 of Table-2.

$$u = 0.265\sqrt{f_c'}\left(\frac{C}{d_b} + 0.5\right) ------(3)$$

Md N.S. Hadi [6] proposed an equation for bond stress as given in equation-4. Using this equation bond stress is calculated and presented in column-10 of Table-2.

$$u = 0.083045\sqrt{f_c'}\,(22.8 - .208\frac{C}{d_b} - 38.212\frac{d_b}{L_d}) ----- (4)$$

M.V.Reddy[7] is proposed an equation for bond stress as given in equation-5, The equation for bond stress is expressed in terms of cube compressive strength of concrete. The bond stress values are estimated using this equation and presented in column-11 of Table-2.

$$u = \sqrt{f_c'} ----- (5)$$

The bond stress values are estimated for corresponding compressive strength of concrete according to IS: 456-2000[8] and presented in column 12 of Table-2. And a graph is drawn between bond stresses for different content of RHA and presented in figure-5. The Figure-5 shows comparison between bond stresses obtained using various equations and experimental data. It is clear from this figure experimental and theoretical bond stress values are higher than the values stated in IS: 456-2000. Hence the design bond stress values obtained using IS 456 are under estimated.

Table-2 Comparison of Experimental and Theoretical bond stress (Mpa) values.

S.no	RHA %	Compr. Strength Mpa	Cover C (mm)	Embedded length Ld (mm)	Dia.bar Db(mm)	Expt [12]	Organ et al [4]	AS3600 [5]	Md.N.S. Hadi [6]	M.V. Reddy [7]	IS:456 -2000 [8]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	0.00	25.28	67	300	16	6.58	6.86	6.25	8.31	5.03	1.41
2	2.50	29.64	67	300	16	7.93	7.43	6.76	8.99	5.44	1.49
3	5.00	41.85	67	300	16	7.80	8.83	8.04	10.69	6.47	1.90
4	7.50	34.00	67	300	16	7.15	7.96	7.24	9.63	5.83	1.66
5	10.00	26.16	67	300	16	7.02	6.98	6.35	8.45	5.11	1.42
6	12.50	24.16	67	300	16	5.85	6.71	6.11	8.12	4.92	1.37

IV. CONCLUSION

Following are the conclusions drawn from the limited experimental work carriedout.

1. The bond stress can be expressed in terms of compressive strength of concrete irrespective of amount of mineral admixture present in the concrete.
2. The design bond stress values presented in IS: 456-2000 is under estimated
3. The specimens tested for bond strength in pull out are failed in splitting of cylinder and with radial crack pattern.

Notations:	
u = Bond stress	P = Pull out Load (N)
d_b = diameter of pull out bar (mm)	L_d = embedded length of pull out bar(mm)
C = Concrete cover to pull out bar	f_c' = Cube compressive strength of concrete (N/mm^2)
Comp. = Compression.	Tens. = Tension

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Figure-1 Typical Test specimens before keeping in curing Tank

Figure-2 Testing cube Specimen Using CTM

Figure-3 The experimental test set up for pullout test

Figure-4 The failure Pattern of Tested Specimens

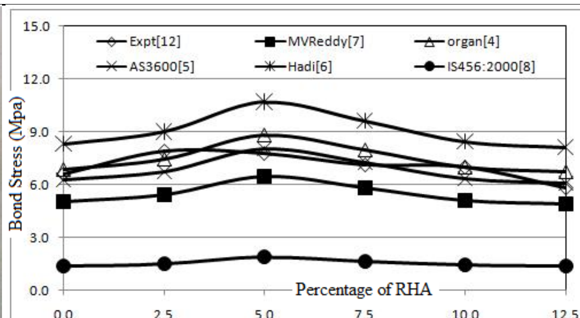

Figure-5 Comparison of Bond stress with Percentage of RHA