Volume : 4 | Issue : 12 | December 2015 • ISSN No 2277 - 8179

Research Paper

Experimental Study on effect of silica fume on ultimate Bond strength of unconfined concrete

Engineering

KEYWORDS : Pull-out, Push-out, Bond strength, Silica Fume, Compressive strength, Concrete

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ABSTRACT

The experimental work is aimed to study effect of silica fume on ultimate Bond strength of unconfined concrete. In this investigation M20 grade concrete considered and the cement quantity was replaced with silica Fume in 0%, 5%, 10%, 15% and 20%. Plain and twist bars of sizes 16mm and 20mm diameter were used in both Pull-out and Push-out tests. A total 144 cylinders and 36 cubes were cast and tested to obtain ultimate bond strength and compressive strength. After analysis of experimental data, it is found that the silica fume is showing similar effect on compressive strength and ultimate bond strength.

INTRODUCTION

Concrete is the most widely used construction material on earth. Since concrete is weak in tension and strong in compression, reinforcements are added to make it a composite material called Reinforced Concrete(RC), which can resist both tensile and compressive stresses. The behavior of RC structures depends up on the type of bond developed between the steel reinforcement and the surrounding concrete. Bond stress is the tangential shear or friction developed between the reinforcement and the surrounding concrete that transfers the force onto the reinforcement. 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. Adequate bonding between reinforcing bars and concrete is essential for the satisfactory performance of reinforced concrete structures. The simplest method to evaluate the bond strength is direct tension-pullout bond test. The main characteristics of the bond stress–slip evolution and especially the maximum bond stress are found to be clearly dependent on material, geometrical or loading parameters. The use of deformed bars can greatly enhance the steel–concrete bond capacity. Proper bond between the steel reinforcement and the surrounding concrete is also crucial for the overall strength and serviceability of RC members. The failure of RC structures may be due primarily to the deterioration of the bond[1-4]. A Lot of literature is available on effect of mineral admixtures on compressive of concrete [5]. But very little literature is documented on effect of mineral admixtures on bond strength of concrete. And according to clause 26.2.1 of the Indian code 456-2000[9], the ultimate bond stress is given for grade of concrete, not strength of concrete. Hence an experimental work is taken up to study the influence of silica Fume on compressive strength of concrete and ultimate bond strength of concrete on steel in tension and compression.

EXPERIMENTAL PROGRAMME

Materials

Cement: The cement for the whole work was procured in a single consignment and properly stored. The properties of cement [10] used in the investigation are, the specific gravity 3.01, Fineness is 4.0%, initial setting time 85 mins, standard consistency 31%.

Fine Aggregate (FA): Locally available River sand was used as FA. The Specific gravity of FA is 2.62.[11]

Coarse Aggregate (CA): Machine crushed granite obtained from a local Quarry was used as CA. The specific gravity of CA was 2.68.[11]

Preparation of Specimens

The concrete grade adopted for this investigation is M_{20}. The quantities of the constituents of the concrete were obtained from the Indian Standard Mix Design method [13]. The mix proportion of concrete for laboratory investigations was arrived by designing as per Indian standard method. The final mix proportion arrived was 1:1.9:3.4 with water/cement ratio 0.48. In this cement was replaced with silica fume in 0%, 5%, 10%, 15% and 20%. A mixer was used to mix pre-determined quantities. The cement, fine aggregate and coarse aggregate were first mixed in dry state, to obtain uniform colour and calculated amount of water obtained from workability test was added and the whole concrete was mixed for five minutes in wet state. The plain and twist bars of 16mm and 20mm diameter are considered in this investigation. The general details of bar is shown below in the Figure-1. The standard sizes of moulds used for 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. The numbers of cubes cast for compressive strength was 18 and numbers of cylinders cast for bond strength was 72 for each diameter. Specimens were removed from moulds after 24 hours of cast and immersed in a clean water pound. The specimens are kept in water for a period of 28 days, and then specimens were removed from the water and allowed to dry under shade. Then all the cube specimens are tested to failure using 200T capacity Compressive Testing Machine [12] to obtain compressive, all the cylindrical specimens are tested to failure using 100T capacity Universal Testing Machine to get bond strength in compression and tension [14]. After taking experimental data bond stress is calculated for all the specimens and presented in Table-1[6, 7]. The testing of cubes is shown in figure-2. The failure pattern of specimen in pull-out test is shown in figure-3. The equation used to calculate bond stress is presented here. Bond stress $=\frac{P}{\pi D L_d}$, Where P = Pull-out /Push-out load (N), D = Diameter in mm, L_d = embedded length (mm).

EXPERIMENTAL RESULTS:

The results obtained from experimental data are presented in Table-1. The variation of compressive strength and bond strength for 16mm dia. bar due to addition of silica fume is shown in figure-4. The variation of compressive strength and bond strength for 20mm dia. bar due to addition of silica fume is shown in figure-5.

CONCLUSION:

Following conclusions are drawn from the limited experimental study:

The variation of compressive strength and bond strength due to addition of silica fume is similar. Hence the bond strength can be expressed in terms of compressive strength, instead of grade of concrete.

The cylindrical specimens tested for bond strength pull out and push out are failed in splitting of cylinders.

The percentage of increase of bond strength due to usage twist bar is more in pullout in comparison with push out.

Volume : 4 | Issue : 12 | December 2015 • ISSN No 2277 - 8179

The percentage of increase in bond strength more in 300mm embedded length compare to 150mm embed length.

Table- 1. The Experimental Results

S.no	SF %	Bar Details		Compressive (N/mm²)	Ultimate bond strength (N/mm²)			
		type	Size mm		Push-out		Pull-out	
					150mm	300mm	150mm	300mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	0	Plain	16	30.738	9.48	5.57	6.245	3.811
2	0	Twist	16	37.714	12.67	9.48	9.107	6.7
3	5	Twist	16	43.818	12.93	9.78	9.693	6.96
4	10	Twist	16	44.036	16.58	9.95	11.339	7.936
5	15	Twist	16	39.24	13.93	8.06	8.847	7.514
6	20	Twist	16	34.88	11.94	6.90	7.749	6.538
7	0	Plain	25	28.77	12.73	8.74	4.58	4.06
8	0	Twist	25	31.17	13.26	10.07	6.87	6.45
9	5	Twist	25	44.03	14.85	10.34	7.70	7.91
10	10	Twist	25	47.52	22.81	13.79	8.27	8.22
11	15	Twist	25	38.58	16.97	9.54	7.70	5.41
12	20	Twist	25	34.66	14.85	7.42	5.20	5.62

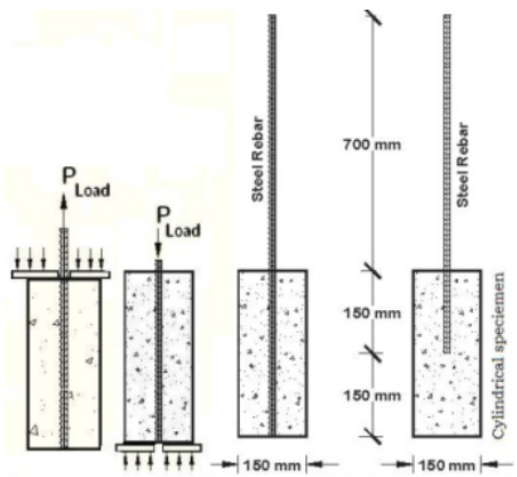

Figure-1.The general details of bar embedded in cylindrical specimens


Figure-2 shows testing of cubes


Figure-3 shows Failure pattern of cylindrical specimen in pull-out test.

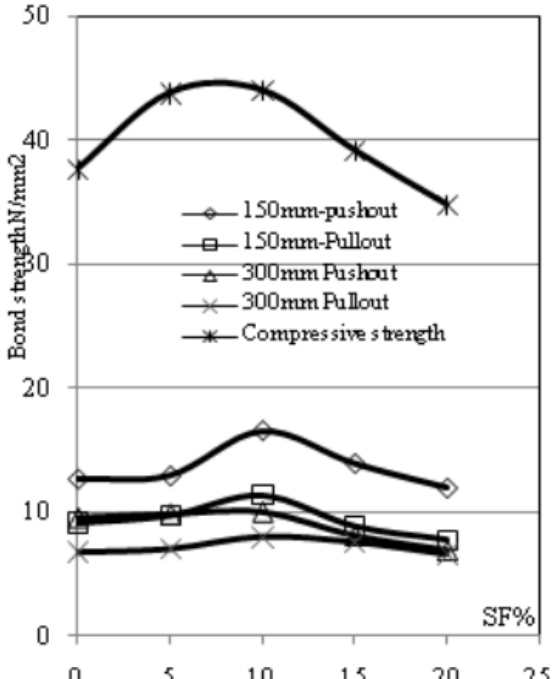

Figure-4 shows variation of compressive and bond strength for 16 mm dia with SF%

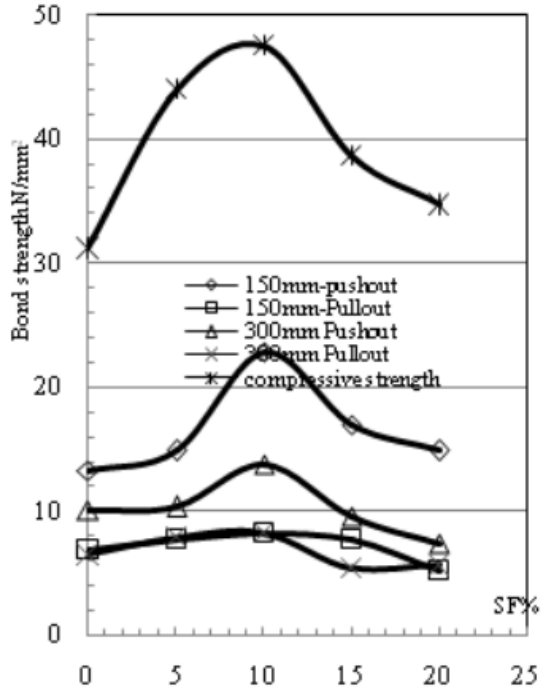

Figure-5 shows variation of compressive and bond strength for 20mm dia with SF%

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