Bond strength of Steel Fiber Reinforced Reactive Powder Concrete Using Fly Ash with Silica fume

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***Abstract*—Reactive Powder Concrete is a developing composite material that will allow the concrete industry to optimize material use,Generate economic benefits,and build structures that are strong,durable,and sensitive to environment. RPC is a new ultra-high-performance concrete with wide range of capabilities. RPC was developed in the 1990s by Bouygues' laboratory in France. RPC represents a new class of Portland cement-based material with compressive strengths of 200 MPa range. It has no coarse aggregates and contains small steel fibres that provide additional strength.RPC include Portland cement, silica flour, fine sand, superplastizer, water and steel fibres. The main object of this study is to check the effect of replacing silica fume by fly ash and percentage variation of steel fiber on reactive powder concrete, to achieve economy without any significant change in properties of RPC. The silica fume is replaced by the fly ash by its weight variation of 0% to 50% with interval of 10 %. It was found that replacement of fly ash upto 40% by silica fume is economical to achieve Bond Stength.**

***Index Terms*—Fly ash,Precipitated silica, Reactive Powder Concrete, RPC, Steel fibers, Silica fume.**

I. INTRODUCTION

Concrete, one of the most widely used construction materials, has been subject to major research and development over the past century.The high-performance concrete (HPC) is also a new trend concrete material that enhances high strength upto 120 MPa, but Richard and Cheyrezy show that Reactive powder concrete (RPC) in which strength is obtained in excess of 200 MPa and flexural strength 30-60MPa [1]. Comparison of the physical,mechanical,and durability properties of RPC and HPC (High Performance concrete) shows that RPC possesses better strength.

Reactive Powder concrete contains very fine materials such as precipitated silica, crushed sand and silica fume.The basic composition for the production of RPC has been explained by the Richard and Cheyrezy[1]. A very dense matrix is achieved by optimizing the granular packing of these powders [2]. Due to inverse effect of high cement content on the early age shrinkage behavior and decreased hardened performance by micro-cracking, supplementary cementations materials such as fly ash, blast furnace slag, and silica fume are commonly used in cement and concrete industry [3]. It is possible to modify some fresh and hardened properties of composite by utilizing these materials.In this study, it has been checked that effect of fly ash as a replacement of silica fume on the parameters of reactive powder concrete such as compressive, tensile and flexural strength.

II. EXPERIMENTAL ANALYSIS

RPC composition used in this study, we referred Richard and Cheyrezy [6] mix proportion from their research.Using this reference, the trial mix were taken by adjusting percentages of silica fume. According to trial mixes appropriate mixes were taken for actual mixing. The aim was to find out the highest compressive strength at optimum percentage of fly ash and silica fume.

Bond Strength (Pull out test)

The specimen was cast with 12 mm diameter for steel rod embedded in 100mm x 100mm x 100mm concrete cube and compacted on vibrating table. The verticality of 12 mm embedded tor steel rod is ensured by supporting till concrete hardens.

The pull-out test was carried at 7 days and 28 days on UTM. The specimen was held between upper and middle cross head. The rod was gripped in upper cross head and cube was held below middle cross head. The tensile load was applied on steel bar for pull out purpose. The maximum pull force is recorded in the test at bond failure. The bond strength has been computed from the following expression:

$$\tau_{bd} = \frac{P}{\pi d L_e} \quad (15)$$

d=diameter of bar in mm

p=force required to pull out the bar, N

Le=embedded length of bar in concrete, mm 7days:

$fcr=59.24V_f^3+87.35V_f^2-18.80V_f+10.64$ *(16)*

28days: $f_{cr}=-81.10V_f^3+110.2V_f^2-12.20V_f+19.39$ *(17)*

Sr.no	Steel fiber content(%V_f)	Bond Strength			
		Exp.Value 7 days	From Eq^n (16) days	Exp.Value 28 days	From Eq^n(17) 28 days
1	0	10.32	10.64	19.34	19.39
2	0.25	11.77	10.47	22.17	21.94
3	0.5	13.73	15.67	30.41	30.65
4	0.75	21.974	20.68	38.25	37.90
5	1.00	19.62	19.95	36.292	36.09

Expressions for Bond strength in 3 rd degree polynomial in terms of Vf are given by the following equations from graph 4.23.

III. REGRESSION ANALYSIS

Comparison of Bond strength by regression analysis

From Table 4.12, it is observed that bond strength is increased with the addition of steel fibers. The trend of variation of bond strength is modelled mathematically in terms of volume fraction of fiber Vf of SFRRPC and is given by equation (16) and (17).

Conclusions

The method of mix design used in the present work is proper for having desired strength and to make fiber reinforced reactive powder concrete. In addition to that following conclusion are drawn based on the result discussed in the previous chapter.

6. The maximum Bond Strength achieved was 21.97MPa and 38.25 MPa at 0.75% fiber volume fraction at 7 and 28 days respectively, which was increased by 10.78% and 12.11% respectively.
7. Mathematical expressions have been established to predict the values of compressive strength, flexural strength, split tensile strength and bond strength for SFRRPC in terms of fiber volume fractions. Results predicted from these expressions are in excellent agreement with the experimental results in this investigation.
9. The significant improvement in various strengths is observed with the inclusion of crimped steel fibers in the plain reactive powder concrete. However, maximum gain in strength of RPC is found to depend upon the amount of fiber.
10. In all fiber contents, mode of failure was changed from brittle to ductile failure when subjected to bending and split tensile testing.
11. Optimum fiber content for bond strength is observed at 0.75%.

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