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Acid Attack On Hybrid Fiber Reinforced High Strength Concrete With Manufactured Sand and Coconut Shell

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ABSTRACT

In this study, the acid attack test is performed on the fiber reinforced concrete incorporating with manufactured sand silica fume and coconut shell. The grade of concrete is M50. Silica fume is partially replaced with 10 % by the weight of cement and manufactured sand is partially replaced with 40% by the weight of sand. The coconut shell is partially replaced for coarse aggregate by 20%. Additionally three types of fibers are used such as steel fiber, sisal fiber, and coir fiber. The volume fraction of fibers ranges from 0 to 3%. The aim of this study is to evaluate the acid resistance of the fiber reinforced high performance concrete. From the experimental investigation, it was found that there is improvement in acid resistance for fiber reinforced high performance concrete when compared to plain cement concrete. Also fiber reinforced concrete improves the cracking resistance compared to plain cement concrete.

Keywords

Silica Fume, manufactured sand, coconut shell, Steel fiber, coir fiber, sisal fiber, Concrete, Acid Attack. Sulphuric Acid, Hydro Chloric Acid

1. INTRODUCTION

Generally Concrete is not fully resistant to acids. Here in this study the conventional concrete making materials are replaced by some supplementary materials to improve the acid resistance property of concrete. The acid entry deteriorates the concrete. With the sulphuric acid attack, calcium sulphate formed can react with calcium aluminate phase in cement to form calcium sulpho aluminate. This will lead to cause expansion and disruption of concrete. The cracks in the concrete are arrested by the fibers. And also the fibers restrict the growth of flaws in the concrete [1]. Fiber hybridization gives the toughness enhancement of steel fibre reinforced concrete. Similarly the deflection hardening response of fiber reinforced concrete with 0.75% by volume of 0.40mm and 0.45mm gives better performance than larger diameter crimped fiber [2]. The hybrid with 0.25– 0.5% of the palm fibers and bar chip fires with 1.5% or 1.75% of steel fibers as volumetric fractions in HSFC mixes significantly improved the compressive strength [3]. The workability of concrete reduces with increase of steel fiber content. splitting tensile strength is increased from 1% to 5%, 1% to 3%, for concrete mixes having 0.25%, 0.5%, 1.0% and 1.5% volume fractions of fibers with fly ash tensile strength is increased from 1% to 5%, 1% to 3%, for concrete mixes having 0.25%, 0.5%, 1.0% and 1.5% volume fractions of fibers with fly ash. [4]The conversion of calcium compounds into calcium salts of the attacking acid by the action of acid attack. By this activity, the deterioration of the concrete structure is occurred. The replacement of silica fume increases the durability against acid attack. This is attributed to the silica present in silica fume which combines with calcium hydroxide and reduces the amount susceptible to acid attack. [5]. The loss of weight is lesser in manufactured sand when compared to the concrete with natural river sand due to the less entry of the solution in to the pores of concrete. Likewise the loss of strength is lesser in manufactured sand when compared to the concrete with natural river sand due to the better interlocking of manufactured sand [6]. The decrease in the compressive strength after treating specimens with hydrochloric acid for 28 days of M20 grade concrete for replacement of natural sand by manufactured sand in proportions of 0%,20%,40%,60%,80%,100% is of order 11.7%, 10.18%,9.82%, 7.12%,9.13%,9.659% for compressive strength [7].The loss of weight in sisal fiber concrete due to acid attack test at 7 days is 1.41% less and at28 days it is 0.79% less when compared with control concrete. In steel fiber concrete, loss of weight compared to control concrete at 7 days is 3.21% lesser and at 28days it is 0.50% less. Acid attack test, percentage increase in strength of sisal fiber compared to control concrete after 7days is 17.57% and increase in strength of steel fiber compared to control concrete after 7 days is 8.67%. After 28 days, percentage increase in strength of sisal fiber and steel fiber compared to control concrete are 18.27% and 11.29% respectively. Percentage increase in strength of sisal fiber compared to steel fiber after 7 days and 28 days are 8.18% and 6.26% respectively [8]. The percent loss of mass of soil concrete was 1.28 per cent and sand concrete was 1.82 per cent. The percentage loss of both soil and sand concretes was much lower. And also soil concrete was more durable and possessed strong resistance to acid attack[9].The coir fiber reinforced concrete has improve ddurability properties when compared to control concrete [10]. Based on the percentage loss of weight, the steel fiber concrete has the better resistance against corrosion than control concrete. After 28 days curing in sulphuric and Hydro chloric acids, the percentage of weight loss is minimum for different percentage of steel fiber when compared to control concrete [11].The maximum percentage loss in weight and percentage reduction in compressive strength due to acids for M40 grade concrete are 1.25%, 16% with replacement of 10% Metakaoline and the minimum percentage loss in weight and strength are 1.18%, 14.9% with replacement of 20% Flyash. There is considerable variation in loss of weight and strength only with Silica Fume replacement. [12]Copper slag incorporating concrete specimens has lesser resistance to acid attack due to its higher mass and higher resistance to sulphate attack, chloride attack and carbonation. [13] the

percentage replacement of coarse aggregate by coconut shell increases the strength of acid attacked cubes than water cured cubes [14].The compressive strength of Coconut shell concrete in H_2SO_4 and Hcl solution curing are partially greater than the normal water curing[15].The contribution of coconut shell and coir fibres as partial replacement in making concrete produces sustainable and eco-friendly construction[16].

The objectives of the present work are (i) To improve the acid resistance of concrete by the incorporation of manufactured sand as partial replacement of sand in and silica fume as partial replacement of cement and coconut shell as partial replacement of coarse aggregate in fiber reinforced concrete and then compared with the conventional concrete. (ii) To determine the combined effect of hybrid fibers on the durable properties like acid attack of fibre reinforced high performance concrete.

2. MATERIALS

Ramco 43-grade cement conforming to IS12269-1987 has been used throughout this investigation [18].The specific gravity of cement was 3.10. The initial and final setting time of cement was 57minutes and 4 hours. The standard consistency of cement was 29.20%.Silica fume is a byproduct of silicon metal or ferrosilicon alloys which was replaced for cement with 10%. Silica fume supplied from ASTRAA Chemicals has been used. The fine aggregate of clean river sand passing through 4.75 mm sieve conforming to IS: 383: 1978was used [19]. The specific gravity and fineness modulus of sand was 2.6 and 2.66 respectively. Locally available manufactured sand is partially replaced by the weight of sand with 40%. And 60% of locally available crushed blue granite metal aggregate of size 20 mm and 20% of 12mm coarse aggregates were used and Potable water was used throughout this study. The specific gravity and fineness modulus of coarse aggregate was 2.7 and 6.18 respectively. The coarse aggregates were replaced with 20% of locally available coconut shell. The superplasticizer used was conplast SP 430 of dosage 2%. Hybrid fiber (A mixture of metallic and natural fiber) has been used in this investigation. Mixtures of both steel and natural fiber (coir and sisal) were used in this research work. Corrugated steel fiber of length 50mm and 1mm diameter was used. Coir fiber of 50mm length and 203µm was used. The length and diameter of 50mm and 100µm of sisal fibers were used. Volume fraction typically ranges from 0 % to 3%.

3. MIX PROPORTIONS

The mix quantity and mix proportions for M50 grade concrete are presented in Table1 and table2 respectively. A total of 4 mixes were prepared using water binder ratio of 0.33. Control mix is designed as per IS 10262-2009 [17].

Table 1. Mix Quantity

Quantity (Kg/m^3)	w/b	Mix Ratio
Cement – 449.72; Fine Aggregate – 620.21; Coarse Aggregate – 1391.4 Water- 155.1	0.33	1:1.38:3.09

Table 2. Mix Proportions

	BINDER (%)		FINE AGGREGATE (%)		COARSE AGGREGATE (%)			FIBERS (%)		
MIX ID	CEMENT	SILICA FUME	SAND	MANUFACTURED SAND	20mm size	12mm size	Coconut shell	STEEL FIBRE	SISAL FIBRE	COIR FIBRE
SMC	100	0	100	0	100	0	0	0	0	0
SMC1	90	10	60	40	60	20	20	1	1	1
SMC2	90	10	60	40	60	20	20	0	1	2
SMC3	90	10	60	40	60	20	20	0	2	1
SMC4	90	10	60	40	60	20	20	2	1	0

4. EXPERIMENTALPROGRAM

The test was carried out on 100 mm size cube specimens at the age of 28 days curing. The cube specimens were immersed in water diluted with 1% by weight of sulphuric acid solution. The solution was replaced at regular intervals to maintain the required concentration throughout the test period. The weight of specimens was measured at 28 days of immersion in acid solution and the percentage loss of weight of specimens was determined. The compressive strength of

the specimens was found out. The losses of compressive strength before and after acid immersion were calculated. Similar procedure was followed for hydrochloric acid also. Table 3 shows the experimental results of acid attack.

Table 3. Acid Attack Results

MIX ID	Sulphuric Acid Attack Results		Hydrochloric Acid Attack Results	
	Loss in Weight (%) At 28 Days	Loss in Compressive strength (%) At 28 days	Loss in Weight (%) At 28 Days	Loss in Compressive strength (%) At 28 days
SMC	2.106	7.03	2.106	9.08
SMC1	0.242	4.34	0.440	5.66
SMC2	0.274	5.08	0.347	6.65
SMC3	0.279	3.29	0.304	4.94
SMC4	0.198	0.32	0.225	0.70

5. RESULTS AND DISCUSSIONS

From the table 3, it is observed that the mix SMC4 has the better acid attack resistance among all the mixes. The mix SMC4 has the least percentage loss in weight after 28 days H_2SO_4 acid curing. Similarly the same mix has the lesser percentage loss of compressive strength in H_2SO_4 acid curing. The loss percentage of compressive strength of SMC4 mix was only 0.198. Similar behavior is obtained for hydrochloric acid also. The mix SMC4 has the least percentage loss in weight after 28 days H_2SO_4 acid curing. Similarly the same mix has the lesser percentage loss of compressive strength in HCl acid curing. The loss percentage of compressive strength of SMC4 mix was only 0.225. The reason behind this is the filling effects of silica fume which make the concrete dense and prevent the entry of acid into the concrete. The concrete containing silica fume was more resistant against acid attack. Adding silica fume and manufactured sand to the normal concrete, the porosity of the concrete was reduced. And also these supplementary materials reduce the leaching of calcium salts from the impermeable surface there by increasing the acid resistance of HPC mixes. Sisal fibres acted as porous bridging elements across cracks and permitted the deposition of new hydration products and subsequently arrested the cracks. Coir fibres are most ductile and energy absorbent material which also take part in resisting acid entry into the concrete specimen. The combined effect of the supplementary materials makes the concrete more acid resistance than control concrete.

6. CONCLUSION

The combined effect of silica fume, manufactured sand and fibers improve the acid resistance of concrete. The mix containing 10% silica fume, 40% manufactured sand, 20% coconut shell, 2% steel fibers and 1% sisal fibers has the least percentage of loss of weight. Similarly the mix containing 10% silica fume, 40% manufactured sand, 20% coconut shell, 2% steel fibers and 1% sisal fibers has the minimum loss percentage of compressive strength. The filler effects of silica fume and manufactured sand and bridging action of fibers make the concrete more resistance to acid attack.

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