ISSN 2321-807X
Volume 12 Number22
Journal of Advances in chemistry

Acid Attack on Reinforced Concrete Incorporated with Industrial Wastes

Dhanaraj R[1], Sakthieswaran N[2]
[1,2]Department of Civil Engineering, Anna University, Regional Campus, Tirunelveli, TN, India.
[1]rdhanam@rediffmail.com

ABSTRACT

The study was conducted to evaluate the durable characteristics of Reinforced Concrete with silica fume and copper slag. The concrete mix design was done for M40 grade concrete with 7% silica fume as cement and 10 to 30% of copper slag as sand. Also the concrete contains the total fiber content 3% of steel, basalt and Alkali Resistant Glass Fiber (ARGF). To study the durability characteristics such as resistance against acid, specimens were cast for different content of industrial wastes, fibers and it was compared with the control concrete.In this investigation an attempt was made in order to know the behavior of standard concrete of M40 grade specimens curing with acids such as HCl, and H_2SO_4 of 1% concentration at 28 days curing. Test results indicate that use of Silica fume, copper slag and fibers in concrete has improved the performance of concrete in durability aspect.

Keywords

Silica Fume, Copper Slag, Steel fiber, basalt fiber, ARGF fiber, Concrete, Acid Attack. Sulphuric Acid, Hydro Chloric Acid

1.INTRODUCTION

Concrete is not fully resistant to acids. The deterioration of concrete occurs due to acid attack. With the sulphuric acid attack, calcium sulphate formed can proceed to react with calcium aluminate phase in cement to form calcium sulphoaluminate which causes expansion and disruption of concrete. Concrete can be attacked by liquids with pH value less than 6.5. Here in this study, the resistance of concrete is improved by adding some industrial wastes and fibers by partial replacement for cement and sand. Based on the percentage of weight loss, the specimen with steel fibers shows better resistance against acid than control specimen. After 28 days curing in sulphuric and Hydro chloric acids, the percentage of mass loss is less for different percentage of steel fiber than control specimen[1].The partial replacement of silica fume is found to have increasedthe durability against acid attack. The reason behind that is the silica present in silica fume which combines withcalcium hydroxide and reduces the amount susceptible to acid attack. When compared to other mix the loss in mass percentage was found to be reduced by 2.23 when the cement was replaced by 10%of Silica fume. [2]. It is observed from the results the maximumpercentage loss in weight due toAcids for M40 grade concrete is 1.25% with replacement of 10% Metakaolineand the minimum percentage loss in weightand strength is 1.18% withreplacement of 20% Flyash. By silica fume replacement, there issignificant variation in loss of weight andstrength [3].The concrete reinforced with coir fibres shows improveddurability properties when compared to control concrete [4].The reason for both the increase in volume and the decrease in densityof the concrete is due to the sulfuric acid-cementpaste reaction. This will lead to be larger the higher the acidityof the acid solution. This is attributed toa stronger acid solution which produces a smallerweight loss in a concrete specimen [5]. The Percentage decrease in compressive strength of the specimens without and with immersion in sulphuric acid for copper slag at 60% replacement for fine aggregate at 28 days was found to be 7.12 %. [6].The concrete having steel slag has good acid resistance when compared with control concrete. The obtained weight loss of control concrete is 3.44% and higher than the concrete with steel slags. The percentage of loss of compressive strength of control concrete is 1.98% and higher than the concrete containing steel slags. The concrete cube containing steel slag resist the acid attack when compared to the control concrete.[7] Copper slag admixed concrete specimens showed lesserresistance to acid attack due to its higher mass and higherresistance to sulphate attack, chloride attack andcarbonation [8].

This work aims at the study of acid resistance of concrete by the incorporation of copper slag as partial replacement of sand in and silica fume as partial replacement of cement infiber reinforced concrete and then compared with the conventional concrete.

2.MATERIALS AND MIX DESIGN

2.1 Cement: OPC 43 grade conforming to IS12269-1987 has been used [10].
2.2 Silica fume: Supplied from ASTRAA Chemicals has been used.
2.3 Fine Aggregate: River sand confirming to IS383-1978 has been used[11].
2.4 Copper slag obtained from Sterilite industry, Tuticorin has been used.
2.5 Coarse Aggregate: Hard granular metal of 20 mm size confirming to IS383-1978 has been used[11].
2.6 Water: Ordinary potable tape water has been used.

2.7 Fiber: Corrugated steel fiber of length 30 mm and diameter 1 mm having aspect ratio of 30 has been used. Chopped strand basalt fiber and Alkali Resistant Glass Fiber(ARGF) have been used.

2.8 Super-plasticizer: CONPLAST SP430 supplied by FOSROC Chemicals has been used for 2% of binder.

2.9 Mix Ratio: M40 (1:1.65:2.92, W/C=0.40) concrete mix design was made according to IS: 10262-2009 and used in this study [9].

2.10ix Proportions: In this study the binder (cement), has been replaced with silica fume of 7%. In addition, fibers of maximum 3% have been used in different proportions of binder. The copper slag ranges vary from 10 to 30%. The mix proportion for various grade of concrete is shown in table 1. Three specimens were cast for each mix and the average value is taken as the result.

Table 1. Mix Proportions

Mix ID	Quantity (Kg/m^3)	w/b	% by the weight of cement	(% by the weight of sand)	Steel Fiber	Basalt Fiber	ARGF
			Silica Fume	Copper Slag			
CM1	(Cement - 400; Fine Aggregate - 660; Coarse Aggregate - 1168; Superplasticizer - 8)	0.4	0	0	0	0	0
SCB1			7	10	1	0.5	1.5
SCB2			7	20	1.5	1	0.5
SCB3			7	30	0.5	1.5	1

3.METHODOLOGY

3.1 Acid attack Test Procedure

The size of 100 mm cubes were cast for finding acid resistance. Firstly, the weight of the cube specimens was determined and they were immersed in water diluted with one percent by weight of sulphuric acid. After 28 days immersion acid, the specimens were taken out from the acid and the surfaces of the cubes were cleaned. Then the weight and the compressive strength of the specimens were found out the average percentage of loss of weight and compressive strengths were calculated.

% loss of weight $=\frac{W2-W1}{W1}$ X 100

Where,

W1 - Weight of specimen after 28 days of water curing.

W2 - Weight of specimen after 28 days of sulphuric acid curing.

The same procedure was followed for hydro chloric acid also.

4.RESULTS AND DISCUSSIONS

Table 2.Sulphuric Acid Attack Results

MIX ID	Percentage loss in weight after 28 days acid curing	Compressive Strength before acid attack (N/mm^2)	Compressive Strength after acid attack (N/mm^2)
CMI	4.679	72.08	43.70
SCB1	2.261	57.26	38.50
SCB2	1.771	33.41	37.55
SCB3	3.299	50.8	39.19

Table 3. Hydro chloric Acid Attack Results

MIX ID	Percentage of mass loss after28 days acid curing	Compressive Strength before acid attack (N/mm^2)	Compressive Strength after acid attack (N/mm^2)
CMI	0.357	72.08	49.40
SCB1	0.309	57.26	50.92
SCB2	0.037	33.41	48.07
SCB3	0.327	50.8	43.86

4.1 Loss in weight of concrete exposed to acid environment

Table no 2and table no 3 show the results of sulphuric acid attack and hydro chloric acid respectively. The percentage of weight loss for control specimen immersed in sulphuric acid after 28 days has the highest value. The percentage ofweight loss for the mix containing 20% copper slag, 7% silica fume, 1.5% steel fiber, 1% basalt fiber and 0.5% ARGFhas lesser value than other mixes. The next minimum loss value was obtained for the mix containing 10% copper slag, 1% steel fiber, 0.5% basalt fiber and 1.5% ARGF. The combined action ofsilica fume, copper slag and fibers improves acid resistance of concrete. Silica fume combines with calcium hydroxide and reduces the acid attack. The durability of concrete is improved by the contribution of fibers. Similar behavior is obtained for hydro chloric acid immersion.

4.2 Average compressive Strength of concrete exposed to acid environment

From Table 2, it is observed that the compressive strength of the mix SCB2 after acid attack is higher than the compressive strength before acid attack. All the other mixes have the compressive strength after acid attack lower than the compressive strength before acid attack.The better acid resistance is achieved for the mix containing 20% copper slag, 7% silica fume. From Table 3, it is observed that the similar results are obtained for hydro chloric acid. The compressive strength of specimen at 28 days sulphuric acid curing is 11.03% greater than the specimen without acid curing. Similarly, the compressive strength of specimen at 28 days sulphuric acid curing is 30.50% greater than the specimen without acid curing. The combination of copper slag, silica fume and fibers improve the acid resistance of concrete.

5.CONCLUSION

The following are the conclusions made from the above experimental results.

- The optimum contents of silica fume, Copper slag and fibers, as partial replacement of concrete improves the acid resistance of concrete than control mix.
- The loss of weight is significantly reduced by the contribution of silica fume, copper slag, steel fiber, basalt fiber and ARGF in both sulphuric and hydro chloric acid environment.
- Similarly the compressive strength of concrete with fibers, silica fume and copper slag after 28 days immersion in sulphuric acid and hydro chloric acid is 11.03% and 30.50% greater than concrete without acid immersion respectively.
- The combined effectiveness of Silica fume, copper slag and fibers makes better acid resistance of concrete.

6.REFERENCES.

1. Sumathi, A., Saravana Raja, K., Mohan. 2015. Study on the Strength and Durability Characteristics of High Strength Concrete with Steel Fibers.International Journal of ChemTech Research.8, 241-248.
2. Amudhavalli1, N. K., Jeena Mathew. 2012. Effect Of Silica Fume On Strength And DurabilityParameters Of Concrete. International Journal Of Engineering Sciences & Emerging Technologies. 3, 28-35.
3. VijayaSekhar Reddy, M., Ramana Reddy, I.V., Madan Mohan Reddy, K., Ravi Kumar, C.M. 2013. Durability Aspects Of Standard Concrete.International Journal of Structural and Civil Engineering Research.2, 40-46.
4. Nithin Sam., Sheeja, M.K. 2016.Durability Study on Coir Fibre ReinforcedConcrete. International Journal of Engineering Research & Technology. 5, 481-485.
5. Emmanuel, K.,Attiogbe., Sami, H.,Rizkalla. 1988. Response of Concrete to Sulfuric Acid Attack, ACI Materials Journal. 85, 481-488.
6. Karthik, V., Baskar, G. 2015. Study On Durability Properties Of Self Compacting Concrete With Copper Slag Partially Replaced For Fine Aggregate. International Journal Of Civil Engineering And Technology. 6,20-30.
7. Thangaselvi, K.2015. Strength and Durability of Concrete Using Steel Slag as a Partial Replacement of Coarse Aggregate in Concrete. International Journal of Advanced Research Trends in Engineering and Technology. 2, 1-6.
8. Premlal, V G.,Nizad, A. 2015. Strength and Durability Characteristics of SteelFibre Reinforced Concrete Containing CopperSlag as Partial Replacement of Fine Aggregate. International Journal of Engineering Research & Technology. 4, 438-441.
9. IS: 10262: 2009. Concrete Mix Proportioning – Guidelines. Bureau of Indian Standards. New Delhi. India.
10. IS: 12269: 1987. Ordinary Portland Cement, 53 Grade — Specification.Bureau of Indian Standards. New Delhi. India.
11. IS: 383: 1978. Specification for Coarse and Fine Aggregates from Natural Sources for Concrete. Bureau of Indian Standards. New Delhi. India.