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Effect of Acid Attack on High strength concrete Blended With Silica Fume

[1]D.Nirosha ,[2]C.Sashidhar,[3]K.Narasimhulu
[1]Reseach Scholar Department of Civil Engineering, JNTUA, Ananthapuramu, India
[2]Professor, Department of Civil Engineering, JNTUA, Ananthapuramu, India
[3]Professor, Department of Civil Engineering, Sree Vidyanikethan engineering college,Tirupati, India

Abstract : The creation of numerous forms of high-strength materials, such as high-strength concrete, has resulted from the development of new technologies and materials. High-strength concrete is defined as having a much higher compressive strength than regular concrete. This is accomplished by incorporating high-strength ingredients into the blend design, such as silica fume, fly ash, and super plasticizers. Aside from strength, high strength concrete has other benefits such as enhanced abrasion resistance, lower permeability, and greater resistance to chemical assault. This study is primarily concerned with the strength and durability attributes of silica fume-based high strength concrete. In this study, SF is preserved at a 15% replacement level in the production of HSC for three distinct mixtures, namely M60, M70, and M80. In this work, the compressive strength of HSC was assessed after 28 days of curing, and the durability property chemical resistance test, i.e. hydro-chloric acid attack test, was performed after 28 days of curing in acid. According to the investigations, an increase in compressive strength has been seen in the concrete mixes M60, M70, and M80 classes. It is apparent that the higher the grade of concrete, the greater the compressive strength. The compressive strength gradually increases as the curing age increases. During acid attack test, it is discovered that the higher the grade of High strength concrete, the less mass is lost and the less compressive strength is lost.

***Index Terms*: High Strength Concrete, Silica fume, Compressive strength, Acid attack**

I. INTRODUCTION

HSC has sparked considerable interest among civil and structural engineers in recent years. When compared to conventional normal strength concrete, the increasing commercial use of these relatively new construction materials can be explained in part by the life cycle cost-performance ratio they provide, as well as their engineering properties, such as durability and mechanical properties. Nowadays, HSC production technology has improved to the point that concretes with compressive strengths of up to roughly 100 MPa are commercially available, and strengths far greater than that can be generated in laboratories. The enormous economic benefits of HSC are well-documented, as seen by the number of recent construction projects in which HSC has been successfully implemented. [3,45].

1.2 High Strength Concrete

The quantitative relationship between water and cement (water binder) underpins the development of high-strength concrete. The w/c quantitative relationship for high-strength concrete should be unbrokenly low. The use of polycarboxylate-ether-based super plasticizers is required due to the low water-cement quantitative relationship and various building material ingredients. Although plasticizers are adequate for reduced strength, super plasticizers essential to water reduction. Increasing the cement content may not always result in better strength. It should have very little effect if it is higher than an exact level. The optimal number of total building material materials appears to be between 450 and 550 Kg/m3. The fundamental proportioning of associate degree HSC mix follows the same process as for traditional strength concrete, with the goal of producing mix with the fewest voids. This could be accomplished using theoretical calculations or subjective three laboratory trials.Concrete with a compressive strength of thirty-four MPa was considered high strength in 1950; by 1960, concrete with a compressive strength of two MPa was commercially used. In the early 1970s, 62 MPa concrete was invented; throughout the following 30 years, concrete of extremely high strength has been used in the construction of high-rise buildings and long-span bridges.
Mineral additive materials are more efficient and cost-effective. It is critical to grasp the distinction between cement and mineral admixtures. They are currently facing several issues due to a severe shortage of raw materials, and the industry requires speedier development of high-strength concrete so that building work can be finished within the time frame specified. The demand is met by using a high early strength cement with a low water-cement ratio and increasing the cement content while decreasing the water content..[6,7,8]

1.3 Applications of High Strength Concrete

- High strength concrete is generally used in components of structures such as columns (especially on lower floors where the loads will be greatest), as it decreases the column size and also the amount of steel required.
- High strength concrete is also occasionally used in construction of highway bridges.
- In bridges use of high strength concrete reduces the no of beams supporting the slab.
- High-strength concrete is generally used in the shaping of high-rise structures. It has been used in components of building such as columns (especially on lower floors where the loads will be greatest), shear walls, and foundations[9].

2.LITERATURE REVIEW

R. Nirmala, S. Praveen kumar & K. M. Akash Nithish (2021) conducted a detailed study on the performance of copper slag, silica fume, and fly ash replaced with aggregates in reinforced beams of various proportions and concluded that the presence of Silica fume, Fly ash in High performance concrete with an ultimate load carrying capacity of up to 21% higher than normal concrete and the reinforced beam with the maximum replacement has the ability to carry the highest load. [1].

Riyadh A. I. Albattat, Zahra Jamshidzadeh, Ali K. R. Alasadi (2020) They conducted a detailed study on the compressive strength and durability of silica fume-based concrete in an acidic environment, with the goal of determining the effect of curing, cementitious content, and w/c ratio on the strength and durability characteristics of normal and silica fume-based concrete exposed to aggressive acid (Sulfuric acid), and the results revealed that the silica fume-based concrete had higher strength than control mixes..[2]

3. EXPERIMENTAL PROGRAM

In this project we used cement, course aggregates and final aggregates. We used mineral admixtures like silica fume and the super plasticizer namely polycarboxylate ether and those are purchased from Astra Chemicals, Chennai.

3.1 Materials

The section deals about the constituent materials used for manufacturing of High strength concrete (HSC) using Silica fume (SF).

1 Cement (OPC 53 Grade)
2 Silica Fume
3 Coarse aggregates
4 Fine aggregates
5 Superplasticizer (Polycarboxylate ether)
6 Water

3.2 Methodology

In this research work, the work is done with the optimization of mix proportions for high strength concrete by using silica fume through the following process.

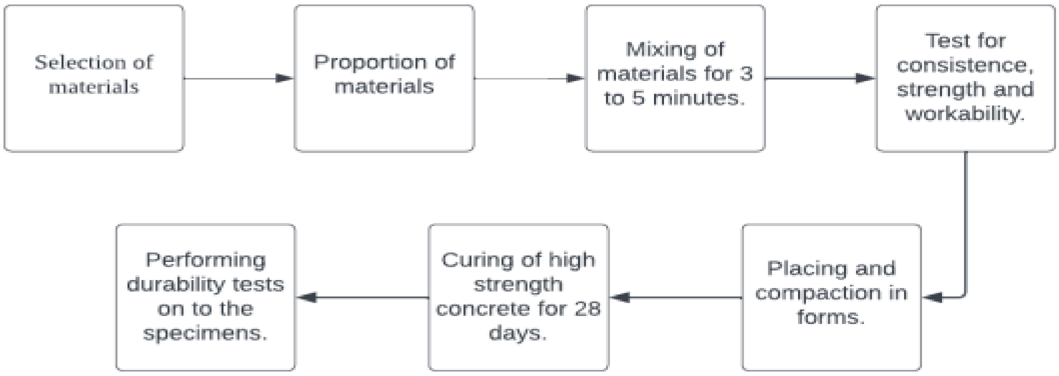

Fig.1.Methodology for mixing of High strength concrete

Materials	Proportion M60	Proportion M70	Proportion M80
Cementitious ratio (Kg/m^3)	402.5	460	517.5
Cement(Kg/ m^3)	350	400	450
Silicafume(Kg/m^3)	52.5	60	67.5
Water(L/m^3)	160	160	130
W/ C ratio	0.398	0.348	0.251
Coarse aggregates (Kg/m^3)	1133	1101	1118
Fine aggregates (Kg/m^3)	692	674	692
Super plasticizer(Kg/ m^3)	3.22	3.68	4.144

Table.1.Proportions for Mix design

3.3 Test Procedure

This study was conducted on a cube sample over a period of 28 days after curing. The compression tests are performed using a compression testing equipment with a maximum load of 2000 KN. The compressive stress for the concrete is calculated by the load introduction. Check whether the strength obtained corresponds to the required strength after completing the computation.

Fig.2.Compression Testing Machine with Cubes

3.4 Acid Attack test

The resistance of concrete specimens to external acid assault was determined using ASTM C 267-01. After the initial 28-day ambient curing phase, each concrete specimen was weighed. After that, the specimens were submerged in 3% and 5% HCl solutions. The changes in the following properties of specimens were determined during this test after 28 days of immersion in 3% Hydro Chloric acid solution.

Properties determined through the Acid Attack Test are,

- Weight of specimen
- Compressive strength of specimen

Fig .3.Acid attack test setup.

4.RESULTS AND DISCUSSION

The durability properties of concrete such as acid attack test are performed and the results are tabulated. The mass loss and compressive strength loss before and after the acid attack test are measured and tabulated after 28 days of curing.

4.1 Acid Attack Test

Acid attack tests are typically performed on 15 cm x 15 cm x 15 cm cube samples. In this experiment, we used 15 cm x 15 cm x 15 cm cubic samples of concrete from the M60, M70, and M80 grades. After curing the sample in water for 28 days, the sample is removed from the water curing tank and dried, and then a compressive strength test is performed on the cubic samples, and the weights for the specimens are calculated in conjunction with the compressive strength test, and the samples are immersed in the acid. Here we used hydrochloric acid in two different concentrations, viz. H. 3% and 5%. After the cube samples have been in acid for 28 days, the samples are removed from the acid, dried and weights are taken to calculate mass loss and the cubes are tested for compressive strength to calculate compressive strength loss.

Fig 4: Compressive strength test after acid attack.

4.2.Performance of SF blended HSC before Acid attack:

Table 2: Compressive strength test results and initial weight of specimens before acid

Grade of concrete	Age	Properties	Concentrations	
			3%	5%
M60	28 days	Initial Weight(in Kgs)	2.546	2.587
		Compressive strength (inMpa)	71.26	71.26
M70	28 days	Initial Weight(inKgs)	2.440	2.403
		Compressive strength(in Mpa)	79.32	79.32
M80	28 days	Initial Weight(in Kgs)	2.568	2.616
		Compressive strength(in Mpa)	88.89	88.89

4.3 Performance of SF blended HSC after Acid Attack

Performance of M60 grade HSC

***Table 3:*Test results ofM60gradeHSC after acid attack.**

Property		Concentrations	
		3%	5%
Weight(kgs)	Initial	2.546	2.587
	After Acid attack	2.515	2.527
Loss of Weight(in %)		1.21	2.32
Compressive Strength(in Mpa)	Initial	71.26	71.26
	After Acid attack	67.63	64
Loss of Compressive Strength (in %)		5.1	10.2

Performance of M70 grade HSC

***Table4:*Test results of M70gradeHSC after acid attack.**

Property		Concentrations	
		3%	5%
Weight(kgs)	Initial	2.553	2.598
	After Acid attack	2.505	2.512
Loss of Weight (in %)		2.87	3.23
Compressive Strength(in Mpa)	Initial	79.32	79.32
	After Acid attack	75.44	72
Loss of Compressive Strength (in%)		4.9	9.2

Performance of M80 grade HSC:

Table 5. **Test results of M80 grade HSC after acid attack.**

Property		**Concentrations**	
		3%	**5%**
Weight(kgs)	Initial	2.568	2.616
	After Acid attack	2.493	2.528
Loss of Weight (in %)		2.9	3.3
Compressive Strength(in Mpa)	Initial	88.89	88.89
	After Acid attack	84.98	81.92
Loss of Compressive Strength (in%)		4.4	7.84

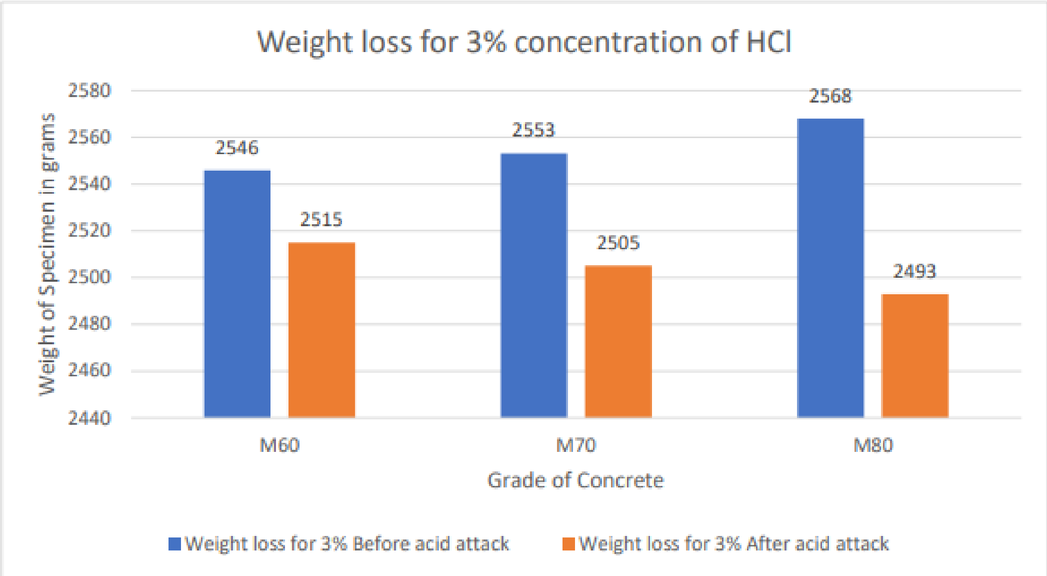

Fig 5: Loss of mass versus grade of concrete for before and after acid attack for 3% concentration of HCl.

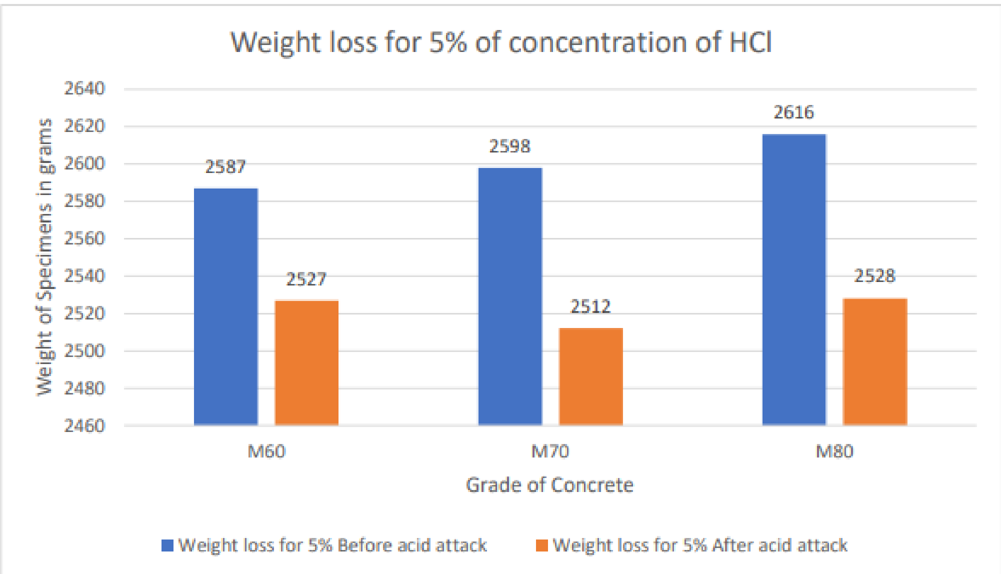

Fig 6: Loss of mass versus grade of concrete for before and after acid attack for 5% concentration of HCl.

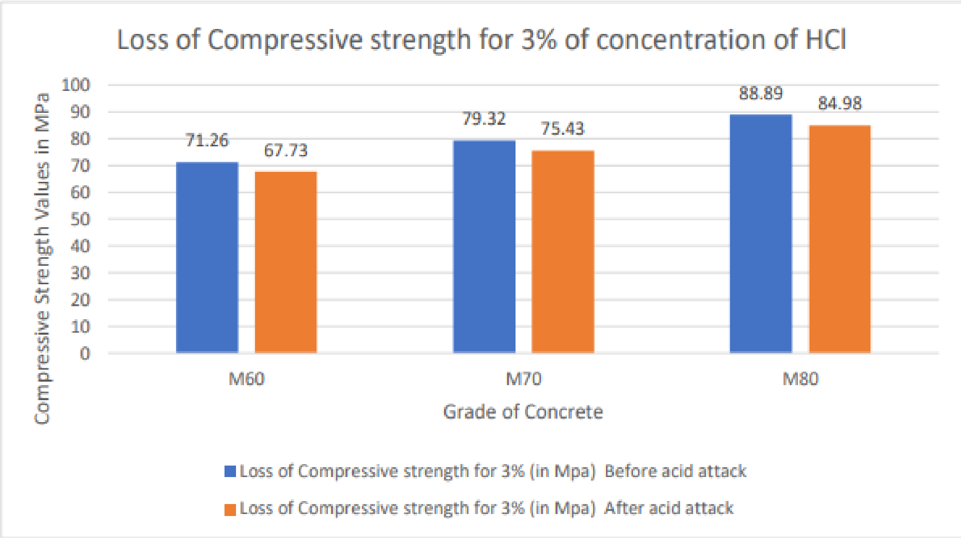

Fig 7: Loss of compressive strength versus grade of concrete for before and after acid attack for 3% concentration of HCl

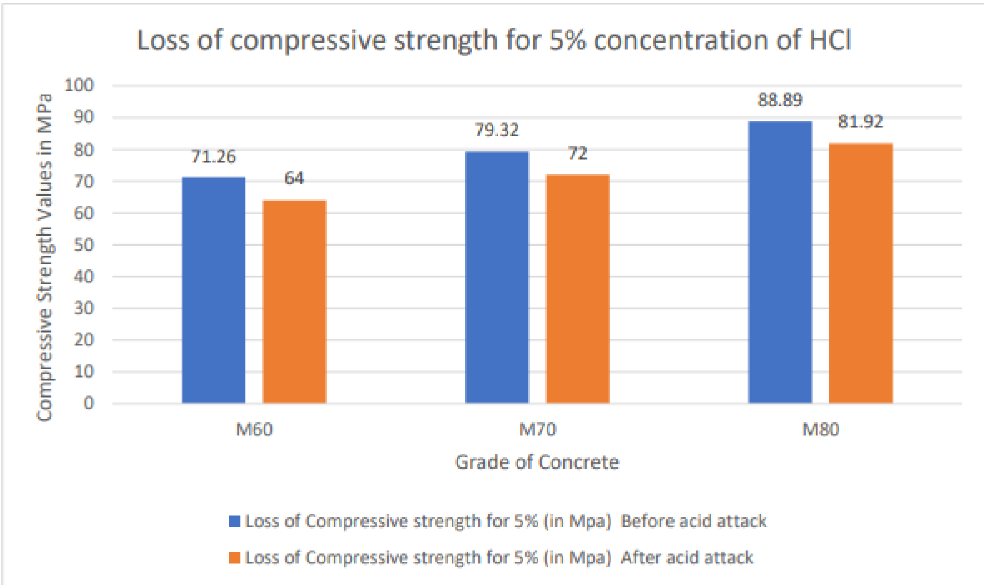

Fig 8: Loss of compressive strength versus grade of concrete for before and after acid attack for 5% concentration of HCl.

From the tables 3, 4 and 5, it is clearly observed that the loss of mass and loss compressive strength values is less in M80 grade concrete when compared to those of the other two mixes. The percentage of reduction in weight and compressive strength values are decreased respectively in M60, M70 and M80 grades which are replaced with silica fume. It is believed that silica fume replacement is increasing the compressive strength and when it is exposed to hydro-chloric acid attack, the compressive strength is slightly decreased due to absorption of acid into pores of concrete.

5.CONCLUSIONS

The following are the conclusions made from the above experimental results

- The maximum resistance to acid penetration was observed for all concrete grades at 15% silica fume replacement.
- The optimal silica fume content as a partial replacement of concrete enhances acid resistance over the control mix.
- In a hydro chloric acid environment, the contribution of silica fume greatly reduces weight loss.
- During acid attack test, it is seen that the higher is the grade of High strength concrete, the lesser is the loss of mass and the lesser is the loss of compressive strength.
- Furthermore, SiO_2 in silica fume interacts with $Ca(OH)_2$ to generate an impenetrable C-S-H gel. This gel considerably reduces the detrimental effects of acid assault and so increases the longevity of the concrete.

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