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Industrial waste-water in silica fumed concrete– A brief study

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ABSTRACT

With the rapid growth in the construction industry, there is an increased demand for concrete for various uses. For concrete mixing and curing potable water is one of the most important ingredients. With increased population and agriculture sector and decreased average annual rainfall, the supply of fresh potable water to the construction industry is on the decline. In many droughts affected areas, water is scarce for even human needs. This may hamper the supply of fresh water to the construction industry. There is dire need to find the alternatives to fresh potable water to sustain the noteworthy growing rate of the construction industry. This paper investigates the effects of industrial wastewater in silica fumed concrete on not only strengths but also on other aspects like abrasion resistance, acid, and alkaline resistance. As silica fume is freely available bi-product in ore production, we normally ground-fill it. Considering the hazards of mixing it with groundwater we decided to use it in concrete as a partial replacement of cement. Also while taking an environmental approach we have to take into consideration the natural environmental conditions for structural strength of concrete. So abrasion resistance and acidic, alkaline resistance was also determined. Overall results show that though the strength of this newly formulated concrete increases, it fails on certain parameters like acid resistance but it certainly has more positive impacts on the environment.

Keywords— *Industrial wastewater, Abrasion resistance, Acid Resistance, Alkaline resistance*

1. INTRODUCTION

Ever since the outbreak of population and industrial revolutions, there is a scarcity of basic concrete materials like lime and potable water. If we use the excessive potable water in the construction industry there will be a deficiency for other sectors. But because of this we can't stop the ever-growing construction industry. The best way to increase the momentum of this field is to search the alternative materials which can cost lesser than usual ones and if possible should be environmentally friendly. Here we are conducting all the research using silica fume and industrial wastewater. Silica fume is the bi-product produced in ore production. Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO2). The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Because of its fine particles, large surface area, and the high SiO2 content, silica fume is a very reactive pozzolan when used in concrete. The quality of silica fume is specified by ASTM C 1240 and AASHTO M 307. The addition of silica fume to concrete improves the latter's durability by reducing permeability and refining pore structure, leading to a reduction in the diffusion of harmful ions and the calcium hydroxide content, resulting in greater resistance to sulfate attack. Because of its extreme fineness and very high amorphous silicon dioxide content, silica fume is a very reactive pozzolanic material. As the Portland cement in concrete begins to react chemically, it releases calcium hydroxide. Silica fume reacts with this calcium hydroxide to form additional binder material known as "calcium silicate hydrate", which is very similar to the calcium silicate hydrate formed from Portland cement. Now coming to wastewater Wastewater management is completely neglected and it should be seen as a resource rather than a burden to be disposed of. Water should be carefully managed at every stage, from fresh abstraction, pre-treatment, distribution, use, collection and post-treatment.

By 2030, global demand for water is expected to grow by 50%. Most of this demand will be in cities and will require new approaches to wastewater collection and management. So, reused wastewater may help in addressing other challenges, including food production and industrial development. As both silica fume and industrial wastewater both are naturally useless in any fresh constructive use or production, they can be used in concrete without disposing of in an environment in a harmful way.

2. AIMS AND OBJECTIVES

The main aim of this research is to investigate the effects of silica fume and chemically untreated industrial wastewater on various parameters of concrete. Other objectives are to determine the abrasion resistance and acid-alkaline resistance.

3. MATERIALS USED

3.1 Cement

Cement used was of the Ultratech brand and having a grade of OPC 53. Cement had a fineness of 230 cu.m/kg, standard consistency of 28%, the specific gravity of 3.15 and final setting time of 580 minutes which confirms to IS: 12269-1987.

3.2 Fine Aggregates

Naturally produced sand in local area confirming to IS 383-1970 was used. Sand had the grading zone II, the specific gravity of 2.61, Fineness modulus of 3.10 and bulking value of 7.8%

3.3 Coarse Aggregates

Coarse aggregates were of zone II and having impact value of 17%, abrasion value of 23%, Specific gravity of 2.74 and max elongation index of 20 mm

3.4 Silica Fume

Silica fume used was of class 920D having a particle size of 150 nanometers, consistency of 17mm, the specific gravity of 2.22, and heat reaction of 2mm.

3.5 Water

Industrial wastewater in Nagpur was used in research. Samples were collected at random sites for an entire week to get the most accurate chemical composition. Visible matters like organic particles, papers, plastics, rubber, and wood were removed by screening and then it was tested for its chemical composition. Water was collected for samples only after that it was prepared in laboratory artificially. Water used in research had the following properties.

Table 1: Chemical composition of industrial waste water

pH value	3.43	Nitric Acid	54 ppm
Lead	30 ppm	Phosphate	139 ppm
Hydrochloric Acid	45 ppm	Sulpher	204 ppm
Boric Acid	34.6 ppm	Manganese	73.5 ppm
Hydrofluoric Acid	21.9 ppm	Starch	20 ppm

4. EXPERIMENTAL PROCEDURE

All the cubes were casted using silica fume as partial replacement of cement in the proportion of 20% and water cement ratio was varied from 0.45 to 0.49, in the moulds of size 15cm x 15cm x 15cm. Concrete was filled in three layers and trampled in mould by trampling rod. The top of all the cubes was levelled by trowels. Water used in mixing had fresh potable water and industrial waste water in the same proportion. Concrete cubes were removed from moulds after 24 hours. After removing the cubes were placed in a curing tank consisting of fresh water and industrial water in a ration of 1 for 7, 14 and 28 days. After curing cubes were taken out and allowed to dry for 24 hours and then they were taken for testing.

5. RESULTS

5.1 Strength Parameters

Concrete cubes were tested on a Universal testing machine of 2000KN capacity and tensile testing machine. Results were determined and compared with normal concrete. Following table shows the strengths of concrete for 7 days, 14 days and 28 days respectively.

Table 2: Comparative strengths of concrete

	Compressive Strength [MPa]			**Tensile Strength [MPa]**		
	7 days	**14 days**	**28 days**	**7 days**	**14 days**	**28 days**
Normal Concrete	18.05	20.65	24.70	3.15	3.85	4.35
Silica Fumed Concrete with Industrial waste water	19.55	22.20	28.35	3.35	4.05	4.95

Above values are average of 3 values taken. As far as water cement ratio is concern from 0.45 to 0.47 strengths goes on increasing and then it gradually decreases. Above values are taken at water cement ratio of 0.47 which gives the best results. The strength of silica fumed concrete is greater because the particle size of silica fume is smaller than cement which allows it to fill up the pores in voids thus giving the concrete more compactness.

5.2 Abrasion Resistance

Testing the abrasion resistance was necessery because we will use industrial waste water in areas where water is scarce. Water scarce regions like deserts, barren lands generally have high wind flowing rates. Theses winds gradually cause wear on finishing surfaces of structures. For structures like roads, fly-overs, high-rise buildings concrete is the main finishing material which is prone to abrasion. Abrasion resistance test was performed on 28 days cured 150mm x 150mm x 150 mm concrete cubes. Fully cured cubes were buffed by using grinder machine and sand paper blade at four different locations and average depth was considered as final results which are shown in the table.

Table 3: Comparative abrasion resistance of concrete

Normal Concrete	Silica fumed concrete with industrial waste water		Decrease
5.1 mm	10 % silica fume	5 mm	1.96%
	15 % silica fume	4.8 mm	5.88%
	20 % silica fume	3.1 mm	39.21%
	25 % silica fume	2.3 mm	54.90%

From the above table, it can be clearly seen that as we increase the % of silica fume abrasion resistance goes on increasing. This is because of the void filling property of silica fume.

5.3 Acid and Alkaline resistance

For this test, concrete cubes which were cured for 28 days were immersed in 5 % sulphuric acid solution for acid resistance test and 5 % sodium sulphate solution for an alkaline resistance test. This test was necessary because in major seaside metro cities like Mumbai, Chennai, Kolkata there is an abundance of industrial waste water and a shortage of fresh potable water. Also, these cities have many sea-links and other structures that are permanently in sea water which is mildly saline and acidic in many regions due to pollution. Cubes were tested for compressive strength and results are drawn in tabular form.

Table 4: Comparative acid and alkaline resistance of concrete

Acid resistance				Alkaline resistance			
Normal Concrete	Silica fumed concrete with industrial waste water [w/c ratio - 0.47]			Normal Concrete	Silica fumed concrete with industrial waste water [w/c ratio - 0.47]		
	% of silica fume	Strength [MPa]	% De-crease		% of silica fume	Strength [MPa]	% Increase
46.00	10%	43.40	5.44	42.65	10%	44.85	5.15
	15%	43.75	4.68		15%	45.45	6.56
	20%	44.00	4.13		20%	46.15	8.20
	25%	44.45	3.15		25%	46.90	9.96

From the above table, it can be clearly seen that the acid resistance of silica fumed concrete with industrial waste water is lower than that of the normal concrete and alkaline resistance is greater than normal concrete. This is because the industrial waste water we used in the research was already mild acidic so when it reacted with acid it made concrete weak. The alkaline resistance of concrete was increased because of the same phenomenon acidic water reacted with an alkaline solution and neutralised it to some extent.

6. CONCLUSIONS

These results clearly indicate that silica fumed concrete with industrial waste water has higher tensile and compressive strength along with abrasion resistance. The alkaline resistance of the silica fumed concrete is higher than normal concrete but acid resistance is low. This indicates that silica fumed concrete cannot be used in marine structures having an acidic nature. Also, it cannot be used in underground structures where acidic ground water contact is likely to happen. This concrete can be used in structures where ground water is alkaline. As the abrasion resistance of this concrete is high this concrete can be used in road surfaces to prevent the faster wear. High rise buildings where we normally consider the wind pressure can be made using this concrete. This concrete can be used in many public projects where high strength is required in an economical way. Overall this concrete can also be used in small scale residential houses and other minor construction work to reduce the burden on the environment.

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