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Scaling resistance of silica fumed concrete using industrial waste water

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ABSTRACT

In the modern era of fast construction practices due to the inappropriate use of various superplasticizers, admixtures and improper curing methods scaling are one of the rapidly up surging complications in exposed concrete. This problem can be seen in many structures which had insufficient curing and porous finishing layer. Excessive use of deicing salts, severe exposure of concrete and improper mix design add acute complexities to scaling. The main reason for scaling is porous finishing surface. This problem can be solved by using silica fume as it fills the voids between cement particles. Another reason is cyclic expansion and contraction of entrapped water which not only widens the pores but also leaves behind harmful chemicals in residual form. These chemicals cannot reside if concrete already possesses the acidic properties. In this research, we used silica fume as partial replacement of cement and mildly acidic industrial waste water in concrete. Results show that when silica fume is added by 20% of cement and industrial waste water is added in the same proportion as potable water chloride concentration can be reduced by 35% which can be very useful in preventing the scaling.

Keywords— *Scaling resistance, Silica fume, Industrial waste water*

1. INTRODUCTION

Scaling is peeling of the exposed concrete surface due to frequent freezing and thawing. Scaling generally starts in small patches which gradually joins each other's to expose the larger concrete surface. Light scaling which is lesser than 2 mm depth generally peels off the outer surface of concrete members, moderate scaling of 2.5 mm to 10 mm depth expose the coarse aggregates and severe scaling of depth greater than 10 mm can result into the exposure of reinforcement in concrete. When scaling reaches to 15 mm depth it can cause the severe danger to the stability of the structure. In India scaling mostly occurs in slabs as they are exposed to rain and natural heat. Due to poor air circulation in many Indian constructions entrapped water doesn't find its way outside and remains enclosed within the concrete. When exposed to sun heat water evaporates and leaves behind the residue of chemicals dissolved in it which further worsen the condition. In Indian sub-continent rain water consist of dissolved sodium chloride and calcium chloride. As water evaporates these salts resides on the concrete structure in the form of white residue. If scaling is not properly treated within time, it goes on increasing and these residual salts cause fatal danger of corrosion of reinforcements inside the concrete element. In India, scaling can be observed also in structures with the unfinished exterior. The unfinished exterior surface of any structure consists of either plastered surface without painting treatment or exposed bricks with mortar binding. Both cases are highly nourishing for scaling as they consist of large numbers of pores to accumulate the water in between them. Basically scaling can be seen in entire Indian constructions due to various reasons. Till today most of the research is done only on strength parameters of concrete but scaling is widely neglected by considering it a fault of poor workmanship. There is an extreme need for vast research on scaling in India.

2. AIM OF RESEARCH

The basic aim of this research was to study the scaling resistance of silica fumed concrete with industrial waste water. As this research mainly focuses on the Indian region, locally available materials were used. Also in major parts of India, super plasticizers and chemicals admixtures are not used, this research aims to study scaling effects on plain concrete.

3. MATERIALS USED

All the materials used in this research were locally available and confirming to respective IS codes. As most of the structures are being erected without using super-plasticizers, chemical admixtures and air entraining agents their use is strictly avoided.

3.1 Cement
Cement confirming to IS: 12269-1987 having a fineness of 230 Kg/cu. m., Consistency of 28% and the final setting time of 580 minutes was used. A grade of concrete was OPC 53 grade.

3.2 Aggregates
The fine aggregate as per IS 383-1970 and coarse aggregates as per IS:10262-2009 was used. Specific gravity and bulking value of sand were 2.61 and 7.8% respectively. Specific gravity and elongation index of coarse aggregate was 2.74 and 20 mm respectively.

3.3 Silica Fume
Class 920D silica fume having a particle size of 100 nanometer and specific gravity of 2.21 was used.

3.4 Water
Primarily treated industrial waste water was used. Water samples were collected from the local area of Nagpur district. Water had a mildly acidic pH value of 3.43. Water consists of 30 ppm lead, 45 ppm hydrochloric acid, 34.6 boric acids, 21.9 hydrofluoric acids, 54 ppm nitric acid, 139 ppm phosphate, 204 ppm sulphur and 735 ppm manganese.

4. EXPERIMENTAL PROCEDURE
The moulds of size 150mm X 150mm X 150mm were casted. An M20 grade of concrete was trampled in three layers in moulds. After 24 hours cubes were removed from moulds and specimens were cured in curing tank for 28 days after which they were stored at 73 degrees Fahrenheit and 50% relative humidity for other 14 days. After these 42 days, the tank was built around the specimens to hold the salt solution in place. The deicing solution consists of 4% solution of calcium chloride. The measured sample of the powder was then dissolved into chloride extracting liquid. The chloride concentration was then decided using activated electrode and electrometer.

5. RESULTS
The chloride concentration in parts per million was decided by using electrometer and arranged into tabular form as below to get the better idea of results.

Table 1: Scaling resistance of concrete specimens

Chloride Concentration [in ppm]					
Conventional Concrete	**% of silica fume**	**Silica fumed Concrete**	**Decrease**	**Silica fumed concrete with industrial waste water**	**Decrease**
327	10	298	8.868%	322	1.53%
	15	234	28.44%	299	8.56%
	20	193	40.98%	245	20.07%
	25	173	47.10%	211	35.47%

To get visual comparisons between all three types of the concrete graph is shown below.

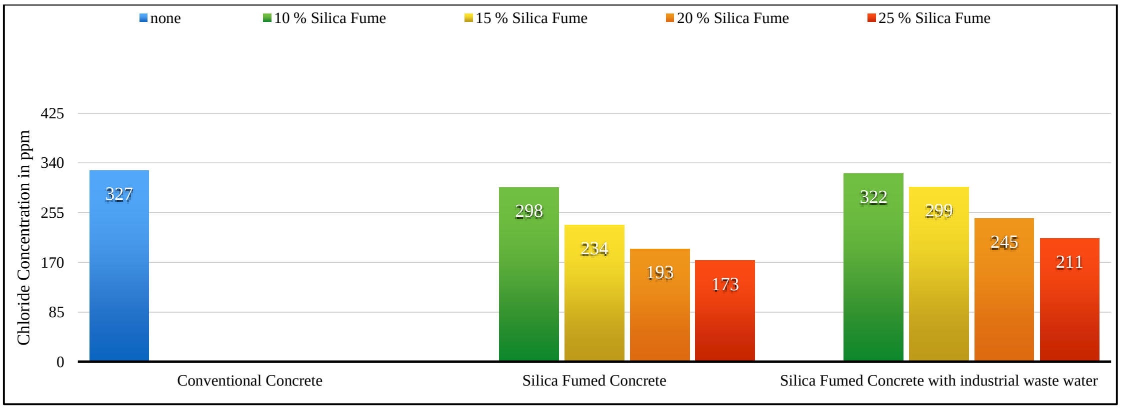

Fig. 1: Scaling resistance of concrete specimens

From the above graph and table, it is clear that the chloride concentration of conventional concrete is highest followed by silica fumed concrete and silica fumed concrete with industrial waste water. This shows that conventional concrete which is prone to scaling attacks has a good alternative of silica fumed concrete with industrial waste water.

6. CONCLUSION
As silica fume fills the voids in between cement particles and mildly acidic water reacts with deposited salts, silica fumed concrete with industrial waste water is less prone to scaling. Structures which are exposed to high temperature and rainfall are prone to scaling attack. Such kind of structures can be erected using silica fumed concrete with industrial waste water to prevent the scaling. As we can see, though this concrete has more scaling resistance than conventional concrete it is not free from salt concentration. Therefore this type of concrete can only prolong the life of structure by preventing the structure from scaling. So it should not be considered as a full proof measure to prevent the scaling it is an only precautionary measure to reduce scaling. Along with this concrete, other measures are necessary to prevent the structure from scaling entirely.

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