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Research Paper

EFFECT OF NACL ON STEEL FIBRE REINFORCED BLENDED CEMENT CONCRETE

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This paper presents the effect of sodium chloride (NaCl) on Steel Fibre Reinforced Blended Cement Concrete (SFRBCC). The SFRBCC was prepared with NaCl concentrations of 0.5, 2, 4, 6, 8, 10, 12, 14, 16 and 20 g/l by adding in deionised water. In addition to this, control specimen was prepared with deionised water (without NaCl) for the purpose of comparison. The setting times and compressive strength were evaluated for 28 and 90 days apart from studying rapid chloride ion permeability. The results show that, as NaCl concentration increases, there is acceleration in initial and final setting of Blended Cement (BC). The compressive strength of SFRBCC increases as the concentration of NaCl goes up at both 28 and 90 days. Compressive strengths of SFRBCC show a significant increase at 12 g/l when compared with the control specimens. It was also observed that chloride ion permeability has decreased with an increase in the concentration of the NaCl.

Keywords: NaCl, Setting time, SFRBCC, Compressive strength, Chloride ion permeability

INTRODUCTION

Water is an important ingredient of concrete, in both fresh and hardened state of concrete. Cement is a mixture of complex compounds, the reaction of cement with water leads to setting and hardening. All the compounds present in the cement are anhydrous, but when brought in contact with water, they get hydrolyzed, forming hydrated compounds. Since water helps to form the strength giving cement gel, the quality of water is to be maintained equally during the process of concrete making. Natural water is available abundantly in universe as a good solvent, but there are more chances of containing large number of impurities ranging from less to very high concentration of them. Many studies show more importance on properties of cement and aggregate, but the quality of water is often neglected.

A normal indicator to the suitability of water for mixing concrete is that, if it is fit for drinking,

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it is fit for making concrete. This doesn't appear to be a true statement for all conditions. Sometimes, water contains a small amount of sugar would be suitable for drinking, but not for making concrete and conversely water suitable for making concrete may not be necessarily be fit for drinking, especially if the water contains pathogenic microbial contaminants. Research work has been carried out on effect of polluted/chemical water on hardened concrete strength and durability. The damage impact of various deicing chemicals and exposure conditions on concrete materials were studied by Kejin *et al.,* and results indicated that the various deicing chemicals penetrated at different rates in to a given paste and concrete resulting in different degree of damages (Kejin *et al.,* 2006). Gorniniski *et al.* (2007) presented an assessment of the chemical resistance of eight different compositions of polymeric mortars. Adnan *et.al.* (2009) reported the effects of environmental factors on the addition and durability characters of epoxy bonded concrete prisms. Fikret *et al.* (1997) investigated the resistance of mortars to magnesium sulphate attack and results reported that there is a significant change in compressive strength properties. Venkateswara Reddy *et al.* (2006) studied the influence of strong alkaline substances (Na_2CO_3 and $NaHCO_3$) in mixing water on strength and setting properties of concrete. In many places ground water and surface water contains the impurities, more than that of limits specified by the IS 456:2000. Ali Reza Bagheri *et al.* (2012) in their study on the effect of incorporation of silica fume in enhancing strength development rate and durability characteristics of binary concretes. Erhan Guneyisi *et al.* (2012) investigated the effectiveness of metakaolin (MK) and silica fume (SF) on the mechanical properties, shrinkage, and permeability related to durability of high performance concretes .

Research Significance

As there is a scarcity of potable water in many places, this impure water is being used for mixing as well as curing of concrete in the civil engineering constructions. Hence an attempt is made to study the effect of water containing NaCl at various concentrations in cements and their concretes.

Outline of This Paper

This paper includes the experimental program, selection of materials and test methods. Discussion of results and conclusions are presented.

EXPERIMENTAL PROGRAM

The influence of NaCl at different concentrations was studied when the NaCl is spiked with deionized water. Test samples were compared with the control samples. This comparison may not be possible in case of control samples made with locally available potable water since it varies in chemical composition from place to place. With the above reason, NaCl was mixed with deionized water as per the dosage mentioned above. This water was used for preparation of test samples for determining the setting times (initial and final) of BC and compressive strength of SFRBCC.

Materials

Portland Pozzolana cement containing 30% of fly ash was used in this investigation. The major chemical composition of cement used in the present study is presented in Table 1. Locally available river sand was used as fine aggregate. Machine crushed granite stones of maximum size 20 mm confirming to IS 383:1970 was used as coarse aggregate. Deionized water was spiked with NaCl at different concentrations of 0.5, 2, 4, 6, 8, 10, 12, 14, 16 and 20 g/l 1 % Crimped Steel fibres have been used in the present investigation in production of Fibre Reinforced Concrete (being referred as Steel Fibre Reinforced Blended Cement Concrete (SFRBCC) in the present study).

Table 1: Chemical Composition of Blended Cement

S. No.	Parameter	Result
1	Insoluble Material (% by mass)	18.90
2	Magnesia (% by mass)	0.99
3	Sulphuric Anhydride (% by mass)	2.67
4	Loss on Ignition (% by mass)	2.04
5	Total Chlorides (% by mass)	0.001

Test Methods

The IS 10262:2009 mix design was adopted for concrete mix. For determining the initial and final setting times of cement, Vicat apparatus was used as per IS 4031:1988. To assess the compressive strength of concrete, 30 concrete cubes of size 150 mm were cast and tested as per IS 516:1959. Rapid Chloride Permeability Test (RCPT) was used as per ASTM C 1202-07 to determine the chloride ion permeability of concrete, for which 15 specimens of size 100 mm x 50 mm were cast.

RESULTS AND DISCUSSION

NaCl Effect on Setting Time of Blended Cement

The effect of NaCl on initial and final setting times is shown in Table 2 and Figure 1, from which it is observed that both initial and final setting times have accelerated with an increase in NaCl concentration in deionized water. IS 456:2000 (Clause 5.4.1.3) stipulates that, when the difference in setting time(s) is less than 30 min, the change is considered to be negligible or insignificant and if it is more than 30 min, the change is considered to be significant. From the experimentation work it is observed that, when the NaCl concentration exceeded 12 g/l, the acceleration of initial and final setting times of BC was significant (i.e., more than 30 min). When NaCl content is 20 g/l (maximum), initial setting time was 95 min which is 38 min less than that of control mix. Similarly, a significant difference of 39 min was observed in the case of final setting time.

NaCl Effect on Compressive Strength of Steel Fibre Reinforced Blended Cement Concrete

The effect of NaCl concentration on the compressive strength of SFRBCC is presented in Table 3 and Figure 2. The degree of variation in compressive strength is also presented in Figure 3. The results indicated that there is a gain in compressive strength of the SFRBCC irrespective of NaCl concentration. In case of SFRBCC, marked increase in 28 days and 90 days compressive strength is observed with increase in concentration of NaCl. Compressive strength for SFRBCC, with NaCl concentration from 0.5 to 20 g/l, has increased from 29.04 to 32.91 and 33.1 to 37.15 for 28 and 90 day aged

Table 2: Setting Times of Blended Cement (BC) Corresponding to NaCl Concentrations

S.No.	Water Sample	Setting Time in Minutes and Percentage Change			
		Initial	% Change	Final	% Change
1	Deionised water(Control)	133	00	361	00
2	0.5 g/l	126	-5.62	354	-1.9
3	2 g/l	116	-12.78	347	-3.98
4	4 g/l	112	-16.1	340	-5.76
5	6 g/l	109	-18.23	336	-6.86
6	8 g/l	107	-19.56	333	-7.84
7	10 g/l	106	-20.28	332	-7.98
8	12 g/l	103	-22.54	330	-8.68
9	14 g/l*	102	-22.96	329	-8.94
10	16 g/l*	100	-24.88	327	-9.44
11	20 g/l*	95	-28.26	322	-10.93

Note: *Significant

Figure 1: Setting Times of Blended Cement vs NaCl Concentrations

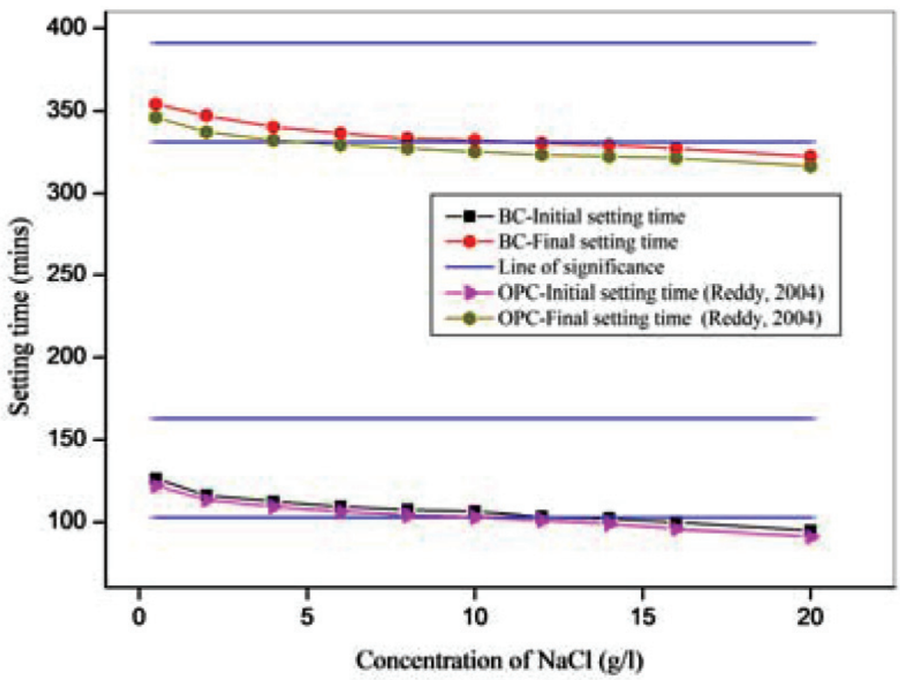


Table 3: Compressive Strength of SFRBCC corresponding to NaCl Concentrations

S. No.	Water Sample	Steel Fibre Reinforced Blended Cement Concrete			
		Compressive Strength		% Variation	
		28 days	90 days	28 days	90 days
1	Deionised Water(Control)	29.04	33.1	—	—
2	0.5 g/l	29.05	33.10	0.03	0.01
3	2 g/l	29.42	33.40	1.3	0.92
4	4 g/l	29.68	33.76	2.2	2
5	6 g/l	29.95	34.07	3.14	2.94
6	8 g/l	30.55	34.70	5.2	4.84
7	10 g/l	31.40	35.74	8.13	7.97
8	12 g/l*	32.09	36.42	10.51	10.03
9	14 g/l	32.29	36.56	11.2	10.44
10	16 g/l	32.60	36.95	12.27	11.64
11	20 g/l	32.91	37.15	13.34	12.24

Note: *Significant

Figure 2: Compressive Strength of SFRBCC vs NaCl Concentrations

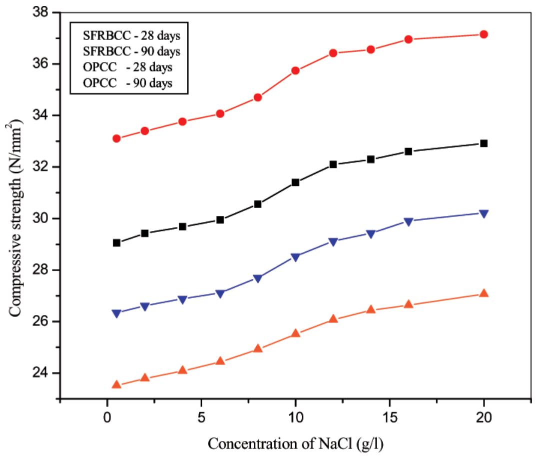
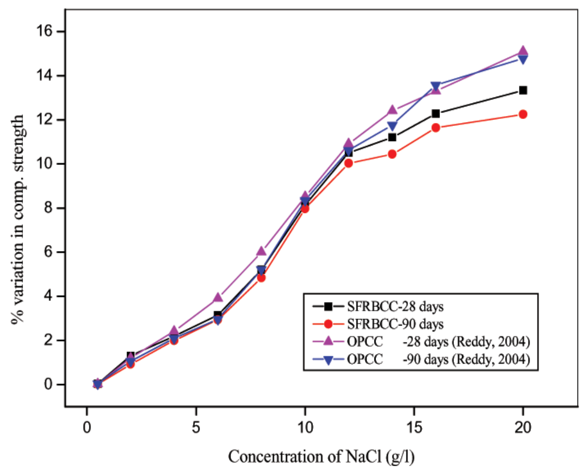


Figure 3: % Variation in Compressive Strength of SFRBCC vs NaCl Concentrations



specimen respectively. The result is significant when the concentration of NaCl is equal to 12 g/l. When NaCl concentration is maximum, i.e., 20 g/l the increase in compressive strength is 13.34% for 28 days age and 12.24% for 90 days age when compared with that of cubes prepared with the deionized water (control test sample).

NaCl Effect on Chloride ion

Permeability of Steel Fibre Reinforced Blended Cement Concrete

The rapid chloride permeability levels in terms of coulombs passed through SFRBCC observed are tabulated and listed in the Table 4 and Figure 4. A glance at the said results establishes that the chloride ion permeability of the concrete studied has come down with the increase in the concentration of NaCl up to 20 g/l which is the maximum experimented concentration. Quantum of variation in coulombs passed is 17.76% at 28 and 18.24 % at 90 days for SFRBCC when compared with the control sample, i.e., it has decreased from 1959 to 1611 coulombs at 28 and 1026 to 839 coulombs at 90 days. The degree of variation in compressive strength is also presented in Figure 5.

Table 4: Chloride Ion Permeability in Terms of Coulombs Passed in SFRBCC Corresponding to Nacl Concentrations

S. No.	Water Sample	Coulombs Passed			
		28 days	% Change	90 days	% Change
1	Deionised Water(Control)	29.04	33.1	—	—
2	0.5 g/l	29.05	33.10	0.03	0.01
3	2 g/l	29.42	33.40	1.3	0.92
4	4 g/l	29.68	33.76	2.2	2
5	6 g/l	29.95	34.07	3.14	2.94
6	8 g/l	30.55	34.70	5.2	4.84
7	10 g/l	31.40	35.74	8.13	7.97
8	12 g/l*	32.09	36.42	10.51	10.03
9	14 g/l	32.29	36.56	11.2	10.44
10	16 g/l	32.60	36.95	12.27	11.64
11	20 g/l	32.91	37.15	13.34	12.24

Figure 4: Charge Passed vs NaCl Concentrations

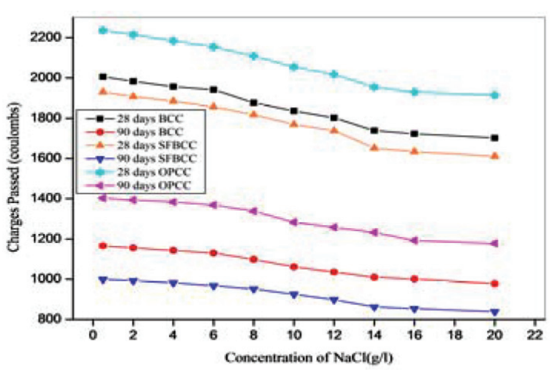
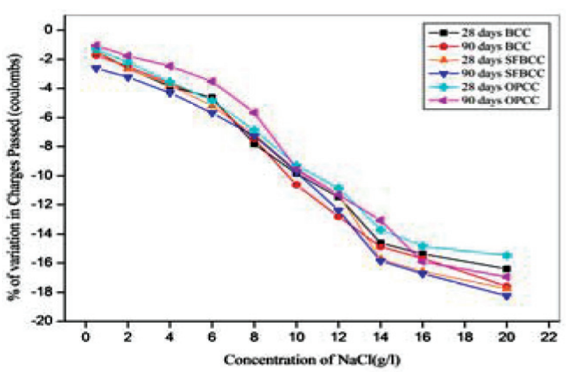


Figure 5: % of Variation in Charge Passed vs NaCl Concentrations



CONCLUSION

Based on the results obtained in the present investigation the following conclusions can be drawn:

It is observed that as NaCl concentration increases, there is acceleration in initial and final setting of Blended Cement (BC). The compressive strength of BCC increases as the concentration of NaCl increases at both 28 and 90 days. Compressive strengths of SFRBCC show a significant increase at 12 g/l when compared with the control specimens. It is also observed that chloride ion permeability has decreased with an increase in the concentration of the NaCl for SFRBCC.

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