Effect of anti- corrosive chemicals on the performance of SCC mixed with sea water

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Abstract—Self Compacting Concrete can be used for the concreting without vibration. Corrosion of reinforcing steel in concrete is a growing international problem. In order to improve the service life of concrete structures it is necessary to study the effects of bond strength and corrosion of rebars in concrete which is focused in this study. Both potable water and saline water were used in the study. Pull out tests were conducted as per IS2770: 1967(Part-I) on specimen subjected to accelerated corrosion. Specimens were of concrete grade M30, M35, M40 and steel grade Fe500D with 16mm diameter. Two different types of corrosion inhibitors were also used to study the change in corrosion resistance in the specimen. The Bond stress variation with the change in grade of concrete, type of corrosion inhibitor and pH of water used in concrete are also studied.

Keywords—self compacting concrete; accelerated corrosion; corrosion inhibitor;

I. INTRODUCTION

Making concrete structures without vibration, have been done in the past. Mass concrete, and shaft concrete can be successfully placed without vibration. But the above examples of concrete are generally of lower strength and difficult to obtain consistent quality. Modern application of self-compacting concrete (SCC) is focussed on high performance, better and more reliable and uniform quality.[6]

Reinforced concrete structures suffer durability problems during their service due to the corrosion of steel reinforcements. Corrosion products are highly porous, weak and often around reinforcing steel, leads to several coupled effects: longitudinal cracking of concrete cover due to expansive corrosion products; steel cross section reduction and the degradation of steel–concrete bond.As aresult of these effects, the service life and the load-bearing capacity of reinforced concrete elements are considerably reduced. Corrosion activity is influenced by many factors, such as cement type, permeability of concrete, concrete cover, pH value of concrete, concrete carbonation, and the presence of corrosion inhibitors etc. Nowadays, mineral admixtures, chemical admixtures, corrosion inhibitors are used to enhance the corrosion resistance of reinforced concrete structures and thereby the bond strength between rebars and concrete. The corrosion of reinforcing steel in concrete has received increasing attention in the recent years because of its wide spread occurrence in many types of structures and a high cost in repairing these structures. In fact, corrosion of reinforcing steel in concrete is a growing international problem. Reinforcement corrosion is the most widespread damage mechanism to which reinforced concrete structures are subjected when they are exposed to aggressive environments.[7]

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II. EXPERIMENTAL INVESTIGATION

A. *Cement*

The cement used for the experiment is Ordinary Portland cement of 53 grade. The cement was tested for fineness and specific gravity. Specific gravity of the cement obtained was 3.15.

B. Fine Aggregates

a. Msand

MSand is used as the fine aggregate which passes 4.75-mm IS Sieve. As per the tests conducted in the laboratory, the specific gravitiy fine aggregates was obtained as 2.63.

b. Crushed rock fine

This is more fine than Msand. This helps to increase flowability and durability of concrete. As per the tests conducted in the laboratory, the specific gravitiy fine aggregates was obtained as 2.63

C. Coarse Aggregates

To increases flowability 12mm aggregates were used. The specific gravity for coarse aggregates was obtained as 2.76.

D. Water

The potable water used in this work was the water from supply system having a pH of 6.5. The seawater is collected from the of Cherai beach in Ernakulam district. The pH value is found out as 8.2

E. Super plasticizer

In this study Masterglenium sky 8233 with specific gravity 1.08 was used as super plasticizer. The percentage of super plasticizer used was 0.8% to 1.2%.

F. Steel Reinforcement

The steel reinforcement used for the pullout specimens is Fe500D grade steel of 16mm diameter.

G. Corrosion Inhibitors

Two types of corrosion inhibitors were used in this study. One corrosion inhibitor has zinc as its basic component and the second inhibitor has cementitious material as its basic component. The reinforcements are provided with two layers of coating. The second coat is applied only after the first coat dried. It will take 30 minutes to 2 hours for the first coat to dry. The second coat is kept for 1 to 2 hours for complete curing for both inhibitors. In cementitious coating the chemical is used with cement. 0.25 litre of chemical is mixed with 500 gram cement. This paste is applied on bars and allow to dry for two hours.

H. Mix Design

The mixes considered for this study are M30, M35 and M40.

TABLE.I CONCRETE MIX PROPORTIONS

Mix	Cement	Fly ash	Water	Msand	CRF	W/C ratio	Coaese agg	Admi xture	
M30	300	150	171	538.36	352.08	0.38	886.76	3.38	
M35	300	200	165	504.11	329.69	0.33	899.53	3.75	
M40	325	175	160	516.77	337.96	0.32	903.85	2.50	

The various specimens casted for the pullout test are as shown in Table. II.

TABLE.I SPECIMEN NAMES

Sl. No:	Specimen	SCC Mix	Type of Water	Type of Inhibitor
1	Ms1C1P1	M30	Potable Water	W/O C.I
2	Ms1C2P1	M30	Potable Water	With C.I - I
3	Ms1C3P1	M30	Potable Water	With C.I - II
4	Ms1C1P2	M30	Potable Water	W/O C.I
5	Ms1C1S1	M30	Sea Water	W/O C.I
6	Ms1C2S1	M30	Sea Water	With C.I - I
7	Ms1C3S1	M30	Sea Water	With C.I - II
8	Ms1C1S2	M30	Sea Water	W/O C.I
9	Ms1C2S2	M30	Sea Water	With C.I - I
10	Ms1C3S3	M30	Sea Water	With C.I - II
11	Ms2C1P1	M35	Potable Water	W/O C.I
12	Ms2C2P1	M35	Potable Water	With C.I - I
13	Ms2C3P1	M35	Potable Water	With C.I - II
14	Ms2C1P2	M35	Potable Water	W/O C.I
15	Ms2C1S1	M35	Sea Water	W/O C.I
16	Ms2C2S1	M35	Sea Water	With C.I - I
17	Ms2C3S1	M35	Sea Water	With C.I - II
18	Ms2C1S2	M35	Sea Water	W/O C.I
19	Ms2C2S2	M35	Sea Water	With C.I - I
20	Ms2C3S2	M35	Sea Water	With C.I - II
21	Ms3C1P1	M40	Potable Water	W/O C.I
22	Ms3C2P1	M40	Potable Water	With C.I - I
23	Ms3C3P1	M40	Potable Water	With C.I - II
24	Ms3C1P2	M40	Potable Water	W/O C.I
25	Ms3C1S1	M40	Sea Water	W/O C.I
26	Ms3C2S1	M40	Sea Water	With C.I - I

27	Ms3C3S1	M40	Sea Water	With C.I - II
28	Ms3C1S2	M40	Sea Water	W/O C.I
29	Ms3C2S2	M40	Sea Water	With C.I - I
30	Ms3C3S2	M30	Sea Water	With C.I - II

I. Accelerated Corrosion

The specimens after 28 days curing were subjected to accelerated corrosion. The corrosion was imparted to the specimens through a galvanic cell arrangement. The corrosion is provided by dipping the pullout specimen in NaCl solution of 5% by weight upto the top face of the concrete cube for a period of 3 days. The specimens were supplied with a constant direct current from a DC regulated supply in which the reinforcement as the positive electrode and a steel plate dipped in the same NaCl solution as the negative electrode. Fig.1 shows the arrangements for accelerated corrosion. About 20 to30% corrosion occurred in bars The mass loss of steel was determined by the amount of current that passes through the reinforcement with the aid of Faraday's law which is as follows.

$$m_t = \frac{t \times I \times 55.847}{2 \times 96487} \qquad (1)$$

where,
t – duration of exposure
I – the average magnitude of electrical current

Fig.1 Accelerated Corrosion Setup

III. TEST RESULTS AND DISCUSSIONS

As part of the study for each mix and pullout tests were conducted.

A. Pullout Test

The pullout test is carried out for all grades after placing in accelerated corrosion set up for 3 days and from the maximum loads at which the specimen fails it is noted that the specimens in which bars are coated with zinc based corrosion inhibitor shows more bond strength compared to specimens in which bars are coated with cementitious coating and uncoated bars. Fig. 4 shows the specimens after failure in pullout test.

Fig.2 Specimen for testing

Fig.3 Specimen After Failure

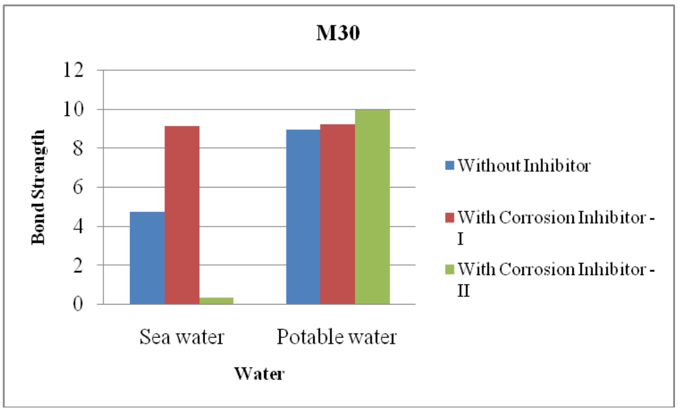

Fig.4 Bond stress for M30 grade concrete

According to above graph in the case of M30 concrete potable water mix shows more strength than sea water and also the mixes with corrosion inhibitor 1 shows more strength in the case of sea water and potable water.

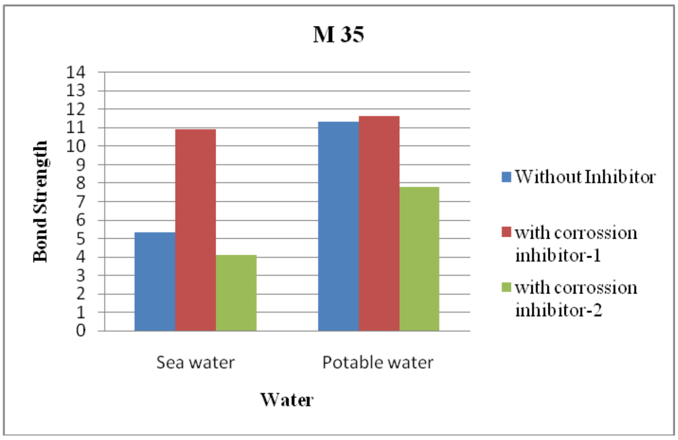

Fig.5 Bond stress for M35 grade concrete

M35 grade concrete shows almost same pattern as M30 grade concrete. Here also potable water mix shows more strength and potable water mix with corrosion inhibitor 1 shows more strength.

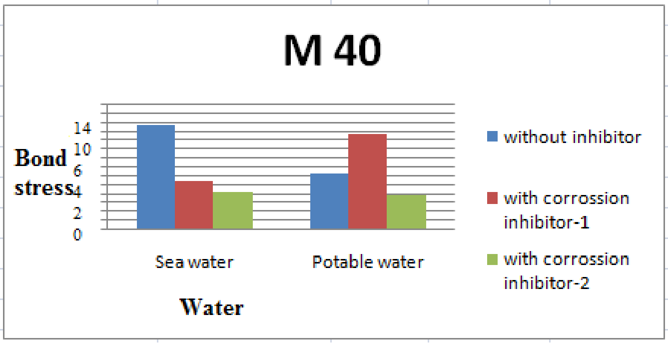

Fig.6 Bond stress for M40 grade concrete

But in the case of M40 concrete the mixes with sea water shows more strength in the case of without inhibitor and corrosion inhibitor 2.But in the case of corrosion inhibitor 1 potable water mix shows more strength. Finally it can be conclude that the corrosion inhibitor 1 shows more strength in the case of sea water and potable water mix.

IV. CONCLUSION

- Bond strength between rebars and concrete can be increase by using anti-corrosive chemicals.
- Sea water mix shows more bond strength and less corrosion.
- Concrete mixed with sea water and the reinforcement bars coated with corrosion inhibitor - 1 shows more strength in the case of M30 and M35 grade concrete. But M40 grade concrete shows more strength with any coating.
- In the case of potable water mix M30 grade concrete shows more strength with the coating of corrosion inhibitor -2. But in the case of M35 and M40 grade concrete maximum strength is shown in the presence of corrosion inhibitor -1.

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