Influence on Concrete Properties Using Multiple Corrosion Inhibitior

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Abstract: ***Integral inhibitors are in the form of liquids or solids that are batched and mixed with other concrete ingredients to prevent for new construction or repair work.This paper, is an experimental study dealing with the strength and corrosion resistance behaviour of various integral type of corrosion inhibitors namely calcium nitrite and sodium nitrate at dosage of 4%, 5% and 6% by weight of cement in concrete. The effects of these inhibitors is evaluated using the mechanical properties such as compressive strength, spilt tensile strength and the optimum dosage of inhibitors are determined . In the case of nitrate based inhibitors, addition of 6% calcium nitrate and 5% sodium nitrate shows maximum strength and further increase in sodium nitrate dosage results in decrease in strength due to decrease in the degree of hydration. It indicates that the admixed inhibitor has no harmful effect on the concrete used. The higher strength in the admixed samples than in the sample cured in water depends on the chemical activity of the inhibitors. It could probably be due to the relative chemical reactions, hardening effect of the inhibitor with the concrete.***

Keywords: concrete, super plasticizer, inhibitor, mechanical properties

1. Introduction

The environment around the steel in the concrete becomes corrosive in the presence of water and oxygen. Corrosion occurrence on the surface of the reinforcing steel causes not only decrease of bonding between the reinforcing steel and the concrete, but also the reduction of the reinforcing steel section. This makes it inevitable for researchers to find out more ways of reducing rebar corrosion rate. Corrosion in concrete can be prevented by several methods. Such methods include anodic protection, cathodic protection, rebar coating and the use of inhibitors. Amongst inhibitors widely employed to minimize corrosion of metallic structures in various environments are nitrates, benzoates, phosphates, chromates and borates. The present paper deals with the usage of Nitrate based inhibitors, such as calcium nitrate and sodium nitrate a long established reputation for effectively inhibiting corrosion of steel in concrete.

Ratul Das and Rama Debbarma(2013) concluded that the two reference concretes and mortars are considered, based on ordinary Portland cement (OPC) and slag cement. At 28 days compressive strength of concrete made with both type of cements get decreases with addition of inhibitor. Further addition of silica fume (10%) with combination of chemical inhabitor improves the compressive strength. **M. Devi (2012)** studied the strength and corrosion resisting properties of concrete containing quarry dust as fine aggregate along with calcium nitrate as corrosion inhibiting admixture at the dosage of 1%, 2%, 3% and 4% by weight of cement. The corrosion resistance performance was determined by rapid chloride permeability test and gravimetric weight loss method. The results proved that quarry dust as substitute for river sand in concrete increases the strength of the concrete, with addition of inhibitor it proffer very good resistance against corrosion. **Anitha selva sofia S.D. et.al (2013)** studied the strength and corrosion resisting properties of concrete containing quarry dust as fine aggregate along with an inhibitor namely calcium nitrate at the dosage of 1%, 2%, 3% and 4% by weight of cement. The resistance to corrosion is evaluated based on the performance of the concrete for the penetration of chloride ions by means of impressed voltage method and weight loss measurement. With the addition of inhibitor it offers very good resistance against chemical attack and increases corrosion resistance in addition to the overall properties of concrete. **Devi1 and K.Kannan**[2] **(2011)** studied the strength and corrosion resistance behaviour of various integral type corrosion inhibitors namely calcium nitrate and sodium nitrate at the dosage of 1%, 2%, 3% and 4% by weight of cement in concrete containing quarry dust as fine aggregate. The resistance to corrosion is evaluated based on the performance of the concrete for the electrochemical techniques such as Rapid Chloride Penetration Test (RCPT), Accelerated corrosion test, A.C. impedance measurement and Gravimetric weight loss measurement. With the addition of inhibitor it offers lower permeability and greater density.

2. Objectives

- To determine the mechanical properties of concrete with the addition of inhibitors by the weight of concrete.
- To determine the optimum percentage of inhibitor compared with conventional specimens.
- The analysis the effects of inhibitor added concrete with the conventional one.

3. Mix Design for M25 Grade Concrete (As Per IS 10262-1982)

Mix design is the process to determine the required and specified characteristics of a concrete mixture. M25 grade of concrete used for this study.

4. Design Stipulations

Mix proportioning is the process of determining the quantities of concrete materials used. The mix proportion for M25 grade concrete for our requirement is as follows:

Table 1: Characteristics of a concrete mixture

Grade of concrete	M25
Characteristic compressive Strength at 28 days	25 N/mm²
Maximum size of aggregate	20mm
Degree of workability	0.9(compaction factor)
Degree of control	Good
Type of exposure	Mild

4.1 Mix Design

The mix calculations per unit volume of concrete shall be as follows:

Table 2: Volume of concrete per unit length

Target mean strength	31.56N/mm²
Water/cement ratio	0.48
Weight of cement	395kg/m³
Weight of water	191.5kg/m³
Weight of fine aggregate	511.2kg/m³
Weight of coarse aggregate	1021kg/m³

4.2 Mix Proportion

Therefore required mix proportion for ternary blended is given below.

Table 3: Mix proportion of concrete

Water	cement	fine aggregate	coarse aggregate
0.048	1	1.2	2.2

5. Specimen Identification

The various specimen cast are shown in below table.

Table 4: Specimen Identification

Mix	Definition
C1,C2,C3	Conventional concrete without inhibitors
CNC -1	concrete with 4% calcium nitrate
CNC -2	concrete with 5% calcium nitrate
CNC -3	concrete with 6% calcium nitrate
SNC -1	concrete with 4% sodium nitrate
SNC -2	concrete with 5% sodium nitrate
SNC -3	concrete with 6% sodium nitrate

6. Test on Hardened Concrete

6.1 Hardened Concrete Property

Hardened concrete test plays an important role in controlling and conforming the quality of cement concrete works. One of the purpose of testing hardened concrete is to confirm the concrete used at site has developed the required strength.

6.2 Tests for Hardened Concrete

1. Compression test 2. Split tensile test

6.2.1 Cube Compression Test

The cube compressive strength of concrete is determined by conducting tests on 150 mm x 150 mm x 150 mm cube specimens at the period of 7th, 28th & 56th days of curing as per IS: 516 – 1959. The test specimen is to be tested in the compression testing machine of 2000 KN capacity. The cubes are placed in the compression testing machine in such a manner that the load is applied on the opposite sides. The load is applied at the rate of 140kg/cm^2/min (approximately) until failure of the specimen. The compressive strength of concrete gives an idea about the performance of concrete.

Compressive strength, C = P/A

Where,
P = load in Newton
A = area of cross section of cube in mm^2

Figure: Testing of Compressive strength test

6.2.2 Split Tensile Strength of Concrete

The tensile strength is one of the important properties of the concrete. However the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure at traverse direction. Direct tensile strength of concrete is determined difficulty in preparation of test specimen and applying truly axial tensile load. Split tensile strength is an indirect method of finding out the tensile strength of concrete. The cylindrical specimen in shape 150 mm diameter, 300 mm long. The test is carried out by placing the cylinder horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder, along the vertical diameter. The test is to be done for 28th & 56th days. The magnitude of this tensile stress σsp is given by the

$$\sigma_{sp} = 2P/\pi DL$$

Where,
P is the applied load,
D and L are the diameter and the length of the specimen

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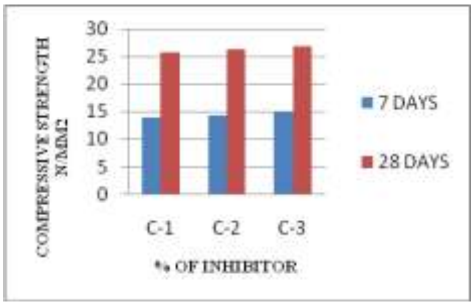
Figure: Testing of Split tensile strength test

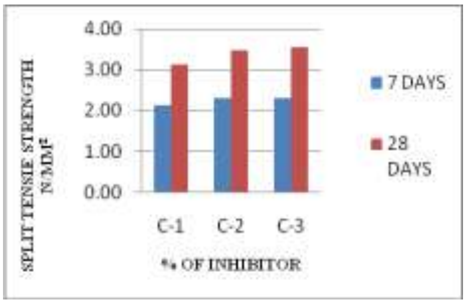
7. Results and Discussion

7.1 Conventional Concrete

The conventional compressive, split tensile strength results after 28 days curing are given in below



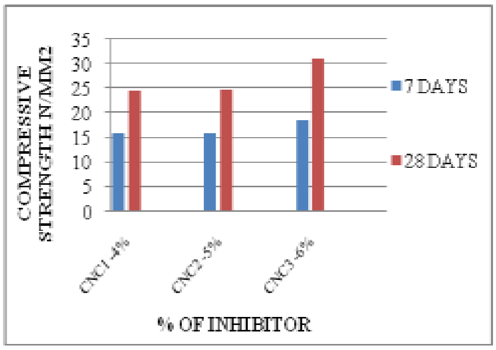
Graph 1: Conventional concrete for Compressive strength



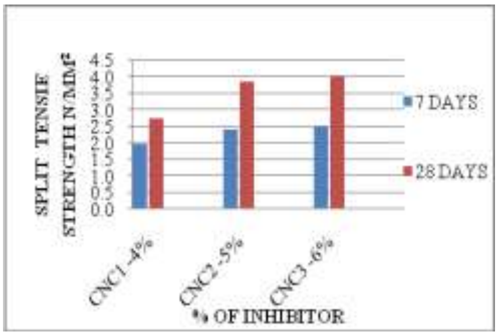
Graph 2: Conventional concrete for Split tensile strength

7.2 Discussion on conventional concrete and calcium nitrate concrete

The compressive, split tensile strength results of conventional concrete at 7 & 28 days are given in a Graph1. The strength test results of inhibitor concrete specimens were compared with the conventional concrete specimens. It is observed that when compared to control specimens, all the inhibitor added specimens display slightly a higher strength than the control specimen. At the end of 28th days there was 5.4% increase in compressive strength, 1.4% increase in split tensile strength on the strength properties. The overall best inhibition was achieved in the concrete sample admixed with 6% of calcium nitrate. This indicates that the admixed inhibitor had no adverse effect on the concrete. The reason for the higher compressive strength in the admixed samples than the sample cured in water is difficult to explain. It could probably be due to the relative chemical reactions hardening effect of the inhibitor with the concrete.



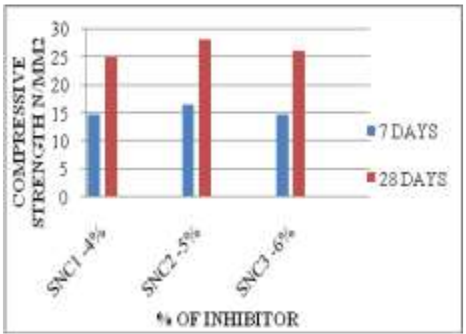
Graph 3: Compressive strength after 7 & 28 days curing



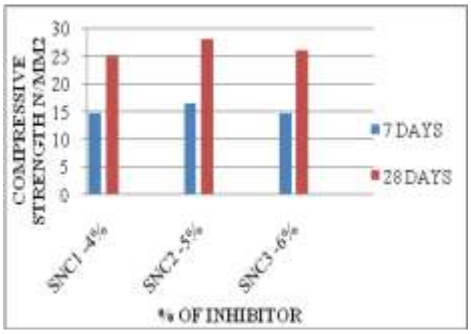
Graph 4: Split Tensile Strength after 7 & 28 days curing

7.3 Discussion on conventional concrete and sodium nitrate concrete

From the results of the strength tests shows the above figure, the figure it is evident that considering the addition of sodium nitrate, the maximum strength value is obtained by adding 5% of the inhibitor to the concrete which yields about 0.42% improvement ant the tensile strength test results at the age of 28 days are shown in Graph-3. According to Figure-3, it In case of the addition of sodium nitrate to the concrete by 5%, it yields maximum improvement in strength about 0.91 % when compared with control specimen. All the inhibitor added specimens display slightly a higher strength than the control specimen. It could probably be due to the relative chemical reactions hardening effect of the inhibitor with the concrete.



Graph 5: Compressive strength after 7 & 28 days curing



Graph 6: Split Tensile Strength after 7 & 28 days curing

8. Conclusion

1) Increasing the concentration of the inhibitor proved more effective in the strength aspect using calcium nitrate than the sodium nitrate.
2) In the case of nitrate based inhibitors, addition of 6% calcium nitrate and 5% sodium nitrate gives maximum strength and further increase in sodium nitrate dosage resulting in decrease in strength due to decrease in the degree of hydration.
3) Calcium nitrate and the specimens with 6% addition of sodium nitrate shows the maximum improvement in the compressive, split tensile strength when compared with the control specimen.

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