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CORROSION RESISTANCE OF REINFORCED CONCRETE WITH GREEN CORROSION INHIBITORS

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***Abstract*- Corrosion is the deterioration of materials by chemical interaction with their environment and this problem cannot be avoided but can be minimized by the use of corrosion inhibitors. Because of the issue of toxicity of some inhibitors, there is strive to make use of eco-friendly and non-toxic green corrosion inhibitors. For this investigation the green Corrosion inhibitors were extracted from Azadirachta Indica (Neem) and Aloe-Vera. The corrosion resistance properties of steel reinforcement was found by the accelerated corrosion test and weight loss measurement. The results showed that concrete with green corrosion inhibitors have high corrosion initiation time and low corrosion rate compared to the conventional concrete and strength properties nearly same as conventional concrete. The inhibitor Azadirachta Indica has superior corrosion inhibition efficiency compared to aloe-vera inhibitor. The addition of given green inhibitors do not significantly affect the hardened properties of concrete.**

Keyword: **Corrosion, inhibitors, Neem, Aloe-Vera**

1. INTRODUCTION

Metals and alloys are generally used as fabrication or construction materials in engineering. If the metal or alloy used are not properly maintained, they deteriorate slowly by the action of atmospheric gases, moisture and other chemicals. This phenomenon of deterioration or destruction of metals and alloys is known as corrosion. In the recent past corrosion in concrete structures has been considered as major durability problem effecting the service life of concrete structures [1].

There are many possible approaches adopted for reducing corrosion of concrete such as Coating to reinforcement, Galvanized reinforcement, improving metallurgy by adding chromium and copper, Corrosion inhibitors, Nonferrous reinforcement, Concrete coatings, cathodic protection, improving the quality of concrete, proper storage & stacking of reinforcing steel. The use of inhibitors is the one of the best options for reducing the corrosion of concrete [2].

Use of some inhibitors, such as chromates, has been banned because of toxicity and the environmental hazards they create. Hence there is a strive to make use of environmental friendly, non-toxic, extracts of naturally occurring plant materials as corrosion inhibitors The inhibitors which are made from the naturally occurring plant extracts are commonly known as green corrosion inhibitors[3]. Extracts of plant materials contain a wide variety of organic compounds. Most of them contain heteroatoms such as P, N, S, O. These atoms coordinate with the corroding metal atom (their ions), through their electrons. Hence protective films are formed on the metal surface and hence corrosion is prevented [4].

A large number of naturally occurring plant extracts are presently under the study to investigate their corrosion inhibition potential. Through these studies it is agreed that plant extracts are effective corrosion inhibitors of iron or steel and the inhibition performance of plant extracts are controlled by the temperature and their concentration [5-8]. Some examples of green corrosion inhibitors are Aloe-Vera[5], Azadirachta Indica[8], Allium Sativum extract[11], Henna[12], Phyllanthus Amarus[13], Hibiscus Subdariffa [14].In this study Azadirachta Indica (Neem) and Aloe-Vera are used as green inhibitors. The green corrosion inhibitors are added 2% weight of cement directly into the concrete while mixing. The

concrete specimens are immersed in 3.5% NaCl solution to induce the corrosion.

The green corrosion inhibitors are obtained from the plant extracts are easily available, cheap, eco-friendly, inexpensive and renewable. Green inhibitors are more environmentally friendly than organic and inorganic inhibitors and also reduce the environmental hazards. Because of this toxicity of chemical inhibitors there is growing interest on use of green corrosion inhibitors.

2. MATERIALS USED

2.1 CEMENT

Ordinary Portland cement 53 grade, commercially available in the market was used for the present study and it is having a specific gravity of 3.14 and normal consistency 32% conforming to the requirements of IS: 12269-1987 specifications.

2.2 FINE AGGREGATE

Locally available river sand passing through IS 4.75mm sieve was used as fine aggregate. Specific gravity of fine aggregate is 2.62 water absorption of 1.93%.

2.3 COARSE AGGREGATE

The coarse aggregate of 20mm size was used for the present study and it is having a specific gravity of 2.65. The aggregates were tested as per IS: 2386-1963 (I, II, III) specifications.

2.4 NORMAL WATER

The water which if fit for drinking should be used for making concrete. The water should be clean and free from harmful, impurities such as oil, alkali and acids etc.

2.5 GREEN CORROSION INHIBITORS

Extracts of plant materials contain heteroatoms such as P, N, S, O. These atoms coordinate with the corroding metal atom and protective films are formed on the metal surface and hence corrosion is prevented. Selecting the green corrosion inhibitors which locally available they are:

2.5.1. Dehydrated Aloe-Vera Powder

It grows wild in tropical climates around the world. It is a stemless or very short stemmed plant growing 60 to 100cm tall. The leaves are thick and fleshy, green to grey green colour. The specific gravity of Aloe-Vera powder is 1.78.

2.5.2. Azadirachta Indica Powder

Neem is a fast growing tree that can reach a height of 15 to 20 metres. It grows in various tropical and sub-tropical regions. Specific gravity of Azadirachta Indica Powder is 1.72.

3. EXPERIMENTAL PROGRAMME

3.1 PREPARATION OF PLANT EXTRACT

1. The leaves were obtained from the plant in the neighborhood and thoroughly washed with water to remove unwanted materials and make it in the powdered form.
2. The weighed amount of sample was put in the container, water was added in the proportion of (1:2).The mixture was left for 48 hours.
3. The residue is collected by heating of mixture in oven

3.2 CASTING

M 25 grade concrete is used. Ordinary port land cement of 53 grade is used and river sand passing through 4.75 mm sieves. Coarse aggregates of 20mm size was used. Portable water was used for both mixing and curing. Water cement ratio 0.5 and Mix ratio is 1: 1.53:3.15:0.50. Three combinations of mixes were carried out such as conventional concrete, conventional concrete with Neem powder and dehydrated Aloe-Vera powder. Three specimens are casted to each combination.

3.3 ENVIRONMENTAL EXPOSURE CONDITION

After curing period the concrete specimens are immersed in the saline environment to induce the corrosion. To get the marine/saline environment, the concrete is kept in the 3.5%NaCl

solution. Sea water, or salt water, is water from a sea or ocean. On average, sea water in the world's oceans has a salinity of about 3.5% (35 g/L), which is a specific gravity of about 1.025. Sea water pH is typically limited to a range between 7.5 and 8.4.

3.4 COMPRESSION AND SPLIT TENSILE TESTS

The strength properties of the concrete are found by the compressive strength and split tensile strength test. The green corrosion inhibitors are added 2% weight of cement directly into the concrete while mixing. Concrete cubes of 150mmX150mmX150mm are casted for finding the compressive strength of concrete at 28 days. Concrete cylinders of 300mm height and 150mm diameter are casted for finding split tensile strength of the concrete at 28 days.

3.5 ACCELERATED CORROSION TEST

To assess the initiation time of corrosion under accelerated test conditions, concrete cylinders of size 75 mm diameter and 150 mm length were cast with HYSD steel bar of 16mm diameter embedded centrally into it. The steel rods were cleaned with pickling acid and degreased and then embedded in such a way that a constant cover is maintained all round and also the protruding rod was insulated by PVC sleeve.

After 28 days curing, all the specimens are dried for 24 hours and immersed in the saline media (3.5% Sodium chloride solution). The rebar is connected to the positive terminal (anode) and the stainless steel plate is connected to the negative terminal (cathode) of the power pack. The test specimens were subjected to a constant voltage of 6 volts from D.C power pack. The applied voltage is kept constant continuously and the current response is monitored with respect to time.

Fig: 1 Test Setup of Accelerated Corrosion test

Fig: 2 curing of the Specimens

3.6 GRAVIMETRIC WEIGHT LOSS TEST

Steel embedded concrete cylinders were cast with inhibitors and also without inhibitors. High yield strength deformed rods of size 16mm diameter and 150mm long was selected. The initial weight (W1) of the rod was measured and embedded in the centre of cylindrical concrete specimens of size of 75mm diameter and 150mm long. The specimens were subjected to 28 days curing in fresh water. After the curing period was completed the cylinders were immersed in 3% of NaCl solution under alternate wetting and drying conditions. At the end of 90 days the cylinders were broke open and the final weight of the specimens was taken. From the weight loss obtained corrosion rate can be calculated using the following formula.

The corrosion rate in millimeter / year = $87600 \times \frac{W}{(p * A * T)}$

Where,

W = Weight loss in grams (W1-W2)

p = Density of steel gm/cm^3

A = Area of the embedded rebar in cm^2

T = Time in hours

Fig: 3 Specimens for weight loss test

4. RESULTS AND DISCUSSIONS

4.1 COMPRESSIVE STRENGTH

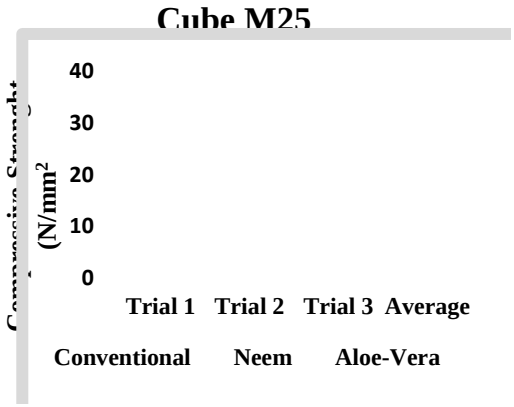

Chart.1: Compressive strength of concrete

The strength of the concrete with green corrosion inhibitors is less than the strength of the conventional concrete, but the strength is always within permissible values.

4.2 SPLIT TENSILE STRENGTH

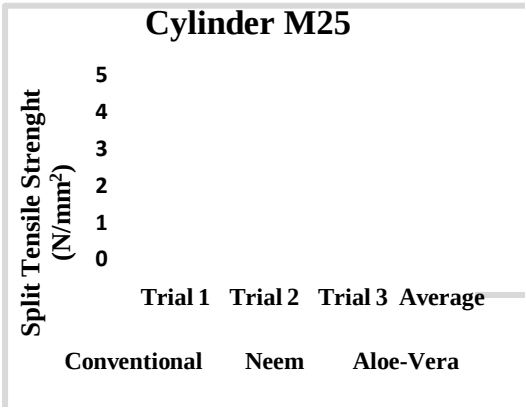

Chart.2: Split Tensile strength of concrete

Strength of the concrete with Neem powder inhibitor is increased by 5.18% than conventional concrete, but in Aloe-Vera inhibitor its 8% is reduced.

4.3 ACCELERATED CORROSION TEST

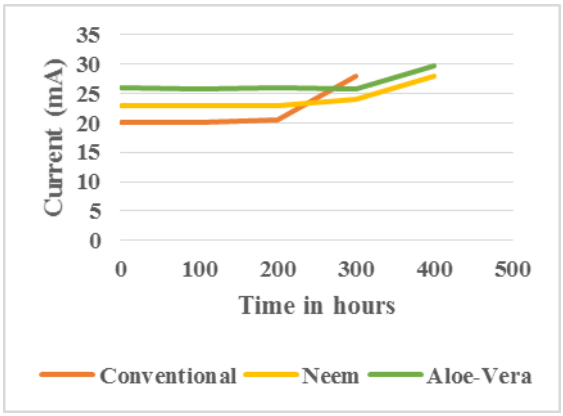

Chart.3: Comparison of Initiation time of corrosion

The sudden increase in current (mA) can be identified as initiation time of corrosion. We observed that the concrete with green organic inhibitors have high corrosion initiation time when compared to the conventional concrete.

4.4 GRAVIMETRIC WEIGHT-LOSS TEST

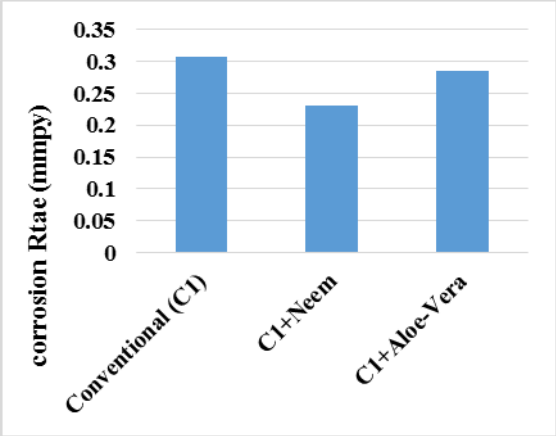

Chart.4: Comparison of corrosion rate of concrete

It is observed that the corrosion rate is high for the conventional concrete. It means the electrons Movement is high when increase in current rate. The green corrosion inhibitors are showed better results compared to conventional concrete.

5. CONCLUSION

The green corrosion inhibitors such as Azadirachta Indica Powder and Dehydrated Aloe-Vera Powder are eco-friendly and locally available. The concrete with green corrosion inhibitors have strength properties nearly same as conventional concrete. The addition of the given green inhibitors does not significantly affect the hardened properties of concrete. The concrete with green corrosion inhibitors have high corrosion initiation time and low corrosion rate compared to the conventional concrete. The results of inhibitors showed that Azadirachta Indica (Neem) has superior corrosion inhibition efficiency compared to the Aloe-Vera inhibitor.

REFERENCE

1. Sunil J. Kulkarni 2015. *A review on studies and research on corrosion and its prevention*. International journal of research and reviews (www.gkpublication.com) Vol 2; Issue 9, pp574-578, E-ISSN: 2349-9788 September 2015.
2. Rajindervir Singh Sandhu, Dr. Jaspal Singh, Dr. Grupreet Singh Dhanoa. 2015. *A review on corrosion: causes and prevention*. Vol 6, issue 6, June 2015, pp 100-107.
3. BE Amitha Rani and Bhrathi Bai J. Basu. 2011. *Green inhibitors for corrosion protection of metals and alloys: an over view*. Vol 2012. Article ID 380217, 15 pages.
4. PB Raja and M.G Sethuraman. 2008. *Natural products as corrosion inhibitors for metals in corrosive media-* a review. Material letters, Vol 62, no 1, pp 113-116, 2008.
5. Pallav Shah, Shruthi Agarwal. 2014 *Aloe-Vera: A Green Corrosion Inhibitors*. International Journal for research in applied science and Engineering Technology (IJRASET) www.ijraset.com. Vol 2, Issue V, May 2014, ISSN: 2321-9653.
6. Eyu D.G, Esah H., Chukwuekezie C, Idris J. and Mohammad I. 2013. *Effect of green inhibitor on the corrosion behavior of reinforced carbon steeling concrete*. ARPN Journal of Engineering and applied Sciences. Vol 8, No.5, May 2013, ISSN 1819-6608.
7. Gupta Pankaj and Jain Gargi. 2014. *Corrosion Inhibition by Aloe-Vera Extract as green inhibitor for Mild steel in HNO_3*. JainGargi et al., IJSRR Special issue 2014 Vol 3, pp 72-83, ISSN: 2279-0543.
8. Peter C. Okafor, Eno E. Ebenso and Udofot J. Ekpe. 2010. *Azadirachta Indica extracts as corrosion inhibitor for mild steel in acid medium*. International journal of electro chemical science Vol 5. June 2010. ISSN: 978-993.
9. Ghulamullah Khan, Nazi MD and Salim Newaz. 2015. International journal of electro chemical science (www.electrochemsci.org) Vol 10, 2015. *Application of natural products extracts as green corrosion inhibitors for metals and alloys*.
10. U.J Ekpe, E.E Ebenso. 1994. West Africal journal of biological and applied chemistry, Vol 37, pp 13-30, 1994 *inhibitory action of Azadirachta Indica leaves extract on the corrosion of mild steel*.
11. Peter C. Okafor, E. E. Ebenso and E.M Umoren and K.E.Leizou, *Inhibitions of mild steel corrosion in acidic medium by Allium Sativum extracts*. Bulletin of Electrochemistry, Vol.21, No.8, pp.347-352.
12. A. Chetouani and B Hammouti, 2003. *Corrosion inhibitions of iron in hydro chloric acid solutions by naturally henna*, bulletin of Electrochemistry, Vol.19, No.1, pp. 23-25.
13. M. E. Ikpi, Peter C. Okafor, E. E. Ebenso and E.M Umoren, 2008. *Inhibitory action of Phyllanthus Amarus extracts on the corrosion of mild steel in acidic media*. Corrosion science, Vol.50, No.8, pp. 2310-2317.
14. A.A.EI Hosary, R.M.Saleh and A.M. Shams EI Din. 1972. *Corrosion inhibition by naturally occurring substances-1. The effect of hibiscus Subdariffa extract on the dissolution of* AL and Zn. Corrosion science, Vol.12, No.12, pp.897-904.
15. IS10262-1982 "*Recommended Guidelines for concrete mix design*"