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Enhancement of Corrosion Resistant Characteristic of Rebar Using Natural Organic Inhibitor

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Abstract: *Concrete is widely recognized as a cost effective and versatile material for construction. In general concrete is highly brittle & lack in flexural strength.To enhance the flexural strength of the concrete, Steel has been used as reinforcement material for concrete structures due its high flexural strength from decades. But Corrosion of steel is the major defect for the deterioration of concrete. Hence Corrosion control of reinforced steel is very important to increase the life of the structure.The main objective of this project is to prevent corrosion on steel. Various strategies such as Coatings & linings, cathodic protection, electrical resistivity method & corrosion inhibitors were adopted as the preventive measure of corrosion. The use of inhibitors is the best choice of protecting metals and alloys against corrosion. In addition to being eco-friendly, plant products are cheap, easily available and renewable. Hence in this project we tried PPE - Pomegranate Peel Powder (Punica granatum L) as a coating material, which is a cheap, raw, and nontoxic corrosion inhibitor for steel.A pomegranate peel powder coated on mild steel rod and it was checked in 5% HCl and 5% H_2SO_4 solutions. The results of PPE Coated Steel was revealed & compared with normal steel in various exposures of time. The results of PPE Coated Steel were discovered & compared with traditional steel and therefore the results shows that PPE acts as a good corrosion inhibitor.*

Keywords: *Corrosion Inhibitor, Pomegranate Peel Powder-PPE, Accelerated Corrosion, pH test.*

I. Introduction

Corrosion is the major defect in the concrete which leads to failure of concrete structures. Corrosion reduce the load carrying capacity of structure and also it break down the bond between concrete and steel so corrosion control measures are required to make the structure more durable [1]. The initial cause for the corrosion is due to permeability in concrete, low concrete cover for the reinforcement & due to various environmental exposures [2].The presence of the porosity in concrete allows the oxygen to diffuse through it and at the end it reaches the surface of the steel. In addition carbon di oxide and chloride are other agents which cause corrosion in steel in the form of carbonation and chloride attack on steel. Carbonation begins with chemical reaction between carbon dioxide (CO2) gas from the atmosphereand the alkaline hydroxides from the concrete [3]. Presence of Calcium hydroxide in the concrete increases the alkalinityand maintains the pH level of 12–13. The carbonates attack inside the concrete will results information of Calcium carbonate.

$CO_2 + H_2O \rightarrow H_2CO_3$

$H_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3 + 2H_2O$

Chloride attack involves no drop in the overall pH while it acts as catalysts to corrosion when there is sufficient concentration at the rebar surface to break down the passive layer.When chloride ions appeared in solution around iron, it reacts with $Fe_2^+$of passive ion over steel surface and forms an iron–chloride complex.Subsequent hydrolyzes of iron–chloride complex resultin ferrous hydroxide and also liberate the chloride ions for further attack over iron surface [4].

$Fe^2 + Cl \rightarrow [FeCl\ complex]^+$

$[FeCl\ complex]^+ \rightarrow Fe(OH)_2 \rightarrow Cl^-$

Various methods of corrosion preventivemeasure were invented such as Coatings & linings, cathodic protection, electrical resistivity method & corrosion inhibitors. Among all those utilization of inhibitorsfor reinforcing steel became common practice [5]Various tests such as weight loss measurements, accelerated corrosion, PH test were done with the PPE extract in HCL & H_2SO_4solution and the results of PPE Coated Steel werecollected and compared with the normal uncoated steel**.**

II. Methodology

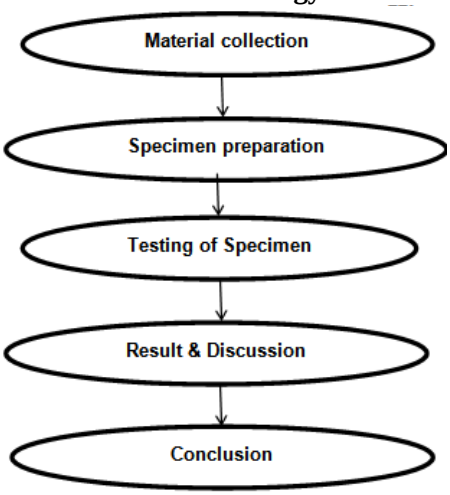

Fig.1. Flow methodology of the work

III. Materials

3.1. Pomegranate Peel Powder

The peel part of pomegranate contains various chemicals which acts as medicine and antioxidant materials which corrosion resistant. These substances with effective constitutive chemical groups in their structure could show corrosion inhibition performance [6]. The peel of the pomegranate fruit has been collected, dried and made as fine powder so that it can be dissolved in the acid medium.

Fig.2. Pomegranate Peel

Fig.3. Pomegranate Peel Powder

3.1.1. Pomegranate Peel Extract Preparation

The pomegranate Peel powder was sieved using 75 micron. 20 gram of sieved Powder was dissolved in distilled water and the solution was boiled and cooled at the room temperature overnight. The solution has been filtered several times and heated to form an extract. Finally the extract was collected in the beaker and now it is ready to coat over the steel [7].

3.2. Hydrochloric Acid

1 M Hydrochloric acid solution was prepared by using distilled water & strong acid to immerse the PPE coated rod for the test. This solution will acts as an aggressive acidic media for the steel to corrode.

IV. Test on specimens

4. 1. Carbonation test

It is the process in which an atmospheric carbon dioxide (CO2) penetrates into the concrete surface and reduces the protective alkalinity of the concrete cover. The rate of carbonation is heavily dependent upon the strength, permeability and quality of the concrete and the exposure environment, with regularly wetted external concrete carbonating more slowly than internal or sheltered concrete. Once the carbonation front reaches embedded steel, the protective passive film naturally present on steel in concrete is broken down and general corrosion can begin (provided sufficient moisture is present within the concrete), as shown in Figure 3. The depth of carbonation can easily be determined on site using phenolphthalein indicator, sprayed onto a freshly broken concrete sample [2].

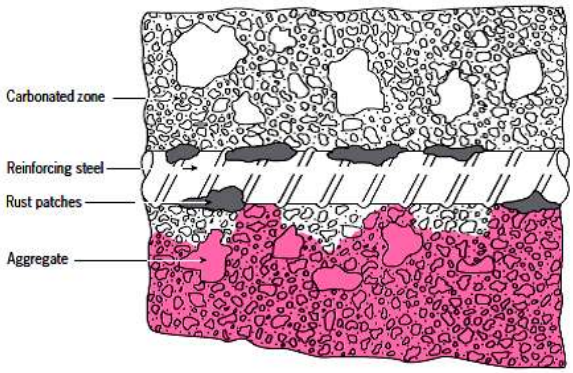

Fig.4.carbonation test

4. 2. pH & Chloride content test

The pH test was carried out in a simple way by using the pH meter. In this test the steel rod has been abraded in the corroded zone and the sample was collected as powder. The rust powder was put in the beaker containing distilled water. Finally after the rusted powder has been dissolved the pH of the solution was observed by using the pH meter. If the observed value is greater than 11.5the solution is in acidic, and the rod is said to be corrosion prone.

4. 3. Impressed voltage test

This test is commonly known as accelerated corrosion test. The PPE coated rebar & uncoated rebar were taken as the specimens and the rods were placed in the concrete such that the 50 mm of the rod should be exposed above the concrete casted. The concrete cube specimens were made to partially immerse in 3% Na-cl solution. The potential of 10 volt has been applied on the specimen as shown in fig 4. This set up has been kept without disturbed till the rod were attaining a weight loss of 20 %. The variation in time to weight loss for both rods has been observed and noted [8].

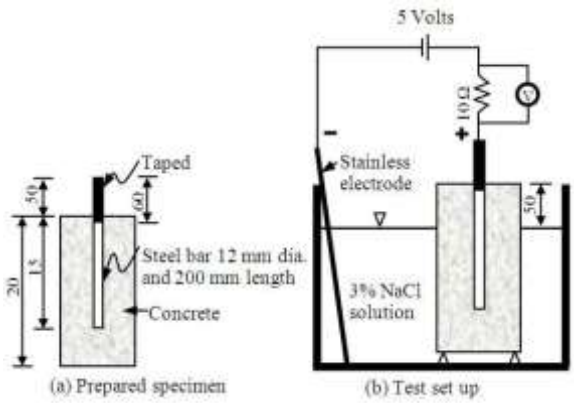

Fig.5. Accelerated corrosion test setup

4. 4. Weight loss measurement test

Weight loss measurement was carried out with mild steel samples. The samples were cleaned using electrolyte and abraded. Powder of dry pomegranate peel is added to 5% HCl and 5% H2SO4concentrations in 40 mg/liter at room temperatures. The initial weights of the samples were measured as W_1 before immersed in to the solution. Thesesamples were kept without disturbed for various exposures of time (7, 14 & 28) days. The samples were taken out cleaned, dried and weighed as W_2. The loss in weight of the samples has been measured and calculated by using the following equation [9].

$$W = \frac{w2 - w1}{A}$$

Where,

W – Weight loss in mg/cm^2

W_1& W_2 are the weight of the samples before and after corrosion.

The inhibitor efficiency for different exposures of time has been calculated by using the following expression

$$\eta = \frac{w - wp}{w} \times$$

Where,

η% = inhibitor efficiency percent,

W = weight loss in mg/cm2 without pomegranate peel and

Wp = weight loss in mg/cm2 with pomegranate peel added forthe same exposure time for W.

V. Results & Discussion

5.1. Carbonation test

Table1. Carbonation test

Specimen	Result
Mild steel	Dark pink colour
PPE coated steel	No colour change

Table 1 shows the observation result of carbonation test for PPE coated bar & uncoated steel rod. The concrete casted with uncoated steel rod shows dark pink colour variation phenolphthalein sprayed which shows that it highly carbonated and prone to corrosion.

5.2. PH test

Table2. PH Test

Specimen	Result
Mild steel	12.7
PPE coated steel	6.2

Table 2 shows the acidic nature of the specimen. It has been found by using the pH value. The normal uncoated steel was acidic & hence it is prone to corrode easily when compared to steel coated with PPE

5.3. Impressed Voltage test

Table3. Accelerated corrosion Test

Specimen	Result
Mild steel	20 %Weight loss in6 hours
PPE coated steel	20%Weight loss within 8hours

5.4. Weight loss measurement test

Table4. Weight loss measurement test

Efficiency of inhibitor in HCL by weight Loss		Efficiency of inhibitor in H_2SO_4 by weight Loss	
Exposure in days	η	Exposure in days	η

7	81.20	7	83
14	88.21	14	86.23
21	94.23	21	95.21
28	95.10	28	94.60

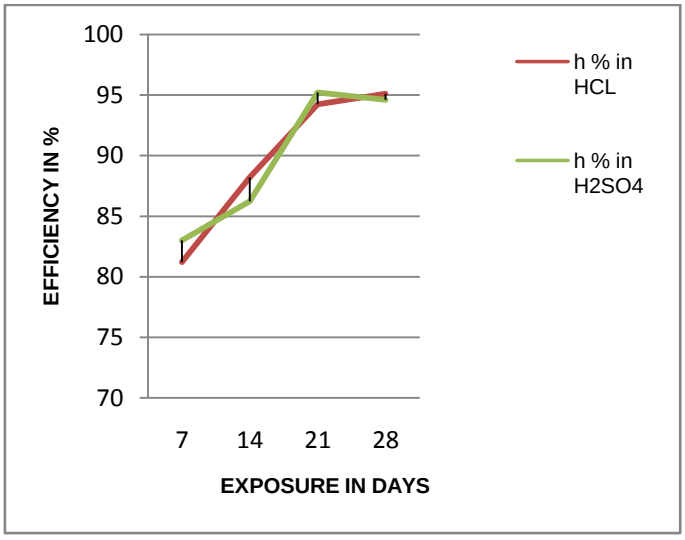

Fig.6. Inhibitor Efficiency graph

Fig.6. shows the graph of efficiency versus exposure days of specimen in two different acidic medium. The value shows that PPE will acts as good inhibitor for steel against corrosion.

VI. Conclusion

The carbonation test clearly shows that the steel coated with PPE has not affected by carbon and hence there is no colour change. pH test shows that the pH value of samples collected from the uncoated steel was greater than 11.5 & hence the solution contains the sample from uncoated rod is acidic & it is prone to corrosion. Accelerated corrosion test was conducted and found that the weight loss occurs earlier in the normal steel later in coated rebar. Weight loss measurement was conducted in two different acidic medium and the result shows that efficiency of the steel in the solution containing the PPE was good. The results prove that PPE is good natural inhibitor for the steel.

Acknowledgements

Fig.4 the diagrammatic illustration of the carbonation test were taken from BRE part 1

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