A Study on Corrosion Resisting Property of Conventional Concrete and Geopolymer Concrete using Natural and Synthetic Inhibitors

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Abstract:
The effect of inhibitors on the corrosion of reinforced steel in Control Mix and Geo-Polymer Concrete (rebar) exposed to 5% NaCl solution has been studied by Half cell potentiometer, Weight loss method, Linear polarization method, Concrete resistivity tests and Visual inspection method. The Corrosion potential values and corrosion current are measured during impressed current technique applied on concrete specimen. The proportion of Natural inhibitors like NEEM, PONGAM, JULIFERA is 5%,10%,15% respectively and Chemical inhibitors like 2-2' 1E,1E' Ethane 1-2-diyblis azan-1-yl-1-ylidiene bis methane-1-yl-1-yidiene diphenol&2-2' 1E,1E' Ethane 1-2-diyblis azan-1-yl-1-ylidiene bis methane-1-yl-1-yidiene nitro phenolis taken 2ml,4ml,6ml dissolved in 1000cc of water to prepare 0%,5%,10%,15%, concentration. The results show that the NATURALINHIBITOR acts as an excellent corrosion inhibitor with efficiency of 80.7% with increasing concentration of inhibitor, there is a regular increase in inhibition efficiency. However, at high concentration of inhibitor there is a decrease in efficiency which may be related to the adsorption phenomenon. CHEMICAL INHIBITOR shows the results immediately while Natural takes time. If the corrosion has to be terminated immediately the Chemical inhibitors can be used while durability of structure goes with the Natural inhibitors.

Keywords: Natural Inhibitor, Chemical Inhibitor Conventional Concrete and Geo-Polymer Concrete

I. INTRODUCTION

Corrosion is a chemical process of degradation of steel when in contact with atmosphere gas and moisture. In civil engineering, the Concrete structures durability is mainly affecting by life of steel that steel life reducing by corrosion. So research is going about prevention of corrosion. Prevention of corrosion by many methods, one of the best and easily applicable method is application of corrosion INHIBITORS. The degradation of reinforcing steel due to corrosion is predominant in concrete structures. Generally most structures are contaminated with chloride. In concrete structure the corrosion is occurs because of pores is present in concrete. Gas like carbon-di-oxide and moisture content entering into the pores then reacts with iron rod which is induce the corrosion progress. To avoid the entering moisture and carbon-di-oxide, **CONVENTIONAL CONCRETE** can be replaced by **GEOPOLYMER CONCRETE** one shall used high density concrete and other types of concrete which is having low permeability and pore spaces. Applying corrosion inhibitors in form of coating on steel or coating in surface of concrete or mixing in concrete like admixtures. Here using coating of steel which forms as an passivation layer (protective layer) like paint that reduces the corrosion rate. Both **NATURAL AND CHEMICAL INHIBITORS** are excellent corrosion inhibitors that is coating by % of weight of total.

2. EXPERIMENTAL METHOD

2.1. MATERIALS: The following materials were used for this project, 1. Fe550 steel rods 8mm, 2. Geo polymer concrete materials, 3. Ordinary Portland cement materials, 4. Stainless steel plate, 5. Electricals setup of inducing corrosion, 6. NaCl for immersion

2.1.1. Material characteristics:
METHOD:
Making of GEO POLYMER CONCRETE: Mixing of alkaline liquid with Fly ash, fine aggregates and coarse aggregates. Alkaline liquid consists of sodium silicate and sodium hydroxide. Sufficient water is added for chemical reactions. If water content is restricted then super plasticizers may be added. Curing may be done by steam for short time curing. Otherwise ambient temperature curing is enough.

Making of CONTROL MIX CONCRETE: Mixing of cement, fine aggregates, coarse aggregates and water. For getting the expected strength water cement ratio may be fixed from the standard graph.

Making of NATURAL INHIBITOR:
NEEM: Azadirachta indica (AZI, commonly recognized as "Neem") is noteworthy both for its chemical and for its biological actions. Tannin content in neem act as corrosion inhibitor Neem is taken and the leaves are powdered. Then they are dissolved in the ethanol for dissolving and kept in both higher and lower concentration. Then they are made to evaporate and the thick concentration liquid is taken as the inhibitor.

PONGAM: (Derris indica) - Flavonoids content in pongam act as corrosion inhibitor. Pongam is taken and the leaves are powdered. Then they are dissolved in the ethanol for dissolving and kept in both higher and lower concentration. Then they are made to evaporate and the thick concentration liquid is taken as the inhibitor.

JULIFERA: MESQUITE (PROSOPIS JULIFERA)

They are a shrub that grows upto 12m. Julifera is taken and the leaves are powdered. Then they are dissolved in the ethanol for dissolving and kept in both higher and lower concentration. Then they are made to evaporate and the thick concentration liquid is taken as the inhibitor.

ELECTRO-CHEMICALPROCESS:CONVENTIONAL CEMENT CONCRETE

- Specimen dimensions\; There are 16 samples of CMC casted and cured.
- Only one sample is taken as O% and 3 samples are taken for 5%,10%,15% for natural inhibitor 1 and similiarly for other natural inhibitors 2.
- 3 samples are taken for chemical inhibitor 1 as 5%,10%,15% and other 3 samples for chemical inhibitor 2 .
- The concrete cylinders specimens immersed in 5% NaCl solution containing box.
- Then constant DC supply (10V to 12V) applying all the rebar takes as a positive (parallel connection for to avoid the dividing the volts) and stainless steel plate takes as negative, both the terminals are connected to the voltage regulator equipment.
- From that day readings has to be noted.

(Impressed current technique experimental setup)

GEOPOLYMER CONCRETE

- Specimen dimensions\; There are 16 samples of CMC casted and cured.
- Only one sample is taken as O% and 3 samples are taken for 5%,10%,15% for natural inhibitor 1 and similiarly for other natural inhibitors 2.
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CORROSION TESTS

Corrosion tests are conducted to the all cylinders.

1. VISUAL INSPECTION

Visual inspection is a Non destructive Evaluation method of corrosion monitoring. It is the simplest and the oldest inspection technique. This method is economical and fast. This simply involves most often the use of the human eyes to observe the surface morphology. Although this technique has some limitations because it can only provide qualitative results but not quantitative results.

2. WEIGHT LOSS TEST

After corrosion of iron rod, the iron rod losses its weight so this test is conducted. First initial weight of rod is noted then after attaining corrosion in particular days the rust of particles is cleaned by weir brush and take that weight.

Weight loss (gm) = initial weight – final weight

Corrosion rate (mm/yr) = (8600) (weight loss) / (density of steel gram per square centimetre) (area in square centimetre) (time in hours)

Where mm/yr is millimetre per year

Inhibitor efficiency (%) = 1- (weight loss with inhibitor/weight loss without inhibitor) x 100 %

WEIGHT LOSS is about 40gms of Reduction due to corrosion.

2. DETERMINATION OF CORROSION RATE (mm/yr) FOR REINFORCING STEEL BAR IN CONCRETE

The corrosion rates in each of the specimens were evaluated from corrosion current density I_{corr}. Using the formulae as stated below

$I_{corr} = B / R_p$

Stern Geary relationship (Stern 1975).

Where ,

I_{corr} = Corrosion current density, $\mu A / cm^2$.

B = Stern Geary constant, 26 mV (Andrade, 1978)

R_p = Polarization resistance , $ohm.cm^2$

Corrosion rates in mm/yr was calculated as $0.0116 \times I_{corr}$ as given by (Devi and kannan, 2011).

3. HALF CELL POTENTIAL TEST

It is an electrochemical method for corrosion rate measurement is the simplest monitoring technique. In this test copper – copper sulphate half cell was used according to ASTM – C 876-87 G3.

The copper sulphate solution poured into half cell container and 3mm copper rod inserted to the half cell container it's called as electrode. Then the electrode is connected in negative terminal in voltmeter with the help of wire.
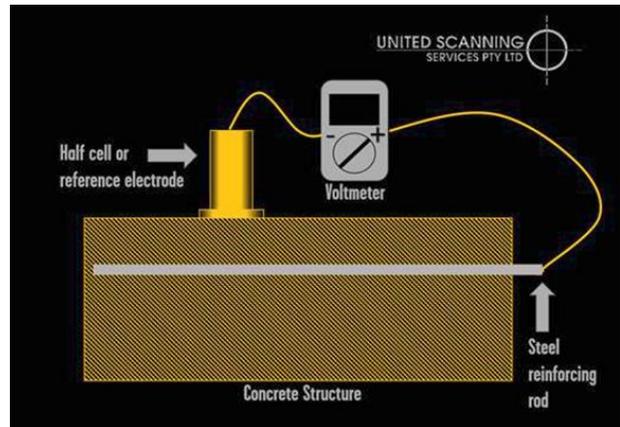
Now the iron rod is cleaned then positive clamp is attached to that, at a same time the electrode is placed on concrete surfaces at 2 or more close intervals The whole test should conducted in dry condition for specimens. Not to be directly measured while immersing or current impressing technique progress. **NEEM-186mV** for **GEOPOLYMER CONCRETE SCHIFF BASE 1-184mV** for **CONTROL MIX** The Natural Inhibitor gives the best results with Geo polymer concrete.

4. CORROSION RATE MEASURMENT AFTER IMMERSION DURATION

It is evident that the corrosion rates of the unprotected carbon steel increased dramatically from 0.8mm/yr to 0.9mm/yr and then reduced slight to 0.0885mm/yr at the end eight weeks. On the other hand, Sodium nitrite inhibitors proved to be effective at 2% v/v in 5%NaCl solution. In similar trend, Corrosion rates for samples with calcium nitrite inhibitors increased from 0.005 mm/yr in day 7 to 0.0066 mm/yr in the second week and declined significantly to 0.007 mm/yr at the end of test. The presence of tannins, alkaloids and saponnins in verrnonia amygdalina act as a barrier on the metal surface, thus preventing the diffusion of ions from the surface of a corroding their by blocking the anodic or cathodic site which consequently reduces corrosion rates .
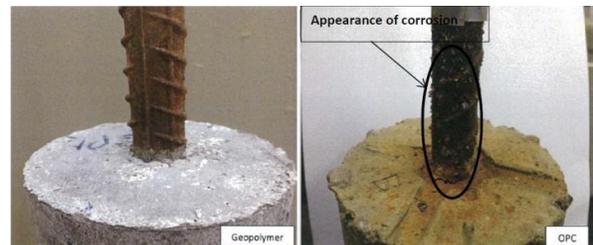

Corrosion of steel in GPC and OPC

5. INHIBITION EFFICIENCY

Chemical Inhibitor 1 and Natural Inhibitor 1 (NEEM) giving similar results in CMC, But, Chemical Inhibitors efficiency is less when compared to Natural Inhibitor in GPC.This is because the alkaline liquid used for GPC reacts with Chemical inhibitors and thus the efficiency is reduced. So, We suggest to use Natural Inhibitor to prevent corrosion in Geopolymer reinforced concrete

elements and also the Natural Inhibitors are a perfect replacement for Chemical Inhibitors.

Half cell potential experimental setup
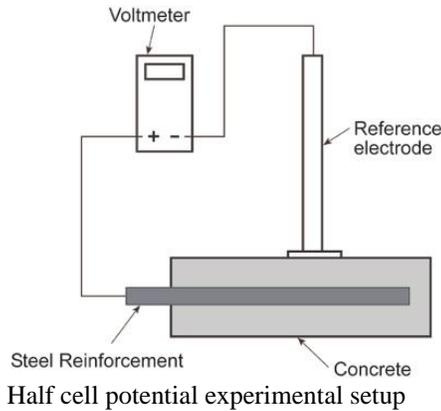
6. CONCRETE EFFICIENCY

The ordinary control mix concrete is only applicable for the Chemical Inhibitors. Whereas Geo polymer concrete has inherent corrosion inhibiting property and shows a good result towards Natural Inhibitors. Geo polymer has more advantages than control mix concrete like reduction in carbondioxide emission, etc.., when gives good bonding with Natural Inhibitors still gives an additional advantage to the Geo polymer concrete respectively. So, We suggest the use of Geopolymer concrete as a perfect replacement for ordinary control mix concrete.

7. CONCRETE RESISTIVITY

The sodium nitrite inhibitors assumed a lower resistant position. This is in accordance with the previous study. The lower resistivity is due to higher ions as a result of the presence of sodium and nitrite in the aqueous phase filling the pores capillary according to Morris , Reinforcing steel are in active corrosion risk and when resistivity is below 10k Ω centimetre and attain passivity and resistivity greater than 30k Ω centimetre . Previously study reveals that resistivity above 20kΩ centimetre indicates negligible corrosion risks while between 10k Ω cm to 20k Ω cm suggest low corrosion risk . However 5% weight sodium nitrite exhibits a lower resistivity of about 15k Ω cm is experimentally confirmed by the above reasons . In addition it is also obvious to reiterate that sodium nitrite inhibitor gives optimum inhibition effect in concrete with inhibition composition between 2-3%wt by cement.


8. RESULTS AND DISCUSSION

Conventional Concrete with Chemical Inhibitor and Geo Polymer Concrete with Natural Inhibitor gives the best results.

Applying corrosion inhibitors on the surface of the steel is the best method (Economy basis & Skilled labour basis) ,when compared with Epoxy coating, Cathodic protection and High density concrete . Most preferences that we give is Geo Polymer Concrete reinforcement with Natural Inhibitors. Certain Natural Inhibiting agents are present abundantly in nature that can be used for corrosion.Natural inhibitors are more environmental friendly and are more sustainable than Chemical Inhibitors.Geo polymer concrete has more advantages in all aspects than ordinary control mix concrete. Since our results projects the Natural Inhibitors have better inhibition with Geo polymer concrete both the concrete and the Inhibitors are eco-friendly and brings out a sustainable environment.When the Chemical Inhibitors are handled by the labors without their knowledge they are infected to certain diseases by the chemicals that they handle. Instead the Natural Inhibitors gives no such problems for the workers who handle it.

COMPARATIVE RESULTS
INHIBITION EFFICIENCY
Efficiency in PERCENTAGE(%)
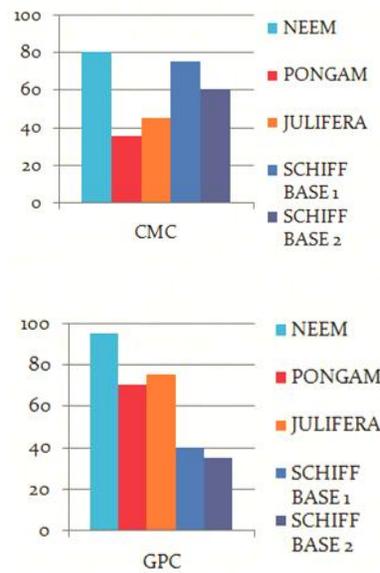
INHIBITOR CONCRETE	NEEM	PONGAM	JULIFERA	SCHIFF BASE 1	SCHIFF BASE 2
CMC	80	65	70	82	60
GPC	90	85	80	55	58
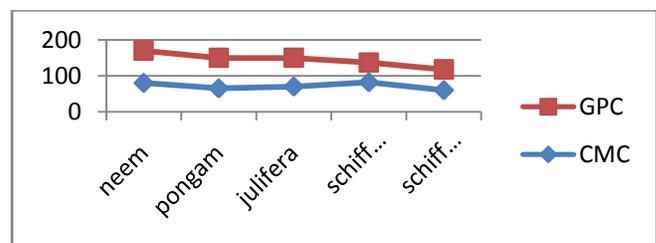
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