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Electrochemical Tests for Quality Asssesment of Structural Concrete

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Abstract:- Light weight concrete (LWC) is gaining momentum in construction industry in recent days due to various advantages that inherently it possess. As a next generation of LWC a floating concrete is becoming popular in countries like Singapore, Malaysia, and Norway. These are used in marine environment for construction of floating structures such as bridges and floating platforms for many purpose and other offshore structures. When these structures are constructed in marine environment budded with reinforcement is like to get corroded and where by durability problems start. Therefore it is essential to study the corrosion behavior of reinforced lightweight – floating concrete. In this paper various electrochemical test are described to study the corrosion and durability aspects.

Keywords:- Electrochemical,Durability, Lightweight, Chloride ion, Calicum leaching, Impressed voltage.

I. INTRODUCTION

Concrete is most versatile construction material used in construction industry starting from ordinary platform to many mega structures, multi storey buildings, industrial structures, marine structures, bridges across the sea and many other structures. The concretes being popular construction material due to its cast ability to any shape and size with or without reinforcement. In present scenario light weight concrete plays a major role in construction industry due to its reduced density, and there by reduction of weight of structure on foundation. In addition to this light weight concrete provides other beneficial effects such as thermal insulation, sound insulation and fire resistance properties. Normally light weight concrete which has got cube compressive strength more than 17Mpa is considered for structural load bearing elements. The reduced dead weight of structure on the soil or earth reduces the cost of construction and their by reduction of steel. [1] The thermal insulation property of light weight concrete reduces the energy consumption. In addition above advantages of lightweight concrete said above the benefit of floating light weight concrete has been utilized in East Asian countries for the construction of floating platforms on seas for housing and marketing, these structures floats on sea water with due anchorages with sea bed. It is essential to test this light weight concretes for its durability particularly in coastal marine environment. In other words it should be tested for electrochemical respond and corrosion of steels.[2] A long-term forecast technique of Ca leaching and a long-term forecast technique of the degeneration with calcium leaching were proposed, and the prediction was carried out.[3]In this study, a short-term immersion test and mathematicalmodel were developed to evaluate the chloride ion diffusion coefficient of concrete structures exposed to marine environments.[4]

II. ELECTROCHEMICAL DURABILITY TESTS

a. Chloride Ion Penetration Test

This test is conducted as per ASTM C 1202.The schematic arrangement is shown in Fig. 1. There are two PVC components each measuring 800ml capacity. In one components 3% NaCl solution is filled and in other 0.1% of NaOH. The concrete specimen of size 100mm diameter and 50mm long cylindrical specimen is cast and cured for 28 days is used for testing after its cured and dried the cylindrical surface is coated with airtight paste. So that the leakage of solution is arrested. This cylinder specimen is inserted in PVC liquid containing shells as indicated in fig. 1.The circumferential periphery is sealed with M seal for no leakage in shell. A potential of 60 volt DC is applied across the specimen using a power source of capacity 60 volt DC and 5 Amperecapacity. Now the both circular surfaces flag it. The duration of test is 6 hours continuously. To begin the test switch on the power source and limit the potential to 60 volt DC with fine tuning arrangements and immediately measure the current. This current corresponds to zero seconds. The similar operation has to be done for every 30 minutes for measuring the current up to 6 hours duration. The charge passed is calculated in coulombs equation by using the

$Q = 900(I_0 + 2I_{30}+2I_{60}+..........+2I_{300}+2I_{330}+I_{360})$ (1)

Where

Q = charge passed (coulombs)

I_{cr}= current (amperes) immediately after voltage is applied, and

I_r = current (amperes) at t min after voltage is applied.

If the specimen diameter is other than 3.75 inches, the value for total charge passed established in as per eqn.(1) must be adjusted. The adjustment is made by multiplying the value established by the ratio of the cross sectional area of the standard and the actual specimens.

$Q_s = Q_x \text{ X } (95/x)^2$ (2)

Where

Qs = charge passed (coulombs) through 3.75inch(95mm) diameter specimen

Q_x = charge passed (coulombs) through x inch diameter specimen

X = diameter (inch) of the standard specimen.

The chloride ion penetration is ranked as shown in table 1 as per ASTM C 1202.

Table 1 Chloride Ion Penetrability Based on Charge Passed

Charge Passed (Coulombs)	Chloride Ion Penetrability
>4000	High
2,000-4,000	Moderate
1,000-2,000	Low
100-1,000	Very Low
<100	Negligible

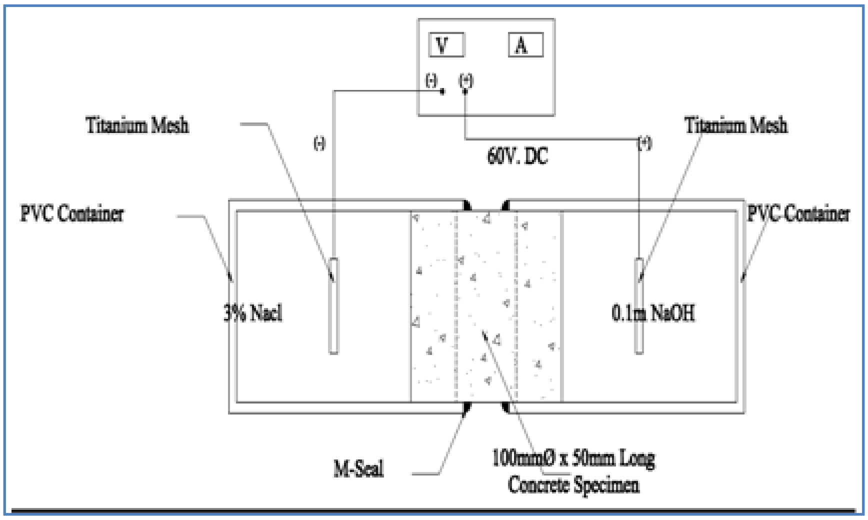

Fig.1 Test Setup for Cholride Ion Penetration

b. Impressed Voltage Test

The Fig. 2 shows set up for impressed voltage test in which container contains 3% of NaCl (equivalent to sea water). The lollypop specimen is made of test concrete with concentrically placed steel rebar of 12mm diameter is placed in the solution and perfected stainless steel plate is placed around the lollypop specimen in the container. A positive terminal from the power source is connected to steel rebar and stainless steel is concocted to negative terminal. A 12 volt DC is applied across the cathode and anode. Now the current is measured and the voltage is continuously impressed in test specimen so that the anode or ion steel reinforcement is accelerated to corrode electrochemically. At every 3 or 6 hours interval, the current is measured and every day the specimen disconnected and taken out and inspect for any development of cracks or rust oozes-out. The test is conducted until a crack is developed. The time period taken for development of crack in specimen determines the durability. If should be noted on development of cracks the current shoots up (very sharply on formation of crack). This crack is usually developed due to expansion of rust within the concrete. The higher the time taken the beat in the concrete. The poor concrete will crack very soon. This is an important test.

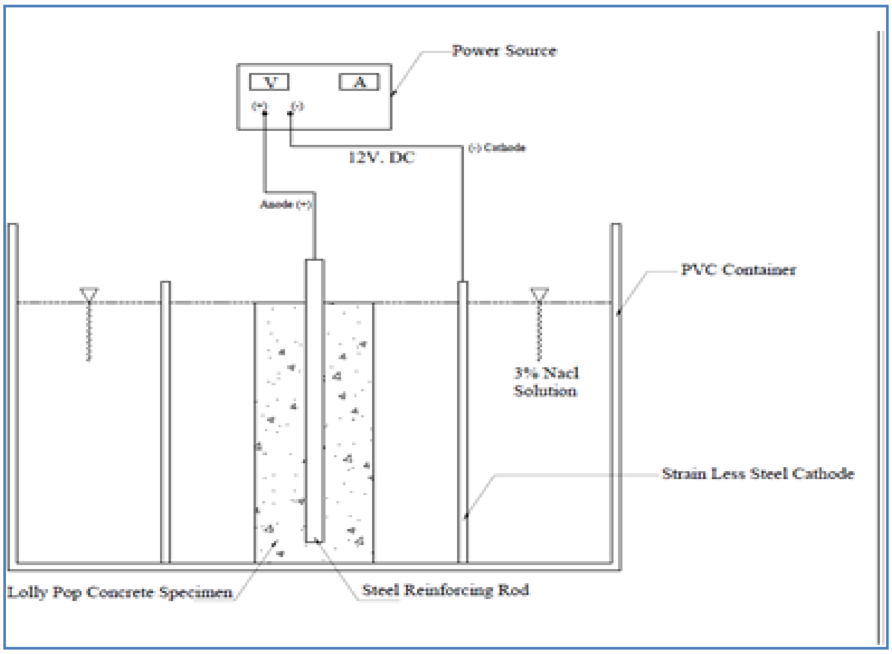

Fig.2 Test Setup for Impressed Voltage

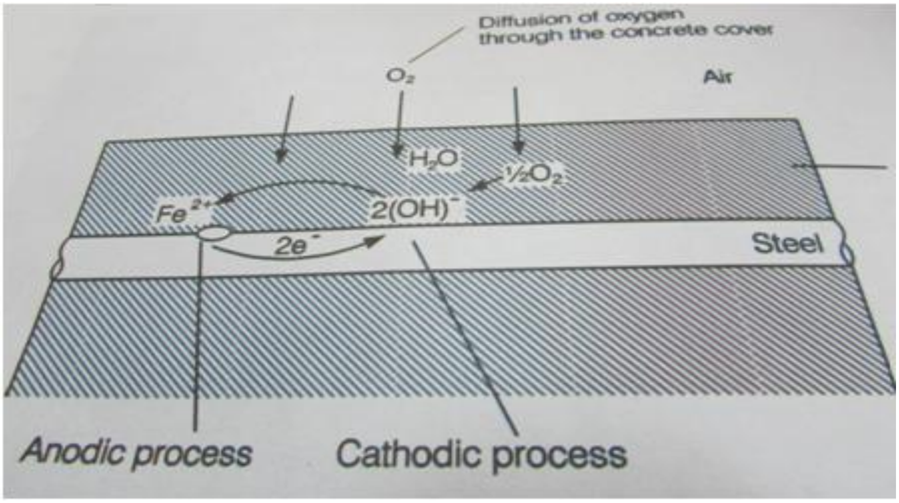

Fig.3Simplified model of the corrosion of reinforcement in concrete

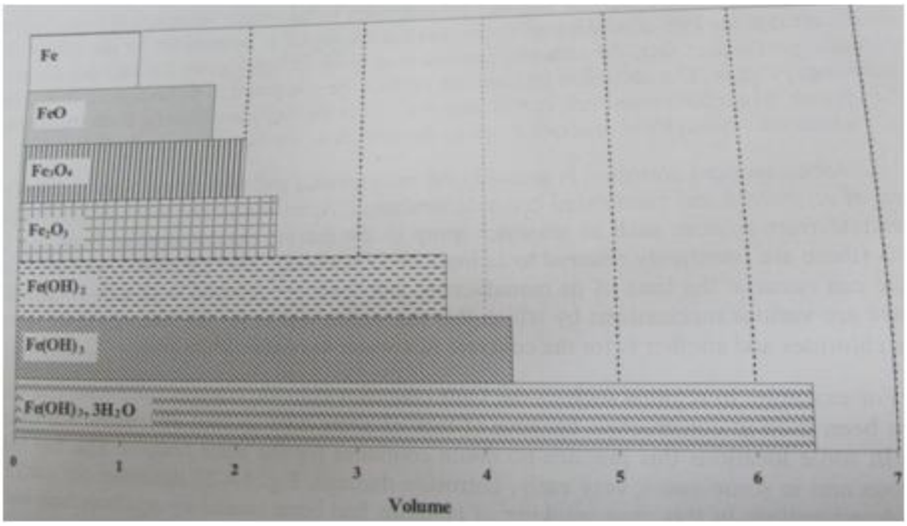

Fig.4 Relative volume of iron and of its oxides created during the corrosion (Ref. 8)

c. Electrochemical Leaching Test

Electrochemical leaching test is carried on concrete to access the leaching capacity of calcium ions, which forms a main component (calcium silicate) for strength and durability. It is an important test for durability. This test helps to access the combining capacity of calcium with fine aggregate. In this test the container is filled distilled water and anode and cathode electrodes are messed (electro codes) are placed as shown in figure on either side of cone specimen. The current density was $5.0 A/m^2$. The five lengths of current application were 100, 200, 400, 800 and 1200 h. As a result of preliminary tests, the current density was chosen considering both the facts that Ca^{2+} mobility are low, and that heat production at high current density is undesirable. Using ion chromatography, the amount of Ca leaching was measured. Fig. 5 shows the test arrangement for electrochemical leaching test.

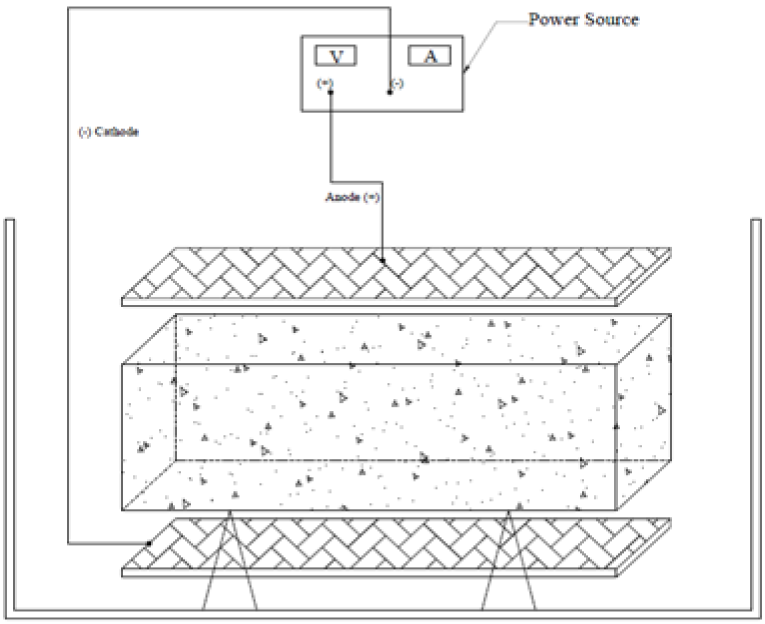

Fig.5 Test Setup for Electrochemical Leaching test (Ref. 8)

d. Carbonation of Concrete

The carbon di oxide present in atmosphere can penetrate through concrete through pore solution. The pore solution contains calcium hydroxide. This carbon di oxide combines with calcium hydroxide and forms calcium carbonates and carbonic acid. This carbonic acid reduces the pH of concrete to greater extend. For example from pH 12.5 to 13.5 to around 9, this leads to uniform corrosion of steel in concrete in Fig. 9. The depth of carbonation can be identified and measured by cutting the concrete or breaking or opening and spray one strength phenolphthalein solution on cut surface. The carbonated surface will not show any colour change(Fig. 7), the uncarbonated surface (Fig. 8) will turn to pink in colour to avoid carbonation of concrete the surface coating of concrete is suggested.

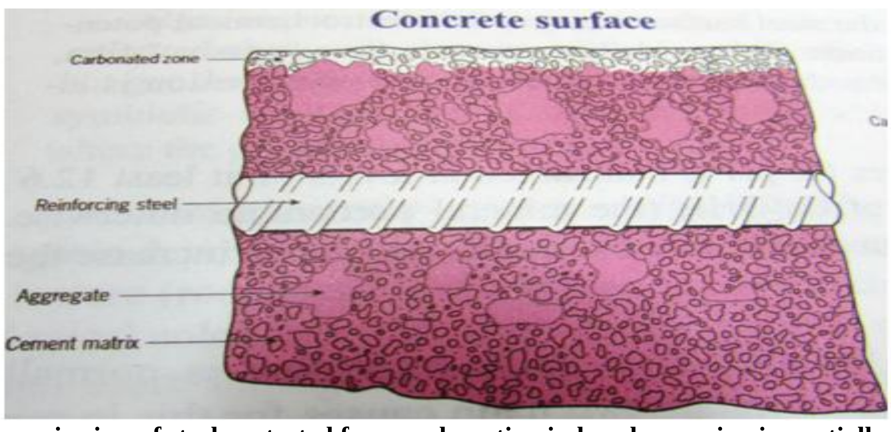

Fig.6 Diagrammic view of steel protected from carbonation induced corrosion in partially carbonated concrete (Ref. 8)

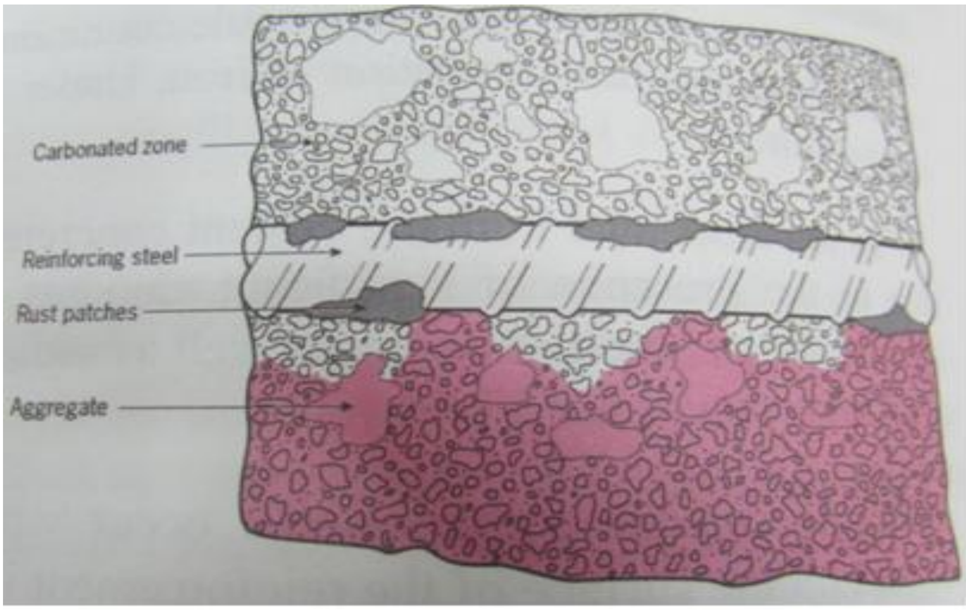

Fig.7Diagrammatic view of steel corroding in carbonated concrete (Ref. 8)

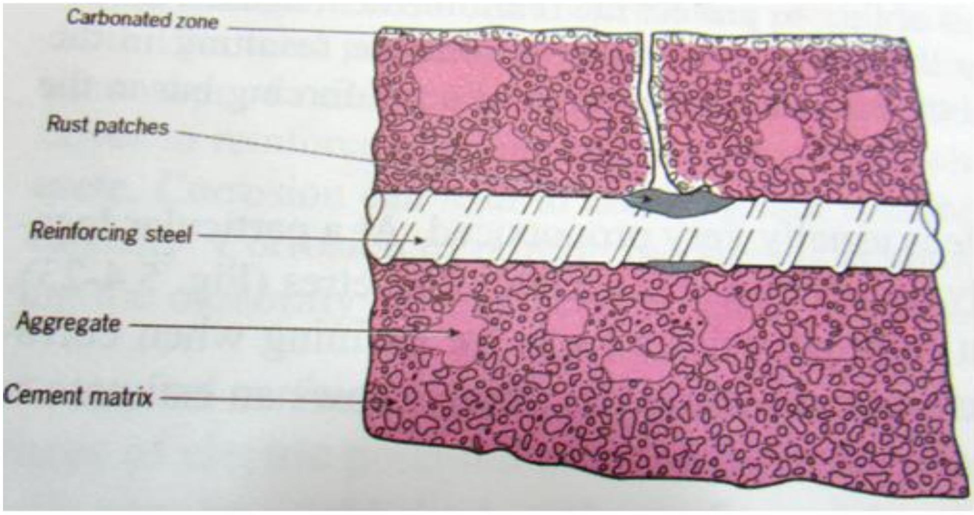

Fig.8 Diagrammatic view steel corroding in cracked concrete

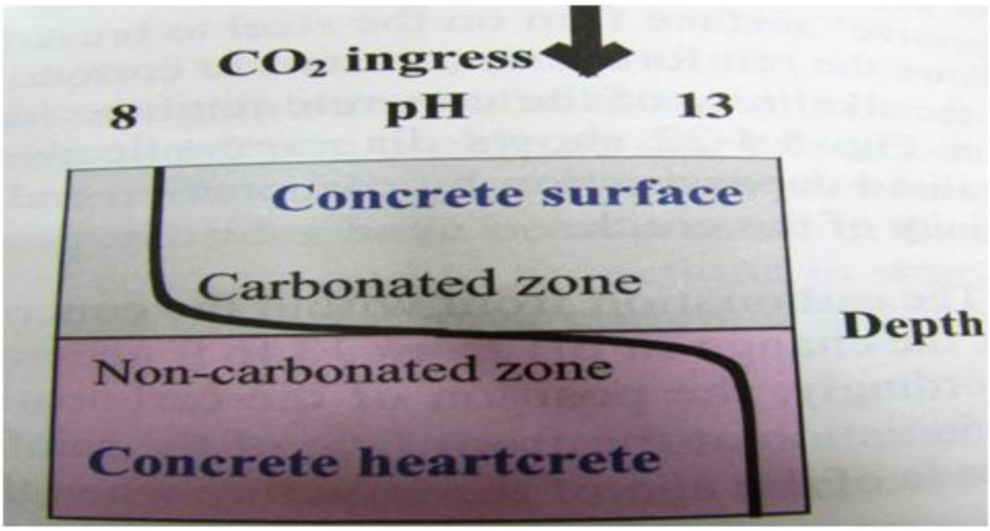

Fig.9Conceptual model showing the typical shape of a carbonation front

III. CONCLUSION

There are several electrochemical tests for durability assessment of concrete, in this paper four important tests are explained and further tests can be referred on standard books in electrochemistry tests.

ACKNOWLEDGEMENT

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