An Experimental Investigation for the Permeability of Chloride in Admixtured Cement Mortars using Rapid Chloride Permeability Test Apparatus

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Abstract— In the present investigation an attempt is made to find out electrical conductance of the cement towards the penetration of chloride ions by replacing the cement with different mineral admixtures. The methodology involved in this study follows the codal specifications of C1202-05.This is most important and advantageous method for the rehabilitation of structures and for different studies.

Key words: Fly Ash, Ground Granulated Blast Furnace Slag (GGBS), Microsilica, Rice Husk Ash (RHA)

I. Introduction

The transport of chloride ions into concrete is a complicated and mechanistic phenomenon. It is important to understand some of the basic concepts underlying chloride ingress into concrete to enable the proper consideration of this eventuality when designing structures in extreme environments with reinforced concrete. At the present time this is the only test method that is widely accepted by concrete industry. As more and more experience is gained with this test as well as with other test methods new procedures may be developed that measure concrete permeability more accurately. This test method covers the determination of the electoral conductance of the concrete to provide a rapid indication of its resistance to the penetration of chloride ions. This test method is applicable to types of concrete where correlations have been established between this test procedure and long term chloride ponding procedures. This test method covers the laboratory evaluation of the electrical conductance of concrete samples to provide a rapid indication of their resistance to chloride ion penetration. In the most cases the electrical conductance results have shown good correlation with chloride ponding tests. The Permeability of concrete depends on the pore structure of the concrete, while electrical conductivity or resistivity of concrete is determined by both pore structure and chemistry of pore solution .Factors that has little to do with the transport of chloride, can have great effects on electrical conductivity of concrete. Thus, the electrical conductivity or resistivity of concretes cannot be used as an indication of their permeability. However, it can be used as quality control indicators when the concretes have the same components and mixing proportions. Supplementary cementing materials such as silica fume,flyash and ground granulated blast furnace slag may have a significant effect on the chemistry or electrical conductivity of pore solution, depending on the alkali content of the supplementary cementing material, replacement level and age, which has little to do with the chloride permeability. The effective diffusivity of an ion in a hardened cement and concrete can be related with the electrical conductivity of concrete through some other parameters. However these parameters are too difficult to be determined that it is practically not feasible to use the electrical conductivity of concrete as a direct indication of diffusivity of the ion. The Rapid chloride permeability test method has proven to be a rapid and effective test method for different types of concrete or concrete containing conductive materials.

II. Materials used

Ordinary Portland cement (ZUVARI 43 GRADE CEMENT), Portland Slag Cement (ULTRATECH CEMENT). Micro silica (also known as condensed silica fume or silica fume) was first tested in 1947, and related tests revealed a variety of potential application benefits. Micro silica is co-product of the Ferro-silicon alloy industry. The fumes collected from the smoke stack of one of the smelting plants showed a very high content of amorphous silicon dioxide-nearly over 90%, realizing Pozzolanic potential of this material. Micro silica 920-D used in the present study was obtained from Elkem India Pvt. Ltd., Mumbai. In the present study Fly ash is collected from Ennore thermal power station, Chennai. It is conformed to grade1 of IS: 3812-1981.Rice milling generates a by product know as husk. This surrounds the paddy grain. During milling of paddy about 78 % of weight is received as rice, broken rice and bran .Rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. This husk contains about 75 % organic volatile matter and the balance 25 % of the weight of this husk is converted into ash during the firing process, is known as rice husk ash (RHA). This RHA in turn contains around 85 % - 90 % amorphous silica. Rice husk, from the locally grown mixed varieties was produced from rice mills in the locality and used. The rice husk procured thus was incinerated in open air. Blast furnace slag is developed during iron production. Iron ore is reduced to a molten state by burning coke fuel with fluxing agents of limestone and/or dolomite. Ground Granulated Blast Furnace Slag (GGBFS) is a glassy, granular material resulting from blast furnace slag being rapidly cooled by water immersion, and pulverized to a fine, cement-like material. Slag is produced from Lanco steel plant, Sri Kalahastri.

III. EXPERIMENTAL PROGRAMME

First of all cylinders of 1:3 mix is prepared with the dimensions of 10.2cm in diameter and 20cm height. The casted cylinders should be set for proper curing.

- After completion of curing the sample should be cut into 5.1cm thickness.
- The prepared samples should be kept in mould of RCPT apparatus.
- Silicone sealant should be applied to the walls of the sample to avoid leakage.
- The moulds should be filled with the NAOH solution (+ve) and NACL solution (-ve).
- A Potential difference of 60V should be maintained.
- Readings should be noted for every 30min up to 6hrs.
- The obtained readings should be substituted in the formula below:
- I cumulative=I0+((I30+I60+I90+I120+I150+ I180+ I210+I240+I270+I300+I330)x2)+I360

IAVERAGE=900 X ICUMULATIVE,

Where I=Current Reading In mille amperes

The obtained values should be compared with the table below and the result is determined.

Charge Passed in Coloumbs	Chloride Ion Penetrability
>4000	HIGH
2000-4000	MODERATE
1000-2000	LOW
100-1000	VERY LOW
<100	NEGLIGIBLE

Table 1: Comparison of values from the Results

IV. TEST RESULTS

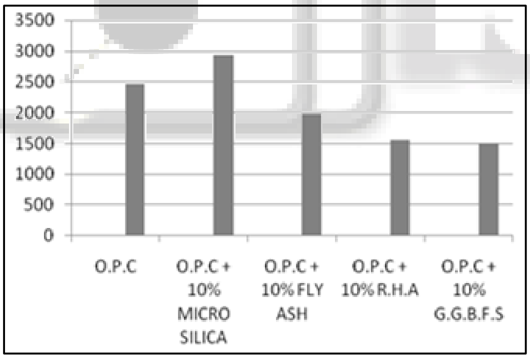

Fig. 1: Test Results

Sl. No	Cement + Admixture	Penetrability of Chloride
1	OPC	Moderate
2	OPC + 10% Micro Silica	Moderate
3	OPC + 10% FLYASH	Low
4	OPC + 10% RHA	Low
5	OPC + 10% GGBFS	Low

Table 2: Determination of Penetrability of Chloride in Ordinary Portland cement

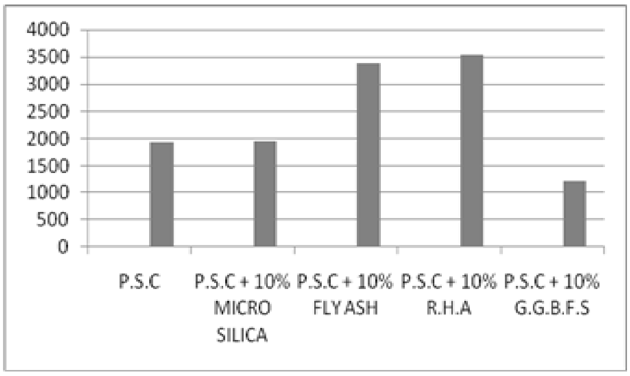

Fig. 2: Test Results

Sl. No	Cement + Admixture	Penetrability of Chloride
1	PSC	Low
2	PSC + 10% MICRO SILICA	Low
3	PSC + 10% FLYASH	Moderate
4	PSC + 10% RHA	Moderate
5	PSC + 10% GGBFS	Low

Table 3: Determination of Penetrability of Chloride in Portland Slag Cement

V. CONCLUSIONS

From the above discussions it is noticed that resistance offered to the penetration of chloride ions is more in case of Ordinary Portland Cement when compared to that of Portland Slag Cement. However the efficiency is increased when it is mixed with the mineral admixtures such as Micro Silica, Rice Husk Ash, Ground Granulated Blast Furnace Slag and Fly Ash.

The numerical results (total charge passed, in coulombs) from this test method must be used with caution, especially in applications such as quality control and acceptance testing. Care should be taken in interpreting results of this test when it is used on surface treated concretes, for example concretes treated with penetrating sealers. The results from this test on some such concretes indicate low resistance to chloride ion penetration, while 90-day chloride ponding tests on companion slabs show a higher resistance.

This test method can produce misleading results when calcium nitrite has been admixed into a concrete. The results from this test on some such concretes indicate higher coulomb values, that is, lower resistance to chloride ion penetration, than from tests on identical concrete mixtures (controls) without calcium nitrite. However long term chloride ponding tests indicate the concretes with calcium nitrite were at least as resistant to chloride ion penetration as the control mixtures.

Since the test results are a function of the electrical resistance of the specimen, the presence of reinforcing steel or other embedded electrically conductive materials may have a significant effect .The test is not valid for specimens containing reinforcing steel positioned longitudinally that is, providing a continuous electrical path between the two ends of the specimen.

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