Understanding of electrical properties

1. Introdution

The corrosion of steel in concrete is an electro-chemical process which creates a current flow causing rebars to dissolve therefore it could be assess the probability of corrosion of steel by evaluating the electrical resistance of the concrete. The factor is measured in terms of resistivity and expressed in Ohm.

The electric resistivity of concrete is one of the major parameters which are controlled the propagation of reinforcement corrosion. Electrical properties are of concern in some specific applications such as railway ties or in structure in which concrete is used for protection from stray currents. Electrical resistance of concrete also influences progress of corrosion of embedded steel. Electrical properties are also of interest in studies of the properties of both fresh and hardened concrete and effective of admixture on it.

Admixture generally do not reduce the resistivity of concrete, however, special addition can be use to vary the resistivity. For instance the addition to concrete of finally divided bituminous material, with subsequent heat treatment increase the resistivity, especially under wet conditions.

It is common knowledge that there is a strong relationship between resistivity and permeability of concrete because basically we are interest in measuring the (pore connectivity which is function of resistivity) therefore it is Useful to clarify the permeability and the porosity.

1. 1 Permeabilty

Permeability is the ease with liquid or gases can travel through concrete. This property is of interest in relation to the water-tightness of liquid retaining structure and to chemical attack.

Although there is no prescribed test by BS and ASTM, the permeability of concrete can be measured by means of a simple laboratory test but the results are mainly comparative and also it can related to electric resistivity measuring. In such test the sides of a concrete specimen are sealed and water under pressure is applied to the top surface only. When steady state condition has been reached the quantity of water flowing through the concrete sample in given time is measured. The permeability is not a simple function of its porosity, but depends also on size, distribution, shape, tortuosity, and continuity of the pores. .(Neville, 1995)

1. 2 Porosity

Strictly speaking, strength of concrete is fundamentally a function of volume void in it. And it influence by entrapped air, capillary pores, gel pores and entrained air, if present.

Fresh cement paste is a plastic network of particles of cement in water but, once the paste has set, it’s apparent or gross volume remains approximately constant. The paste consists of hydrates of the various cement compounds and of Ca(OH)2, and the gross volume available for all these products of hydration consists of the sum of the absolute volume of the dry cement and the volume of the mix water. In consequence of hydration, the mix water takes one of three forms: combined water, gel water and capillary water.

1. 3 Electrical resistivity of concrete and its role in corrosion

The electrical resistivity of concrete plays a major role in the steel rebar corrosion. If the concrete has low resistivity (high conductivity), there is a high chance for corrosion cells to develop due to high ions concentrations at the rebar level as opposed to low conductivity concrete. Corrosion of steel occurs because of electro-chemical action which is usually encountered when two dissimilar metal are in electro contact in presence of moisture and oxygen. However the same process takes place in steel alone because of the electrical-chemical potential on the surface which forms anode and cathodic regions. When chlorides are present and with low resistivity of concrete, more ions are present for this process to mobilize and spread corrosion. The corrosion that take place is manifested as the formation of corrosion, which when it is constituted has an expansive reaction. When the corrosion expands, the concrete is no longer able to withstand the cracks and tensile forces. Cracking and spalling fetches more water, air, and the ions entering very quickly when cracks are exists, and thus propagate the corrosion. Conversely, with a concrete has low permeability there are less chloride ions present, therefore the reaction is much slower if it develops at all. This induces a sustainable structure caused by the reduction of corrosion in the reinforcement. The strongly alkaline nature of Ca (OH)2, of pH13 prevent the corrosion of the rebar by formation of a thin protective film of iron oxide on the metal surface, this protection is known as passivity. However, if the concrete is permeable to the extent that carbonation reaches the concrete in contact with steel or soluble chlorides can penetrate right up to the reinforcement, and water and oxygen are present, then corrosion of reinforcement will take place. The passive iron oxide layer is destroyed when

pH falls bellow about 11 and carbonation lowers the pH to about 9. These reasons are why we are measuring the resistivity of concrete is crucial in concrete buildingcontaining steel rebar. Hammond (2010)

1. 4 Test of Conductivity and Resistivity

The 4-point electrical measurement testing method (Wenner linear array), figure (1. 1) was used by geologists to measuring the resistivity of soil; it has since been revised for use in testing some materials such as concrete. This method is one of the most commonly technique is used for measuring concrete resistivity, by using AC current. This method contains a 4-poin probe device (as shown in fig1. 1) used to measure the electrical resistivity of a concrete, a small AC current, passes between the outer contacts, the result is difference of potentialbetween the two inner contacts. The resistivity of concrete is calculating by equation (1. 1). This technique for this purpose is relatively new, about 11 years ago has been used for measuring the resistivity of concrete.

? = 2a?

Where, ? is resistivity, a is spacing between probes, V is Potential difference between inner contacts, I is current passed between outer contacts.

Figure 1. 1 wenner 4-point resistivity meter

1. 5 The electrical properties of cement and concrete

The electrical properties of concrete and cement are extremely variable and it depend on the size and shape of the particle, the mix proportions including the type and grading of aggregate, the age and curing conditions and the

moisture content as determined by water/cement ratio and subsequent drying or moisture absorption.

The most important electric properties of concretes and cements are their resistance to both direct and alternating current and their dielectric strength.

The resistance can be of two form, volume resistance and surface resistance and it is through afailureto separate those two that much of the early work on the subject exhibits such inconsistence. (Orchard,)

It is difficult to generalise on the resistance of cement paste and concrete as it is so variable and depends on many factors. As very rough guide, however, the volume resistivity of a freshly made cement paste may be 1/5000 of a megohm centimetre and may rise to 1/20 of a megohm centimetre after storing in air for long time.