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Deterioration of Modern Concrete Structures

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ABSTRACT—
We are experiencing a growing interest in the field of building construction using the latest technologies. Many concrete structures have been constructed in India. But still in country like India the problems of deterioration of concrete structures prevails. Some concrete structures show severe deterioration and need repair or strengthening to keep their serviceability. The causes, precautions and solutions to such problems are described in our paper. Development of strategic maintenance is the highest priority under the background of aging of huge amount of stock of concrete structures and restrained budget. I.C.I has been undertaking comprehensive research projects for effective maintenance techniques for existing concrete structures. As part of the research, we carried out nationwide survey of soundness of concrete structures and maintenance cost of concrete structures deteriorated due to physical, mechanical, chemical attacks. In this paper, the research results are introduced and discussed to recognize importance of preventive maintenance against deterioration of structures. Building practices in the past have not properly addressed the current concerns about the optimum use of energy in buildings or the minimizations of the environmental effects. In addition aging installations and facilities result in an even grimmer scenario. This does not finish here the factor we are accounting is in association with the concern for deterioration of structures which causes the environment to aggravate.

Key Words: — concrete deterioration, causes, preventive measures, life cycle

INTRODUCTION

Many civil concrete structures have been built in India, many of which keep good performance and satisfy their intended service ability. However some concrete structures show deterioration and need repair or strengthening to achieve their service life. It is very important to establish strategic maintenance programme for the existing civil concrete structures. The exceptional durability of Portland cement concrete is a major reason why it is the world's most widely used construction material. But material limitations, design and construction practices, and severe exposure conditions can cause concrete to deteriorate, which may result in aesthetic, functional, or structural problems.

I.C.I carries out comprehensive research and development on strategic maintenance for existing concrete structures. This paper outlines research results on current state of performance of existing concrete structures, maintenance cost of concrete structures deteriorated by physical, chemical and mechanical attacks.

RESEARCH ON DURABILITY PERFORMANCE

Aggression By Carbon Dioxide

Aggression due to CO2 may be manifested in two different ways according to the surrounding conditions. In constructions exposed to the atmosphere, carbonation of concrete takes place, while in hydraulic constructions,

there is a phenomenon known as leaching which acts upon the cementious paste. Carbonation is due to the penetration of CO2 into the concrete. This phenomenon consists in the transformation of the lime, which then generates hydration of the cement into calcium carbonate due to the presence of carbon dioxide, the level of which depends on the environment in which the construction is located (the amount of industrial pollution in the area, for example).

Aggression By Sulphates

The most common soluble sulphates in the ground, in water and in industrial processes are calcium and sodium. There are also magnesium sulphates, but these are less common, although they are more destructive. Sulphate ions may be present in water and in the ground, and they may also be found directly in the aggregates as impurities. If the sulphates come from the ground or from the water in contact with the structure, the sulphate ions carried inside the cementations matrix by water (fundamental for transportation) reacts with the calcium hydroxide to form gypsum Aggression By Chlorides Aggression by chlorides on concrete occurs if it is in contact with environment with a high chloride content, such as seawater or de-icing salts, or if it is prepared using contaminated raw materials. Once the chloride penetrates into the concrete and reaches the reinforcement rods, it eliminates the passivating ferrous oxide film on the rods so that they are exposed to the corrosion process. Penetration starts on the surface and continues into the concrete. Penetration time depends on:

- The concentration of chlorides which come into contact with the surface of the concrete;
- Permeability of the concrete;
- Percentage of humidity present.

Causes of deterioration and their circumstantial evidence

Cause of deterioration	Circumstantial evidence
low-quality concrete	· noticeable honeycomb, cold joint and segregation of coarse aggregate · noticeable surface staining caused by efflorescence · excessive erosive-wear · noticeable cracks
shortage of cover concrete	· appearance of reinforcements on the surface of concrete · noticeable surface staining caused by corrosion (but chloride cannot be brought from outside)
alkali-aggregate reaction	·characteristic cracking pattern of alkaliaggregatereaction
chloride attack	· rusty reinforcements · circumstance where chloride can be brought from outside (as airborne salts or deicing salts)
frost damage	· scaling of concrete · circumstance where freezing and thawing action would occur
uncertainty	· difficult to estimate

Alkali-Aggregates Reaction

An alkali-aggregates reaction may cause considerable expansion and serious deterioration of concrete structures. Some types of aggregate, such as those which contain reactive silicon, react with two alkalis contained in the cement, potassium and sodium, or as mentioned in the previous paragraph, with those which come from the surrounding environment in the form of sodium chloride (NaCl) (de-icing salts or seawater). This reaction forms a gel which is highly expansive if exposed to humidity, and the gel creates forces which break the concrete around the aggregates. The alkali-aggregate reaction is a process which takes place slowly and heterogeneously, since it is bound to the composition of the aggregates containing amorphous silicon. The product of the reaction under such conditions is sodium silicates and hydrated potassium, which are very voluminous.

Shrinkage and Cracking

This section discusses two types of shrinkage, plastic and hygrometric. Plastic shrinkage occurs during the plastic phase of concrete, when it releases part of the humidity contained within it into the surrounding environment, causing it to contract. Cracking in this case depends on the surrounding conditions when the concrete is cast. When cast into formwork, for obvious reasons, evaporation does not take place, whereas if the concrete is in direct contact with the surrounding environment, evaporation occurs because of the temperature, very low external humidity or strong winds. When plastic shrinkage occurs while the concrete is fresh, micro-cracks may form on the surface. Hygrometric shrinkage is due to the release of humidity into the environment with a low level of R.H. during the entire service life of the structure.

In order to avoid the problems due to plastic shrinkage, precautions must be taken to avoid the water present in the mix evaporating too quickly, which may be done in various ways:

- By laying waterproof sheets on the casting, to block evaporation
- By spraying the entire surface during the first few days after casting
- By applying a protective anti-evaporation filming product on the concrete while still fresh.

Cracking By Crystallization of Salts in Pores

The crystallization of salts in the pores of concrete can produce stresses that may damage the concrete structure. This can happen when the concentration of the solute(c) exceeds the saturation concentration (Cs).
Higher C/Cs ratio (degree of super-saturation) produces higher crystallization pressure.

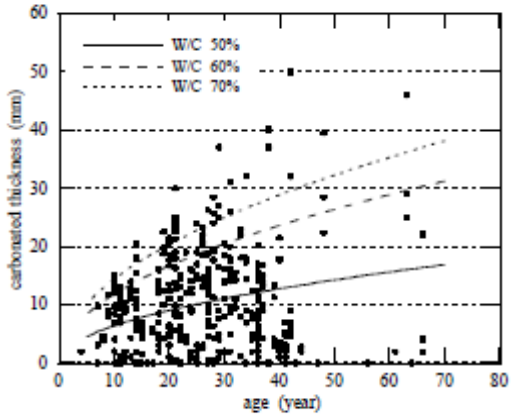

Fig.3 Carbonated thickness and age of structure

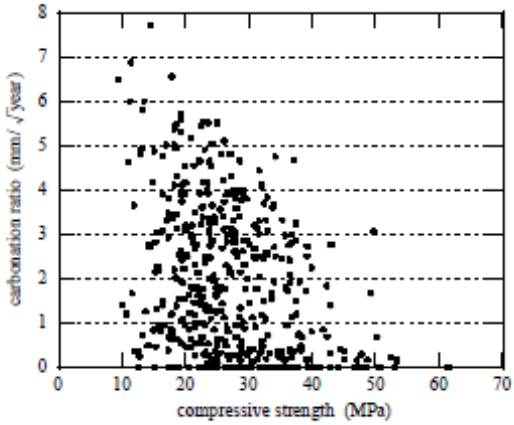

Fig. 4 Relationship of carbonation ratio and compressive strength

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