A review paper on Deterioration of Concrete in Marine Structures

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Abstract: The research and studies regarding concrete structures exposed to extreme environmental conditions are under development. The studies regarding service life and durability of structure in marine environment is also in progress. The paper emphasizes on the study of deterioration of concrete in marine structures. Temperature, moisture, biological factor and chemical factors are the influencing factors for deterioration of concrete in marine structures. The acids, salts and chlorine ions present in sea water act as an aggressive agent in the process of deterioration of concrete. The chlorine ion which is termed as an external agent is mainly responsible for depssivation of reinforcement and initiate corrosion. The process of deterioration also depends on position of concrete sections. The various position called as zones and are namely as follows submerged zone, tidal zone, splash zone and atmospheric zone.

The paper has future scope for study of various preventive measures that can be taken to avoid deterioration of concrete in marine structure during construction phase and to suggest various remedial measures for existing concrete structures exposed to marine environments undergoing deterioration.

1. Introduction

Concrete is a very important construction material. It is highly resistant to compression forces, but weak under traction forces. Durability of a reinforced concrete structure depends on the environment in which it is exposed, as also on the time and properties of concrete. Inner causes of damage are chemical reactions occurring inside concrete, volume changes caused by differences in physical and chemical properties of aggregates and cement paste and particularly to its water permeability. Durability of Concrete structures in marine environment has been an issue for many decades, due to the perception of sea water as aggressive to concrete and reinforcement and the long service life that is expected for marine infrastructure such as harbour and coastal defense structures. The deterioration of concrete exposed to marine environment is a result of collective action of physical, chemical and biological factors.

As demand for construction in harsh environments increases, so do the desired service lives of these structures. Typically, concrete structures are designed to perform, with minimal maintenance, 50 to 100 years. The formability of structural concrete represents its unique usefulness with remarkable architectural challenges. Thus it becomes an economic disaster when urban dwellings, large bridges, or major marine structures deteriorate just after a few years in service. The concrete provides reinforcing steel with an excellent corrosion protection under normal conditions. The high alkaline environment in concrete results in the formation of tightly adhering films which protects the steel from corrosion. Corrosion of reinforced steel occur in concrete due to poor quality, inadequate consideration of service environment or change in environment the service life of the concrete structures.

Many studies about deterioration of concrete in marine exposure are under development worldwide. However much more advanced knowledge in this area is still needed. With respect to deterioration, concrete structures have some important characteristic properties, which differ fundamentally from structures made from other structural materials. These properties are the following (fib 1999):

- The quality and the performance of concrete adopted at the design and contracting stages are assumed values.
- The true quality and performance characteristics of structural concrete are created through the actual execution process during construction on site. Hence, this very short period of time (hours and days) constitutes the most important phase during which the true initial qualities are established.
2. Literature Review

Title - Deterioration of Concrete Structures.

Author - Hitesh Kodwani

Harsh environmental conditions which cause physical and chemical degradation of concrete structures. There are several performance influencing parameters responsible for the deterioration of structures which includes carbonation, penetration of chloride ions, corrosion initiation etc. Visual characteristics are important part of preliminary investigation which includes surface scaling, spalling and cracking pattern etc.

Title - Reinforcement Corrosion Assessment through Half – Cell in Concrete Structure Exposed in Marine Environment

Author – Kishanrao M Godbole.

Reinforced Concrete structures deteriorate under water in the Marine environment. It is not the disintegration of concrete itself, but the electrochemical corrosion of the reinforcing steel. Corrosion of steel reinforcement is one of the main causes of damage in concrete structures. The most critical and serious problems to the durability and safety of concrete structures. The corrosion of reinforcement in under water of R.C.C. structures depends on the factors of steel, water cement ratio, concrete cover, salinity of water, here an attempt is made to know the corrosion of reinforcement in under water of concrete structures in conjunction with factors grade of concrete, construction material, design type, quality control measures used.

Title - Durability-Critical Issues for the Future

Author – Mehta

The progress of deterioration is closely related to the environmental and structural conditions a well-constituted, properly consolidated, and cured concrete continues to be substantially watertight and durable as long as capillary pores and micro cracks in the interior do not become interconnected pathways leading to the surface of concrete. This mechanism causes a gradual loss of water tightness. Then initiation and propagation of damage of Reinforced Concrete Structures (RCS) can occur due to the penetration of aggressive agents available in a marine environment (water, air, and ions such as Cl-, SO4=, Na+) through the interconnected porosity. Due to the expansive character of all the interactions between the RCS components (cement matrix, aggregate, reinforcing steel) on the one hand, and the aggressive agents on the other, damaging effects such as cracking, spalling, loss of mass, and strength reduction can occur and then increase more and more the permeability.

Title - Recurrent Studies of Chloride Ingress in Uncracked Marine Concrete at Various Exposure Times and Elevations.

Author - Sandberg

Another important consideration in both bridge decks and marine exposures is the potential for periodic wet and dry cycling. Periodic wetting due to tidal or splash action in marine structures, or periods of rain/snow and dry on bridge decks can allow chlorides to ingress at high rates during wet periods and then precipitate and deposit during dry periods, the increased Cl- concentration occurring in the splash zone and submerged areas relative to the dry regions. Even though Cl- contents can be very high in submerged areas, corrosion is of little concern due to the lack of O2 to carry out reactions at the cathodic site. It is only in the wet/dry areas of the splash and tidal zone where a supply of both chlorides and oxygen is present and corrosion rates are accelerated.

Title - Service Life Design of Concrete Structures - An Experience-Based Discipline Becoming Scientific

Author - Steen Rostam

With respect to service life design one of the most important decisions to be taken by the designer is the determination of the exposure conditions for which each member of a structure shall be designed, as the structure itself has decisive influence on the future micro-climate to be expected. The exposure shall be related to the type and severity of deterioration that may result from the exposure. In this respect a differentiation is needed between mechanisms deteriorating concrete and mechanisms leading to reinforcement corrosion. Different parts of a structure may therefore be in different exposure conditions.
Obvious examples are the submerged, the tidal, the splash and the atmospheric zones of a marine structure. Among the main deterioration mechanisms relevant for concrete structures chloride induced reinforcement corrosion is by far the most serious. In the following service life design will therefore focus primarily on chloride ingress and chloride induced reinforcement corrosion. The two phases of deterioration are the initiation phase. During this phase no noticeable weakening of the material or the function of the structure occurs, but the aggressive media overcomes some inherent protective barrier. The propagation phase. During this phase an active deterioration develops and loss of function is observed.

Title - On Site Monitoring of Corrosion of Marine Structure Using Self Sacrificial Galvanic Anodes – Case Study
Author – V. Rajendran

The experience of the marine engineers is that normally after the repair of the corrosion affected marine structures with the normal anti corrosive surface coating on the rebar’s gives way after a year i.e. the corrosion reoccurs resulting in repairment. In the case of self-regulating sacrificial anodes i.e. the galvanic protection system is serving well and from the half-cell potential readings, this may continue to perform well for a few more years without any problem. In addition to that, even if the corrosion reoccurs after say 5 years, it is required only to cut open the particular place to install another piece of self-regulating anode rather than redoing the entire operation.

3. Scope, Methodology and Purpose

3.1 Scope:-
Following are the objectives of the proposed dissertation work.

a) To study and identify the factors causing deterioration of concrete in marine exposure.

b) To study and understand precautionary measures taken to avoid concrete deterioration.

c) To identify the various methods adopted for to control the further deterioration of concrete structure exposed marine environment.

d) To give suggestive recommendations in order to avoid further deterioration of concrete in existing case study.

3.2 Methodology:-
For carrying out the proposed work, following methodology will be adopted for data collecting and analysis.

a) Collection of information through literature review and or preliminary study of the factors causing deterioration of concrete in marine exposure.

b) To study and understand precautionary measures taken to avoid concrete deterioration.

c) To identify the various methods adopted for to control the further deterioration of concrete structure exposed marine environment.

d) To give suggestive recommendations in order to avoid further deterioration of concrete in existing case study.

3.3 Purpose of Dissertation:-
The proposed work will help to understand the various methods which can be adopted for controlling the deterioration of concrete in structures exposed to marine environment.

References


