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ASPECTS REGARDING OF SUSTAINABILITY OVER TIME REINFORCED CONCRETE STRUCTURES

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Abstract: *The paper presents several issues that could lead to increased durability while reinforced concrete structures. For most of the last type structures cannot count on systematic inspections or maintenance. In such cases it is advisable to design and execute a little more robust structure to ensure safety during the entire period of service required. Nonstructural elements as finishing and installation may have a shorter service life and even desirable, thus achieving more frequent repairs and modernization in accordance with the latest requirements.*

Key words: *Reinforced concrete durability, diagnosis, finishing materials.*

1. Introduction

The modern concept of sustainability for concrete structures developed last them decades primarily by CEB and FIB seeks to ensure a rational design and coherence for service life and is based on models of engineering principles which describe the mechanisms of deterioration that affect resistance, the functionality and sustainability. The models are based on engineering knowledge in a wide range of disciplines such as: structural analysis, materials technology, how to design, code of design, execution mode, statistics, economics, etc.

Due to its excellent overall properties, more than hundred years background, and constantly increasing performance, concrete is the most widespread and internationally used construction material, being no other material so versatile and cost-effective. When compared to equivalent materials, concrete permits to obtain more durable and economical structures. Regarding these factors, durability problems are among the more questioned aspects nowadays. Repair actions of reinforced and prestressed concrete structures are growing exponentially, mainly due to the corrosion of the steel.

It is well known that the properties of chloride ion and sulfur ions penetration through concrete are the most important factors to evaluate the durability against corrosion of reinforced concrete structures [11].

2. Mechanisms of Deterioration

The mechanisms of deterioration that really shows the significance and importance are:

- corrosion of reinforcement followed by

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concrete damage;

- alkali-aggregate reaction;
- concrete carbonation;
- chemical Attack;
- repeated freeze and defrosting action.

All mechanisms of deterioration listed above are great extent influenced by the following parameters:

- Water if it is in abundance can cause: enlargement of cracks, especially if accompanied by periods of frost, wash and drain the concrete, allows the dissolution of salts damaging the concrete, facilitates the penetration of potentially harmful substances, participate in reinforcements oxidations, etc.
- salts: salt based chlorine are some of the most harmful materials to which concrete can be exposed; salt of de-icing can cause thermal shock and cracking concrete; salt is hygroscopic and retains water, in this salt the concrete is difficult to dry and stop the damage developments.
- permeability and phenomena transport: initiation and propagation mechanisms of deterioration depends on some substances that penetrate through the surface to the inside concrete. Understanding and highlighting permeability areas are fundamental to performance structure; the penetration and the transport system are no linear in time (accelerated at the beginning); wetting and drying cyclic accelerates more aggressive penetration especially near the evaporation surface; a thin layer of concrete cover than anticipated in design can lead to severe shortening the length of service.
- environmental aggression: Definition and classification of aggressive environment in which it is placed structure is an essential part of the design process for service life, but at the same time is the weakest link in the chain decisions necessary for achieving sustainable structure in the long term, requiring research.
- Temperature variations may cause in reinforced concrete elements of a structure, additional internal tension by compression or stretching when growth occurs respectively decreasing temperature. If concrete element is prevented thermally expand, there is an increase in the stress with temperature difference. Internal tension is influenced by the thermal expansion coefficient and elastic modulus of the material.
- Action of rain: especially rainfalls can influence directly occurs over time with the abrasion phenomenon and depends on: tilt raindrops hitting the surface, the density drops, the speed of fall and others and indirectly degradation of concrete elements action is manifested by the appearance of blackish spots on the surface elements.
- Biological action and dust: Surfaces of concrete often provide proper conditions for the development of biological elements such as algae and lichens. Algae green or dark colours grow on wet concrete. There are certain algae that can live alkali surfaces, causing reduction of the pH of the surface of the concrete and finally, the onset of corrosion; dust in the air is transported and deposited by wind. Speed of movement of air masses increases with height, and effect is intensified by the dust from the street or from traffic.

All mechanisms of deterioration develop into a longer or shorter time duration depending on the factors described above. Whatever the mechanism, there are two phases:

- Initiation phase: an insignificant decrease in material properties or function of the structure, but some protective barriers are overcome by aggressive media (ex. carbonation, penetration chlorine, sulphates accumulation, the last two being accelerated by alternating wetting drying);
- Propagation phase: deterioration activate grow quickly and in some cases

accelerated (ex. corrosion of reinforcement).

3. Inspection, Maintenance, Repair, Consolidation

The issues durability of concrete products in the past, can be avoided in the future if necessary and make coordinated efforts in all phases of conception, design, construction and use of the building by the end of the life expectancy.

An important part of the entire process is the construction user who is normally responsible for maintaining the structure during use. The lack of attention or early intervention can help the unsatisfactory state of durability.

Conception and design must consider both the functionality required and the environmental conditions and duration of the proposed service. After handing over building it is important to start the maintenance through preparing an initial inspection and maintenance manual [10].

Quality records and inspection can provide useful knowledge, respective a basis for practice and future decisions. The work and responsibility of designers will become more precise and in many ways will be to extend his knowledge.

If an early inspection is done it would mean that preventive interventions will be made possible during the initiation phase of degradation. In this case it will be enough time for design, planning and achievement of interventions. Some sensitive parts of the structure may be subject to professional prosecution.

Repair costs depend largely on when they do these interventions during service.

Service life of reinforced concrete structures can be divided into the following phases:

Phase A: Design, manufacture, treatment

Phase B: initiation process is underway, but not yet started spreading damage.

Phase C: Starting propagation of damage.

Phase D: advanced stage of propagation occurrence of extensive damage.

Of concrete structures to ensure a satisfactory service life is necessary interventions at the propitious times. Costs for interventions increased several times if it goes into a higher stage.

For this reason must be introduced for inspection and maintenance techniques so that the existing structures have not progressed in phases C and D. It is important that in the initial stages of the construction process the investor to take longer term decisions based on technical and economic information rigorous.

When applied in practice the concept of service life must be considered the owner position. Thus for industrial structures or artwork can be only one owner over the entire service life, while for homes, offices and several structures accommodating economic activities there may be a multitude of successive private owners.

Regular and systematic inspection will be conducted in order to identify and quantify possible damage and to consider the economic consequences of measures to address short or long term. Inspection is an integral part of the structural safety and capacity utilization ensuring a connection between the environmental conditions to which it is subject structure and how it behaves over time.

Since prevention is better than treatment if needed remedial work must be done before they develop [10].

4. Basic Protections

Measures of base protect can be made in the following ways:

- Avoid direct damage to the structure under the action of chemical aggression.
- Is to avoid direct contact by covering the concrete element with layered or membranes protector.

- By using non-reactive materials like: stainless steel, coated steel, polymer fibres, non-reactive aggregates, cements with low alkali sulphate diffusion.
- By inhibiting the reaction of damage by various ex. cathodic protection.
- Measures to reduce the effects of deterioration mechanisms to implement in the current environment with or without aggression: by choosing suitable corrosion protection coating and concrete composition, design of appropriate details such as rounded corners or water drainage [2].

Particularly important is avoiding some gross errors such as failure to minimum concrete cover, segregation and gaps in concrete due non vibrate dosage of cement failure, failure of water cement ratio, no specification on the type of cement to use in aggressive environments and so on.

5. Additional Protections

Concrete is an excellent and durable building material also is good in hot and humid environments, provided that it is used correctly. With few exceptions, durability and long service structure satisfying (ex. more than 50 years) can be achieved using a good quality concrete in a well-designed structure without additional safeguards [1].

However additives like microsilica pozzolan, flyash or slag have been increasingly used lately because of the effects of increasing the durability. These additives are available and have some ability to neutralize the alkali-silica reactions and have a very low chloride ion diffusion and sulfur.

As additional protection consider the following:

- special additives that increase the impermeability of concrete;
- Special additives that neutralize or inhibit deterioration mechanisms;
- Skinning steel or concrete;
- Protective bituminous membranes or polymer;
- Electrochemical protection;
- Reinforcing uncorroded as stainless steel, polymer fibres bars;
- Reinforcing fibre (polypropylene, glass, steel) [4].

Kind of finishing materials and permeability values Table 1

Nr.	**Kinds of Finishing materials**	**Thick** [mm]	**Air Permeability** [%]	**Vapour Permeability** [h • g/m^2]	**Water Permeability** [h • g/m^2]
1	Exterior finish synthetic resin emulsion system thin textured finish coatings	1.6	22	2	9
2	Exterior finish synthetic resin emulsion system thick textured finish coatings	3.2	41	3	14
3	Synthetic Resin Emulsion System Multi-Layer Wall Coatings(polyurethane)	1	1	2	5
4	Acrylic resin paint	0.2	4	2	10
5	Acrylic resin silicon paint	0.2	1	1	7
6	Urethane paint	0.2	0	3	10
7	Emulsion paint	0.2	0	2	11
8	Cardboard bituminous	0.6	60	21	18

In table 1 are given some examples of the types of finishes that depending on the thickness obtain the approximately these values to air permeability, vapour permeability and water permeability [13].

Vapour permeability is the most important indicator to describe properties of finishing materials. All the concrete specimens with a finishing material demonstrate smaller carbonation depth than those without a finishing material, resulting in specific carbonation preventing effects on the finishing materials.

Based on the literature surveys with regard to mechanisms of deterioration preventing effect in each finishing material, the following findings are made:

- carbonation preventing effect in each finishing material can be estimated by vapour permeability [1];
- with changes in colour difference for a finishing material due to aging, no change in carbonation preventing effect was observed [1].

6. Conclusions

Based on mechanisms of deterioration and some parameters can determine the of service life.

In both phases, initiation and propagation, all significant deterioration mechanisms depend on some of substances that penetrate from the outside to the inside concrete through one or more transport mechanisms.

The first task of designing a long service life is to ensure a sufficiently long period of initiation. In practice this is achieved by providing a barrier against penetration and accumulation of aggressive substances.

For this purpose it is necessary to provide a good layer protective at exterior through:

- selection of concrete quality;
- choosing a higher coatings for reinforcement;
- coverage with various protective materials.

A structure that is easy to execute will most likely be built correctly and therefore sustainable. Avoid difficult details and reinforcement are fixed formwork well in order not to move. Formwork must be rigid, tightly closed and leak-proof to prevent leakage of cement laitance forming the porous concrete. Details complexes means difficulties. It is necessary and it's recommends a review of the possibility of execution of the geometric shape of the formwork and reinforcement details, it can compact the concrete, before being introduced in the project.

On during the life of the construction it is necessary to take early measures of inspection, maintenance, repair and / or reinforcement of concrete elements as well as possible measures to basic protections or additional protections.

It is important to understand that the problems of durability of concrete products in the past can be avoided in the future if make coordinated efforts in all phases of conception, design, construction and use of the building until the end of life awaited project.

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