BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LXI (LXV), Fasc. 1, 2015
Secția
CONSTRUCȚII. ARHITECTURĂ

ACCELERATION PROCESS OF CONCRETE'S DISSOLVING – LEVIGATION CORROSION

BY

DIANA PLIAN[*] and LIVIA-INGRID DIACONU

"Gheorghe Asachi" Technical University of Iaşi
Faculty of Civil Engineering and Building Services

Received: February 24, 2015
Accepted for publication: March 12, 2015

Abstract. This paper presents a method for accelerate the dissolving-levigation corrosion of the concrete. Test steps and the device used for this purpose are described. The presented method simulates the behavior of the concrete in exploitation subjected to of this type of corrosion to assess the behavior in time of the concrete.

Key words: concrete; corrosion; dissolving-levigation.

1. Introduction

The corrosion represents the spontaneous, partial or entire destroy or decay of a material during its utilisation. The corrosion represents a natural phenomenon that can not be stoped but only retarding. There exists only a few materials that don't suffer this phenomenon.

The corrosion phenomenon is generated by the natural interactions between the environmental factors and a material. The interactions multitude between the environment (water and atmosphere) and materials can be classified in physical, chemical and microbiological interactions.

[*]Corresponding author: *e-mail*: plian.diana@yahoo.com

Each type of interaction individual or often cumulated are leading to the degradation of the material properties. As a consequence its sustainability is reduced and its exploitation duration, as well.

As each material, the simple or reinforced concrete is affected by the corrosion phenomenon.

Nowadays, due o the accumulated scientific and technical knowledge, a concrete is realised to present a greater sustainability in the environment were it wil be used. Therefore the concrete must present a series of properties (physical, chemical and mechanical) that have to resist as long to the aggressive agents actions that are present in the environment.

A concrete that is correctly realised has to resist to the environment's action more decades without the expensive repairing to be necessary. This is available only for modern concretes that are presenting high performance properties. So, the concrete is potentially vulnerable to the chemical attacks and to the physical attacks, as well.

The physical property that presents the greater influence on concrete's sustainability is its porosity (influenced by the water/cement ratio) because the resulted degradations as a consequence of a chemical attack on its surface are slowly propagating. A heavy weight concrete that suffers an appropriate treatment after casting is presenting a similar property to the natural rocks, instead to the greater permeability of the cement paste. That leads to the idea that in such a concrete the water's circulation occurs by a molecular diffusion process through its pores. The permeability can be reduced to minim values by thermal power station ashes and microsilicas utilisation.

It is known that the concrete represents a sustainable composite material that can have a good behaviour in the concrete structures when an intense chemical aggresivity is missing.

The study of corrosion process's nature and intensity represents a very complex problem because in this moment a more intense aggresivity of the environment can be noticed.

One of the most important factor that influences the corrosion is the temperature but near it the osmosis and shrinkage phenomena are distinguishing. Even these factors have a great share in the cases of corrosion's appearance, the fundamental phenomenon is the solubilisation process of the cement's hydration products by the aggressive agents especially of the calcium hydroxide. This solubilisation phenomenon is the main phenomenon responsible for the concrete's corrosion, the other previously mentioned factors are participating in the most of cases only in this phenomenon's intensification.

The corrosion chemical cause is manifesting by the chemical interaction between the aggressive agents and the cement's hydration products.

In his book *"Korrozia betona"* Moskvin *et al*., (1990), concludes that the concretes deterioration in aggressive environments is due to:

1º Cement's hydration product's dissolving, the most often found being the calcium hydroxide dissolving; due to this reaction the components that are suffering the dissolving process are levigated.

2º Chemical interaction between the cement's stone components and the aggressive environment's components when easy soluble components and hard soluble compounds are resulting.

3º Chemical interaction between the cement's stone components and the aggressive agents from the aqueous solutions when are forming components that are producing a solid phase's volume significant increase.

2. Dissolving-Levigation Corrosion

Studying the speciality literature can be mentioned that the experimental determinations are relative at least represented (Popescu, 2002; Ilinoiu, 2004). The case studies were performed in time on different reinforced concrete buildings (tanks, tiles) subjected on dissolving-levigation corrosion.

Worldwide, the most of the studies are referring to the concrete's or reinforced concrete's dissolving-levigation processes that are occurring under the rainfall waters action, and the degradations that are appearing under the soft waters action are nor very significant and are occurring with relative low velocities.

In contrast, in the case of industrial buildings, were the technological soft waters are actioning, the concrete's degradation is more important, being studied the incipient phases and the start of the corrosion at the reinforcement's level.

The worldwide published studies having this research subject are relative few, even that some types of structures are existing whose degradation in time can be appreciated having as main cause the disolving – levigation corrosion.

Studying the existing situation in our country, in different economic fields, could be established that the concrete's degradation cases are frequent mainly or even exclusively by the dissolving-levigation corrosion (Popa & Vasile, 2004). From the research reports realised in time by the INCERC – Bucureşti scientists was found that a great number of reinforced concrete buildings affected by the type I corrosion exists, as a consequence of their uncorresponding exploitation and maintenance.

There were mentioned especially the situations when due to the chemical attack's intensity and complexity, the degradations have come to affect even the respective construction elements strength (Budan *et al*., 2008).

The studied case can be clasified in a few categories:

1º The reinforced concrete buildings from the treatment bases of the balneal – climacteric resorts. In these cases the corrosive atack is complex because, near the compositional particularities of the treatment waters (geothermal waters, sea water) and the erosion and freez – thaw are simultaneous actioning. The affected buildings have diverse destinations (cleaning units, treatments spaces, hygienic-sanitary spaces) and the particular environment conditions led to many observations regarding the occurring conditions of the corrosive attack and its evolution in time. Some common aspects could be observed in all these situations: the significant degradations were appearing after almost 20 years of exploitation and the corrosion that is produced at the reinforcement bars leads to the cover layer's destroy, as a consequence of this phenomenon the reinforcement being exposed.

2º The reinforced concrete buildings exploited in bakery industry. The environment conditions are referring on high temperatures in the bread's baking and preparation units. The high humidity is simultaneous actioning and the sweating appearance, as well. These conditions (temperatures of almost 60ºC and a humidity of over 75%) were generated by the production activity's specific, but by a lack of corresponding ventilation. In this case, the dissolving-levigation attack it is intensified by the high temperatures and by the abundant sweating that is favourising the microorganisms (mushrooms) development. It is known that the last due to its own metabolism is negatively affecting the cement stone's structure. The most affected structural elements were the roof elements: beams, caissons.

3º The cooling towers and the adjacent buildings. The dissolving-levigation attack on the concrete from the cooling towers structure are depending on the compositional factors that are defining the cement stone's structure and on factors that are specific of the corrosion agent, as well, respectively the soft water. It is necessary to identify the ions, salts and dissolved gases and the water's temperature and percolation pressure.

The fact that all these degradations occurred without some dangerous noxies for the human activity makes to accord less attention to this corrosion type, so the effect of the corrosion process were neglected for a long time.

3. The Mechanism of the Dissolving – Levigation Corrosion

Is due to the dissolving of some cement's hydration products.

The resulted compounds are easy levigated. The presence of some salts that are not directly reactioning with the concrete's components are changing the solution's ionic concentration accelerating the corrosion.

All these chemical reactions have as effect the tensions appearance in the hardened concrete's mass and are leading to microcracks appearance that

are favourising the diffusion process. The concrete mass's compounds reactions are occurring until the entirely decalcification of the cement stone, that at least will transform in a gels mixture such as hydrated silicon dioxide, aluminium hydroxide and iron hydroxide (Teoreanu *et al*., 1982).

The concrete's constituents transformations into the gels mixture mentioned above have as effect the loss of the mechanical strength and in the end the entirely deterioration of the structural elements. A redusing of the calcium oxide contain of the cement stone with more than 20% coincids with a degraded concrete.

4. The Factors that are Influencing the Dissolving-Levigation Corrosion

The levigation's intensity due to the soft waters is influenced by the following factors (Ilinoiu, 2007):

a) water's hardness;
b) stagnant or flowing state of the water;
c) volume of water that is percolating under pressure;
d) water's temperature;
e) cement's type;
f) concrete's density;
g) covering concrete's quality and state;
h) dimensions of the concrete elements;
i) concrete's age.

5. Accelerating Method of the Dissolving-Levigation Corrosion

During the experimental study assessed on some concretes supposed to this type of corrosion the acceleration necessity of the phenomena that are occurring in material's structure, was appeared.

Because *in situ* the modifications are manifesting in a relative long time (ten years) a device's conception was necessary, that realising conditions similar with exploitation, to be able to intensify these processes, so to obtain relevant results in a relative reduced time (36 months).

The method presented in this paper supposes to maintain of some concrete samples in a steaming chamber, where are supposed to dissolving – levigation corrosion.

At significant time periods (3, 6, 12, 18, 24, 30, 36 months) the samples are subjected to some tests that are observing the variation in time of some characteristics. These are determination for density, water absorption, permeability and compression strength.

For this experimental study five types of concrete mixtures were used and a great number of samples supposed on corrosion were realised. The

concretes had different admixture percentages (thermal power station ash or microsilica) so the obtained results put into evidence the influencing of these admixtures and the differences due to the percentages were are found in these mixtures.

6. Device Description

The device is made of a cylindrical chamber realised from steel sheet treated in the interior by priming and painting the device's dimensions (1.8 m heights and 0.9 m diameter) allow the samples placing on three grills made of welded mesh (Fig. 1).

Fig. 1 – Device.

On the lateral wall at a half of the heights it is provided a door that allows a easy access to the three grils were the concrete samples are placed. In this case cubic samples having a 14.2 cm side were realised. To realise an uniform steaming/pulverisation on the samples surfaces on each grill were placed a number of 8 samples having an enough space between them.

The device is realising a continuous pulverisation on the samples surface of a water or steam spirt function on the selected temperature. The water is continuously recycled being taken from the inferior part of the chamber added by an aspiration pump and transmitted by an exterior circuit (rubber hose) at the superior part of the device. From there, by a extremely fine pulverisation system it is dispersed in the interior, all the samples coming into contact with the water and steam. The water's heating is realised with a resistance placed in the water

collecting tank. The device is provided with a thermostat that allows the desired temperature setting, in this case 65ºC. In the water tank zone there is a temperature sensor that is actioning the thermostat, so the resistance comes into operation automatically to permanent maintain the water to the desired temperature (Fig. 2).

Fig. 2 – Concrete samples position in device.

The operating of the entire device is automatically being controlled by an electronic system (control panel) because the continuous regime where it is working makes impossible the permanent surveillance by an operator.

The water used in this study is a soft water having the same composition with the water used in the cooling towers.

7. Conclusions

The proposed acceleration method represents a valuable work instrument that allows the obtaining of a great results volume in an acceptable time, taking into account that in exploitation, the buildings that are supposed to this type of corrosion are presenting visible degradations after a longer time. The realised device has been shown to be reliable and allowed the testing of some series of 24 samples, so at the end of the experimental program, the obtained data after the results interpretation gave a clear image on the

modification that are appearing in time in the concrete's structure supposed on dissolving-levigation corrosion.

REFERENCES

Budan C-tin ., Niste M., Spătărelu I., *Coroziunea betonului* I. *Cauze şi fenomene*. Revista Construcţiilor, Bucureşti, 2008, www.revistaconstructiilor.eu.

Ilinoiu O.G., *Cauze şi factori de degradare a betonului şi betonului armat* (I) *Coroziunea betonului*. Rev. Construcţiilor, Bucureşti, 2006, www.academia. edu.

Ilinoiu O.G., *Controlul calităţii betoanelor*. Bucureşti, 2004, www academia .edu

Moskvin V.M., Ivanov F.M., Alekseev S.I., *Corrozia betona i jelezobetona, metodâ ih zascitâ*. Stroyizdat,Moskva, 535, 1990.

Popa I., Vasile V., *Zona litorală a Marii Negre - o solicitare severă pentru construcţiile supraterane din beton armat*. Rev. INCD URBAN-INCERC, **1**, *1*, Bucureşti, 2010, uac.incd.ro.

Popescu P., *Degradarea construcţiilor*. Edit. Fundaţiei România de Mâine, 2002.

Teoreanu I., Moldovan V., Nicolescu L., *Durabilitatea betonului*. Ed. Tehnică, Bucureşti, 1982.

PROCEDEU DE ACCELERARE A COROZIUNII BETONULUI PRIN DIZOLVARE-LEVIGARE

(Rezumat)

Se prezintă o metodă de accelerare a coroziunii prin dizolvare-levigare a betonului. Sunt descrise etapele de încercare şi instalaţia utilizată în acest scop. Metoda prezentată simulează comportarea din exploatare a betoanelor supuse acestui tip de coroziune în scopul evaluării comportării în timp a betonului.