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GELIVITY EFFECTS ON CONSTRUCTION ELEMENTS

BY

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Abstract. Complex nature of environment effects on concrete structures has imposed an improvement of material characteristics, an adequate design, accurate execution and inspection, maintenance and prevention of deterioration risks.

Large complexity of concrete elements deterioration processes, it is determined by the relation between adopted structural conceptions, exposing climatic conditions, concrete composition, quality of execution processes, but also due to synergetic action of destructive agents.

When water freezes in a porous material, like cement stone, raise its volume about 9%, and can lead to concrete cleavage, when pores are saturated with water. Using deicers on concrete surface for melting of ice or snow, cause a thermal shock. Temperature difference between the surface and the core of concrete leads to interior stress and deformation state, capable to influence cracking of concrete layer from the surface of element.

Prevention of damages and their amplification needs inspection, maintenance and overhauling of structures.

Key words: concrete; freeze thaw; external factors; degradation.

1. Introduction

International preoccupations regarding determination of causes and character of concrete structures degradation processes, but also for adoption and implementation of some strategies and preventive actions to deal with these situations, are becoming more numerous. On the base of engineering description of deterioration processes have been elaborated lots of models for causes, deterioration mechanisms and factors which are governing them, so as through integration of fundamental knowledge and experience concerning concrete durability being possible the elaboration of different recommendations and rules concerning design, execution and maintenance.

Because complex nature of environment effects on concrete structures, but also their characteristic response, performance assurance for a building needs equally improvement of materials characteristics, adequate design, accurate execution and inspection, maintenance and prevention of deterioration risks.

Concrete gelivity is a feature which considers its behavior to freezing–thaw cycles. Behavior at freezing–thaw is a characteristic of concrete durability determined by its porous structure. The importance of this feature drifts from rapid degradation of concrete elements saturated with water, under conditions of repeated freeze–thaw cycles with consequences on constructions resistance and stability.

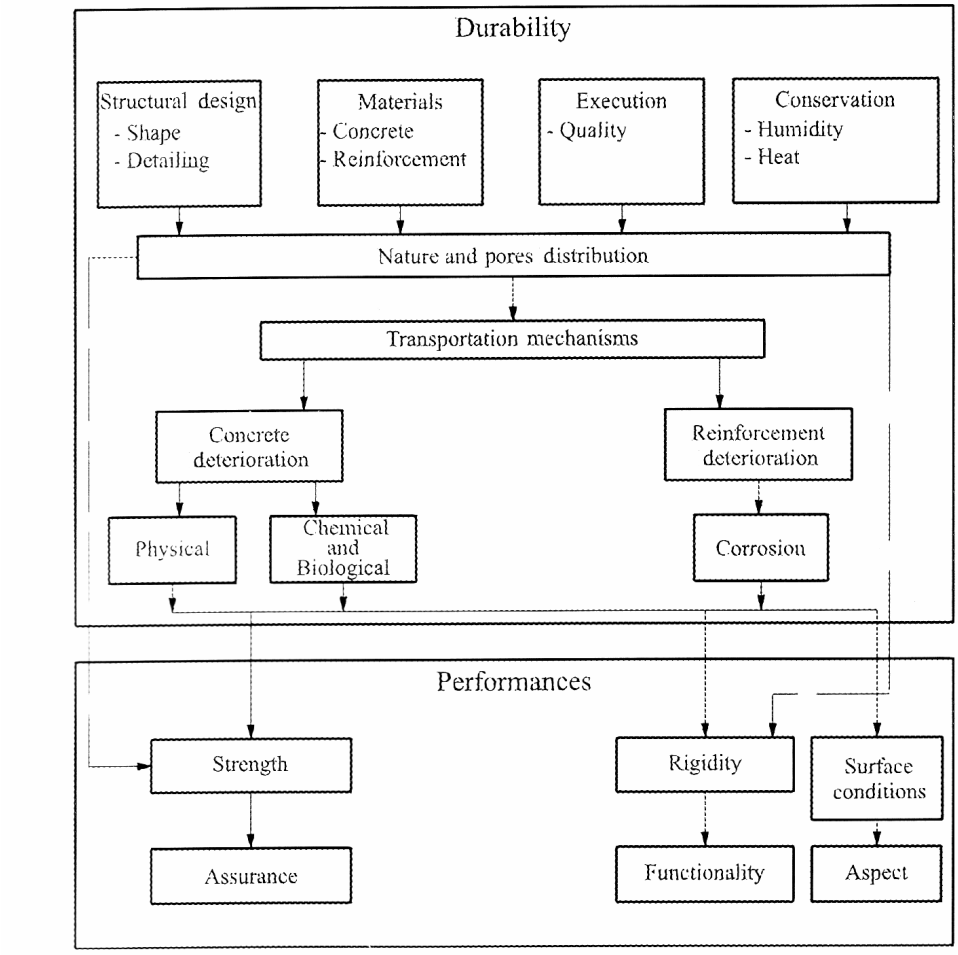

Fig. 1 – Interaction between main factors conditioning durability.

Freeze–thaw resistance expresses saturated concrete capacity to resist on alternate action of negative temperatures. According to our country regulations, freeze–thaw resistance is expressed through the number of freeze–thaw cycles, successive (realized according to a ruling program), which can be supported by the material, so as depreciation of its mechanical characteristics, not to exceed certain imposed limits.

Deterioration processes of concrete structures are very complex because of relation between adopted structural conception, exposing climatic conditions, concrete composition and quality of execution processes, both because of synergetic action of destructive agents (for example, frost action in presence of chemical agents). Interaction between factors conditioning concrete structure durability is presented in the Fig. 1.

2. Gelivity Action on Construction Elements

Influences and effects of repeated freezing–thawing are taking place with a different intensity. Three main categories of fluids cut decisively over concrete durability, as follows:

a) Pure water or bearer of aggressive ions.

b) Carbon dioxide (CO_2).

c) Oxygen (O_2).

Their motion into concrete can be realized in different ways, but transport, on the whole, depends firstly on hydrated cement structure. Resistance to freeze–thaw of concrete depends on easiness of penetration and motion of fluids into concrete. All those are evaluated through *permeability of concrete.* Permeability has an important signification for flowing through a porous medium, but motion of fluids into concrete isn't realized only by flowing through pores system, but also through diffusion and adsorption.

Depending on their nature and influence, external factors which act unfavourable on concrete structures can be grouped as it follows:

1. *Physical factors*
   a) concrete laying conditions (temperature, humidity);
   b) freeze–thaw phenomena.
2. *Chemical factors*
   a) carbonatation;
   b) acidity effects;
   c) sulphatic attack effects;
   d) efflorescence.
3. *Mechanical factors*
   a) mechanical breakage by shock;
   b) concrete crack;
   c) abrasion;
   d) erosion;
   e) cavitation.

When water freezes in a porous material, like cement stone, more physical phenomenas of major importance for determination concrete resistance exposed to freeze–thaw cycles took place.

a) Increase of volume with 9% by water freezing, which can lead to concrete cleavage, when pores are saturated with water (Fig.2).

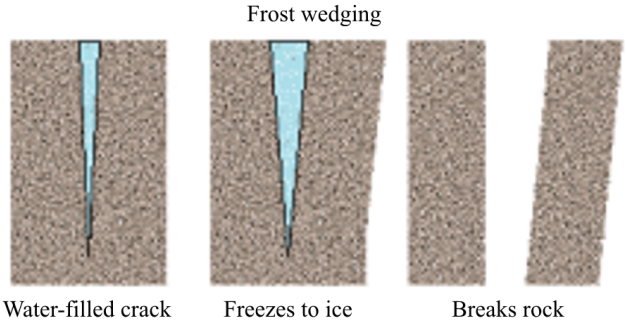

Fig. 2 – Concrete cleavage caused by freeze–thaw process.

b) Freezing-point decreasing because of energy excess from pores surface, which reduces potential energy of water from pores. Chilling point will be the lowest as the pores diameter is more reduced (Fig. 3).

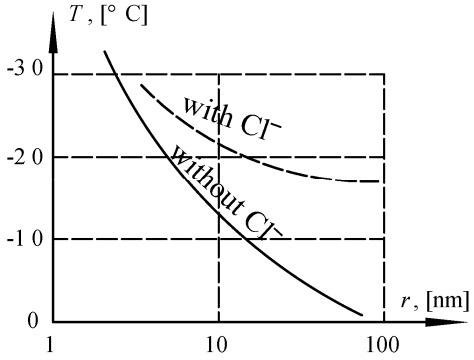

Fig. 3 – Relation between freezing-point (T) and pores radius (r).

c) Water transition to ice in porous systems is possible to cause evaporation of a big quantity of water, if environmental conditions and saturation degree are favourable (concrete completely saturated doesn't allow gas diffusion, respectively of water vapours).

d) Water diffusion, still unfrozen, from pores with small diameter towards pores with bigger one, where frost has already produced, which leads to growths of efforts in pores system, emphasizing crack danger.

Deicers (salt) utilization on concrete surface for melting of ice or snow cause a substantial fall of temperature (thermal shock), with a speed of 14ºC/min. Temperature difference between surface and core of concrete leads to

interior stress and deformations state, capable to influence cracking of concrete layer from the surface of the element. Another effect of deicers utilization consists in frost properties modification of pores filled with water (Fig. 3).

Diffusion of deicers into pores filled with water, the reduced will be the pore radius is smaller. Hereupon, frost temperature will less depend on pores diameter, and this will lead to freeze of water in all pores at the same temperature so that water redistribution between pores of different dimensions to be considerably diminished.

Concrete damage by action of freeze–thaw cycles can be hardly diagnosed like other types of destruction mechanisms of concrete like alkali-aggregate reaction, which goes hand-in-hand with freeze–thaw process. Many times are hard to determine which destructive effect has induced initial damages, but if we put out the other ways of exhibition, typical signs of freeze–thaw are

a) spalling and scaling of the surface (Fig. 4);

Fig. 4 – Spalling and scaling of the surface.

b) exposing of aggregate (Fig. 5.);

Fig. 5 – Exposing of aggregates.

c) surface parallel cracking (Fig. 6);

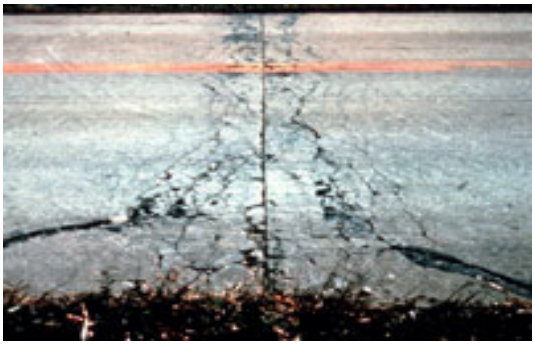

Fig. 6 – Surface parallel cracking.

d) gaps around aggregate.

Freeze–thaw can occur under two forms:

a) When water accumulates at the upper part of a horizontal surface made of concrete (Fig. 4), freeze–thaw cycles take place right there, causing progressive damage of concrete.

b) When big quantities of water penetrate and they are collected in any cracks rather then concrete pores. Here we can mention damages of vertical elements made of concrete (Fig. 7).

Fig. 7 – Damages of concrete caused by freeze–thaw.

We mustn't forget that lots of concrete damaging mechanisms can action simultaneously with possible synergetic effects. Diagram from Fig. 8

illustrates how different destroying mechanisms acts over concrete exposed to sea water. If we talk about cumulative negative effects we have to mention also, deficient maintenance of roads, when deicers combined with water from snow melting are passing through contraction joints, destroying reinforced concrete strength structures of bridges or road guards.

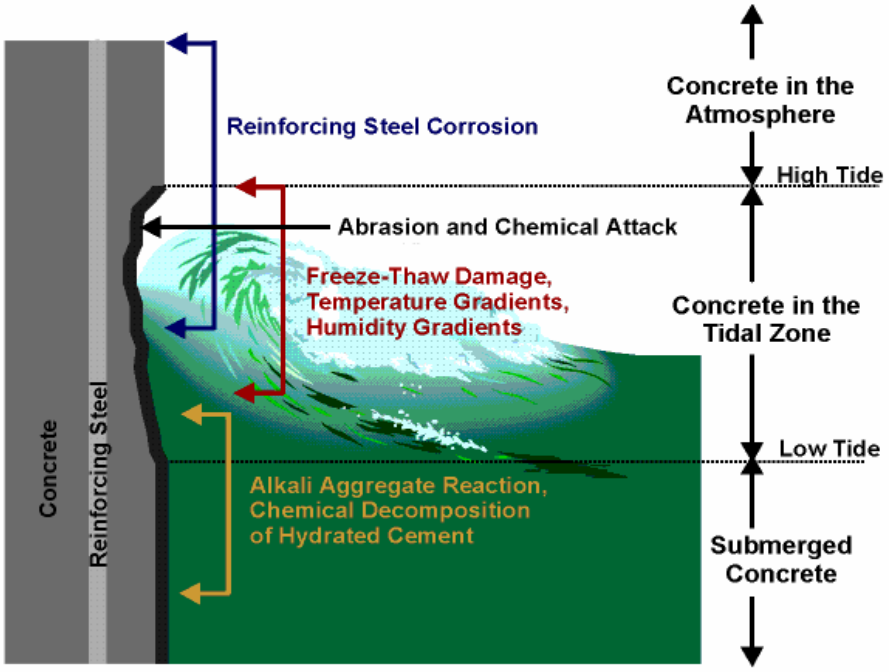

Fig. 8 – Combined mechanisms of concrete degradation exposed to marine environment.

4. Conclusions and Recommendations

Prevention of damages and their amplification needs inspection, maintenance and overhauling of structures. Evenly and systematic inspections are made in order to quantify and identify the emerged damages. Maintenance and reparations are including necessary activity to maintain the purpose of the structure and to guarantee continuous assurance in exploitation.

The purpose of safety measures it is to stop or reduce the speed of possible deterioration mechanisms of the hereof structure.

Some of the necessary safety measures that has to be provided for the structures working in environments where are exposed to freeze–thaw cycles, are the followings:

a) improvement of material composition;

b) growth of concrete cover degree of reinforcements;

c) coverage of concrete and steel external surface: painting of concrete surface with permeable paints or impermeable to vapours, utilization of some membranes impermeable to water;

d) saturation of concrete surface with polymers or mixing into concrete small granules of wax, which after thermal treatment will fill capillary pores.

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EFECTELE GELIVITĂŢII ASUPRA ELEMENTELOR DE CONSTRUCŢII

(Rezumat)

Natura complexă a efectelor mediului asupra structurilor din beton impun deopotrivă îmbunătăţirea caracteristicilor materialelor, proiectarea corespunzătoare dar şi măsuri de inspecţie, întreţinere şi prevenire a riscurilor de deteriorare. Complexitatea mare a proceselor de deteriorare a construcţiilor din beton este determinată de relaţia dintre concepţia structurală adoptată, condiţiile climatice de expunere, compoziţia betonului şi calitatea proceselor de execuţie, dar şi datorită acţiunii sinergetice a agenţilor distructivi.

Atunci când apa îngheaţă într-un material de construcţii poros, cum este piatra de ciment, aceasta îşi măreşte volumul cu 9%, ceea ce poate conduce la despicarea betonului, când porii sunt umpluţi complet cu apă. Utilizarea agenţilor degivranţi pe suprafaţa betonului pentru topirea gheţii sau a zăpezii produce un şoc termic. Diferenţa de temperatură dintre suprafaţa şi miezul betonului produce o stare de eforturi interioare şi de deformaţii, ce poate induce fisurarea stratului de beton de la suprafaţa elementului.

Prevenirea deteriorărilor şi a amplificării defectelor necesită inspectarea, menţinerea şi repararea structurilor.