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CONSIDERATIONS REGARDING THE DAMAGE OF THE CONSTRUCTIONS' STRUCTURAL ELEMENTS

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The damage processes of the reinforced concrete constructions are very complex due to the relationship between the adopted structural conceptions, the climate conditions for display, the composition of the concrete, the quality of the execution process and the synergetic action of the destructive agents. The measures to be taken against premature damage of the reinforced concrete regard the design, the execution process, the exploitation conditions and the protection techniques.

1. The combined transfer of heat, humidity and chemical substances, both within the concrete mass and in exchange with the environment (micro-climate), as well as the parameters conditioning this type of transfer, are the main elements for the durability and type and degree of concrete' damage (physical, chemical and biological) and that of the reinforcement (corrosion). The transfer processes are conditioned, in their turn, by the porosity (type, size, distribution of the pores). The factors regarding the quality of execution, which have the greatest influence on the durability of the reinforced concrete structures, are the proper compaction and the further treatment of the concrete, especially of the layer at the surface which is in a direct contact with the environment and therefore needs to protect the reinforcement and the core of the element.

Considering the fact that actions can be any possible cause generating damage, they can be: actions of the natural environment (polluted air, sea air, aggressive waters in the soil and at the surface, the biological action of the micro- and macro-organisms), the actions of the climate, exceptional actions (earthquakes, soil flow, floods, eructation, rocks falling, materials ageing), actions of the industrial environment (excessive humidity and temperatures, substances resulted from the industrial processes, fires and shock-creating actions) and actions that are specific to the building (corrosion, alkali-aggregate reactions, temporal loading due to exploitation, overloads, impact, tiredness).

The damages caused by these "actions" are produced by physical processes (concrete's cracking, erosion, etc.), chemical processes (the chemical attack under the action of acids, sulphates, bases), biological processes, corrosion of the reinforcement. Although they are one of the long lasting creations of man, the constructions are also deteriorating because of the behaviour in time of the construction materials.

No matter the type of material used in the process, the constructions suffer damages in time as consequence of the action of the environment. Among all these materials, the reinforced concrete proved to be vulnerable at the action of most environmental factors. Considering the characteristics of the actions producing damages, the features of the materials, elements and the structure as a whole, as well as the fact that it is quite impossible to totally eliminate the causes of damages, one thing stands up – the necessity to know the way in which the actions damage the structures.

2. The transfer phenomena within the concrete of gases, water and dissolved agents represent the fundamental processes acting on the durability of the constructions and, consequently, regard the damage. These phenomena depend upon the connection mechanisms, the structure of the pores, the environment conditions (micro-climate) and the transport equipment. In order to describe the structure of the pores in relation to the transfer of substances within the porous construction materials (such as concrete) there are two important parameters to be considered: the relevant porosity and the distribution of the pores according to their sizes. Generally, it can be said that the concrete's resistance to chemical and physical influences is considerably reduced by increasing the amount of capillary pores.

The physical damage of the concrete happens by cracking. This damage occurs when the concrete cracks and the tensile strains exceeds the limit elongation. The cracks in the reinforced concrete may appear from many causes and they can lead to several working inconvenients since they allow the aggressive substances to get into the strength elements, affecting the concrete's durability and/or that of the integrated reinforcement. In normal working conditions, the cracks caused by loads or imposed deformations (temperature, contractions or unequal pressing of the foundation) do not usually lead to pronounced unfavourable effects.

3. The physical damage from the frosting effects occurs when the water freezes within the pores of the concrete; this is the moment when there may occur three major phenomena in the determination of the concrete' strength, when the concrete has been the subject of several frosting–defrosting cycles: a) volume increase of about 9% because of the frozen water which may lead to concrete cleaving when the pores are filled with water; b) the freezing point gets lower due to the surplus of energy at the surface of the pores which reduces the potential energy of the water in the pores; c) the transition of the water within the ice into the porous systems, leading to a relatively large quantity of water being evaporated, while the still unfrozen water goes from the small diameter pores to the pores with large diameters where the freezing process has already taken place, increasing the stresses in the system of pores and heightening the risk of cracking.

Applying the de-icing agents (salt) on the surface of the concrete causes a substantial lowering of temperature (thermal shock). The difference of temperature between the surface and the core of the concrete produces a state of inner tensions and deformations capable to induce cracks in the concrete layer found at the surface of the element. Another side effect of the usage of de-icing agents consists in the changes of the frosting properties of the water-filled pores, which will make the water

freeze in every pore at the same temperature, while the redistribution of water into the pores will be considerably diminished. The third effect of this usage is the frosting of certain layers of concrete elements at different temperatures. In conclusion, the use of de-icing agents makes the freezing process to be more severe.

4. The physical damage by concrete' erosion happens through the abrasive wear-out mechanism of the surfaces of concrete. It may be caused by several factors, such as: the friction and polishing action of the people's traffic on boards, the carving and the rebound impact of the chained tyres on the pavement (as in the case of roads constructions), the impact or the slipping of the granular materials (as in the case of industrial constructions), the action of the heavy particles in suspension, especially during the water' high speeds (the hydrotechnical constructions).

5. The durability of the concrete structures is often determined by the rate of concrete decomposition following chemical reactions. These ones, that may lead to a diminishing of concrete quality, are the reactions between acids, ammonium salts, magnesium salts, water and cement stone, the reactions of the sulphates with the aluminates in the concrete, the reactions of the bases (alkali) with the reactive aggregates in the concrete.

The destruction of the concrete elements under the action of the chlorine ions consists in the diffusion of the ions into the concrete and the corrosion of the reinforcement, the expansion of the rust leading to the pushing out of the concrete covering layer.

The action of the sulphur's compounds on the concrete is reduced to the action of the ion SO_2^{2-}, which substitutes the ion OH^{1-} in $Ca(OH_2)$, thus forming gypsum. The action of the sulphur's compounds on the reinforcement manifests itself when the diluted brimstone acid immediately and violently attacks the iron.

The action of the nitrogen compounds is due to the azotic acid which, in a humid environment, produces the concrete peeling in successive layers by forming the soluble calcium nitrate. The action of the nitrogen on the reinforcement has as consequence a more frail reinforcement that breaks in the areas where the crystal lattice was altered by bending.

The waters with a low hardness have the tendency to dissolute the calcium hydrate from the cement stone, phenomenon which is accompanied by tensions in concrete and the emergence of micro-cracks which accelerates the diffusion processes.

The acid corrosion happens in the presence of different acids. The carbonic acid acts on the cement stone forming the calcium carbonate (indissoluble) and acid calcium carbonate (very soluble); the damaging phenomena are very spectacular. The fluorine acid violently attacks the concrete, although it forms indissoluble salts because it gets decomposed into calcium hydro-silicates and reacts with cherty aggregates, diminishing their adherence to the cement stone. The phosphoric acid attacks the cement stone by forming soluble phosphates until the neutral calcium phosphate is formed; the calcium phosphate is indissoluble and creates a protective layer stopping the process of corrosion.

The basic corrosion is determined by the destructive action of the alkali (NaOH,

KOH) and it is characterized by the dissolution of the aluminium- and silicon oxides from the concrete. The carbamide is a very weak base that damages by expansion and dissolution.

It has been noticed that mineral oils and fats damage the concrete, when this suffers a long period of aggression; the damage consists in a process of peeling due to the penetration through structural flaws. The oils that have got into the concrete diminish its mechanical strength and act as a lubricant between the particles of cement stone, as well as between these and the aggregate.

6. The biological deterioration of the concrete happens due to the mechanical actions of the vegetation that grows on or near them (mosses, algae, roots of small plants and trees), vegetation that penetrates the concrete through cracks and weak points, thus creating cleavage forces.

Under normal conditions the steel reinforcement in the concrete is protected against corrosion by passivation. The alcaline character of concrete, characterized by a water value $pH > 12.5$ in the pores, favours the formation of a microscopically oxide layer on the reinforcement surface, the so-called *passive film*. This prevents the dissolution of the iron, therefore the corrosion of the steel becomes impossible, even though all the other conditions of corrosion are fulfilled (especially the presence of moisture and oxygen). The alcaline character of concrete can be locally reduced due to the process of carbonation, the action of the chlorine ions (Cl), the water that dissolute and involves the alkali in the concrete, usually in the weak points of the structure (unsealed joints, opened cracks) or within low quality concretes. If the pH value goes beneath 9 near the reinforcement or if the concentration of the chlorine ions exceeds the critical value, the passive film dissolves and the anti-corrosion protection disappears. Consequently, the corrosion of the steel is possible if and when there is enough moisture and oxygen.

7. In the most difficult situations the materials are expected to work over their cracking limit, respectively with forays in the post-elastic domain. In other words, the official standards accept the emergence of damages and, consequently, that of remaining deformations in the case of all constructions that have been built or are going to be built. During the seconds or micro-seconds that an earthquake lasts, there takes place an ample damage process in all the structural elements, especially the vertical ones, by an irreversible damage of the materials, starting from the base and up to their superior ending.

8. Designing a construction represents the first stage within a complex of activities needed to realize all types of constructions. This first stage is the most important one and plays a very special role in providing the quality and safety the construction needs. Therefore, the design must not contain major mistakes. The most disadvantageous mistakes possible are those due to the conception of the entire structure, those of misinterpreting and incorrectly applying some of the technical stipulations, the omission of the designing rules, and the poor choice of materials. The design errors can have as consequence a building with strength and stability deficiencies and a short durability of the elements and the assembly.

The execution errors are those appearing during the process of construction and regard any digression from the stipulations of the design. These digressions may regard the concrete strength, the reinforcement strength, and the geometrical characteristics of the elements section shape or the structure shape. The execution errors have multiple and important effects on the structure – they can reduce the bearing capacity of the elements, they can change the calculation efforts, may provoke damage of the good functionality of the building and they always negatively influence the quality and the cost of the building. Consequently, the design and execution activities should always consider the above facts and take the proper decisions. In the designing stage there are not taken into consideration the effects of the major mistakes because they are eliminated during the quality control. In our country are considered probable digressions the inaccuracies between the values of the concrete and reinforcement strength in accordance with those stipulated in the design. The geometrical digressions, whose consequences are considered less important, are treated in a deterministic manner and their effects are introduced as a coefficient for strength diminishing.

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CONSIDERAŢII PRIVIND DETERIORAREA ELEMENTELOR STRUCTURALE ALE CONSTRUCŢIILOR

(Rezumat)

Procesele de deteriorare ale construcţiilor din beton armat sunt foarte complexe datorită relaţiei dintre concepţia structurală adoptată, condiţiile climaterice de expunere, compoziţia betonului şi calitatea proceselor de execuţie, cât şi datorită acţiunii sinergetice a agenţilor distructivi. Măsurile care trebuie luate împotriva deteriorării premature a betonului armat privesc, prin urmare, aspectele de proiectare, procesele de execuţie, condiţiile de exploatare şi tehnicile de protecţie.