

Assessment of Reasons behind and Level of Destruction of Aquatic Supports in a Hydraulic Ash Removal Bridge

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1 Introduction

For years now, not much attention has been given to industrial reinforced concrete structures. Unfortunately, the consequences of this are progressing phenomena of various types of corrosion, especially when the structures are under conditions posing a risk of corrosion. It is known that the corrosion of materials which buildings are made from is of fundamental importance to their durability (Błaszczyński *et al.*, 2008). The reasons behind the corrosion of concrete, and therefore reinforced concrete, can be manifold. Such corrosion usually takes place under the influence of external effects. In the recent years, a frequent phenomenon in building practice is the occurrence of cracking of reinforced concrete structures across their entire width as early as at the stage of their realization. The reason behind such a state of things, as proven in works (Błaszczyński *et al.*, 2008, Łowińska-Kluge *et al.*, 2012), is internal corrosion in concrete. Concrete, as a structural material, is subjected to the corrosive effects of the outside environment. One type of corrosion that this material undergoes, frequently neglected by designers, is biological corrosion – a specific case of chemical corrosion. It ought to be pointed out that numerous physical and chemical transformations taking place in concrete are the result of the activity of metabolic organisms, *i.e.* bacteria, fungi or algae. The destruction of material caused by these living organisms takes place, among others, under the influence of biogeophysical processes, such as the changes in the porosity of material as a result of the development of a biological membrane on the surface of the concrete (Horbik *et al.*, 2013, Łowińska-Kluge *et al.*, 2016, Mejía *et al.*, 2019).

Based on the description of the existing state, carried out tests and earlier analyses, it can be stated that the observed phenomena are mainly caused by leaching, carbon and biotic corrosion. Signs of sulphuric corrosion were not noted, though the use carbon aggregate and small amounts of fly ashes were confirmed in the concrete.

2 Analysis Along with Assessment

Unfortunately, the contractor refused to provide data on water and air contamination, making it much more difficult to search for reasons behind the occurrence of the present phenomena. The lack of adequate tightness of the surface layer caused constant dampening of the remaining layers of the analyzed concretes. Therefore, the moisture contained and persisting in the concrete led to the slow dissolvent of calcium compounds from the cement stone. This moisture, being the result of precipitation waters, that is soft waters with low carbonate hardness as well as water evaporating from the surrounding lake, leads to the emergence of leaching corrosion. Leaching is a diffusion process, the course of which is significantly

influenced by water flow speed and pressure. The aggressiveness of soft water increases in lower temperatures. The leaching of calcium hydroxide begins in the surface layers. Over the course of time, $\text{Ca}(\text{OH})_2$ from increasingly deeper layers is leached into the environment. First, $\text{Ca}(\text{OH})_2$ (so-called free calcium) is dissolved, and along with the lowering of pH, also the calcium from hydrated silicates and calcium aluminates. These calcium compounds settled on the steel reinforcement bars and, in the presence of moisture, reacted with carbon dioxide (CO_2) that got through from the atmosphere. These gases, along with moisture, also entered the inside of the cement stone with the leaching of Ca compounds. The occurring reactions resulted in the formation of, among others, calcium carbonate and iron carbonate. These products are clearly identified during microscopic studies and over the course of EDS microanalysis. Steel reinforcement bars, in places of contact with concrete, were in a constantly moist environment.

Non-model EDS microanalysis revealed, above all, the presence of products from the cement matrix “interspersed” with products of rebar corrosion, as well as showing the occurrence of products of the decomposition of the cement matrix and reinforcement bars (in the form of mainly calcium carbonates, iron and zinc). The probable distribution of calcium silicates and aluminates was determined on the basis of the carried out non-model x-ray EDS microanalysis of a zone of Concrete B surface contaminated with biotic factors. The lack of portlandite (significantly lower amount of C-S-H phases), very high amount of calcite (3.5 times higher) and decreased amount of quartz (twice lower), as compared to Concrete A, point to the extensive corrosion of the cement matrix in Concrete B. Sulphur compounds recalculated for total sulphur, MgO and $\text{Na}_2\text{O}_{\text{eq}}$ content in the assessed concretes may come from the applied aggregates and their contaminants, as well as from cement.

As indicated by the results of the carried out laboratory studies and conducted analyses, the corroded surface layer of the concrete ought to be removed all the way to the reinforcement bars, with the uncovering and cleaning of the rebars. Next, new layers ought to be made in accordance with one of the systemic repair technologies.

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References

- Błaszczyszki T and Łowińska-Kluge A. (2008). *Durability assessment of RC floors based on concrete properties*, 6th International Conference AMCM'2008, Łódź, Poland, 371-372 + CD.
- Horbik D., Łowińska-Kluge A., Górski Z., Stanis E. and Zgoła-Grześkowiak A. (2013). *Microwave-Assisted Extraction Combined with HPLC-MS/MS for Diagnosis of Fungal Contamination in Building Materials*, J. Braz. Chem. Soc., Vol. 24, No. 9, 1478-1486.
- Łowińska-Kluge A. and Błaszczyszki T. (2012). *The influence of internal corrosion on the durability of concrete*, Archives of Civil and Mechanical Engineering, vol. XII, No 2, 219-227.
- Łowińska-Kluge D., Horbik D., Zgoła-Grześkowiak A., Stanis E. and Górski Z. (2016). *A comprehensive study on the risk of biocorrosion of building materials*, Corrosion Engineering, Science and Technology, DOI: 10.1080/1478422X.2016.1174326.
- Łowińska-Kluge A. and Józwiak K (2006). *A study of the resistance of concrete to corrosion using SEM and microanalysis*, Microscopy and Analysis, 20, 1, 2006, 19-21.
- Mejía E., Tobón J.T. and Osorio W. (2019). *Urban structure degradation caused by growth of plants and microbial activity*, Materiales de Construcción, Vol. 69, Issue 333, January-March, DOI.10.3989/mc.2019.09517.