Corrosion and abrasion resistance of underwater repair concrete under hydrostatic pressure

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INTRODUCTION

Concrete is widely used in the marine environment to create structures near, in, or under the water. Operating in the environment of the water influence, concrete is the subject to a variety of chemical and physical effects. Most common processes responsible for deteration of a concrete in the marine environment are:

- chemical aggression,
- corrosion of reinforcement as a result of chlorides actions,
- frost destruction,
- salt erosion (so-called salt weathering),
- abrasive erosion as a result of the water flow and the impact of debris transported by sea water.

Types of the effects and their impact intensity on the particular structure depends on its location relative to the water surface. Generally there are three main zones: atmospheric, tidal and submerged [1,2].

The underwater concrete was designed in such a way that it met the requirements given in [3] and DIN 1045-2. Portland cement CEM I 42.5N-HSR/NA according to EN 197-1, and the natural aggregate: gravel up to 16 mm and washed river sand up to 2 mm were used. The amounts of anti washout admixture (AWA) containing polysaccharides and high-range water reducing agent were calculated in the way to obtain acceptable wash-out losses and the flowability of self compacting concrete for 60 minutes after mixture preparation. Water/binder ratio was 0.4.

A special experimental stand has been used for testing underwater repair concrete under variable hydrostatic pressure [4]. Test elements with a volume of about 20 dm^3 were cured for 7 days under the hydrostatic pressure from 0 to 0.5 MPa and later were kept under the water in laboratory conditions. After 28 days of maturing, specimens were cut out from the test elements for further testing. The part of the test element from which specimen was taken was recorded: top or bottom. After preparation of the specimens the following tests were carried out:

- determination of resistance to ageing by salt mist (EN 14147),
- determination of air void characteristics in hardened concrete (EN 480-11),
- determination of the abrasion resistance - Boehme disc wet method (EN 14157),
- determination of the compressive strength of concrete (EN 12390-3).

The aim of the study was to assess the possibility of using methods designed for natural stone testing for concrete corrosion and abrasion resistance testing.

RESULTS

After 60 cycles in the salt chamber, the specimens showed no visual signs of surface damage. No scratches or peels were observed on their surfaces. Fig. 1 shows the change in the mass of the specimens. Just after the test the weight gain of the specimens was observed, which was caused by accumulation of the salt. Even after desalination not whole salt introduced and absorbed by the specimens during the tests in the salt chamber was washed out, because all samples showed a slight increase in weight. This was confirmed by SEM images of concrete samples taken from the cubes.

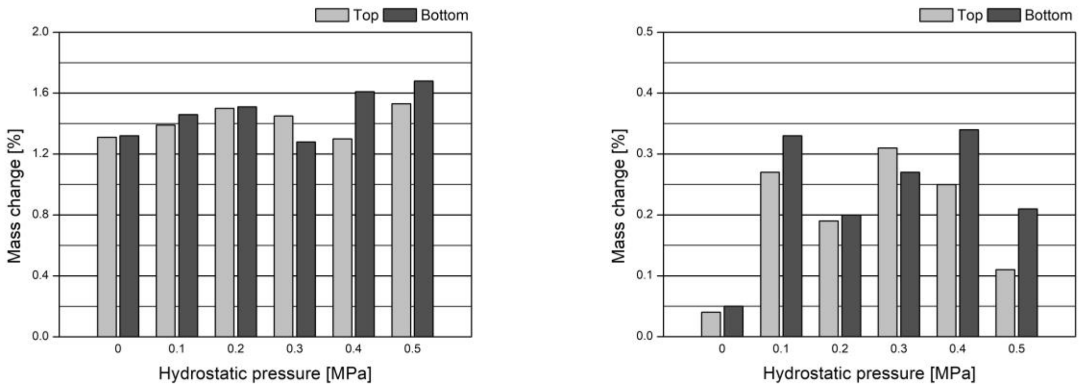

Figure 1. Change in mass of the specimens after 60 cycles in salt chamber (left) and after desalination (right)

The results of determination of air void characteristics in hardened concrete are presented in the Fig. 2. The substantial impact of the hydrostatic pressure on the total air content of the tested specimens was observed. There was the decrease of air content of concretes exposed to the hydrostatic pressure. What is more, for pressures from 0.2 to 0.5 MPa there was higher percentage share of micropores in total porosity. In each case the specimens cut from the top parts of the elemnents had a lower total air content than those from the top parts.

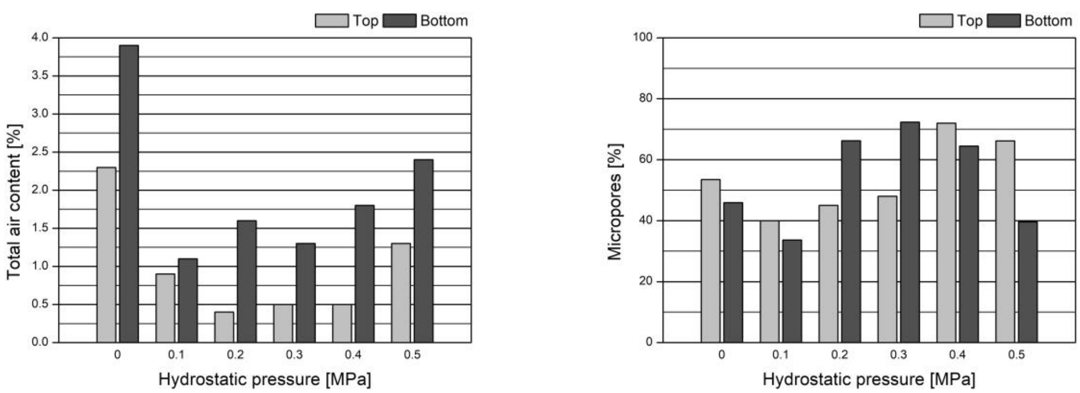

Figure 2. Total air content (left) and percentage share of micropores in total porosity (right)

In the case of abrasion tests performed using Boehme disc an increase in volume loss of specimens exposed to the hydrostatic pressure was observed (Fig. 3). For most pressures, there was no significant change in compressive strength of tested concrete. In case of the pressure of 0.1 MPa there was a noticeable decrease of compressive strength of the concrete compared to the base value (0 MPa). On the other hand the highest value was achieved for the pressure of 0,5 MPa.

In most cases the specimens from the top part of test elements had higher compressive strength than those from the bottom. However, in the same time they showed higher volume loss during the abrasion test (Fig. 3).

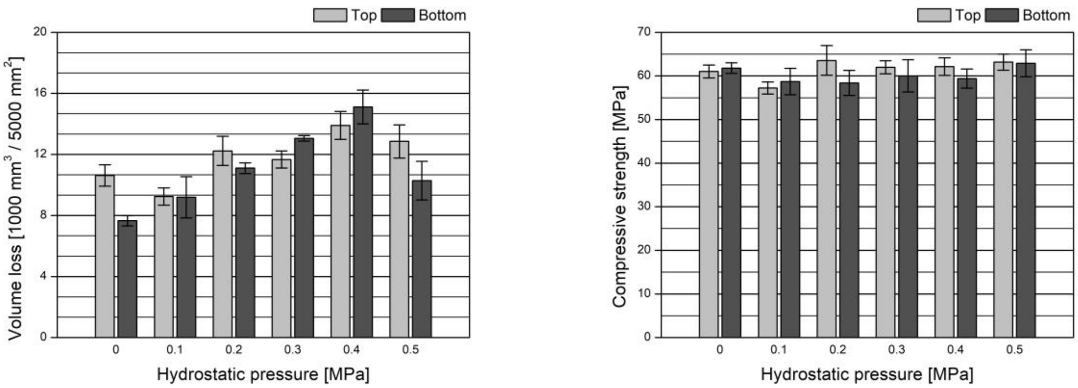

Figure 3. Boehme disc wet method abrasion volume loss (left) and compressive strength of the concrete (right)

CONCLUSIONS

It is possible to use natural stone testing methods in concrete corrosion and abrasion resistance testing. Positive effect of hydrostatic pressure on the concrete resistance to ageing by salt mist was observed. This phenomenon was the effect of the change in air void characteristics of hardened concrete. As described in [5], micropores contribute to extending the life of materials by slowing down the effects of chloride corrosion taking place in their structure, while the open pores and external structure damages accelerate chloride corrosion.

No clear relationship between abrasion resistance and compressive strength of the concrete was observed. The effect of the increased volume loss of the concrete exposed to the hydrostatic pressure can occur due to the increased concrete homogeneity.

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