Evaluation of anti-fouling strategies for cementitious materials

Willem De Muynck

Supervisor(s): Willy Verstraete, Nele De Belie

I. Introduction

The aesthetic quality of outdoor exposed concrete is seriously impaired by the development of biological stains. Biological stains result from the growth of microorganisms among which phototrophic organisms result in the occurrence of the first visible stains.

In addition to environmental conditions, the rate of stain development largely depends on the bioreceptivity of the material. For building materials such as stone and concrete, bioreceptivity relates to the surface roughness, moisture content, chemical composition and the structure-texture of the material. Building materials, such as aerated concrete, that have a high roughness and high macroporosity therefore show a high bioreceptivity.

Nowadays, different treatments are available on the market for the prevention of biological stains. In this research the effectiveness of two kinds of treatments in preventing algal growth on aerated concrete was investigated. The use of water repellents aimed at reducing the bioreceptivity of the material, while the use of biocides aimed at reducing the biological activity.

The qualification of the behaviour of these treatments towards biological growths was done by the use of an accelerated fouling test. The choice of the design was governed by the ease of operation, low costs and possibility to test several biocidal products at the same time.

W. De Muynck is with the Structural Engineering Department, Ghent University (UGent), Gent, Belgium. E-mail: WillemDeMuynck@UGent.be .

II. Materials And Methods

A. Surface Treatments

All surface treatments were applied by sprinkling. The biocides were applied in a final concentration of the metal of 100 mg/m² (M1) or 250 mg/m² (M2.5).

B. Accelerated Fouling Setup

Accelerated fouling of building materials was achieved by means of a water run-off test [1]. A modular setup was built to allow both simultaneous and separate evaluation of different test series.

The setup (Fig. 1) consisted of several stainless steel compartments supported by a wooden frame at 45° inclination. Algae were introduced at the top of the compartment by means of an aquarium pump, a plastic tube and a sprinkling rail. The run-off period was set to start every 12 h and ran for 90 min. Furthermore, the setup was submitted to a 12 h day and night regime, which started simultaneously with the run-off periods. Each test cycle lasted one week.

C. Evaluation

As the problems of aesthetics are related to the proportion of the area covered with algae and to the intensity of coloring, the degree of fouling was evaluated by means of colorimetric measurements and image analysis.

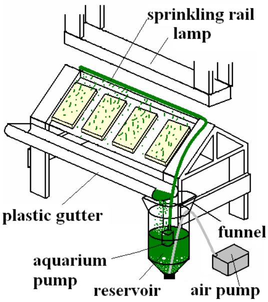

Figure 1. Schematic presentation of one unit of the modular setup.

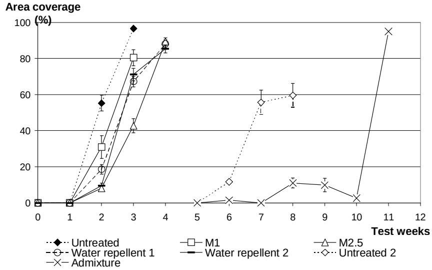

Figure 2. Evolution of the area that is covered with algae during the accelerated fouling tests.

Specimens that were covered with algae showed a characteristic reflectance spectrum, corresponding to the absorbance spectrum of chlorophyll a, the photosynthetic pigment of algae. From these findings, the algal density was quantified by means of the difference in reflectance between the wavelength of 550 nm and 670 nm.

For the image analysis, photographs of the specimens, obtained with the use of a scanner, were processed by means of ImageJ 1.38x software. For the quantification of the area covered by algae, colour thresholding was performed on the b (blue to yellow axis) coordinate of the CIE LAB colour space.

III. Results And Discussion

Due to the high porosity and roughness of the aerated concrete, the flow of water covered the complete specimen. This resulted in a homogeneous fouling of the specimens.

The presence of a water repellent resulted initially in distinct paths of water flow. Along these paths, intense colonization rapidly occurred. However, after 3 weeks of accelerated tests, the water repellent effect was strongly reduced. Eventually a complete fouling of these specimens was also observed.

The untreated specimens and the specimens treated with the lowest concentrations of biocide showed initially the highest algal growth (Fig. 2). In the first test series (week 1-4), the least rapid colonization was observed for the specimens treated with the highest concentrations of biocides.

After 4 weeks of testing however, almost 90% of the surface of these specimens was also covered with algae. As metal based biocide formulations exert their inhibitory effect upon direct contact with the microorganisms, the loss of biocidal activity could be due to the piling of dead biomass upon the biocidal compound. This is in accordance with the fact that no leaching of the compound occurred.

IV. Conclusions

Two types of treatments were investigated towards their performance to prevent algal fouling on aerated concrete. Both water repellent and biocidal product formulations were shown to slow down the rate of fouling. However, complete coverage of the specimens with algae already occurred after 4 to 6 weeks of accelerated tests. The accelerated fouling setup developed in this research allowed for a rapid evaluation of antifouling strategies on building materials. Due to its low cost and simplicity of design, this setup can be easily built in other laboratories.

References

[1] Escadeillas, G. et al. *Accelerated testing of biological stain growth on external concrete walls*. Materials and structures 40(10): 1061-1071, 2006.