The Impregnation of Concrete with Super-Hydrophobic Powder

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Introduction

The ingress of water is responsible for many of the physical and chemical processes that result in the deterioration of concrete. Water ingress is related to concrete sorptivity and therefore developing concrete that has water-repellent surfaces could have significant advantages. This project has used a super-hydrophobic powder manufactured from paper sludge ash that was developed in previous research. The aim was to use this as a waterproofing agent by impregnating the concrete surface with the powder to produce hydrophobic concrete.

Super-hydrophobic powder

The super-hydrophobic powder used in this project was developed in previous research and is produced by dry milling paper sludge ash (PSA) in the presence of stearic acid (Spathi, 2015).

High-presssure impregnation method

Concrete samples with a constant w/c ratio of 0.55 were impregnated with super-hydrophobic powder-hexane solutions with different mix ratios. The samples were impregnated using a high-pressure impregnation at a pressure of 10 bars for 1 hour.

After impregnation, excess solution was left on the surface of all the concrete samples, which after drying leaves a hardened hydrophobic paste - see Figure 1.

Pressing method

An additional treatment procedure was also developed in order to explore other methods of creating hydrophobic concrete. This method involved mechanically pressing super-hydrophobic powder into setting concrete. As a first attempt at the method, different additions of powder were pressed into samples at various times after the samples were cast. This produced a non-uniform coating of powder on the treated surface of the sample - see Figure 2.

Testing procedure

Before testing, the impregnated samples were cleaned before testing. For samples in Test Series 1, the excess powder was removed using a steel spatula and then the surface was wiped clean with a dry cloth. As this resulted in the treated surface losing its hydrophobicity, samples in Test Series 2 were not wiped clean and only had any excess powder removed using a steel spatula. The cube samples in Test Series 3 that were treated using the pressing method were not cleaned before testing.

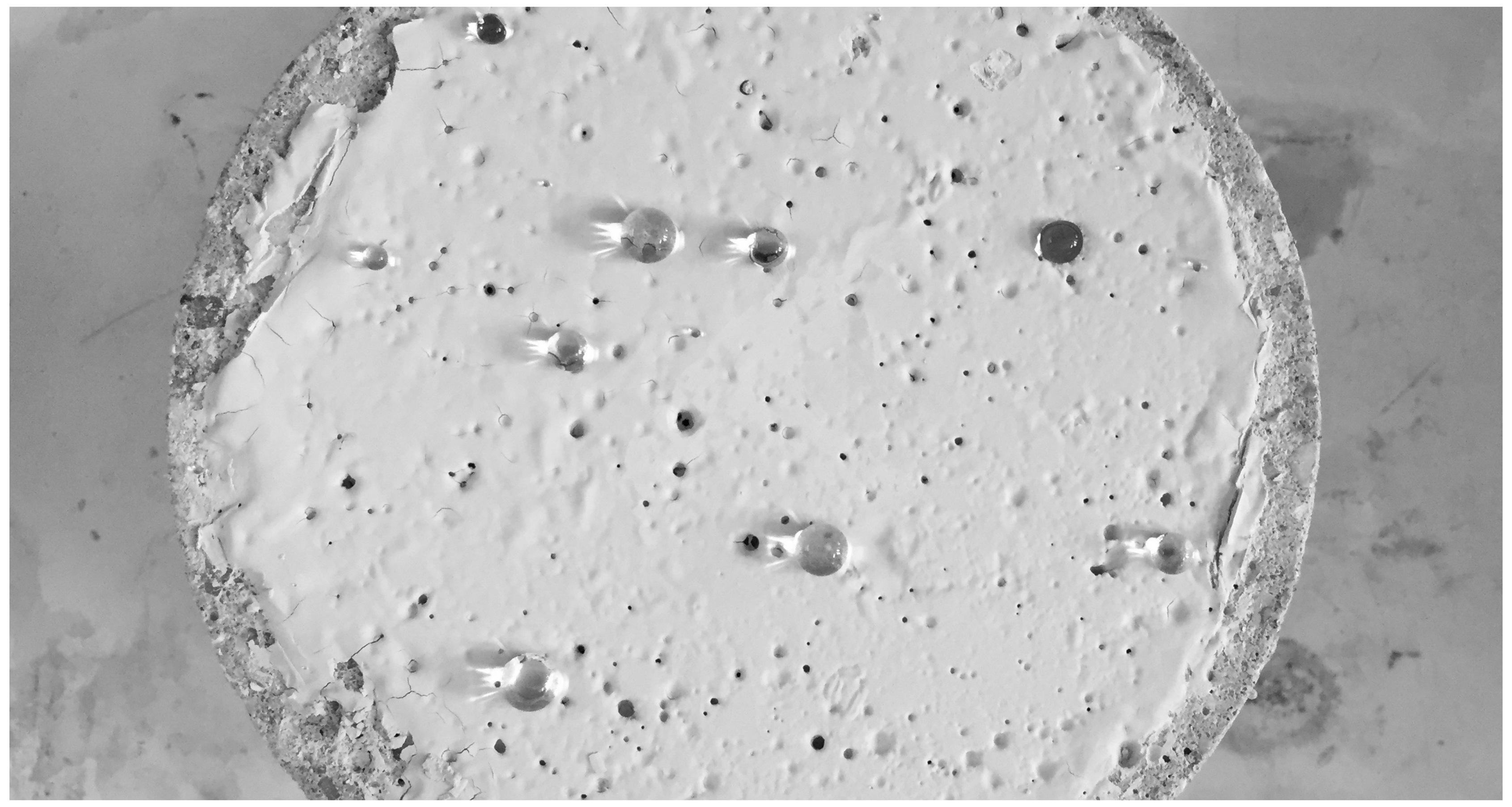

Figure 1. Paste exhibting hydrophobicity

Figure 2. Sample after treatment using pressing method

Samples in all test series were water sorptivity tested and the surface hydrophobicity was checked at various stages throughout the experimentation.

The impregnated samples were subjected to two additional tests:

- the excess powder mass removed during cleaning was used to approximate the mass of powder sucessfully impregnated
- the samples were also split and the cross-sections wetted to determine the impregnation depth

Test results and discussion

During sorptivity testing, all impregnated samples that had been cleaned exhibited an increased sorptivity coefficient, showing that the impregnation method has detrimental effects on water absorption and may have damaged the pore structure. All samples showed a reduced water mass gain during the initial wetting period, suggesting that the majority of super-hydrophobic powder particles are removed during the early stages of testing.

Where excess paste had not been removed, the sorptivity coefficient was reduced by 25%. However, the paste has a low durability and can be easily removed by hand.

Unfortunately, after splitting the impregnated samples, there were no visible signs of hydrophobicity when wetting the cross-sections.

Although in its infancy, the pressing method yielded more promising results with a maximum reduction in the sorptivity coefficient of 17% and it should continue to be developed.

Conclusions

- Impregnation method was not successful in depositing significant/ visible quantities of super-hydrophobic powder in the internal structure of concrete. A hardened hydrophobic paste formed of excess powder and hexane is left on the surface.
- For samples that had the excess paste removed, high-pressure impregnation resulted in an increased sorptivity and in many cases a greater water mass gain during water sorptivity testing. It is suggested that the impregnation process may have damaged the microstructure of the concrete and increased the porosity, either by physically changing the pore structure or by preventing further hydration.
- Treatment of cracked samples in preliminary experimentation showed that it is possible that the impregnation method may be more suitable for crack repair - see Figure 3.
- The mechanical pressing of super-hydrophobic powder into setting concrete is capable of producing concrete with a hydrophobic surface. This method requires further development but even in its preliminary form is promising.

Figure 2. Cracked sample after impregnation

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References

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