The counteraction of the damage of the concrete surface due to cyclic freezing and thawing

Summary

The dissertation is devoted to investigations of the damage of the concrete surface – scaling - due to cyclic freezing and thawing in the presence of de-icing salts. The possibility to replace various air-entraining admixtures by other more efficient technique is considered. The aim of the dissertation is specified in tree main theses described in chapter 1.

The main kinds of air pores in the concrete and the process of water filling and freezing of water inside the pore structure is described in chapter 2. A review of publications concerning the mechanism of both internal and external deteriorations of concrete structure due to cyclic freezing and thawing is presented in the next chapter. Chapter 4 is devoted to characterisation of concrete with regard to scaling phenomenon. Standards and methods of scaling resistance testing in the presence of de-icing salts used in the European countries are described in chapter 5.

In Chapter 6 the laboratory tests are described in full detail. Salt scaling tests were performed according to the Swedish Standard SS 13 72 44 (so-called Borås method). Freeze/thaw exposure was carried out on the upper horizontal surface of the specimens – cast surface, while the remaining surfaces were isolated against humidity and heat transfer. The scaled material was collected and weighed after a given number of freeze/thaw cycles, and the results expressed as mass per unit area were recorded. The laboratory tests were divided into a few specially planed test programs. The internal frost resistance of the same concretes was tested according to ASTM method - chapter 7. Additionally, air-content A, specific surface a, spacing factor $\overline{L}$ and the content of micropores below 0.3 mm A_{300} in the hardened concrete specimens were measured with the PN-EN 480-11 method on plane sections.

Chapter 8 is devoted to an analysis of the scaling phenomenon by the Fine Element Method model. The proposed model concerns only one freezing-thawing cycle. The microcracks that are caused by excessive tensile strength of concrete in the first cycle propagate in next cycles. It was shown that the deterioration of the concrete surface is depending of the depth of the air-pore location, the saturation coefficient, the rate of cooling and the kind of the liquid. Application of the proposed FEM model enables to perform virtual tests of the resistance against scaling when the concrete mix proportions are described.

The laboratory tests confirmed all three theses of the dissertation and the results are described in the conclusions in chapter 9.

It has been found out that the replacement of the fine fraction of the natural aggregate by the adequate fraction of the pre-wetted lightweight aggregate improved the scaling resistance of concrete. Moreover, fraction 0÷0.5 of sand proved to have a particular role in the frost resistance.

The modified Borås method appeared to be the most appropriate for application because of its clear criteria and facility of execution in laboratory conditions.

The dissertation is closed by a proposal of further research program.

In Annex I a series of photographs is given with views of concrete structures damages by scaling. All details of the test methods and obtained results are given in Annexes II – XV.

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