Reduced scaling of colored concrete pavements by means of super absorbing polymers

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Summary

This research project aims to improve the durability and resistance to freeze thaw cycles of colored concrete. The goal of this study is to study the effect of the red pigment on the frost-thaw resistance of concrete and to evaluate possible improvement actions by adding super absorbing polymers (SAPs) to the fresh mix. Also the combined effect of frost-thaw with de-icing salt is investigated.

By means of a laboratory investigation the influence of the red pigment on the scaling and degradation due to frost-thaw cycles is investigated according to the standard ISO/DIS-4846-2 and by means of compressive strength tests, measurements of the weight loss due to scaling and scanning electron microscopy. Secondly, the effect of various amounts and different types of SAP added to the fresh mix is studied and evaluated by means of the previously mentioned testing equipment.

Keywords: colored road concrete; super absorbing polymers; frost-thaw resistance; scaling.

1. Introduction

To overcome degradation due to frost-thaw actions, the concrete has to contain small cavities into the concrete matrix which form a network of expansion vessels. This network of pores will intercept the increasing pressure of the freezing water; reducing the tension pressure built-up in the upper and inner concrete layers, hence reducing the degradation processes. Previous research proved that the red pigment particles used in colored concrete roads has a super filling and fills the created air expansion vessels during mixing. To overcome this neutralizing effect, an answer was found in this research by adding super absorbing polymers (SAPs) into the fresh mix. SAPs have the ability to absorb large amounts of water and to release it when pressurized. The polymer can absorb mixing water during the fresh concrete production and gradually releases this water during the hardening process of the concrete, leaving cavities in the concrete matrix. These cavities can act as expansion vessels to counteract the expansion of frozen (expanding) water, as mentioned previously. As the SAPs form a physical barrier, the color pigment cannot fill the expansion cavities during mixing. Once the available mixing water is consumed by the hydration process, the absorbed water by the SAPs is gradually released and reacts with the unhydrated cement grains. Due to this process, the SAPs shrink, leaving expansion vessels into the matrix.

2. Experimental research program

This research project aims to improve the durability and resistance to freeze thaw cycles of colored concrete. The goal of this study is to study the effect of the red pigment on the frost-thaw resistance of concrete and to evaluate possible improvement actions by adding super absorbing polymers (SAPs) to the fresh mix. Also the combined effect of frost-thaw with de-icing salt is investigated. By means of a laboratory investigation the influence of the red pigment on the scaling and degradation due to frost-thaw cycles is investigated according to the standard ISO/DIS-4846-2 and by means of compressive strength tests, measurements of the weight loss due to scaling and scanning electron microscopy. Secondly, the effect of different amounts of SAP added to the fresh mix is studied and evaluated by means of the previously mentioned testing equipment.

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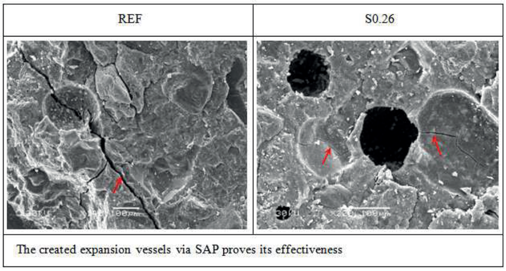
3. Obtained results and conclusions

3.1. Evaluation of the mechanical strength

Clearly the amount of color pigment positively influences the compressive strength: more color results in a higher compressive strength, due to the superfilling effect of the red pigment particles.

Increasing the amount of SAPs into the mix leads to a small reduction of compressive strength of colored concrete after 90 days of hardening. Small cavities (between 100 µm up to 600 µm) are created into the colored concrete explaining the observed strength reduction. However, due to the absorbed water, self-desiccation during the hydration process is reduced, leading towards a higher ultimate degree of hydration, which clearly compensates the strength reduction due to the more porous matrix. The optimal percentage of SAP in this research study is quite close to the percentage of 0.26 wt% (weight of dry SAP relative to the cement weight).



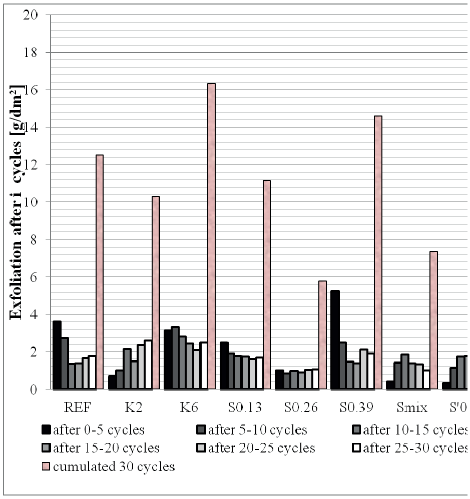


Fig.1: SEM image of REF (x70) and S0.26 (x80) (scale 200 µm, before F/T)(left)

Fig.2: Scaling of the cylindrical core samples after 5-10-15-25-30 freeze-thaw cycles (right)

3.2. Evaluation of the freeze-thaw resistance and of the microstructure

- *By adding color pigment*

The scaling or exfoliation of the upper concrete layer after 30 freeze-thaw cycles increases with increasing amount of pigment (Figure 2). Overall, the reference mix, frequently used in practice, exceeds the recommendation of exfoliation (must be inferior to 10 g/dm²) up to 25% due to freeze-thaw attack. Due to the lack of an appropriate amount of expansion vessels available in the dense colored matrix. Through-going internal cracks with a thickness up to 20 µm were observed after 30 freeze-thaw cycles by means of SEM-analysis (Figure 1). Also the amount of pigment has an important effect on the degree of scaling and internal degradation.

- *By adding SAPs*

By adding an optimal percentage of SAPs there is a clear reduction of scaling (Figure 2). The cumulated mass loss after 30 freeze-thaw cycles of the mixture can be inferior to 6 g/dm² in case 0.26 wt% SAPs (relative to the cement weight) is added to the mix. SEM analysis indicates that the internal cracking is less severe in the samples containing SAPs (with a crack thickness inferior to 4 µm), and the cracks move towards the created cavities (Figure 1). In case an adequate considered dosage of SAP is added, the application of SAPs in (colored) concrete for the improvement of the resistance against frost-thaw attack can be effective.