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SHORT REPORT

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Development of cement-based self-levelling screeds with a high freeze-thaw resistance

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1 AIM OF THE RESEARCH PROJECT

Building elements as terraces and balconies count among the most delicate building elements at all. It is estimated that defective balconies and terraces in Germany amount to at least 20 million. Here, the cause of the damage to the building parts is often a damage by frost to a customary, manually compacted cementitious screed which serves as a base for the pavement. The reason why these screeds are so highly sensitive to frost lies in the porous structure which enables a fast water saturation. When the water cannot flow out of the screed, e. g. due to a bituminous sealing of a terrace or a balcony, the result is a damage by freeze-thaw exposure. In the majority of cases, this damage is done within the first five years upon completion of the building element. Often, damages become discernible only much later, mostly when the building company is no longer liable for the defects. As a protection against these damages by frost, in the past the method to customarily manufacture screeds which serve as a base for ceramic tiles and slabs was modified. The standards provide for a protection of the screed against a lasting moisture penetration.

It is the aim of the research project to develop cementitious self-levelling screeds (CTF) which feature a high resistance to frost. In this project, characteristic values for suitable compositions shall be stated, e. g. cement and water content or even the kind of cement. The application of cementitious self-leveling screeds with a high frost resistance prevents building damages resulting from freeze exposure which often develop in customary cementitious screeds and enables damage-free reconstruction measures. In addition, it entails a rationalization of the building process and a decrease in building costs as the higher material costs are compensated by a more effective installation without any further measures (sealings to protect the screed).

2 REALIZATION OF THE RESEARCH PROJECT

The research program is divided into three steps. In the first part, the mixes shall be optimized. In the second part of the research program, mixes are developed on the basis of the first step and the influence of the used basic material and the mix composition on selected characteristic values is determined systematically. In the third and last part of the investigations, the practical suitability of the mixes is tested on the basis of the findings gained so far. Within the framework of this research project a CTF was developed and applied in practice in a pilot project.

3 SUMMARY OF THE RESULTS

Within the rheological investigations, the grading curve of the basic materials was systematically varied by a volumetric exchange of the basic materials and the effects on the rheological behavior were analyzed. The investigations were conducted on self-compacting mortars (SCM), the basic mortars of CTF with a maximum grain size of 2 mm.

It was established that SCM feature an optimized rheological behavior when the grading curves lie as close as possible to the ideal grading curve according to Funk and Dinger. The distance between the solid particles and the water demand which is an indirect parameter for the particle distance are directly linked to the grain size distribution and to the grain shape. At an ideal grading curve all spaces between grains are filled with solid particles. The water which is displaced from these grain spaces surrounds the grains and increases the distance between the particles.

At a known grain composition of the basic materials, the gained findings enable the precise mix design of a CTF and a powder-type SCC which is essentially faster and more practicable than the usually applied methods e. g the Japanese Concept. Transferred to the application of CTF, these results prove that an accurate choice of the basic materials and a granulometric optimization of the fines enable a manufacturing of CTF with a low water content and a low viscosity necessary for the workability. Low water contents and low water-to-cement ratios, respectively, are the prerequisite for the manufacturing of CTF with a high freeze-thaw resistance as well as for a minor deformation due to shrinkage.

As a rule, CTF feature higher compressive and flexural strengths than CT produced according to standard. A decrease in the nominal thicknesses of the indoor to the permissible values of calcium sulfate screeds which is not provided for in the standards is thus technically possible.

The application of cements of the strength classes 32,5 N and R, respectively, is entirely sufficient due to the high strengths. In principle, the cement content of CTF for indoors can be significantly reduced to contents of about 100 - 150 kg/m³ in comparison to customary contents. The required mechanical properties are definitely yielded by a granulometric optimization.

The water content must be kept as low as rheologically possible because low water contents induce a low shrinkage. The application of a shrinkage-reducing admixture significantly reduces the shrinkage but it also decreases the compressive strength of the CTF. This fact must absolutely be taken into account when designing such mixes.

A sufficient freeze-thaw resistance of the CTF is obtained by a dense package of the solid particles in combination with a cement content according to standard for outside steel-reinforced concrete building elements as well as a low water content. Artificially induced micro air voids additionally increase the freeze-thaw resistance, they are however not compulsory.

Finally, the findings of the research project were put into practice within the framework of a pilot project. In doing so, a rheologically optimized CTF was designed by a granulometric improvement and manufactured in a ready-mix concrete plant. The excellent suitability of this building material for this application proved when casting the CTF under practical conditions.