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SHORT REPORT

Development of novel cement-based self-leveling screeds for housing under special regard of rationalisation of construction progess and ecological aspects of preservation of resources

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1 AIM OF THE RESEARCH PROJECT

It was the aim of the research project to develop novel cement-based self-leveling screeds (CTF) for housing. In Germany the following screed systems are used: the manually inserted and smoothed cementitious screed (CT) and the calcium sulfate self-leveling screed (CAF). The CT have the advantages that for these screeds decades of experience are consisting and with proper use the risk of damage can be minimized. However the CT have economic disadvantages due to the increased workforce for casting and the required large screed thickness. In contrast, the CAF are less expensive due to their small workforce for casting and by using gypsum from wet flue gas desulphurisation plant it preserves natural resources. CAF are very sensitive to the charging with water. After a water damage in the kitchen, which has in contrast to the wet area "bathroom" no systematic sealing for CAF, a complete renovation of the floor structure is required.

Therefore cement-based self-leveling screeds could combine the benefits of CT and CAF. This is especially possible by using new expertises from the concrete technology for designing CTF. These expertises had been demonstrated in the context of a project by the Institute of Building Materials Research (ibac) funded by the Federal Office for Building and Regional Planning (BBR) in 2006.

Nevertheless the use of CTF in practice is infrequently because it is often difficult to achieve the necessary rheological properties through the design of CTF with regional materials (sand). The Producers attribute this to an unfavorable rheological sand. Also the acceptance of such systems on the market is missing currently due to the bad experiences with cement-based self-leveling screeds from the 80's as yet no highly effective superplasticizer, i. e. based on polycarboxylate ethers, were available.

Through the development of novel CTF, which are due to the targeted selection of raw materials and preserving resources by the design respectively, the construction process can be rationalised and a more cost-effective construction of housing is possible. Thus, this development could set new impulses in the building sector.

2 REALIZATION OF THE RESEARCH PROJECT

The research program was divided into three parts. In the first part investigations were performed to adjust the rheological properties of cement-based self-leveling screeds. Therefore mortars (CTFM) have been developed form the CTF and were tested. Since the durability of cement-based systems at a low water-cement-ratio was demonstrated fundamentally the emphasis of this research project was to handle the rheological questions and the investigation of the practical feasibility.

To produce flat surfaces CTF must have a pourable consistency for levelling fully only under the influence of gravity. To produce CTF with a incline (1 to 2%) the consistency must have to be less pourable. This means the screed must be so fluid that it compact by itself on the one hand. On the other hand the rheological properties (especially the yield strength) must be adjusted to special values so that the screed is not completely leveled.

In the second part of the research program it was investigated by which measures the shrinkage can be reduced and if the bending of floor corners can be reduced too. Furthermore, it was investigated what compressive and flexural strengths with the developed screeds can be achieved. Next to a low absolute water content, a low cement content and the influence of shrinkage reducing admixtures the use of different cements were investigated.

Finally it should provide evidence for lower nominal thickness of screeds on an insulating or separating layer similar to the performance test according to DIN 18560-2:2009-09. In addition the capillary water absorption of selected mixtures was investigated to determine the drying behaviour and the moisture vapour emission rate .

3 SUMMARY OF THE RESULTS

Within the rheological investigations the effect of volumetric exchange of raw materials on the rheological behavior were analyzed. The tests were conducted on mortars (CTFM), the basic mortars of CTF with a maximum grain size of 2 mm. It was established that the viscosities increased by decreasing the cement content. At the same time the superplasticizer content could be reduced to achieve the same workability and increasing yield stresses. All CTF showed shear thickening behaviour. With decreasing the cement content, the shear thickening decreased. The cement type had no systematic influence on the rheological properties.

In previous investigations ideal grading curves for achieving a close packing have been developed. It was determined that self-compacting mortars showed an optimized rheological behaviour when the grading curves lied as close as possible to the grading curve according to Funk & Dinger. Due to the used raw materials all CTF showed nearly identical grading curves which however did not comply with the grading curve by Funk & Dinger. Nevertheless the CTF showed a different rheological behaviour and achieved partially good rheological properties despite a low water.

Transferred to the application of CTF, these results prove that an accurate choice of the basic materials and a precise mix design enable a manufacturing of CTF with a low water content and a low viscosity necessary for the workability. Low water and cement content are the basic prerequisite for the design of CTF with low shrinkage deformation and a quick dryness.

Within the framework of this research project the following results were determined by the systematic investigation of raw materials and the mix design of CTF:

- CTF have usually in spite of lower binder contents the same compressive and flexural strengths such as standard-compliant CAF. A reduction of screed thickness for housing according to acceptable values for calcium sulphate screeds is technically possible.
- The application of cements of the strength classes 32,5 R (42,5 N 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. The tests on the standard prism showed a more favorable shrinkage behaviour, which was confirmed by the investigations in the channel for vertical shrinking.

- The type of cement had no influence on the mechanical properties and deformation behaviour.
- The water content is to be keep as low as rheologically possible, due to the fact that the shrinkage is significantly reduced by a low water content.
- The use of a shrinkage reducing admixture had no influence on the shrinkage for mix designs with low cement content. Shrinkage reducing admixtures are therefore not required for such mix designs.
- A definite influence of extended curing on the shrinkage was not determined.
- CTF with low cement content at a low water content are very quickly cured sufficiently at normal humidity.
- CTF, in mod. L-box test not leveled, can be used as screeds with incline, as they reached the required strength.
- Due to the high flexural strength of the tested mix design the thickness of cement-based self-leveling screeds could be significantly reduced for the respective classes of strength especially by exploiting the flexural strength depending on thickness. For the used mix designs a thickness of 30 mm or less could be even possible.

Within the framework of this research project self-leveling screeds with low cement content were developed, showing a low horizontal and vertical shrinkage and also a significantly better drying behaviour compared to the behaviour of CAF. The CTF achieved equal or higher strength values than comparable CAF. In addition, they allow a reduction of construction costs considering environmental issues.