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SHORT REPORT

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Development of self-compacting concretes of the viscosity agent type for special application in housing

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1 AIM OF THE RESEARCH PROJECT

The Self-Compacting Concretes (SCC) of the powder type mainly applied in Germany feature a very good flow behaviour due to the high powder contents of up to 600 kg/m³. The powder suspension is an excellent medium of transportation for the coarse aggregate and, at the casting, these concretes yield comparatively long flow distances of up to 10 m. Powder type SCC, however, often feature a distinctly higher strength than the vibrated concretes of the strength class C 20/25 normally applied in housing. Depending on the mix proportions, the material costs are about 20 to 40 % higher than those of vibrated concretes. This considerable amount along with the increased costs arising due to the necessary monitoring has up to now counteracted a wide application in the area of housing. Moreover, in practice, the required self-compacting properties were not always ensured or the concretes tended to segregate in individual cases.

The outstanding properties of the powder type SCC as the flowability and the self-levelling ability at long flow distances are, however, not always needed for all types of building elements. In this case, a viscosity agent type SCC is also applicable. With significantly less than 500 kg/m³, the powder content of the viscosity agent type SCC lies within the range of standardised vibrated concretes. At the viscosity agent type SCC - just as at the powder type SCC - the necessary flowability is yielded applying a superplasticiser on the basis of polycarboxylate ether, the stability is achieved adding a viscosity agent.

Thus, it is the aim of the research project to point out the efficiency and profitability of these concretes when used in housing. Especially with model concretings it shall be examined to which extent the viscosity agent type SCC are suited for building tasks in the field of housing. These examinations are conducted with comparative investigations on powder type SCC which feature similar rheological properties. The filling abilities of an SCC in a given formwork are decisively influenced by its flowability. The flowability are determined by the rheological properties of SCC as well as the friction between SCC and formwork, the so-called fluid-structure interaction. Because of their mix proportions viscosity agent type SCC in comparison to powder type SCC show a higher percentage of coarse aggregate which influences this friction. Therefore, the focus is directed on the examination of the fluid-structure interaction.

2 REALISATION OF THE RESEARCH PROJECT

To investigate the flowability of viscosity agent type SCC as compared to powder type SCC, at first two viscosity agent type SCC as well as two powder type SCC with a maximum grain size of 16 mm, each, were designed. Subsequently, to characterise the mixes, selected fresh and hardened concrete properties were determined. One powder type and one viscosity agent type showed a comparatively high viscosity. The other powder and viscosity agent type showed a comparatively low viscosity. All concretes featured the same slump flow of 710 mm. To determine the influence of the grain size, two powder type SCC with a low and a high viscosity with a maximum grain size of 8 mm was additionally examined.

To investigate the influence of the tribological properties, i. e. the friction between SCC and formwork, on the flow behaviour, the respective tribometer tests were conducted. To identify influencing parameters the results of these tribometer tests were correlated with rheological properties of the SCC and of the respective self-compacting mortars (SCM). The influence of the surface was investigated selecting a smooth-wetting, a smooth-nonwetting and a rough-wetting formwork surface.

To comparatively investigate the flowability of the examined SCC, model concretings were finally conducted in order to model the casting of a horizontally oriented as well as a vertically oriented building element. To model a horizontally oriented element, e. g. a slab or beam, a modified L-box was used. In comparison to the L-box known from literature, the flow channel of the L-box used for the model concretings was enlarged from 0.70 m to 2.00 m. At horizontally oriented building elements the SCC should be able to flow long distances without additional compaction or distributing work and a fast placement should be possible. To investigate the flow processes at vertically oriented building elements, a model wall with the outer dimensions of $l \cdot h = 1.0\ m \cdot 2.0\ m$ was used. It is the aim of the model concretings to determine the flow and filling behaviour of SCC under defined geometric boundary conditions.

3 SUMMARY OF THE RESULTS

From a fluid mechanical point of view, the flow of an SCC in the formwork is an incompressible, friction-afflicted flow. The flowability is decisively determined by the friction between concrete and formwork, the so-called fluid-structure interaction. Therefore, a focus was directed on these investigations.

The six investigated SCC were classified regarding their viscosity with the fresh concrete tests slump flow, V-funnel time and flow time in the L-box. This classification was tested and confirmed on the respective extracted mortars by viscometer tests. In the tribometer tests on these SCC it could be determined that viscosity is the factor which decisively influences the friction, the mix proportions, however, exert also an influence. With increasing viscosity also the shear stress increases.

The results of the tribometer tests showed that roughness is an important influencing factor. This could be verified with the determination of the flow times in the L-box which was lined with either a smooth or a rough surface. The rough surface showed significantly higher flow times and friction forces.

A clear statement regarding the influence of the flow velocity in the tribometer tests could not be made. Here, clear tendencies could not be discerned. There was, however, an almost proportionate correlation between the fresh concrete pressure and the determined shear stress.

Finally, with the casting of model building elements the suitability of viscosity agent type SCC for housing was investigated in a practice-oriented way. At the castings it turned out that the viscosity agent type SCC features the same filling abilities as the powder type SCC when they have a comparable slump flow and V-funnel time. A powder type SCC yields better results only where the de-airing ability below recesses as well as the fair-faced concrete quality are concerned and when there are special requirements regarding the flowability.

All in all, it was demonstrated that reinforced concrete building elements for housing can be produced in a high quality with viscosity agent type SCC. As a rule, powder type SCC show a clearly better flow behaviour. These properties, however, are only necessary where geometrically complex building elements are applied. When increased requirements are placed in the quality of the fair-faced concrete, powder type SCC is better suited. Building elements normally used in housing without increased requirements on the surface quality, e. g. walls, columns, slabs and stairs, can well be produced using a viscosity agent type SCC. A higher quality of the building members in housing applications can be anticipated when both, a viscosity agent type SCC as well as a powder type SCC are used more frequently. In the long run, this will lead to a more sustainable residential construction.