RELEVANCE of STAR 228-MPS

Given to the fast growth of research output in the field of Self-Compacting Concrete and the growing acceptance of this high-performance material around the world in both precast and cast-in-place applications, the RILEM Technical Committee TC 228-MPS "Mechanical Properties of Self-Compacting Concrete" was formed in 2008. Its members diligently worked to gather a large body of technical knowledge whose summary and analysis resulted in the publication of STAR 228-MPS. The following STAR in a nutshell provides an insight of the original STAR published in 2014. Some more up-to-date details can be found in the list of references at the end of this document.

STAR in a nutshell 228-MPS
"Mechanical Performance of Self-Compacting Concrete"

Self-Compacting Concrete (SCC) can be considered as a new type of high-performance material of a different approach to mix design and rheological characteristics when compared to conventional concrete (in this report referred to as **vibrated concrete VC**). It offers a valuable solution for accelerating the placement rate and reducing labour demand needed for placing concrete. Although SCC has been used in actual structures for a while, until recently it was not fully clear whether existing designing codes for structural design could be fully applied to SCC. In order to give a detailed answer to this issue, this state-of-the-art reviewed the properties of SCC with respect to mechanical behaviour, stress strain relations, bond properties, etc.

An extensive database, containing the results of **mechanical properties** of fresh and hardened SCC has been generated and analysed. It originates from numerous (around 250) journal and conference papers published between 1990 and 2011. This database also includes information on the mixture proportion and design. Only mixtures with slump-flow values within the limits defined by EN206 (550 to 850 mm) were considered. The following major considerations have been made:

1) All types of cement are applied in SCC mixtures.
2) The Water/Cement values are between 0.19 and 2.73, with a mean value of 0.54.
3) The high powder content needed for SCC, compared to VC, is obtained by increasing the cement content or more often by increasing the amount of power-type additions. These are commonly instance pozzolanic materials like limestone filler, fly ash, blast furnace slag and silica fume. However, in some cases also marble powder, glass powder, rice husk ash, metakaolin, volcanic ash and granite powder are used.
4) The total paste volume of a SCC mixture is, in most cases, higher (mean value around 370 l/m^3) than that of a VC mixture (290l/m^3).
5) Results originating from the literature seems to indicate that the conversion factor f_{ccyl} /f_{ccub} between compressive strength determined on cylinders (f_{ccyl}) and on cubes (f_{ccub}) may be higher for SCC than reported for VC: for the latter it is generally situated within the region of 0.7 to 0.9; for the former, it tends to situate beyond the upper limit of 0.9. No dependency on the compressive strength was noticed.
6) Water/Cement and cement strength class are the principal factors influencing the compressive strength, as it is the case for VC.
7) At a constant Water/Cement ratio, a higher Cement/Powder ratio generally leads to a lower strength.
8) 1% increase of air content generates a decrease of about 4 MPa of the compressive strength of SCC.
9) Addition of limestone filler in SSC results in higher peak strains and toughness than VC.
10) An increasing trend of direct, splitting and flexural tensile strength is noticed for increasing strength of SCC samples.
11) Analysis of the data available in the database shows that the modulus of elasticity of SCC seems to be very similar to VC.

12) On average, the strength loss after heating of SCC is comparable to VC. The probability of spalling of SCC seems higher compared to VC, although some conflicting results are found as well.
13) Overall, it can be confirmed that SCC cast in-situ can provide similar or even slightly better properties compared to cast in-situ VC.

With the appearance of SSC as a valuable alternative for VC, some of the established **stress-strain relations** have to be re-evaluated, because of the significant changes in the paste volume and binder composition and their influence into the viscoelastic properties. On this regard, the main points found in the literature are:
1) Creep coefficient and specific creep seem to be generally higher (5-10%) for SCC compared to VC with the same binder composition.
2) The use of Ground Granulated Blas-Furnace Slag (GGBFS) and fly ash can result in a decrease of the creep coefficient.
3) The influence of the strength-gain rate on the creep coefficient needs further research.
4) Autogenous shrinkage in SCC increases with increasing cement content and decreasing W/P by vol, as it happens in VC.
5) SCC should be more susceptible to plastic shrinkage cracking than VC. Results in the literature are, however, scarce and more research is needed.
6) Current (up to 2014) numerical models are designed for VC and do not take into account the influence of paste volume. An adaptation of these models to SCC is necessary.

The bulk of the available literature agrees that **bond properties** of SCC to embedded reinforcement, pre-stressing strands and hardened concrete are higher than those of VC, due to the different rheological properties of the former. These are the major conclusions on this topic:
1) Static stability of SCC is critical in reducing the top-bar effect to embedded reinforcement and prestressing strands.
2) To avoid entrapment of air-voids during casting, plastic viscosity should be kept below 80 Pa.s and t_{50} below 6 seconds.
3) SCC used as a repair material develops greater strength to existing surfaces than repair overlay made with VC.

When the proportions of coarse aggregate (size and shape) or paste content of SCC mixtures significantly differ from those of VC, some researchers have observed a difference in engineering properties such as shear and bond strength. This observation has triggered the need to investigate the **structural behaviour** of SCC. The final remarks on this matter are:
1) SSC structural elements seem to be characterised by an increased value of the strain at peak, reduced value of the axial stiffness and increased value of the flexural strength, with respect to VC.
2) Ductility of SCC is in general higher than that of VC. If the structural element if confined by means of stirrups, SCC shows larger ductility.
3) The structural behaviour of reinforced structural elements under flexure made of SCC is very similar to that of the corresponding elements made with VC. Conventional design predictive models and equations proposed for VC can be applied also to SSC.
4) The shear strength of SSC is around 10-15% lower than that found in VC. This difference disappears when considering beams with stirrups.

RELATED DOCUMENTS:

1) *Rheology and Processing of Construction Materials, RheoCon2 & SCC9* (2019), Edited by V. Mechtcherine, K. Khayat and E. Secrieru, RILEM Bookseries Vol 23.
2) Proceedings PRO 100: *8th International RILEM Symposium on Self-Compacting Concrete* (2016) Edited by Kamal H. Khayat
3) Proceedings PRO 90: *Rheology and processing of Construction Materials – 7th RILEM International Conference on Self-Compacting Concrete and 1st RILEM International Conference on Rheology and Processing of Construction Materials* (2013), Edited by N. Roussel and H. Bessaies-Bey
4) *Design, Production and Placement of Self-Consolidating Concrete*, *Proceedings of SCC2010*, Montreal, Canada (2010), Edited by K. Khayat, D. Feys.
5) *Durability of Self-Compacting Concrete* (2007) State-of-the-Art Report of RILEM Technical Committee 205-DSC
6) *Casting of Self Compacting Concrete* (2006) State-of-the-Art Report of RILEM Technical Committee 188-CSC
7) *Self-Compacting Concrete* (2000) State-of-the-Art Report of RILEM Technical Committee 174-SCC