Reasons to the low use of self-consolidating concrete in Norway

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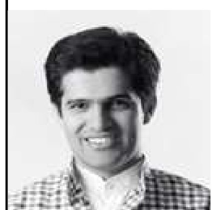

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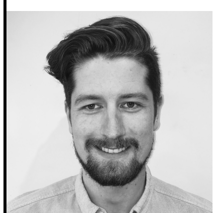

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ABSTRACT

According to several research papers, self-consolidating concrete (SCC) should be able to offer advantages over conventional vibrated concrete (CVC) [1-3]. Nevertheless, in Norway SCC has a relatively low market share, and the use is mainly concentrated to the capitol and nearby districts. In this paper, through interviews with professionals in the construction industry, possible causes of the low use of SCC in Norway have been investigated. Lab tests have also been conducted to study effects of variations in the concrete composition, as well as the effects of poor execution that can occur due to inadequate competence of construction workers. According to the paper´s results, perceived advantages of the SCC are not nearly as many as those mentioned in various research papers [2-4].

Key words: Self-consolidating concrete, reinforced concrete, segregation, quality control, admixtures.

1. INTRODUCTION

SCC is a modern type of concrete which originated in Japan in the 1980s [5]. Due to high seismic activity, constructions in Japan require a large amount of tightly spaced reinforcement [2] which complicates the use of vibrators. In such constructions SCC is more suitable, because the properties of fresh SCC allow it to flow and fill the formwork without vibration. Various research papers mention quite a few other advantages, such as improved quality of the concrete, and overall costs lowered by up to 15% [4].

SCC might also reduce construction times [2] and improve health and safety on the construction site, as operation of vibrators is eliminated [2]. Despite these advantages the usage of SCC has not reached the levels that were expected, as the product was introduced to the Norwegian construction industry in the late 1990s [6].

In some parts of the world the access to resources used in concrete production, and especially components that are highly present in SCC, might be limited, which makes the use of SCC uneconomical [4, 7]. This is not the case in Norway, as both fly-ash and silica fume is available [8, 9]. So, are Norwegian contractors not seeing the benefits, are they slow to adapt new materials and casting methods, or isn´t the quality of Norwegian SCC satisfactory? By improving the understanding of what the biggest challenges with SCC are, one can more easily point out what needs to be done to improve the quality of finished constructions. In this paper, the results from 12 interviews with contractors, producers and suppliers will be presented through interview summaries. Lab tests are conducted on the basis of statements from the interviews that concern challenges experienced with SCC, often allegedly caused by unsatisfactory properties of the delivered, fresh concrete.

2. METHODS AND MATERIALS

2.1 Interviews

The interview guide is developed based on the theory of "Diffusion of Innovations" [10] by Everett Rogers. This theory explains how, why, and at what rate new ideas and technology spread in a market. In this paper, the theory is mainly used to review the decision-making process that leads to accepting SCC, or rejecting further use after the product has been tried and evaluated. Twelve interviews have been conducted with individuals holding different roles in the Norwegian construction industry, such as clients, contractors, producers of concrete and suppliers of aggregate and admixtures. The main topics revolve around the respondents' first-hand experience with SCC, which structural parts SCC is considered to be appropriate for, whether SCC fills a unique need in the industry, perceived quality of the delivered product, and the use of SCC in the future. A summary from the interviews is presented in chapter 3.1.

2.2 Experimental procedures

Test 1: Accelerating admixtures in SCC: Some respondents state that they experience lower early strength in SCC than in CVC, especially at low temperatures. Felekoğlu and Sarıkahya [11] support this by describing polycarboxylate-based superplasticizers' retarding effect on cement hydration. The concrete used in the test specimens is one mixture of SCC with different dosages of accelerating admixture, and one mixture of CVC with equal quality as reference, the latter without any accelerating admixture. Half of the specimens were cured for 12 hours, and the rest for 24 hours, before compression testing. The curing temperature was 5°C ± 1°C for both the 12- and 24 hour specimens.

Test 2: Segregation test: A wall formwork system (2700x1200x200mm) was assembled and a surface retarding additive was applied onto the inner side of one of the walls. The purpose was to be able to expose the aggregate after a curing period of 48 hours, to show the distribution of the aggregate throughout the wall surface. The bottom half of the formwork was filled with SCC that had been visually controlled and showed no signs of segregation of cement paste from aggregates**.** Two hours later the top half was filled with an SCC that had 1.5 liters of superplasticizer added, enough to induce clear signs of segregation of cement paste from aggregates. The formwork was removed after 48 hours and the retarded cement paste was flushed off of using a high-pressure washer, enabling the exposed aggregate to be studied.

3. RESULTS AND DISCUSSION

3.1 Interviews

Concrete producers estimate that SCC makes up approximately only 5-10% of the total concrete volume produced nationally. There is agreement among the interviewees that the most important advantages with SCC are its fresh properties that make it possible to cast in tight spaces with dense reinforcement without the need of vibrating, as well as increased efficiency due to faster casting. Few mention other advantages as significant for choosing SCC over CVC and many claim that they get just as good, or even better, results with CVC. It is indicated that quality control of the SCC on site very often is neglected, even though they consider this as an important parameter for the end results. Most of the interviewees claim that they don't have any particular estimate on gains from choosing SCC over CVC, as this is mostly based on perceived profitability. All respondents say that the same measures need to be taken in cold weather, regardless of whether one is using CVC or SCC, but some claim that they achieve lower early strength with SCC, presumably caused by the superplasticizers´ retarding effect. Ready mixed SCC from the factory is, by many contractors, said to often have large variations in quality, which is surprising, since concrete is very rarely returned to the factory for this reason. This might be due to a very tight schedule that forces progress to be made. Some contractors state that the tolerances for variations in the concrete standards are too wide, and some producers agree and mention that a tightening here would lead to better results, and this should apply to all from suppliers of concrete components to execution on site.
There is a general agreement that the use of SCC in Norway will increase in future, although this would require more researches on SCC composition and the additives´ effect on SCC. This, combined with stricter tolerance requirements, could lead to more consistent quality and increased competence.

3.2 Experiment results

Results from Test 1 show that when curing concrete in low temperatures (constant core temperature at around 5℃), the retarding effect caused by superplasticizer in SCC is not significant, compared to the retardation caused by the low temperature itself (in relation to curing at 20℃). Figures 1a show that the SCC has approximately the same early strength as the CVC. Accelerating admixture can be used in both types of concrete in order to reach the necessary strength for early removal of formwork, but other measures as formwork insulation and external/internal heating, should also be considered. Differences in early strength is shown in Figure 1a. A simulation of the temperature development in the specimen is shown in Figure 1b.

According to the results of test 2, a noticeable difference in aggregate distribution in the normal and segregated SCC was observed. In the bottom layer, both fine and coarse aggregates were evenly distributed through the whole layer. In the bottom part of the upper layer, coarse aggregates (8-16mm) was overrepresented, and in the top part of the upper layer, only small aggregates (0-8mm) and cement paste was to be found. The early compressive strength (24 hours) of the concrete from both layers also differed substantially; the segregated SCC only had ¾ of the compressive strength compared to the unsegregated SCC.

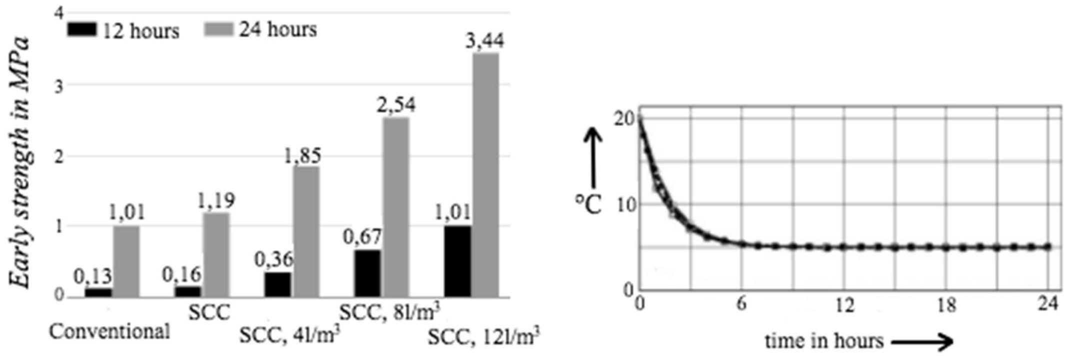

Figure 1 – a) Early compressive strength of concrete for different dosages of accelerator (curing temperature 5°C), b) simulation of the core temperature in the specimen throughout the curing period.

4. CONCLUSION

The quality of SCC is nearly always within current requirements as it leaves the factory. Since quality control on site often is neglected, deviations aren't detected before after casting the concrete. As SCC is a more fragile product than CVC, experience is important to be able to judge the quality on site, and to handle the product correctly. The industry would benefit from better communication and transfer of experience. Much research is being done on the subject, but the distance from PhD level to construction site is perhaps too far for the knowledge to ever reach the construction worker.

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