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Current Status of Self-Compacting Concrete in South Africa

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ABSTRACT: Self-compacting concrete (SCC) requires no external vibration to achieve consolidation and generally results in savings in labour and time, improved workability, improved quality, higher durability and better surface finish. SCC is a widely accepted technology in Europe, East Asia and North America. In South Africa, on the other hand, SCC has only been used for a relatively small number of applications and the acceptance of the new technology by the local industry is at this time very limited. A limited investigation into the South African concrete industry was performed, in addition to a market review to gain insight into the extent of us of SCC in South Africa. The review showed that the reluctance to accept the new technology is partly related to the limitations that presently surround the use of SCC locally. These include sparse knowledge and experience of specifying and working with SCC using South African materials, and the reluctance of concrete product manufacturers to change their production processes. In addition, there is an absence of South African standards or guidelines that can be used to facilitate the design, manufacture and application of self-compacting concrete. Ongoing education efforts may result in the situation where the advantages of SCC will be applied more frequently to improve construction procedures and concrete quality in South Africa.

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The Current Status of Self Compacting Concrete in South Africa

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Abstract

Self-compacting concrete requires no external vibration to achieve consolidation and generally results in savings in labour and time, improved workability, improved quality, higher durability and better surface finish. SCC is a widely accepted technology in Europe, East Asia, and North America. In South Africa, on the other hand, SCC has only been used for a relatively small number of applications and the acceptance of the new technology by the local industry is at this time very limited. A limited investigation into the South African concrete industry was performed, in addition to a market review to gain insight into the extent of use of SCC in South Africa presently. The review showed that the reluctance to accept the new technology is partly related to the limitations that presently surround the use of self-compacting concrete locally. The limitations include sparse knowledge and experience of specifying and working with SCC using South African materials and the reluctance of concrete product manufacturers to change their production processes. In addition, there is an absence of South African standards or guidelines that can be used to facilitate the design, manufacture and application of self-compacting concrete. Ongoing education efforts may result in the situation where the advantages of SCC will be applied more frequently to improve construction procedures and concrete quality in South Africa.

Introduction

Self-compacting concrete (SCC) is a relatively new concrete technology. Developed in Japan in the late 1980's, it is characterised by its ability to flow and completely fill formwork, even in the presence of dense reinforcement, whilst still retaining its homogeneity **(Figure 1)**. The fresh properties of self-compacting concrete are possible due to the use of advanced superplasticisers and re-designed mixes containing lower coarse aggregate contents and higher fines contents. Self-compacting concrete differs from traditional vibrated concrete in that it requires no external vibration to achieve consolidation. The advantages of this are economic benefits of savings in labour and time, in addition to improved quality, better surface finishes and improved workability.

Figure 1: Self compacting concrete does not need any external vibration for full compaction and filling of formwork

The acceptance of the new technology by the South African construction industry is at this time very limited, which is partly due to a limited amount of knowledge and experience of specifying and working with SCC using South African materials, in addition to an absence of South African standards or guidelines that can be used to facilitate the design, manufacture and application of self-compacting concrete. The required significant investment, both economically and in terms of education, that is necessary to successfully produce SCC leads to a consequent price premium on the final delivered product. These factors result in there being no incentive for the cement and concrete producers to market a new product. An investigation into the mindset of the South African concrete industry was performed, in addition to a market review to gain insight into the extent of use of SCC in South Africa presently.

Advantages of SCC compared to conventionally vibrated concrete

The advantages of SCC are well documented in the literature (for example RILEM, 2000). In general, the economic advantages of self-compacting concrete relate to the following factors:

- Faster construction
- Reduction in site manpower
- Better surface finishes
- Easier placing
- Improved durability
- Greater freedom in design
- Reduced noise levels
- No compaction necessary
- Safer working environment
- Less repair and making good after formwork is removed
- Risk of poor workmanship is reduced

SCC enables a faster construction time because no time is spent on consolidating the fresh concrete. This also leads to a reduction in manpower, whereby workers who traditionally vibrated the fresh concrete are no longer necessary. Most of the advantages directly relate to economic benefit (faster construction, reduction in manpower, easier placing, less repair work and improved durability), while the rest relate to aesthetics and ease of use. In how far these advantages, which were identified mainly for industrialised countries, apply to South Africa will be discussed in the following sections.

Market review on the South African mindset on SCC

A market review, conducted to gauge the level of use and understanding of SCC in South Africa, was undertaken

in the form of questionnaires and personal interviews. Various construction companies, architects, consultants and concrete product manufacturers were approached and asked to fill out a questionnaire. In total, about 40 individuals were approached and 20 replied to the request and completed the questionnaire, the respondees consisting of approximately 30% contractors, 30% consultants, 20%

Readymix producers, 15% precast concrete manufacturers, and 5 % Architects. The questions focused on whether individuals had heard about self-compacting concrete and its advantages, and if they had heard about it whether they had used it in practice. The reasons for using SCC, as well as the volume and method of manufacture were also asked. If the individual filling out the questionnaire had never heard of or used SCC in practice then they were made aware of the advantages of the new technology, followed by a question as to whether they would or could use SCC in practice. Two questions aimed to gather information as to whether potential users of SCC would be more likely to use it if a practical set of guidelines existed for the design, manufacture and application of SCC in South Africa.

Awareness about SCC and its advantages

Of the twenty responses, seventeen had heard about SCC, and of those, eleven had used SCC at least once. Most of the respondents heard about SCC through international industry-related conferences or technical journals, although the respondents' knowledge of the benefits of SCC was either limited or specific to their fields. This indicates that a marketing campaign, detailing the economic, time-saving and other advantages, is necessary to educate the market and that conferences, journals and magazines have a definite role to play in advancing the use of SCC in South Africa. In order for this to happen, more articles and papers need to be written and presented. This will come about as SCC is used more in research and practice and more general awareness is generated.

Those involved in the production of SCC and its constituents have also played an important role in advancing the use of SCC in the construction industry, as a number of respondents had heard about SCC from Readymix producers or admixture suppliers.

Of those interviewed, 16 replied that they were aware of the advantages of SCC. The advantages that were listed by the respondents were as follows (the number in the brackets indicates how many respondents listed that particular advantage).

- No need for compaction (10)
- Better surface finish or improved off-shutter quality can be obtained (5)
- Reduced labour requirement on site (5)
- Intricate or complex geometric shapes can be cast (4)
- Reduced construction time, therefore labour can be used more effectively (3)
- Ease of placing / alternative placing methods are possible (2)
- No segregation (2)
- Self-levelling (2)
- Reduced noise levels (2)
- Better product can be produced (in terms of precast concrete products) (2)
- Improved durability (2)
- Reduced air voids (1)
- No vibration needed therefore health and safety benefits (1)
- Honeycombing is reduced. Concrete can be placed in restricted areas and areas with high reinforcement congestion (1)
- Concrete can be pumped long distances (1)
- Higher strengths are obtained (1)

Most of the advantages listed indicated that the respondents had a limited view of the advantages of SCC, with none of the respondents (except those involved in research and production) listing more than four advantages. The main advantage of SCC, namely that it requires no compaction, was listed as an advantage by ten respondents. Only one then went on to further analyse this advantage and relate it to the health and safety benefits of placing concrete without vibration. Reduced labour requirements were listed by five respondents as an advantage of using SCC but there were no respondents who applied this advantage, or any other, to savings in terms of cost. Three respondents listed reduced construction time as an advantage, and then went further to say that with these time savings, labour could be used more effectively or efficiently.

Application of SCC in South Africa

The areas in which SCC found application in South Africa were mainly high rise buildings and bridges, where most respondents used SCC for the technical advantages that it offers **(Figure 2)**.

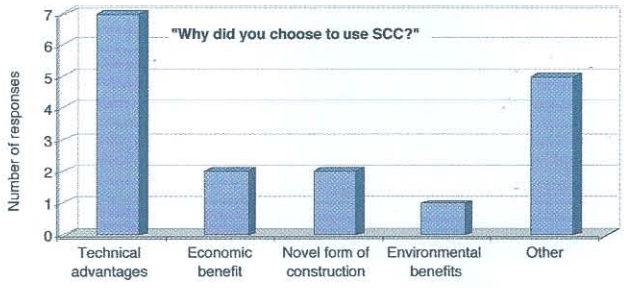

Figure 2: Market review – Reasons for using SCC

Five respondents used SCC for other reasons which are listed below:

- Trial run for future use in precast yard
- SCC used to cast a slab which was very close to the soffit of another slab. The proximity of the slab to an existing one made external compaction impossible.
- Column construction, where the limited access made compaction of traditional concrete impossible.
- SCC used for precast parapet wall infill and poured into the small gap in the parapet wall.
- SCC used to create bridge superstructure elements in the vicinity of moving trains. SCC construction techniques simplified the construction works and made the use of concrete in a restricted access site simpler.

The volumes of SCC used were generally low, where most respondents reported using up to 10 m3 of self-compacting concrete for their applications. The most used form of SCC production was Readymix. Of the benefits listed by those who had used self-compacting concrete in practice, the fact that it saved them or their company time was listed most often **(Figure 3)**.

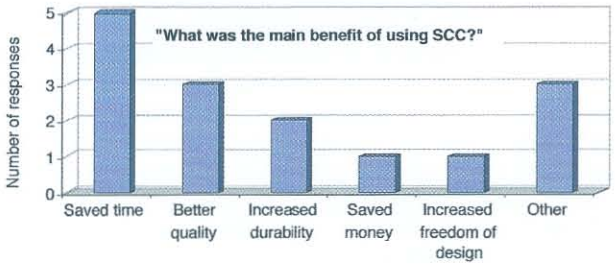

Figure 3: Market review – Main benefits resulting from the use of SCC

The advantage that self-compacting concrete gives better quality was the second most highlighted benefit that users perceived they gained by using SCC. Other reasons or benefits that users felt were that the use of self-compacting concrete gave them peace of mind and that the use of SCC benefited the customer. The advantages of increased quality and durability were not listed as often as expected, leading to the conclusion that education is needed to create awareness about these important issues.

Of those that had used SCC, all indicated that they would use it again. Of the nine who had never used SCC in practice, eight were interested in learning more about the product. There was the general feeling that SCC could be used in their field.

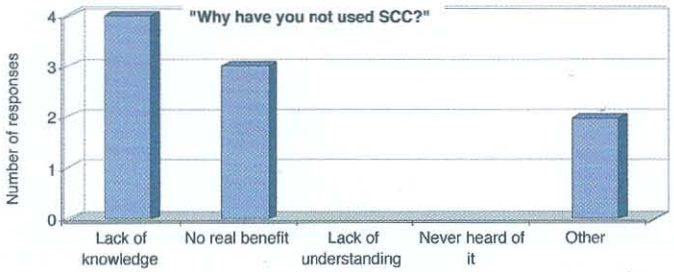

Figure 4: Market review – Main reasons for not having used SCC

Lack of knowledge was listed as the primary reason for not using SCC **(Figure 4)**, indicating that the development of a practical set of guidelines would facilitate the use of SCC in South Africa **(Figure 5)**.

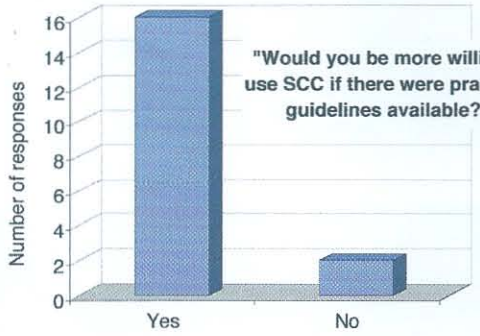

Figure 5: Market review – Potential interest of the industry to apply SCC

Most respondents were interested in learning more about SCC, and most felt that industry or professional bodies, such as the Cement and Concrete Institute, the Concrete Society of Southern Africa, or the South African Institution of Civil Engineering should be responsible for the development of such recommendations.

Materials used

According to the answers received in the questionnaire, most SCC used in South Africa is made using a coarse aggregate size of between 9 mm and 19 mm. There seems to be a preference for this size stone in SCC use, probably due to the fact that a smaller sized aggregate provides the best results for self-compacting concrete in terms of workability characteristics.

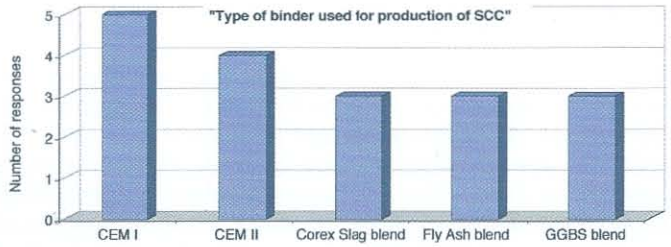

Figure 6: Market review – Type of binder used in the production of SCC in South Africa

As can be seen from **Figure 6**, Corex slag, fly ash and ground granulated blastfurnace slag have all been used in equal measure as extenders by the respondents. Admixtures used included common commercial superplasticisers and, in one reported case, a viscosity modifying agent.

Conclusions drawn from a more specific market review

As the market review process progressed it became apparent that various individuals within the concrete industry played a large role in SCC in South Africa. A second, more advanced questionnaire was therefore developed to aid in eliciting more information from those who have been instrumental in the introduction of SCC in the country, to determine whether those who had intimate knowledge of SCC felt that its benefits and advantages were applicable to South Africa. The most notable points that were highlighted by those interviewed surrounded the mindset of those in industry, the role of those involved in education and marketing, and whether there exists a viable market for self-compacting concrete in South Africa.

It was believed by most of the selected interviewees that the mindset of potential users of SCC needs to change. The mindset that presently exists is one of conservatism, traditionalism and habit. Potential users are unwilling to adopt the use of SCC in their operations simply because it is an unknown technology and the potential benefits are either not well known or not well understood. It was noted in the first questionnaire that many potential or existing users of SCC were unaware of the benefits of the product that relate to increased durability and quality. This was again highlighted in the second questionnaire, where most interviewees felt that these two benefits, while being the most important, were the least understood. Clients and

specifiers of concrete and concrete products were also thought to be accustomed to a certain way of thinking that will require a determined education and marketing campaign to change.

Other reasons for the market being unwilling to accept the new technology were the higher cost of SCC, the lack of marketing and education strategies, and the belief that SCC is at the moment still a specialist concrete in South Africa. Although most interviewees felt that in South Africa there is a viable market for SCC, which has the potential to expand, the afore-mentioned issues need to be addressed. The fact that South Africa in general is seen to lag behind more advanced markets by at least five years was also seen as a reason why the use of SCC is not more widespread. It was generally believed that the use of SCC will reach the same levels as other markets such as Japan and Europe, but that this will take up to ten years.

All of the interviewees believed that education and marketing should be the main method of overcoming the various disadvantages and problems that presently surround the production and use of self-compacting concrete in South Africa. Where the interviewees differed was in their belief as to who should be responsible for such an education and marketing campaign. The authors took the view that a combined approach, involving academics, researchers, concrete producers and their suppliers, as well as official industry bodies, such as the Cement and Concrete Institute, will be the most effective in changing mindsets and educating the market.

Are the main advantages of SCC applicable to the South African market?

Most of the advantages of SCC relate directly to economic benefits (faster construction, reduction in manpower, easier placing, less repair work and improved durability), while others relate to aesthetics and ease of use. Based on the market review discussed above, the main advantages offered by SCC technology are analysed in view of their applicability for the South African construction industry.

Reduction in manpower

The labour-saving advantages associated with self-compacting concrete are a contentious issue in South Africa. The construction industry in South Africa is intentionally labour-intensive, and the government is seeking to address the current unemployment crisis by utilising the resources of the construction sector and thus supporting the use of "labour friendly" technologies. These goals are contrary to the benefits that SCC can offer and political imperatives play an important role in the current lack of acceptance of this technology.

Automation of casting processes

SCC can be pumped over longer distances and at a faster speed than conventional concrete. All major Readymix suppliers in South Africa have truck-mounted pumping equipment, but despite this, pumping is not a readily accepted form of placing concrete in South Africa. It is therefore debatable whether the advantage of self-compacting concrete in terms of automation and pumping is currently applicable to the South African market. However, with increasing construction volumes and time constraints, pumping is expected to become a more commonly used procedure for concrete placement.

Concrete durability

In South Africa, durability of concrete structures, especially on the coast, is of particular importance. As a result, durability specifications in the design process of such structures have developed to be the norm rather than the exception. The benefit of increased durability of self-compacting concrete should provide some impetus for acceptance by both developers and designers. Higher durability of SCC is generally linked to high workability and high fines contents, as well as elimination of construction errors during compaction.

Reinforcement congestion and thin sections

SCC allows for the design of thin sections and sections with congested reinforcement, which traditionally would be difficult to compact effectively. There are few applications with high reinforcement congestion requiring the use of SCC in South Africa, which somewhat eliminates this advantage. However, the use of SCC is often also of benefit in situations where the configuration of formwork or the production process makes access to the fresh concrete difficult for vibrators. Inclined formwork, beam and deck repairs and high casting heights often preclude the use of mechanical vibrators, leading to the use of SCC to solve such problems. Some contractors in South Africa have used SCC for this reason.

Architectural concrete

New developments in architectural concrete have been facilitated by the advent of SCC, enabling the design and construction of concrete facades and cladding. In South Africa there is potentially a large market for architectural concrete members. However, at present South African architects and precast concrete product producers are either mostly unaware of SCC or have yet to exploit it. The Cement and Concrete Institute of South Africa has recently significantly increased its efforts in promoting architectural concrete, thus opening new opportunities for the use of SCC.

Working environment

Traditionally, health and safety measures in many precast yards and on construction sites in South Africa have fallen short of international standards and are still not receiving sufficient attention. However, in recent years this has gradually changed and increasing awareness of safety regulations will probably promote the use of SCC in future.

Concluding remarks

Successful implementation of SCC in the South African construction industry is currently retarded by a number of factors relating to general disadvantages or challenges concerning the manufacture and use of SCC.

The South African market will require a considerable amount of education and time before the use of SCC substantially increases and it can be confidently used. Many of the difficulties associated with SCC are directly related to inadequate knowledge of the product, but these are expected to be gradually overcome by education and marketing, or by Readymix companies assuming a greater role in concrete supply. Other factors will also play a role in the acceptance of SCC, such as special formwork requirements for using SCC on site, as well as more sophisticated moisture and water control equipment needed during the manufacturing process. Precast plants may also have to investigate in how far they need to invest in plant upgrades to distribute SCC efficiently to the moulds.

Conditions on construction sites in South Africa are not ideal for the production of SCC but there are a number of relatively high-tech Readymix plants that are in a position to produce SCC. Notwithstanding the favourable economic and marketing conditions that exist for the production and provision of SCC to a wide range of clients, little use has been made of this technology so far. Very recent developments (subsequent to this study), however, show that Readymix producers are now starting to market this new technology. Economic factors will play a role in the success of SCC implementation, whereby Readymix plants in South Africa are already operating at full capacity, and local cement production is unable to supply the demand.

Precast operators, who are in full control of the process, are in the best position to reap the benefits of self-compacting concrete. The situation in South Africa currently shows that there are few, if any, precast operations making use of self-compacting concrete. Most precasters felt that changes to their production processes were not necessary, and that the advantages of SCC were outweighed by the disadvantages.

Despite the above challenges, industry demands resulting from the current construction boom and increasingly stringent regulations for concrete quality can in future be expected to shift the industry towards more sophisticated production methods for prestigious projects. This, in connection with ongoing education efforts may result in the situation where the advantages of SCC will be applied more frequently to improve construction procedures and concrete quality in South Africa. The market review revealed that one of the main reasons why SCC has not been used more extensively in South Africa is the absence of a local set of guidelines for the production and application of SCC. Therefore, if the industry is to make use of the numerous advantages of this technology, a set of relevant guidelines needs to be developed.

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