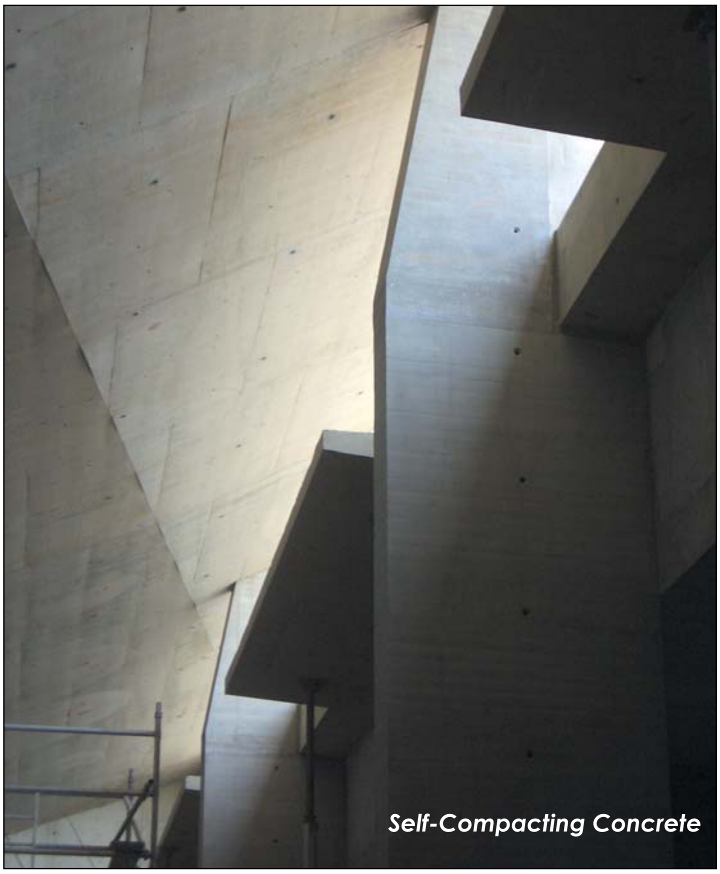
New European Guidelines for Self-Compacting Concrete (SCC)

by Brian Ó Murchú

In 1994 five European Organisations, BIBM, Cembureau, ERMCO, and ENFARC, all dedicated to the promotion of advanced materials and systems for the supply and use of concrete, created a 'European Project Group' to review current best practice and produce a new document covering all aspects of SCC. The work was recently brought to a successful conclusion with the publication of New European Guidelines for SCC, a clear and concise document, outlining the current state of knowledge in relation to this increasingly popular form of concrete. This key document is of particular interest to specifiers, designers, producers and purchasers who wish to enhance their level of expertise in the specification and use of SCC, and is now available from the Irish Concrete Federation.


Self-Compacting Concrete

To date, self-compacting concrete has received little attention in Ireland, although some producers have experimented with it. However, its use across Europe is increasing year on year. In Holland, SCC is now substituting traditional forms of concrete at a rate of 5% per annum and now accounts for 40 % of all concrete production. The experience is that manufactures and specifiers who gain experience with SCC, are quickly converted by its benefits. Although slow to take off in Ireland, there is every reason to believe that SCC will gain popularity, sooner rather than later.

Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete. The fluidity and segregation resistance of SCC ensures a high level of homogeneity, minimal concrete voids and uniform concrete strength, providing the potential for a superior level of finish and durability to the structure. SCC is often produced with low water-cement ratio providing the potential for high early strength, earlier demoulding and faster use of elements and structures.

Concrete that requires little vibration or compaction has been used in Europe since the early 1970's but self-compacting concrete was not developed until the late 1980's in Japan. In Europe it was probably first used in civil works for transportation networks in Sweden in the mid 1990's. The EC funded a multi-national, industry lead project 'SCC' 1997-2000 and since then SCC has found increasing use in all European countries.

Self-compacting concrete offers a rapid rate of concrete placement, with faster construction times. Although it has a higher cement content and therefore higher material costs, reports from European manufacturers indicate that by eliminating the need for vibration, shorter construction times are achievable, with time savings of up to 20% in some instances. The elimination of vibration equipment improves the environment on and near construction and precast sites where concrete is being placed, reducing the exposure of workers to noise and vibration. The result can be lower overall costs with improved performance and better health and safety conditions.

To achieve adequate levels of strength and durability, concrete must be properly compacted. Achieving uniform levels of compaction throughout the pour is one of the key challenges in traditional concrete and success is labour dependent. Self-compacting concrete, as the name suggests, achieves uniform compaction and removes the element of uncertainty. The new publication covers durability and other engineering properties of hardened concrete to provide reassurance to designers on compliance of SCC with EN 1992 -1-1 Design of concrete structures (Eurocode 2).


SCC Flow Characteristics


SCC has an exceptional slump

SCC Seminar March 2006

The Irish Concrete Society, in association with Engineers Ireland, propose to hold a 1 day seminar in early March 2006 on "Building With Self-Compacting Concrete". This seminar will cover Design, Concrete Mix/Production, Architectural Issues, Costs/Benefits and Practical Applications.

Full details will be available later this year from the Irish Concrete Society
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The Guidelines are drafted with an emphasis on ready-mixed and site mixed concrete where there are requirements between the purchaser and the supplier in relation to the specification of the concrete in both the fresh and the hardened state. In addition, the Guidelines cover specific and important requirements for the purchaser of SCC regarding the site preparation and methods of placing where these are different to traditional vibrated concrete.

The improved construction practice and performance, combined with the Health & Safety benefits, make SCC a very attractive solution for both precast concrete and civil engineering construction.

Mix Design

The new 'European Guidelines on SCC' document, gives advice to the producer on constituent materials, their control and interaction. Because there are a number of different approaches to the design of SCC mixes, no specific method is recommended, but a comprehensive list of papers describing different methods of mix design is provided.

Speaking in general terms, the need to achieve high fluidity while increasing the cohesiveness seems to represent conflicting requirements. The first alteration to the mix usually involves utilising a much higher quantity of fines (typically at least 50% sand is used) to obtain stability, with lower coarse aggregate content to reduce interparticle friction. The normal rules apply concerning maximum aggregate size and the gap between the reinforcing bars, irrespective of concerns about blocking due to congestion of reinforcement. It is difficult to achieve appropriate fluidity and viscosity by changing the grading of the sand alone and either an active cement replacement ingredient (such as slag or ash) or a filler (such as limestone powder) is added in relatively large quantities, depending on the local economics and availability. Typically, changing a normal C30/35 mix to a self-compacting mix might demand the addition of over $200kg/m^3$ of limestone filler to the original cement content of $300kg/m^3$. Furthermore, while the SCC admixture can be made to produce flowing and cohesive concrete by adjusting the fines content (particularly that passing the 150µm sieve), the increased water demand which the filler (or cement replacement) and additional sand generates means that the water content is critical to obtain good flow. In these circumstances, it is not easy to avoid segregation without adding a viscosity modifier. Special training is required to design, produce, transport and place SCC. However, a wide range of mixes can be made to meet the required properties. It is essential to undertake trials on proposed mixes using locally available materials.

Production Control

Self-compacting concrete is less tolerant to changes in constituent characteristics and batching variances than lower workability concrete. Accordingly, it is important that all aspects of the production and placing process are carefully supervised. SCC is also more sensitive than normal concrete to variation in the physical properties of its constituents and especially to changes in aggregate moisture content, grading and shape, so more frequent production checks are necessary. The high paste content and fluidity of SCC can make it more difficult to achieve a uniform mix than concrete of lower consistence. The main difficulty is the formation of unmixed 'balls' of constituents and once these have formed they are not easily broken down. This problem can be avoided by first batching the concrete to a lower consistence than self-compacting concrete until it is uniformly mixed. Addition of further water and superplasticiser will increase the consistence to the required level while avoiding 'balling'.

Properties required of SCC

It is understood that three properties are demanded of SCC in its fresh state for it to be successful:

a) Filling Ability – the concrete must flow into all areas of the formwork under its own self-weight;
b) Passing Ability – the concrete must flow through obstructions, such as congested reinforcement, without becoming blocked;
c) Stability – segregation must not occur – the concrete must be cohesive.

In its hardened state, the primary requirement is that the compressive strength must be optimized through the achievement of full compaction under its own self-weight. Many tests have been done by coring cast elements with highly congested reinforcement and verifying that the strength is equivalent to mixes to which mechanical vibration has been applied; usually marginally higher compressive strengths with better uniformity is achieved. Further, from an aesthetic viewpoint, the uniformity of compaction thus achieved improves the quality of finish (there are fewer defects such as grout loss, honeycombing and blow holes), and the impermeability of the cover concrete is expected to enhance durability.

Despite the lower coarse aggregate content, shrinkage and creep are not increased and bond is marginally improved due to better densification in the interfacial transition zones around the reinforcing bars and especially the elimination of any voidage under bars due to plastic settlement.