SELF-COMPACTING HIGH-PERFORMANCE CONCRETE

High-performance concrete that self-compacts into confined zone of reinforcing bars with minimum spacing of 35 to 60 mm

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1. Characteristics

Self-compacting high-performance concrete is a high performance concrete that can be compacted into every corner of a formwork, purely by means of its own weight and without the need for vibrating compaction (Fig. 1). This concrete is defined as follows at the three stages of concrete: (1) Fresh: self-compactable; (2) Early age: avoidance of initial defects; (3) After hardening: protection against external factors.

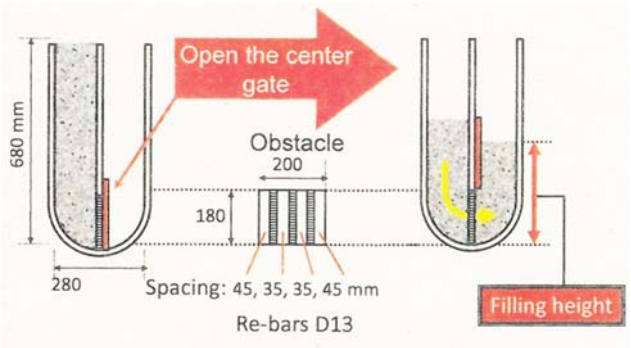

図-1 自己充填性試験装置
Fig. 1 Test for self-compactability

2. History of development

To make durable concrete structures, sufficient compaction by skilled workers is required. However, the gradual reduction in the number of skilled workers in Japan's construction industry has led to a similar reduction in the quality of construction work. A solution for the achievement of durable concrete structures independent of the quality of construction work is the employment of self-compacting concrete. The necessity of this type of concrete was proposed by Okamura in 1986. Studies to develop self-compacting concrete (SCC), including a fundamental study on the workability of concrete, were carried out by Ozawa and Maekawa at the University of Tokyo. The prototype of self-compacting concrete was first completed in 1988 using materials already on the market. The prototype performed satisfactorily with regard to drying and hardening shrinkage, heat of hydration, denseness after hardening, and other properties. At almost the same time, "High Performance Concrete" was defined as a concrete with high durability due to low water-cement ratio by Aitcin et. al. Since then, the term high performance concrete has been used around the world to refer to high durability concrete. Therefore, Okamura adopted the term "Self-compacting High Performance Concrete" for Japan's SCC.

3. Mechanism for the technology

The self-compactability of fresh concrete depends mainly on its ability to flow through obstacles[1] (Fig. 2). The method for achieving self-compactability involves not only high deformability of paste or mortar, but also resistance to segregation between coarse aggregate and mortar when the concrete flows through the confined zone of reinforcing bars. Okamura and Ozawa have employed the following methods to achieve

self-compactability: (1) Limited aggregate content; (2) Low water-powder ratio; (3) Use of superplasticizer. Highly viscous paste is required to avoid the blockage of coarse aggregate when concrete flows through obstacle. When concrete is deformed, paste with a high viscosity also prevents localized increases in the internal stress due to the approach of coarse aggregate particles (Fig. 3). High deformability can be achieved only by the employment of a superplasticizer, keeping the water-powder ratio to be very low value. Poly-carboxylate type of superplasticizer is suitable for SCC (Fig. 4).

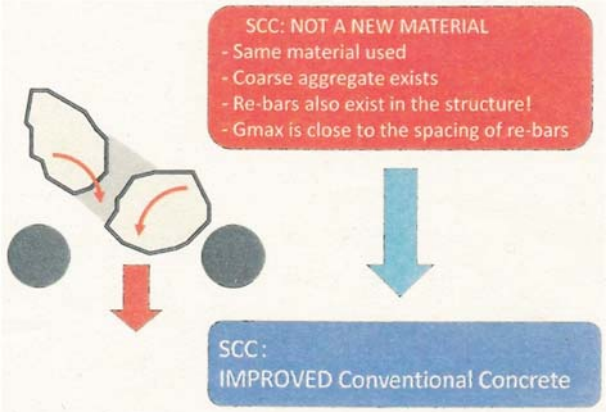

図-2 間隙通過性が自己充填性を特徴づける
Fig. 2 Flowability through obstacle characterizing self-compactability of fresh concrete

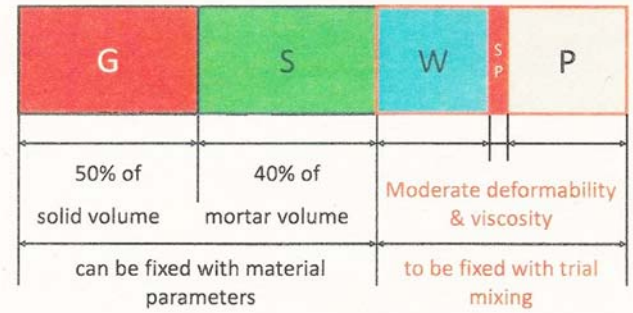

図-3 SCCの合理的配合設計法
Fig. 3 Rational mix-design method for self-compacting high-performance concrete

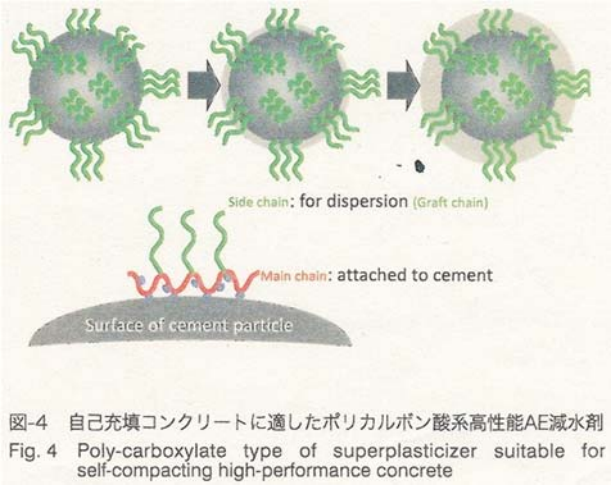

図-4 自己充填コンクリートに適したポリカルボン酸系高性能AE減水剤
Fig. 4 Poly-carboxylate type of superplasticizer suitable for self-compacting high-performance concrete

4. Practical applications

Self-compacting concrete has been used in many practical structures since 1990. Currently, the main reasons for the employment of self-compacting concrete can be summarized as follows: (1) To shorten construction period (Fig. 5); (2) To assure compaction in the structure: especially in confined zones where vibrating compaction is difficult (Fig.s 6 and 7); (3) To eliminate noise due to vibration: effective especially at concrete products plants. Also, SCC is applied to tunnel lining for preventing the cold joint (Fig. 8).

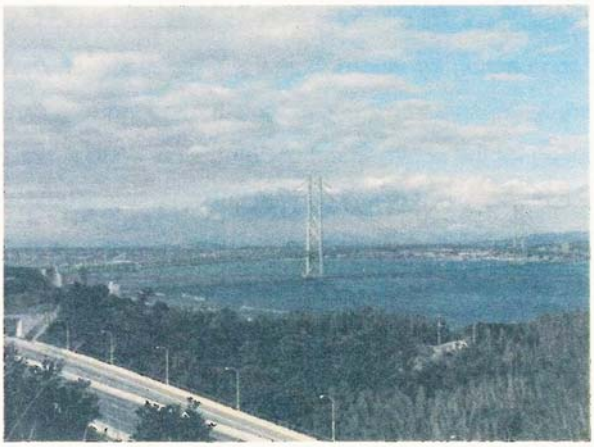

図-5　明石海峡大橋とアンカレイジ
Fig. 5　Anchorage of Akashi-kaikyo Bridge

図-6　LNG地上タンク
Fig. 6　LNG on-ground tank

図-7　高橋脚と過密配筋
Fig. 7　High pier of bridge and confined zone of reinforcing bars

図-8　トンネルアーチクラウン部に確実に充填
Fig. 8　Self-compacting concrete for reliable placement into archcrown of tunnel

Reference

[1] Ouchi, M. State-of-the-art report on self-compactability evaluation, Proceedings of the international Workshop on Self-Compacting Concrete (CD-ROM), Kochi, Japan, March 1999, Also available from Concrete Engineering Series, No. 30, Japan Society of Civil Engineers, March 1999.