Self-compacting concrete (SCC) to improve structural reliability

Concrete is the most-used construction material in Japan, in terms of both volume and value. Consisting of just water, cement, and aggregate (sand and gravel), this inexpensive material is close to nature, and it is easy to produce and use. However, concrete cannot deliver the designed level of performance unless it is firmly consolidated in formwork with rebar, and the work of compaction requires a high level of skill. When this is inadequate, not only strength but also long-term durability may be impaired.

Ordinary concrete

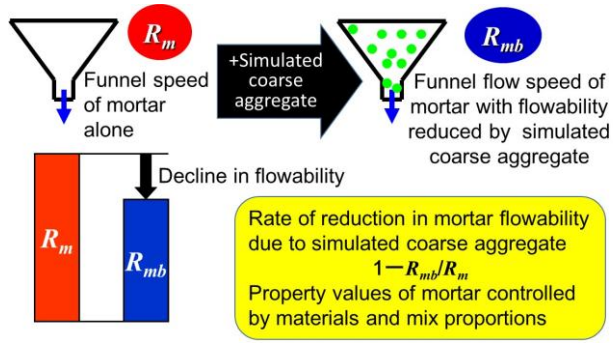
Self-compacting concrete

Self-compacting concrete is the solution. This is a type of concrete that reliably consolidates in formwork with rebar by the action of gravity alone. Its performance is not dependent on the skill of compaction work. This concept was first proposed by Professor Hajime Okamura of the University of Tokyo (former President of Kochi University of Technology), and a prototype was completed in 1988 by Koichi Maekawa and Kazumasa Ozawa at the University of Tokyo. This type of concrete uses only the conventional materials of concrete.

Self-compacting concrete (SCC) is known as an original technology pioneered by Japan. Research on SCC has been performed in many countries, and it has been used in structures and buildings. Because there is no need to use vibrators for compaction work, SCC also helps to improve the work environment.

Research base for SCC

Ever since its founding in 1998, the concrete laboratory of Kochi University of Technology has performed research to expand the utilization of SCC. It has taken the lead in developing elemental technologies for the practical application of SCC, including methods for quantification of the dispersion, water reducing, and thickening effects of chemical admixtures, methods for simultaneous adjustment of the water-cement ratio and the quantity of water reducing agents, methods for quantification of the inter-particle friction of fresh mortar using glass beads as simulated coarse aggregate, and testing methods for acceptance of the entire quantity of concrete just before casting at the job site.



Simple test to quantify inter-particle friction in fresh mortar by simulated coarse aggregate

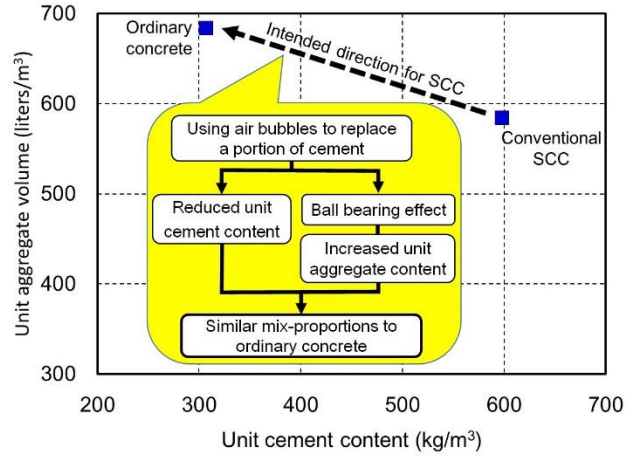
These technologies have contributed to the success of many projects using SCC, including shorter construction periods for large-scale structures, reliable consolidation in structures with dense rebar arrangements, cold joint prevention, and realization of architecturally creative designs. The results are being used in the development of materials using SCC, and in the recommendations of the Japan Society of Civil Engineers (JSCE) and manuals of the All Japan Ready-mixed Concrete Industry Association.

Breakthrough for SCC applications: Bubble-lubricated SCC (air-SCC)

Although SCC is acclaimed as an innovative high performance material that contributes to structural reliability, its cost is approximately double that of ordinary concrete because of its high unit cement content, and this has been an obstacle to its adoption in ordinary structures that do not require high levels of strength.

Using technologies for the quantification of self-compaction factors and technologies for the evaluation of chemical admixtures as its tools, the concrete laboratory of Kochi University of Technology has found solutions for these challenges. The key is the introduction of air bubbles (air entrainment) to improve the freeze-thaw resistance of concrete. Air entrainment is used in designing the mix proportions of concrete, as these air bubbles act like ball bearings for greater flexibility in fresh concrete, increasing its performance. In this way, the proportions are kept about the same as ordinary concrete, using only ordinary cement as the powder, with unit cement content of less than 400 kg and unit water content of approximately 170 kg. Meanwhile, the level of self-compaction is about the same as that of conventional SCC. This material is called air-enhanced self-compacting concrete (abbreviated as air-SCC). A prototype was completed in 2013.

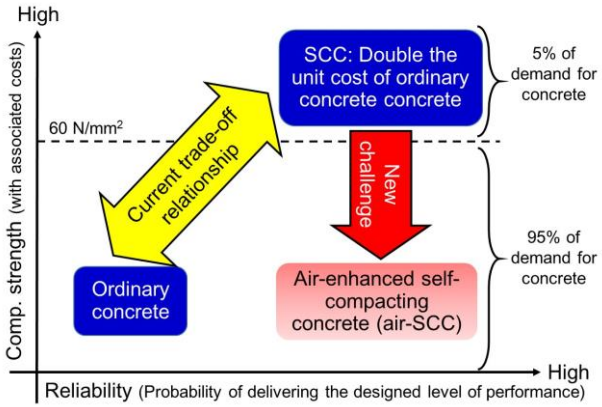
air-SCC is a material that can improve the reliability of general structures. This highly reliable concrete material keeps costs low while delivering the same strength as ordinary concrete after hardening.

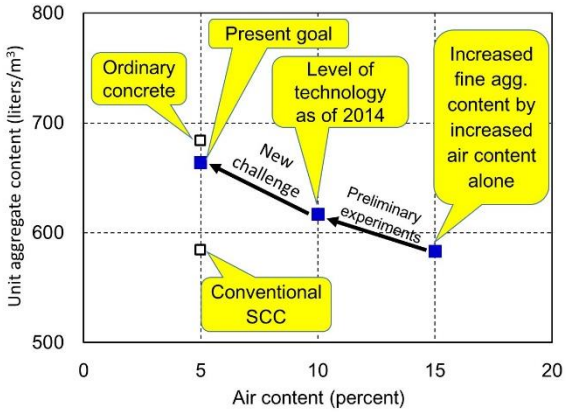


Training engineers through the development of useful technologies with high quantitative contributions

The concrete laboratory of Kochi University of Technology engages in technical development based on a paradigm shift from high performance to high reliability. To improve the economic efficiency of civil engineering structures and buildings, whose primary purpose is to ensure and maintain spaces over long periods of time, it is more effective to use adequate amounts of inexpensive and highly reliable materials than it is to reduce the quantities of materials (dimensions and thickness) through high strength.

The goal of the concrete laboratory of Kochi University of Technology is to develop concrete technologies that are useful in practical applications, and thereby to train engineers who can work in a wide range of useful areas.





Professor Masahiro OUCHI

Born in 1968 in Ibaraki, Japan
Areas of specialization: Civil engineering, concrete engineering
Research subjects: Self-compacting concrete, costs of infrastructure construction and maintenance
Education: Dr. of Engineering (The University of Tokyo, 1997)

Major patents related to air-SCC

- Self-compacting concrete with less reduction of flowability due to coarse aggregate, Japanese Patent Application No. 2013-157174, July 29, 2013
- Fresh mortar quality evaluation method, Japanese Patent Application No. 9912161, December 16, 1999

Reference on air-SCC

- Attachaiyawuth, A., Tanaka, K., Sovannsathya, R., Ouchi, M.: Air-enhanced self-compactability of fresh concrete with effective mixing method, Proceedings of the Japan Concrete Institute, Vol. 37, 2015.

Technical instructor: Hideo MIYAJI

- Formerly technical director of the Kochi Ready-Mixed Concrete Industrial Association
- Formerly of Nihon Cement (now Taiheiyo Cement) Research Institute

Number of students (as of May 2015)

- Doctor's program: Three students (two from Thailand and one from Cambodia)
- Master's program: Two second-year students, one first-year student
- Six undergraduate seniors

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air ENHANCED SCC

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from high performance
to high reliability

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