Recommendations for
Mix Design and Construction of
Mechanically-compacting Flowable Concrete (Concrete Library 161)
Subcommittee on Construction of Mechanically-compacting Flowable Concrete

1. Purpose of Publishing Recommendation (draft)

Mechanically-compacting flowable concrete has been employed for the secondary linings of mountain tunnels, as high-strength concrete, and as concrete that is pumped over long distances. As the working-age population of Japan is predicted to decline into the future, improving productivity is an extremely important issue in the field of construction. As such, the Ministry of Land, Infrastructure, Transport and Tourism has been considering various measures to improve productivity in an initiative named "i-Construction" and one such measure under discussion is the use of concrete that has been made more flowable. Here, it is proposed that the target slump or slump flow at the time of design be used as a reference value and that construction workers select the appropriate flowability (slump or slump flow) of the concrete based on structural or construction conditions or the like.

Concrete of ordinary strength can be classified, in terms of flowability, into three broad categories, namely concrete requiring compaction and managed by slump adjustment, concrete requiring compaction and managed by slump flow adjustment (mechanically-compacting flowable concrete), and concrete not requiring compaction (self-compacting concrete) and managed by slump flow adjustment (see Fig. 1). Of these types of concrete, technical recommendations for mechanically-compacting flowable concrete have not yet been established, so currently this type of concrete cannot be used in the construction of structures. Of particular importance is the lack of clarity regarding mix design methods and workability verification methods for mechanically-compacting flowable concrete when used for construction under various structural or construction conditions. This subcommittee has formulated technical recommendations for mechanically-compacting flowable concrete that clearly show these points and has worked with the aim of promoting the widespread use of mechanically-compacting flowable concrete.

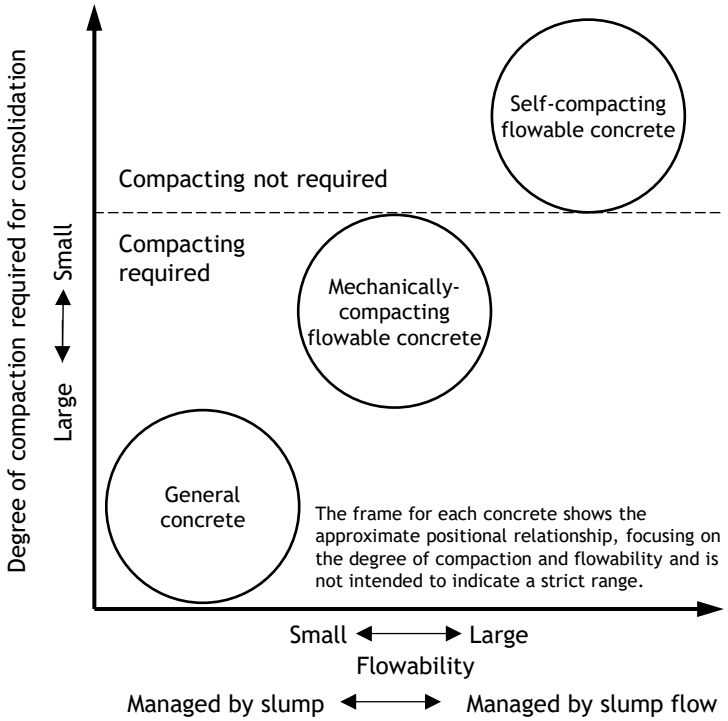

Fig. 1 Relationship between flowability and degree of compaction required for consolidation

By using mechanically-compacting flowable concrete, a high-quality concrete structure can be constructed. It prevents deterioration in construction quality due to poor concrete consolidation or segregation and it will save on labor for casting concrete in response to the coming labor shortage in the construction industry.

2. Activities of the 256-subcommittee

The 256-subcommittee, the Subcommittee on Construction of Mechanically-compacting Flowable Concrete (Chairman: Hiroshi Watanabe, managing director of Public Works Research Center (General Incorporated Foundation)) was established by the Concrete Committee of the Japan Society of Civil Engineers (JSCE) in April 2020 at the request of 25 construction companies and organizations. The 256-subcommittee consisted of 50 members who are experts from the private sector, contracting agencies, universities, *etc*. The subcommittee involved the activities of five working groups that tackled issues relating to creating recommendations, performance regulation, construction standards, quality evaluation, and case collection, and continued up to September 2022.

3. Outline of the Recommendations (draft)

The recommendations (draft) consist of the general principles, construction standards, inspection standards, JSCE standards, and the reference materials section.

The general principles presents the basic principles for designing mixes of mechanically-compacting flowable concrete and the use thereof in construction. This section is based on performance verifications, so it is highly versatile. In mechanically-compacting flowable concrete, ensuring flowability according to construction conditions and preventing segregation due to compaction work is very important in terms of quality. In the main section, the term ‘homogeneity’ is defined as an index for verifying the quality of consolidated fresh concrete and basic principles are presented to confirm that concrete used for actual construction does not fall below this homogeneity. By clarifying such basic principles, a technical system that is consistent with conventional recommendations regarding ordinary concrete and self-compacting flowable concrete has been established and the requirements of mechanically-compacting flowable concrete are shown based on the concept of performance regulation.

The construction standards set the structural conditions and construction methods in order to promote the adoption of mechanically-compacting flowable concrete at construction sites. The quality evaluation index and standard values for fresh concrete that conforms to the construction standards are specifically shown (see Table 1). According to these construction standards, the construction method and quality of fresh mechanically-compacting flowable concrete are combined and categorized as belonging to one of two types, namely “type 1” for cases where the concrete has the same passability as general concrete and “type 2” for cases where a higher passability than that of type 1 is required.

For the quality evaluation index of fresh concrete, its flowability, segregation resistance, and passability were presented as evaluation items for both types. For flowability, a conventional slump flow test was adopted and the target slump flow is 450 mm for type 1 and 550 mm for type 2. In order to evaluate resistance to segregation and passability, a proposed new test method (JSCE-F702) for measuring the sedimentation status of coarse aggregate by vibration compaction was conducted. Supplementary notes were compiled for a test method in which the “test method for passability of concrete through obstacle in a box-shaped container with vibration (draft)” compliant with JSCE-F 701-2018 can be applied to mechanically-compacting flowable concrete.

Congruity tests for the two test methods pertaining to resistance to segregation and passability have also been implemented to validate these tests, and standardization of these tests for application to JSCE testing standards has been carried out. Furthermore, when formulating a construction plan for mechanically-compacting flowable concrete, standards are also given for free-fall height, flow distance associated with casting, and compaction time, which are important

for construction methods. In the congruity tests, experiments pertaining to the state of segregation of concrete when free-fall height is changed and tests to ascertain the vibration compaction energy of concrete were also combined and implemented, thus providing the technical basis for setting these standard values.

Table 1 Target ranges for construction methods based on structural conditions and quality of fresh concrete.

	Item	Type 1	Type 2
Structural conditions and quality of fresh concrete	Minimum space for steel materials (mm) passability	~125 or more —	60–100 Predetermined quality
	Flowability (slump flow, mm)	450	550
	Segregation resistance	Predetermined quality	Predetermined quality
Construction method	Free-fall height (m)	Within 1.5	Within 1.5
	Flow distance associated with casting (m)	5 or less	5 or less
	Compacting time (s)	~5	~5

The inspection standards give standards for methods of inspecting whether the mechanically-compacting flowable concrete satisfies a predetermined quality. These standardize the use of slump flow as an inspection index for changes in the quality of fresh concrete.

The main topics of the Reference materials section include I. The concept of verification regarding construction based on performance regulations, II. reference materials for numerical values set in construction standards, III. examples of mix design, IV. explanation of test criteria, V. summary of congruity test results, and VI. current status of mechanically-compacting flowable concrete. This section is a valuable resource that presents the technical basis and supplementary items behind the descriptions in the main section and construction standards.

4. Future outlook

Mechanically-compacting flowable concrete is expected to be used in various situations and can be expected to reduce casting and compaction work for general reinforcement structures and to ensure passability in structures with high-density reinforcement and thus reduce the work required, *etc*. It is expected that mechanically-compacting flowable concrete will become widespread in the future through the wide utilization of the “Recommendation for Mix Design and Construction of Mechanically-compacting Flowable Concrete (draft)”, which is a product of this committee.