Committee Report : JCI- TC095A

Technical Committee on Interpretation of Quality Standards and Testing Methods for Concrete

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Abstract

To ensure concrete quality and improvement of concrete structure performance, it is necessary to fully understand the quality, method of use, etc., of the materials used in concrete. In order to prepare technical literature which helps the proper understanding and utilization of concrete-related technology as well as quality standards for concrete materials and concrete test methods including their background, purpose and provisions, this research committee collected test methods stipulated by Japanese Industrial Standards (JIS) and data on quality standards for materials used, etc., analyzed the background and reasons for their existence or amendment, international standards, relationships such as to the prevailing social situation, and the state of material usage, and identified present issues and future recommendations.

Keywords: Concrete, Quality standards, Test method,
Japanese Industrial Standards (JIS), Interpretation

1. Introduction

The environment surrounding the construction business continues to change radically along with the social situation. Conventionally, the importance of developing technology for a change from a scrap-and-build society to a sustainable society, as well as development of related technical standards, has been pointed out.

Regarding concrete structures, this means the assurance/improvement of diverse performance such as durability for long-term use as well as the prolongation of the life of existing structures through active maintenance/protection. Considering the depletion of natural resources, effective use of recycled resources and environmental aspects, including mitigation of environmental loads and inhibition of waste generation, are also a contemporary issue for the construction business.

In other words, the quality required of concrete and concrete materials is rapidly changing with the times, and to keep addressing these issues is the primary role of the construction business. At the same time, the sector must steadily address issues such as

quality assurance of recent concrete structures, material certification in the sector of concrete materials, and organization of a quality assurance system to answer social needs as well as higher consistency with international standards.

To ensure concrete quality and improvement of concrete structure performance, it is necessary to fully understand the quality, method of use, etc., of the materials used in concrete before manufacturing and using the concrete. In such cases, it is indispensable and quite essential not only to remember “reference values in quality standards,” or “test method procedures”, but also to understand “what they mean” in order to develop related technology and prepare relevant technical standards that can meet the various demands mentioned above for the concrete sector.

However, it may be a reality that, as regards concrete-related quality standards and test methods provided for in JIS and other documents, the background and purpose as well as the proper meaning and interpretation of items, numerical values, etc., stipulated therein are not correctly understood, and most of the discussions focus on compliance with provisions and consistency such as with international standards and laws, thus giving rise to a variety of obstacles.

2. Purpose and Outline of Research

2.1 Purpose of Committee

This research committee was engaged for two years in activities targeted at the proper understanding of the background and purpose of concrete material quality standards and concrete testing methods, as well as preparing technical data which assist the proper understanding and use of concrete-related technology. The purpose of this research committee in Phase I (FY2009 to FY2010) was, for concrete-related quality standards and test methods specified in JIS, to re-examine their background, purpose and provisions through means such as hearings and document searches, and put them together into commentary-like technical data conducive to quality evaluation/safety of concrete.

In Phase II (2011 and thereafter), the Committee intends to organize reference material and the content of provisions, etc., such as in laws and specifications relating to reinforced concrete structures and concrete, and verify how to use it, as well as the system of various concrete-related standards/criteria. At the same time, the Committee would also like to examine the possibility of preparing (and publishing) a commentary, as a final product, to allow a correct understanding of the purpose, background or amendment of concrete-related quality standards and test methods, and the provisions contained therein.

2.2 Content and system of research

Prior to examination, the Committee (chaired by Michihiko Abe, Professor, Kogakuin Univ.) and a Board of Governors were established to discuss work policy, coordination and other policies. Next, to start the actual work, Test Method WG for researching concrete-related test methods, and Quality WG for researching quality standards for materials used for concrete, were set up. **Table 1** shows the members of the Committee.

These two WGs respectively collected data on test methods relating to concrete and quality standards such as for concrete and concrete materials stipulated in JIS, and then analyzed the background and reasons for their existence or amendment, referenced international standards, examined the relationship with the social situation of those days, and considered how the materials and other items are used. To do this, not all concrete-related JIS were covered, but considering their importance such as direct involvement in ensuring concrete quality, the JIS mentioned in **2.3** were specifically extracted or selected. The primary jobs of WGs are the following (1) to (3):

(1) Checking and consolidation of what was provided for in the JIS at the time it was drawn up or amended (interpretation of purpose, meaning, etc.)
(2) Survey of the reason for the standard and/or its amendment such as through literature search before and after standard amendment (interpretation of purpose, meaning, etc.)
(3) Identification and arrangement of contemporary problems, points to be improved, etc., as well as preparation of future recommendations, etc.

2.3 Target of survey

The standards to be surveyed by Test Method WG and Quality WG are listed as follows.

(1) Test Method WG (researched 12 standards)

- JIS A 1101 (Method of test for slump of concrete)
- JIS A 1116 (Method of test for unit mass and air content of fresh concrete by mass method), JIS A 1118 (Method of test for air content of fresh concrete by volumetric method), JIS A 1128 (Method of test for air content of fresh concrete by pressure method)
- JIS A 1106 (Method of test for flexural strength of concrete)
- JIS A 1107 (Method of sampling and testing for compressive strength of drilled cores of concrete)
- JIS A 1108 (Method of test for compressive strength of concrete)

- JIS A 1113 (Method of test for splitting tensile strength of concrete)
- JIS A 1129-1 to 3 (Methods of measurement for length change of mortar and concrete)
- JIS A 1145 (Method of test for alkali-silica reactivity of aggregates by chemical method), JIS A 1146 (Method of test for alkali-silica reactivity of aggregates by mortar bar method)
- JIS A 1148 (Method of test for resistance of concrete to freezing and thawing)

Table 1: Committee Members

Chairman	Michihiko ABE	Kogakuin University
Manager	Hiroshi WATANABE	Public Works Research Institute
	Hiroshi JINNAI	Taisei Corporation
	Tadatsugu KAGE	Building Research Institute
	Akira NISHIDA	Shimizu Corporation
Test Method WG		
Chief examiner	Hiroshi WATANABE	Public Works Research Institute
Deputy chief examiner	Hiroshi JINNAI	Taisei Corporation
Group member	Atsushi UENO	Tokyo Metropolitan University
	Yoshiaki OHNO	Better Living
	Ema KATO	Port and Airport Research Institute
	Masanori KONO	Okumura Corporation
	Sumie SUZUKI	Japan Testing Center for Construction Materials
	Nobufumi TAKEDA	Obayashi Corporation
	Masaru NAGAYAMA	General Building Research Corporation of Japan
Quality WG		
Chief examiner	Tadatsugu KAGE	Building Research Institute
Deputy chief examiner	Akira NISHIDA	Shimizu Corporation
Group member	Yasuji ITO	Zennama
	Shigeki SEKO	Aichi Institute of Technology
	Susumu HASHIZUME	Toho Chemical Industry Co., Ltd.
	Shingo MIYAZAWA	Ashikaga Institute of Technology
	Toru YOSHIMOTO	Japan Cement Association
	Kenzo WATANABE	Kajima Corporation

(2) Quality WG (researched 18 Standards)

- JIS R 5210 (Portland cement), JIS R 5211 (Portland blast-furnace slag cement), JIS R5212 (Portland pozzolan cement), JIS R 5213 (Portland fly-ash cement), JIS R 5214 (Eco Cement)
- JIS A 5002 (Lightweight aggregates for structural concrete), JIS A 5004 (Manufactured sand for concrete), JIS A 5005 (Crushed stone and manufactured sand for concrete), JIS

A5011-1 to 4 (Slag aggregate for concrete), JIS A 5021 (Recycled aggregate for concrete-class H), JIS A 5022 (Recycled concrete using recycled aggregate class M), JIS A 5023 (Recycled concrete using recycled aggregate Class L)

- JIS A 5308 (Ready-mixed concrete)
- JIS A 6201 (Fly ash for use in concrete), JIS A 6202 (Expansive additive for concrete), JIS A 6204 (Chemical admixtures for concrete), JIS A 6206 (Ground granulated blast-furnace slag for concrete), JIS A 6207 (Silica fume for use in concrete)

3. Results of Research

Each WG organized an overview of the JIS standards to be surveyed and their revision as shown in **Table 2**, and then extracted changes of provisions in each of the JIS standards into **Table 3** for review.

Table 2: Overview of Revision of JIS (JIS A 5005 as an example)

Standard No.	JIS A 5005:2009	
Title	Crushed stone and manufactured sand for concrete	
Title in English	Crushed stone and manufactured sand for concrete	
Overview of standard	Specified for crushed stone and manufactured sand for concrete made by crushing rocks in the factory	
History	Established	March 1, 1961
	Confirmed	March 1, 1964
	Revised	May 1, 1965
	Confirmed	June 1, 1968, June 1, 1971, April 1, 1974
	Revised	August 1, 1977
	Confirmed	October 15, 1982
	Revised	September 1, 1987, March 1, 1993
	Confirmed	June 20, 2000
	Revised	March 20, 2009
Referenced JIS standards		A1102 , A1103 , A1104 , A1109 , A1110 , A1121 , A1122 , A1145 , A1146 , Z8801-1 , Z9015-0
Drafted by		Japan Crushed Stone Association

Table 3 Change in Provisions Contained in JIS (JIS A 1108 as an example, excerpt)

	Established in 1950	Revised in 1963	Revised in 1976	Revised in 1993	Revised in 1999	Revised in 2006	Compatibility of the newest edition with ISO
Shape of test piece	Cylinder	Same as on the left	Same as on the left	Same as on the left	Same as on the left	Same as on the left	MOD/deleted
Diameter of test piece	・Three times or more the maximum aggregate size ・15cm as standard if the maximum aggregate size is 5cm or less.	・15cm as standard if the maximum aggregate size is 50mm or less. If less than 15cm, three times or more the maximum aggregate size, and 10cm or more. ・If the maximum aggregate size is over 50cm, three times or more the maximum aggregate size.	Same as on the left	・Three times or more the maximum aggregate size, and 10cm or more. ・The standard of the diameter shall be 10cm, 12.5cm, or 15cm.	Same as on the left	Same as on the left	MOD
Height of test piece	・Twice the diameter	Same as on the left	Same as on the left	Same as on the left	Same as on the left	Same as on the left	IDT
Number of test pieces	・3 pieces or more	・3 pieces or more from 2 batches or more of concrete	Same as on the left	・3 pieces or more ・Collect from two batches in principle.	Not specified (quantity provisions deleted)	Same as on the left	-
Curing temperature of test piece	・Cure at 18 to 24°C ・If the concrete strength of a structure is tested, cure under conditions as similar to those of the structure as possible.	・Typically at 18 to 24°C. ・If the concrete strength of a structure is tested, cure under conditions as similar to those of the structure as possible.	・Typically at 20±3°C. ・Description of structures was deleted.	・In principle at 20±3°C	・At 20±2°C (if cured at another temperature range, record the curing temperature).	Same as on the left	IDT
Flatness of test piece's plane of loading	・There shall be no convexoconcave area of 0.02mm or more on the finished upper surface.	・The finished upper surface shall have a flatness of 0.05mm or less.	Same as on the left	Same as on the left	・Within 0.05% of diameter	Same as on the left	-
Angle of test piece's loading plane with the bus line	Not specified	Same as on the left	Same as on the left	Same as on the left	・90±0.5°	Same as on the left	IDT
Precision of mold form	・1/200 or less for diameter ・1/100 or less for height	・1/200 or less for diameter ・1/100 or less for height ・The basal plane's flatness of 0.02mm or less ・The mold form's side plate axis shall be vertical with respect to the bottom plane.	Same as on the left	・1/200 or less for diameter ・1/100 or less for height ・Basal plane flatness of 0.02mm or less ・The mold form's side plate axis shall be almost vertical with respect to the bottom plane.	・One that can deliver the required test piece precision ・Tolerable diameter difference of resulting test piece of 0.5% or less ・Tolerable height difference of resulting test piece of 5% or less ・Loading plane flatness of 0.05% or less	Same as on the left	IDT

3.1 Change in concrete test methods

It was surveyed that the background of previous amendments in concrete test methods, and stated the problems to be examined in the future. Future problems in each test extracted by this survey were as follows:

(1) The problem of JIS A 1101 (Method of test for slump of concrete) as a quality control test is considered to be a difference in test results from those obtained under the current ISO. Simple comparison of both tests indicates that smaller slump values are obtained with the ISO method than with the JIS method. In the future, to avoid various confusions due to the difference between these standards, it is considered necessary to address this issue such as by indicating correspondence with slump values according to the ISO method in JIS, or by requiring the measurement point of slump, time of pulling up, and how to charge the specimen as report items.

(2) Although the air volumetric method seemed to be a test method with fewer problems in the future, as for JIS A 1118 (Method of test for air content of fresh concrete by volumetric method), it is considered better from the viewpoint of compatibility with other JIS concerning air volumetric methods to use 40mm for the maximum coarse aggregate size of a concrete specimen, restore the grounds for the coefficient of “1.02” in the air volumetric equation, and correct “×1/10” (which is ambiguous) to “×1/1000×100” so as to become clearer in meaning.

(3) The size of a test piece used in JIS A 1106 (Method of test for flexural strength of concrete) was stipulated in JIS A 1132 (Method of making and curing concrete specimens) since the revision of 1964. Its tolerance is however specified as 0.5% or less per side of cross section, and so the tolerable difference in the direction of placement height becomes ±0.5mm or less for 100mm. It seems that this value is too stringent as a placement height-direction tolerance compared with 5% or less of the tolerable difference in the height direction of test pieces for a compressed strength test, and the tolerance in the direction of placement height is considered an issue to be examined in the future.

(4) JIS A 1107 (Method of sampling and testing for compressive strength of drilled cores of concrete), needs to be reviewed along with the trend in international standards, as there is a corresponding international standard (ISO-1920 part 6). JIS A 1107 contains examples of how to cure test pieces, which has been a topic of discussion at the time of each revision, as a different technique is sometimes used depending upon the purpose of the test. It seems more appropriate to define the content such as in applicable specifications and/or product standards, and how much to cover as a standard for the test method is

considered a problem to be examined in the future.

(5) Since JIS A 1108 (Method of test for compressive strength of concrete) is implemented in a variety of ways throughout the world, the content of the test may vary greatly depending upon compatibility with the related ISO. The change of loading speed in the 1999 revision is considered to be the greatest amendment, and in such an amendment, it is necessary to examine carefully how the result of tests using the revised method should be reflected in actual practice. As for the age of the test material whose description remains since the standard was established in 1950, the description may possibly be deleted since it seems not to be required in the existing test method.

(6) Regarding JIS A 1113 (Method of test for splitting tensile strength of concrete), the diameter of a test piece was changed in the 2006 revised edition from “15cm or more” to “100mm or more.” Experimental tests conducted in association with such a revision demonstrated that, in the case of ϕ100mm, the coefficient of variation in splitting tensile strength test results tends to be larger than for ϕ150mm, and the commentary states that it is desirable to increase the quantity of ϕ100-mm test pieces. A recent finding also reports that, if end faces are ground, the coefficient of variation in splitting tensile strength among several test pieces tested decreases. How to include these findings in the standard is considered to be a problem at the time of revision.

(7) JIS A 1129-1 to 3 (Methods of measurement for length change of mortar and concrete) has been consolidated, and it became possible to select from three kinds of method; the Comparator Method, the Contact Gauge method, and the Dial Gauge Method. However, the side of a test piece is measured in the Comparator Method and Contact Gauge Method while the length along the central axis is measured in the Dial Gauge Method, and a slight difference between measurements has been revealed. In actual practice, such a difference should sometimes be taken into consideration as well. Moreover, for expansion additives and other items which give rise to drying shrinkage mitigation effects during their initial wet curing time, the evaluation of drying shrinkage is difficult, and a sunken strain meter based approach, the use of a laser displacement sensor or other new test methods are proposed. In future, the effectiveness of new test methods would need to be examined.

(8) With respect to JIS A 1145 (Method of test for alkali-silica reactivity of aggregates by chemical method) and JIS A 1146 (Method of test for alkali-silica reactivity of aggregates by mortar bar method), although both the chemical method and the mortar bar method are stipulated based on ASTM standard provisions, it is necessary to understand that there is

a difference in the purpose of the test, the test conditions are not exactly the same, and under the circumstances in Japan where measures are taken to limit alkali-silica reactions, mechanisms such as giving priority to test results are involved and have their own place. On the other hand, from an engineering standpoint, since the alkali-silica reactivity test uses a rapid or promotion method or a method applied to concrete, and the aptitude of each test method as well as reactivity with certain kinds of rock are unknown, one future task will be to make improvements so that the reliability of the results of the chemical and the mortar bar method, and the relationship of one test method to another, etc., can be better understood.

(9) Concerning JIS A 1148 (Method of test for resistance of concrete to freezing and thawing), future tasks are considered to be examination of deterioration due to freeze/thaw and a suitable index to evaluate it, interpretation of the difference between environmental conditions under which deterioration was reproduced in the freeze/thaw test and to which an actual structure is subjected, and reproducibility of the speed at which the temperature of each freeze/thaw tester changes as well as that of its test results.

3.2 Change of quality standards for concrete materials

It was identified that JIS for concrete materials (18 standards) to analyze their background (and reasons) or amendment, international standards, relationships to the prevailing social situation, and how materials and other items are used. For the JIS surveyed, a brief description and future tasks, etc., are summarized below.

(1) For cement, future tasks include: a) handling of matters related to durability that became a social problem, b) readiness for international standardization, and c) addressing how to promote utilization of waste.

(2) For aggregates, it is necessary to comply with each of the JIS relating to depletion of natural resources, effective use of recycled resources, and consideration of environmental aspects (such as mitigation of load on the environment and inhibition of waste generation), etc., and for some JIS standards (for slag aggregate and ready-mixed concrete), an examination has already started.

(3) For ready-mixed concrete, there are a number of problems including: a) a decrease in output reflecting the social situation, e.g., effects of declining public works, b) review of compatibility with international standards, and c) examination in readiness for the next JIS amendment (compatibility with ISO 22965, aggressive use of sludge water, recycling of aggregate recovered from remaining or returned concrete, utilization of environmental

labels, improvement of traceability, and quality assurance).

(4) For mixing water, it is considered necessary to understand the actual status of how recovered water is utilized and/or managed, and the effects of the quality of mixing water including recovered water on the performance of different concrete types in order to promote the utilization of recovered water to address environmental issues.

(5) For fly ash for use in concrete, despite its present substantial contribution to the recycling-oriented society, further efforts would be necessary in order to try to further mitigate the load on the environment, such as cost reduction, stabilization of fly ash quality, revitalization of distribution, and identification of the merits/demerits of Class I to Class-IV fly ash, as well as development of corresponding standards.

(6) For expansion additives for concrete, their range of use is clear and they are technologically mature. Incorporation of quality standards for low-dose expansion additives in JIS A 6202 is a future task.

(7) For chemical admixtures for concrete, their standard is high quality in terms of performance. However, there are still many problems to be examined to achieve perfect quality assurance and enhancement of international compatibility. For instance, it will be necessary in future to discuss details of the evaluation test and ordinary management test, or what such tests should be like.

(8) For ground granulated blast-furnace slag for concrete, it is considered necessary to expand the use of powder having a small specific surface area in the future. It is possible to define the value of specific surface area and replacement rate, select the kind of base cement, and optimize combination with other admixtures depending on the purpose of the concrete structure, which also leads us to expect its effective use from the standpoint of reducing CO_2 emissions as with blast-furnace cement.

(9) For silica fume for use in concrete, the present situation where more and more is used as blended cement for high-strength concrete suggests the future need to examine standards for such fume to be applied not only to admixture, but also to blended cement.

4. Conclusion

We will be satisfied if this research committee report can serve as a useful information document for correct understanding of concrete-related technology by undergraduate/graduate students and young researchers/engineers engaged in JIS drafting undertaken by the Japan Concrete Institute, or concrete-related research and developments.

For further details of the research and results of the Committee, a symposium was held in

2011, based on this Committee Report[1)] published by JCI.

References

1) Japan Concrete Institute : Technical Committee Report on Interpretation of Quality Standards and Testing Methods for Concrete, 2011.3