Part4 “JSCE Standards for Sprayed Concrete”

（‘Sprayed concrete’ is also referred to as ‘Shotcrete’）

Introduction

In total eleven JSCE standards on the test method for sprayed concrete and mortar have been examined in the Testing and Inspection Section of the Shotcrete Research Subcommittee, that is, one standard for admixtures, six standards for fresh concrete, and four standards for hardened concrete. Those JSCE standards are listed below.

JSCE-D 102-2005 Specification for Set Accelerating Agent for Sprayed Concrete (Mortar)(Draft)
JSCE-F 561-2005 Method of Making Specimens for Compressive Strength Tests of Sprayed Concrete (Mortar)(Draft)
JSCE-F 562-2005 Method of Making Specimens for Durability Tests of Sprayed Concrete (Mortar)(Draft)
JSCE-F 563-2005 Test Method for Rebound Percentage of Sprayed Concrete (Mortar)(Draft)
JSCE-F 564-2005 Test Method for Dust Concentration in Air During Spraying Concrete (Mortar)(Draft)
JSCE-F 565-2005 Test Method for Mechanical Properties, Spraying Performance and Durability of Sprayed Concrete (Mortar)(Draft)
JSCE-F 566-2005 Method of Making Specimens of Bond Strength Tests of Sprayed Concrete (Mortar) for Repairing and Strengthening (Draft)
JSCE-G 561-2005 Test Method for Early Strength of Sprayed Concrete (Mortar) by Pull-out Method (Draft)
JSCE-G 562-2005 Test Method for Early Strength of Sprayed Concrete (Mortar) Using Prism Specimens (Draft)
JSCE-G 563-2005 Test Method for Strength of Sprayed Concrete (Mortar) for Repairing and Strengthening Using Prism Specimens (Draft)
JSCE-G 564-2005 Test Method for Length Change of Sprayed Concrete (Mortar) for Repairing and Strengthening (Draft)

JSCE standards, D 102, F 561, G561, and G562 have been revised from previous versions, while other seven JSCE standards have been newly established. The examination of JSCE standards were done so that (1)JSCE standards for the test method of sprayed concrete can be applied to sprayed concrete for tunneling, slope stabilization, and repair and strengthening, (2)they can be applied to both sprayed concrete and sprayed mortar, (3)they match the current technology of sprayed concrete, and (4)they would not need special ability for testing and use commonly available testing tools only.

The previously established JSCE standards for sprayed steel fiber reinforced concrete have also examined: Method of making specimens for strength and toughness of sprayed steel fiber reinforced concrete (JSCE-F 553-1999) and Test method for content of steel fiber in sprayed steel fiber reinforced concrete (JSCE-F 555-1999), which are valid as they are.

In the process of examining the methods of testing and inspection related to sprayed concrete, it turned out that some test methods would need more time for discussion. Among them are the test method for the bond strength of mortar sprayed under vibration, that for the compressive strength of sprayed concrete for slope stabilization using a mold formed by steel wire net, that for the bond strength between the slope surface and the sprayed concrete for slope stabilization, that for the length change stability of sprayed concrete for repair and strengthening, and that for the early compressive strength of sprayed concrete using the penetration depth of air-pressure-driven pins. The testing and inspection section hopes that those test methods would become JSCE standards in the near future.

June 2005

The Concrete Committee of Japan Society of Civil Engineers
Shotcrete Research Subcommittee
Leader of the Testing and Inspection Section
Tatsuya Tsubaki

JSCE-F 561-2005

Method of Making Specimens for Compressive Strength Tests of Sprayed Concrete (Mortar) (Draft)

1. Scope

This specification stipulates the method of making specimens for compressive strength of sprayed concrete (mortar) (also referred to as shotcrete).

2. Referenced Standard

The following standard is referenced in this specification to constitute part of its provisions.

The latest version is referenced for the standard.

JIS A 1107 *Method of sampling and testing for compressive strength of drilled cores of concrete*

3. Sampling Procedure and Specimen Types

The following types of specimens shall be sampled according to the procedure below.

a) Specimens shall be sampled from the site where the shotcrete was actually applied or from the concrete object fabricated by gunning the shotcrete on a panel form defined in section 5 below, using the shotcreting machine (gun) to be actually used.

b) Specimens shall be part of the shotcrete (mortar) cut out in the shape of a cylinder. (1)

Note 1: The top and bottom of specimens shall be polished smoothly while taking care not to affect the concrete (mortar).

4. Dimensions and Number of Specimens

The dimensions and number of specimens shall comply with the following description.

a) Specimens shall be cylindrical objects with a diameter of 50 mm and a height of 100 mm for mortar, and a diameter at least three times as long as the maximum dimension of coarse aggregates and a height of twice the diameter for concrete. If the height of the cylindrical specimen is less than twice the diameter, the compressive strength obtained from the tests shall be corrected according to the provision in JIS A 1107.

b) Three or more specimens shall be prepared.

5. Material, Dimensions and Structure of Panel Form for Cutting Specimens

The material, dimensions and structure of the panel form for cutting specimens shall be as specified below.

a) The material of the panel form shall be the same material for the formwork for slope stabilization or wood/plywood/metal that is thick and rigid enough to withstand impact from gunning and prevent deformation. (2)

b) The panel form shall have a bottom plate, as shown in Fig. 1. It shall also have a structure having one open end in order to prevent rebound from being trapped. This rule is not applicable to a case where shooting is done upward. (3)

c) For testing shotcrete (sprayed concrete or mortar) in which no accelerator is used, place a metal fabric on the board.

d) The minimum dimensions of a panel form shall be as shown in Table 1.

Table 1 Minimum Dimensions of Panel Forms (in mm)

Usage	A	b	c
Tunneling	500	500	150
Slope stabilization	300	300	200 (4)
Repair and strengthening	300	300	150

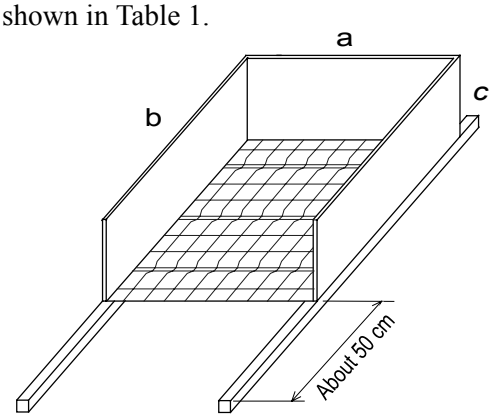

Fig. 1 Panel Form

Note 2: For plywood, it is typically about 12 mm.

Note 3: When using a wooden form, square timbers shall be used as an outer reinforcing member in order to make it sturdy against impact from gunning.

Note 4: The minimum height of the panel form shall be determined so as to allow a wire fabric to be placed on the bottom of the panel form.

6. Spraying Method

The spraying method shall be as follows.

a) To perform gunning on the panel form defined in section 5, place the panel form against the wall, as shown in Fig. 2, so that it has the same grade as the actual slope, and place the open end down to prevent rebound from being trapped.

b) Hold the nozzle at right angles to the target surface at an appropriate distance from it to perform gunning.

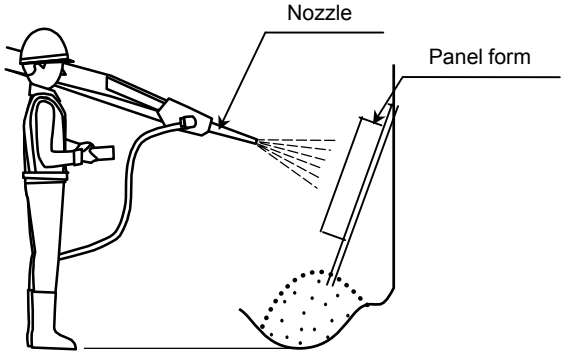

Fig.2 Spraying Method

7. Timing and Method of Cutting Specimens and Preparation for Tests

Follow JIS A 1107 to determine the timing and the method of cutting specimens from the concrete shotcreted on the actual construction site or on a panel form, and to prepare for tests.

8. Reporting

The following items shall be reported.

8.1 Items That Must Be Reported

a) How specimens were sampled from the actual site or the panel form (the construction, the type and dimensions of the panel form)

b) Shotcreting method (construction machine, shotcreting conditions)

c) Types and quality of materials used

d) Mix proportion of concrete (mortar)

e) Date of the actual shotcreting work or when the specimens were made using a panel form

f) Temperature at the actual shotcreting site or when the specimens were made using a panel form

g) Number of specimens

h) Curing conditions before and after cutting

i) Shapes and dimensions of specimens and the direction of the cut

j) Age of specimens when they were cut

8.2 Items to Be Reported as Needed

a) Temperature at the actual shotcreting site, or temperature of the concrete when the specimens were made on a panel form

JSCE-F 562-2005

Method of Making Specimens for Durability Tests of Sprayed Concrete (Mortar) (Draft)

1. Scope

This specification stipulates the method of making specimens for the durability tests defined in the following standards.

JSCE-G 571 *Test method for effective diffusion coefficient of chloride ion in concrete by migration (draft)*

JSCE-G 572 *Test method for apparent diffusion coefficient of chloride ion in concrete by submergence in salt water (draft)*

JIS A 1129-1 *Methods of test for length change of mortar and concrete Part 1: Method with comparator*

JIS A 1129-2 *Methods of test for length change of mortar and concrete Part 2: Method with contact-type strain gauge*

JIS A 1129-3 *Methods of test for length change of mortar and concrete Part 3: Method with dial gauge*

JIS A 1148 *Method of test for resistance of concrete to freezing and thawing*

JIS A 1153 *Method of accelerated carbonation test for concrete*

JIS A 1304 *Method of fire resistance test for structural parts of buildings*

JCI-AAR-3 *Method of testing alkali-silica reactivity of concrete (concrete method)(draft)*

2. Referenced Standards

The following standards are referenced in this specification to constitute part of its provisions.

The latest versions are referenced for the respective standards.

JSCE-F 553 *Method of making specimens for strength and toughness of sprayed steel fiber reinforced concrete*

JSCE-F 561 *Method of making specimens for compressive strength of sprayed concrete (draft)*

JIS A 1107 *Method of sampling and testing for compressive strength of drilled cores of concrete*

3. Definition

This specification uses the following key term as defined here.

a) **Panel specimen:** Shotcrete applied on a panel form, a state before specimens for various durability tests are cut.

4. Sampling Procedure and Types of Specimen

The following types of specimens shall be sampled according to the procedure below.

a) Specimens shall be sampled from the site where the shotcrete was actually applied or from the concrete object produced by gunning the shotcrete on a panel form defined in section 6 below, using the shotcreting machine (gun) to be actually used.

b) Specimens shall be prepared by cutting specimens as defined in various standards for durability tests on concrete.

5. Dimensions and Number of Specimens

The dimensions and number of specimens shall comply with the following description.

a) Specimens shall have the shape and dimensions provided in various standards for durability tests on concrete.

b) The number of specimens shall be as provided in various standards for durability tests on concrete.

6. Material, Dimensions and Structure of Panel Form for Cutting Specimens

The material, dimensions and structure of the panel form for cutting specimens shall be as specified in JSCE-F 561.

7. Spraying Method

The spraying method shall be as specified in JSCE-F 561.

8. Timing and Method of Cutting Specimens and Preparation for Tests

It is imperative to follow JIS A 1107, JSCE-F 553 and other applicable standards for various durability tests to determine the timing and the method of cutting specimens from the shotcreted site or on the panel form, and prepare for tests according to the same JIS standard.

a) The method of curing before and after cutting specimens shall follow the respective test standards.

b) When cutting specimens, care should be taken in the preparation process to allow the shotcrete surface to be tested if it is the case.

9. Reporting

The following items shall be reported.

9.1 Items That Must Be Reported

a) Items to be reported that are listed in the applicable durability test method documents.

b) How specimens were sampled from the actual site or the panel form (the construction site, the type and dimensions of the panel form)

c) Shotcreting method (construction machine, shotcreting conditions)

d) Types and quality of materials used

e) Mix proportion of concrete (mortar)

f) Date of the actual shotcreting work or when the specimens were made using a panel form

g) Temperature at the actual shotcreting site or when the specimens were made

h) Number of specimens

i) Curing conditions before and after cutting

j) Shapes and dimensions of specimens and the direction in which they were cut

k) Age of specimens when they were cut

l) Age and time when the durability tests were performed and measurements taken

9.2 Items to Be Reported as Needed

a) Temperature at the actual shotcreting site, or temperature of the concrete when the specimens were created on the panel form

JSCE-F 563-2005

Test Method for Rebound Percentage of Sprayed Concrete (Mortar) (Draft)

1. Scope

This specification stipulates the method of testing for obtaining the rebound percentage of sprayed concrete (mortar) (also referred to as shotcrete).

2. Referenced Standard

The following standard is referenced in this specification to constitute part of its provisions.

The latest version is referenced for the standard.

JSCE-F 561 *Method of making specimens for compressive strength tests of sprayed concrete (mortar) (draft)*

3. Types of Tests Methods

The following two types of tests shall be conducted.

a) Shotcreting on a panel form

b) Shotcreting on the actual structure

4. Concrete Specimens

To make concrete specimens on site by actually shotcreting, in principle, shotcreting shall be performed using the same material, plant equipment, etc., and under the same conditions as the actual construction conditions.

5. Scale

A scale that can provide readings of 0.5 % of the quantity for each measurement shall be used.

6. Spraying on a Panel Form

6.1 Material, Dimensions, Structure of Panel Form

The material, dimensions, structure of the panel form shall be as specified below.

a) The material of the panel form shall be the same material for the formwork for slope stabilization or wood/plywood/metal that is thick and rigid enough to withstand impact from gunning and prevent deformation. (1)

b) The minimum dimensions of the panel form shall be as shown in Table 1. (2)

Table 1 Minimum Dimensions of Panel Form (in mm)

Usage	Length	Width	Height
Tunneling	500	500	150
Slope stabilization	300	300	200
Repair and strengthening	300	300	150

c) The panel form shall have a bottom plate, as shown in Fig. 1. It shall also have a structure having one open end in order to prevent rebound from being trapped. This rule is not applicable to a case where gunning is done upward (See Fig. 1). (3)

d) For testing shotcrete (sprayed concrete or mortar) in which no accelerator is used, place a metal fabric on the board, as specified in JSCE F-561.

Note 1: For plywood, it is typically about 12 mm.

Note 2: If the specimens are also used for strength tests, the dimensions shall be determined according to the dimensions of the specimens needed.

Note 3: When using a wooden form, square timbers shall be used as an outer reinforcing member in order to make it a sturdy structure that can withstand impact from gunning.

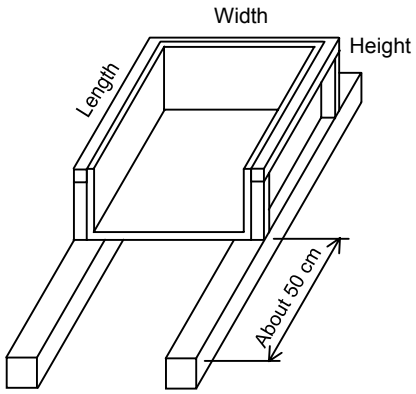

Fig. 1 Panel Form (example)

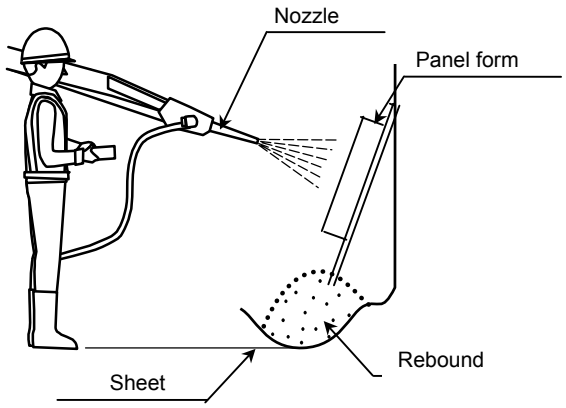

Fig. 2 Spraying Method

6.2 Measuring Rebound Percentage

a) Measure the mass of the panel form before shotcreting.

b) As shown in Fig. 2, place a sheet at the bottom of the panel form and set the form against the wall at a certain angle with its open end down and so as to allow rebound. (4)

c) Hold the nozzle at right angels with the target surface and at an appropriate distance.

d) Measure the mass of the shotcreted panel form and the concrete rebound on the sheet.

e) Calculate the rebound percentage using the following equation, rounding the second decimal place to the first decimal place.

$$W_s = \quad W_1 - W_p$$

$$W_r = \frac{W_2 \times 100}{W_s + W_2}$$

where W_s: Mass that has bonded on the form (kg)

W_p: Mass of the panel form (kg)

W_1: Mass of the panel form and concrete bonded on it (kg)

W_r: Rebound ratio (%)

W_2: Mass of concrete rebound on the sheet (kg)

Note 4: The panel shall be placed against the wall at an angle suitable for the type of application (tunneling, slope stabilization or repair/strengthening).

7. Spraying Using Actual Structure

7.1 Measuring Rebound Percentage

The following is an example of measuring the rebound percentage using the actual structure. (5)

a) Establish the extent of shotcreting for each measurement and forecast the range over which rebound will scatter.

b) Take countermeasures against water inflow over the anticipated range of scattering and lay a sheet over the area.

c) Prepare the sheet by attaching a metal ring for hoisting to each corner , hoist it and measure its mass with a load cell. (6)

d) Mix the materials to be used and record the mass for each measurement by referencing the measured data.

e) Perform shotcreting. (7)

f) Carefully hoist the sheet retaining rebound and measure the mass with a load cell.

g) Obtain the rebound quantity by subtracting the mass of the sheet itself from the mass of the sheet retaining rebound.

h) Calculate the rebound percentage using the following equation, rounding the second decimal place to the first decimal place.

$$W_r = \frac{W_2 \times 100}{W_1}$$

where W_r: Rebound ratio (%)

W_1: Mass of all materials used in one instance of measurement (kg)

W_2: Mass of concrete rebound (kg)

Note 5: Fig. 3 shows an example of how the rebound percentage is measured in a tunnel, and Fig. 4 shows an example in bridge repair work.

Note 6: It is also possible to measure the rebound quantity by weighing rebound lot by lot, using a bucket for example, without using a load cell. In that case, steps c), f) and g) can be omitted.

Note 7: If the volume of work is too little for one measurement, only the rebound at the initial stage can be measured. If it is too much, the rebound scatter range is too large to measure. Therefore, it is necessary to set an appropriate volume of shotcreting, taking into account the capacity of the measuring equipment, according to the condition of the structure. The reference value is about one tenth of the discharge per hour.

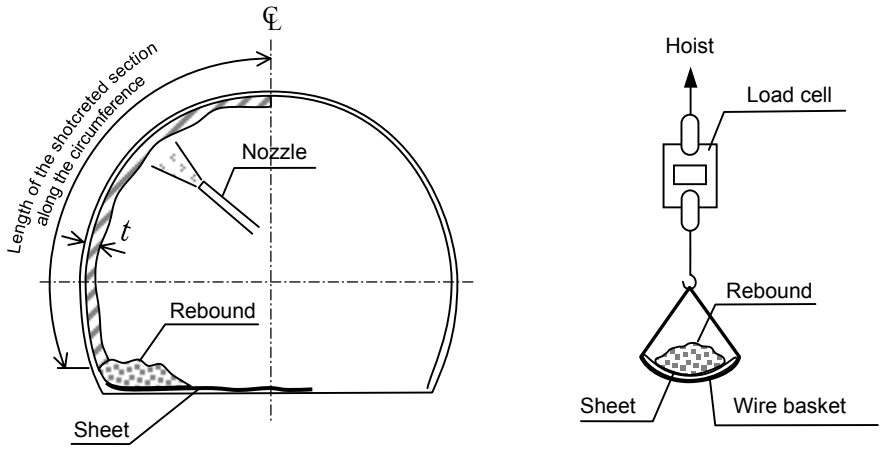

Fig. 3 Example of Rebound Ratio Measurement in Tunnel

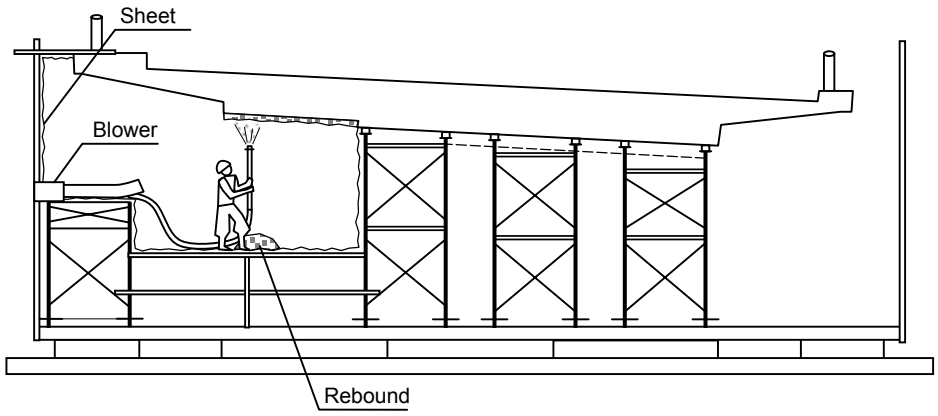

Fig. 4 Example of Rebound Ratio Measurement in Repairing of Bridge

8. Reporting

The following items shall be reported.

8.1 Items That Must Be Reported

a) Test date

b) Testing method (panel form or actual structure)

c) Shotcreting method (shotcreting machine and direction)

d) Types and quality of materials used

e) Mix proportion of concrete

f) Temperature on the test day

g) Rebound percentage

8.2 Items to Be Reported as Needed

a) Material, thickness and dimensions of a panel form

b) Shotcreting conditions (distance from the nozzle to the target surface, discharge pressure, discharge rate, compressed air rate)

JSCE-F 564-2005

Test Method for Dust Concentration in Air During Spraying Concrete (Mortar) (Draft)

1. Scope

This specification stipulates the method of testing for the purpose of measuring dust concentration accompanying spraying of concrete (mortar) (also referred to as shotcreting).

2. Referenced Standards

The following standards are referenced in this specification to constitute part of its provisions.

The latest versions are referenced for the respective specifications.

JIS Z 8813 *Measuring methods for suspended particulate matter concentration in air – general requirements*

JIS Z 8814 *Low volume air sampler*

3. Definitions

This specification uses the following key terms as defined here.

a) **Low volume air sampler:** An air sampler defined in JIS Z 8814 that is used for measuring the mass concentration of suspended dust, having a suction flow rate not exceeding 30 ℓ/min and a sizing function. JIS Z 8813 classifies this type under the category of the filter-based weighing method.

b) **Digital dust meter:** A device used for the scattered light method among the SPM (suspended particulate matter) measurement approaches, a dust concentration measurement methods defined in JIS Z 8813, to determine the particle concentration. This approach irradiates light on suspended dust and measures the quantity of light scattered from the dust, and then expresses the value as a relative concentration.

c) **Dust concentration:** Mass concentration of dust suspended in the air during shotcreting. The value is expressed as a mass of dust contained in 1 m^3 of air that is measured on a digital dust meter. It is expressed in mg/m^3.

d)**Generated dust concentration:** Mass concentration of dust that is generated during shotcreting and suspended in the air. Its value is obtained by subtracting the dust concentration before shotcreting that has been obtained from the background test of dust concentration. The value is expressed as a mass of dust contained in 1 m^3 of air in mg/m^3.

e) **Relative concentration:** The count of dust particles suspended in the air. The value obtained on a digital dust meter is converted into the number of particles per unit time. Generally, the value is expressed in a value per minute as in c.p.m. (counts per minute).

f) **Mass concentration conversion coefficient:** The coefficient used to convert a measurement of relative concentration of dust suspended in the air. It is also referred to as the *K* value. It is expressed in (mg/m^3)/c.p.m.

g) **Background test:** Dust concentration measuring tests conducted immediately before shotcreting in order to obtain the concentration of generated dust.

4. Test Equipment

The following measuring instruments and equipment shall be used in testing.

a) **Dust concentration indicator**

Low volume air sampler and digital dust meter.

b) **Precision balance**

A balance with a scale interval of 0.01 mg or higher precision.

c) **Drying equipment for filter material**

A chamber with constant temperature and humidity, desiccator, and electrical dryer.

5. Test Methods

5.1 Test for Measuring Mass Concentration Conversion Coefficient

The mass concentration conversion coefficient to be used for calculating the dust concentration and the concentration of generated dust shall be obtained for the following digital dust meter to be used for the tests below. [1]

Note 1: If a reliable mass concentration conversion coefficient is known for the digital dust meter used, this test may be omitted.

a) **Measuring position**

A position shall be selected so that the necessary amount of dust may be collected to calculate the mass concentration using a low volume air sampler. [2]

b) **Measuring time**

Time up to the point when the necessary quantity of dust has been collected to allow calculation of the mass concentration by a low volume air sampler.

c) **Measurement procedure**

Place a digital dust meter and a low-volume air sampler with the suction port and the height oriented the same at the measurement point so that concurrent measurements may be possible. The mean of the relative concentration values per minute shall be obtained from the output of the digital dust meter, and then the mass concentration of dust is calculated using the low volume air sampler. [3] [4] [5]

Note 2: When measurements are made near the gunning position, there is danger that shotcrete rebound could damage the suction port. To avoid such trouble, the suction port should be preferably directed normal to the gunning position.

Note 3: The filtering element before and after dust collection shall be left for 24 hours or more in a chamber kept at constant temperature and humidity, then it shall be weighed without any delay. The dust amount is represented by the difference between weights determined before and after the dust collection. If humidity is kept constant by air conditioning or with a desiccator, a suitable humidity adjusting agent shall be selected.

Other available means are drying till the quantity becomes constant, being kept in an electric dryer for one hour or more at 105 to 110 degrees C, or in a dehumidifier containing silica gel for 2 to 3 days or longer at room temperature.

Note 4: A precision balance accurate to within 0.01 mg is usually employed for weighing. However, weighing of a very small amount of dust tends to produce larger errors. Thus, dust should preferably be 20 times or more the smallest division of the balance scale.

Note 5: When the generated dust content is too small to be able to measure the mass concentration using a low-volume air sampler, use of a high-volume air sampler stipulated in JIS Z 8814 is recommended.

5.2 Test for Background Dust Concentration

a) **Time for measurement**

Measurements should be made immediately before shotcreting, once excavation and other work is no longer affecting the area and the dust concentration has returned to normal. Heavy vehicles should not be operated while measurements are being made.

b) **Duration of measurement**

Continuous 10 minutes or more for each point measured.

c) **Measurement**

Using the digital concentration meter, the mean of relative concentration values per minute shall be obtained.

5.3 Test for Dust Concentration During Spraying

a) **Measuring position**

The same as for section 5.2.

b) **Time for measurement**

Measurements should be made at the peak concentration time during shotcreting. No equipment other than what is needed for shotcreting shall be operated. The ventilation equipment shall be in the same operating condition as for section 5.2.

c) **Duration of measurement**

Continuously 10 minutes or more for each point shall be measured. Notwithstanding this provision, shotcreting duration may be too short to enable continuous measurement for 10 minutes or more. In this case, the measurement is still deemed valid. However, it should be noted that the duration of measurement at each point must be maintained as specified. Also note that the start of measurement shall be at least 10 minutes after shotcreting has started, because it usually

takes about 10 minutes for the dust status to stabilize. Therefore measurement shall start 10 minutes or more after shotcreting has started.

d) **Measurement**

On a digital dust meter, the mean of relative concentration per minute shall be obtained.

6. Calculations

6.1 Calculation of Mass Concentration of Dust Using Low-Volume Air Sampler

Use the following equation in JIS Z 8813 rounding the value obtained to the second decimal place.

$$\text{Mass concentration of dust} = \frac{W_2 - W_1}{V} \ (\text{mg/m}^3)$$

where W_2: Mass of the filter element after dust collection (mg)

W_1: Mass of the filter element before dust collection (mg)

V: Suction rate (m^3)

6.2 Calculation of Mass Concentration Conversion Coefficient

The mass concentration conversion coefficient K shall be calculated by putting relative concentration R obtained by a digital dust meter (See 5.1) and mass concentration C obtained by a low volume air sampler in the following equation defined in JIS Z 8813.

$$K = \frac{C}{R}$$

where K: Mass concentration conversion coefficient [$(mg/m^3)/c.p.m$]

C: Mass concentration obtained by a low volume air sampler measuring concurrently (mg/m^3)

R: Relative concentration obtained on a digital dust meter measuring concurrently ($c.p.m$)

6.3 Calculation of Dust Concentration Using Digital Dust Meter

Dust concentration D using a digital dust meter shall be calculated by multiplying mean of relative concentration measurements R_D during measurement time by the mass concentration conversion coefficient K.

$$D = R_D \times K$$

where D: Dust concentration from a digital dust meter (mg/m^3)

R_D: Mean of relative concentration measurements from the digital dust meter ($c.p.m$)

K: Mass concentration conversion coefficient [$(mg/m^3)/c.p.m$]

6.4 Calculation of Generated Dust Concentration

Concentration of dust generated from shotcreting shall be calculated as follows:

subtract the mean relative concentration measurements obtained in section 5.2 from the mean of relative concentration measurements obtained in section 5.3 and
multiply this value by the mass concentration conversion coefficient *K*

7. Reporting

The following items shall be reported.

7.1 Items That Must Be Reported

a) Date of measurement and person in charge

b) Measurement location or point and height where measurements were made

c) Name of dust concentration tester, manufacturer and model type

d) Mix proportion and materials of the shotcrete used

e) Shotcreting method (dry-process or wet-process)

f) Environmental conditions (climate, wind direction and velocity, temperature)

g) Ventilation method

h) Dust concentration and concentration of generated dust

i) Duration of measurement

7.2 Items to Be Reported as Needed

a) Sampling conditions of the low volume air sampler (suction flow rate, suction time)

b) Mass concentration conversion coefficient

JSCE-F 565 2005

Test Method for Mechanical Properties, Spraying Performance and Durability of Sprayed Concrete (Mortar) (Draft)

1. Scope

This specification stipulates mechanical properties, spraying performance and durability of sprayed concrete (mortar) (also referred to as shotcrete).

2. Referenced Standards

The following standards are referenced in this specification to constitute part of its provisions.

The latest versions are referenced for the respective specifications.

JSCE-F 553 *Method of making specimens for strength and toughness of sprayed steel fiber reinforced concrete*

JSCE-F 561 *Method of making specimens for compressive strength tests of sprayed concrete (mortar) (draft)*

JSCE-F 562 *Method of making specimens for durability tests of sprayed concrete (mortar) (draft)*

JSCE-F 563 *Test method for rebound percentage of sprayed concrete (mortar) (draft)*

JSCE-F 564 *Test method for dust concentration in air during spraying concrete (mortar) (draft)*

JSCE-F 566 *Method of making specimens of bond strength tests of sprayed concrete (mortar) for repairing and strengthening (draft)*

JSCE-G 552 *Test method for bending strength and bending toughness of steel fiber reinforced concrete*

JSCE-G 561 *Test method for early strength of sprayed concrete (mortar) by pull-out method (draft)*

JSCE-G 562 *Test method for early strength of sprayed concrete (mortar) using prism specimens (draft)*

JSCE-G 563 *Test method for strength of sprayed concrete (mortar) for repairing and strengthening using prism specimens (draft)*

JSCE-G 564 *Test method for length change of sprayed concrete (mortar) for repairing and strengthening (draft)*

JSCE-K 561 *Test method of patching repair materials in concrete structures (draft)*

JIS A 1107 Method of sampling and testing for compressive strength of drilled cores of

concrete

3. Types of Tests

The following two types of shotcrete tests shall be employed.

a) Shotcrete tests under conditions simulating the actual construction site

b) Shotcrete tests conducted on actual construction

4. Preparation of Materials and Concrete Mix Proportion

In shotcrete tests under conditions simulating the actual construction site, the materials for shotcrete shall be those planned for use in the actual construction and the preparation including material storage shall be the same as the actual conditions. Also, the concrete mix shall be the same as that for the actual construction. (1)

Note 1: When studying the optimal selection or applicability of new material, the mix proportion can be selected according to the test conditions.

5. Spraying Method for Spraying Test under Conditions Simulating Actual Construction Site

Shotcrete tests under conditions simulating the actual construction site shall be conducted in a modeled tunneling space (4) reproducing the construction conditions as close to the actual construction conditions as possible by using the material and concrete mix shown in section 4, and also using a concrete production plant (2), machinery for concrete delivery and shotcreting, compressor, accelerator feeder (3), nozzle, etc.

Note 2: In the wet-process application, if it is possible to produce the same shotcrete as that immediately before being used in the actual construction, concrete may be produced using a mixer in a laboratory, without using a concrete production plant.

Note 3: For shotcrete for use for slope stabilization or for repair/strengthening without application of accelerator, no accelerator feeder shall be used.

Note 4: Fig. 1 shows an example of test construction for shotcreting for tunneling, Fig.2 shows an example of test construction for shotcreting for slope stabilization, and Fig. 3 shows an example of test construction for repair/strengthening. For dust concentration measurement, the same ventilation conditions as those in actual construction shall be used.

6. Spraying Method for Spraying Test Conducted on Actual Construction

Shotcrete tests conducted on actual construction shall use the same materials, concrete production plant (2), machinery for delivery and shotcreting, compressor, accelerator feeder (3), nozzle, etc. as those in the actual construction.

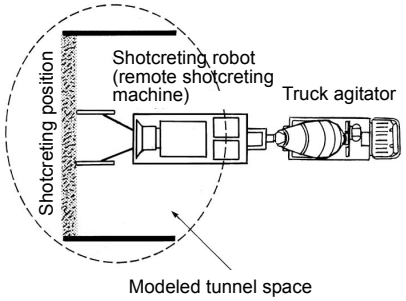

Fig. 1 Example of Spraying Test for Tunneling

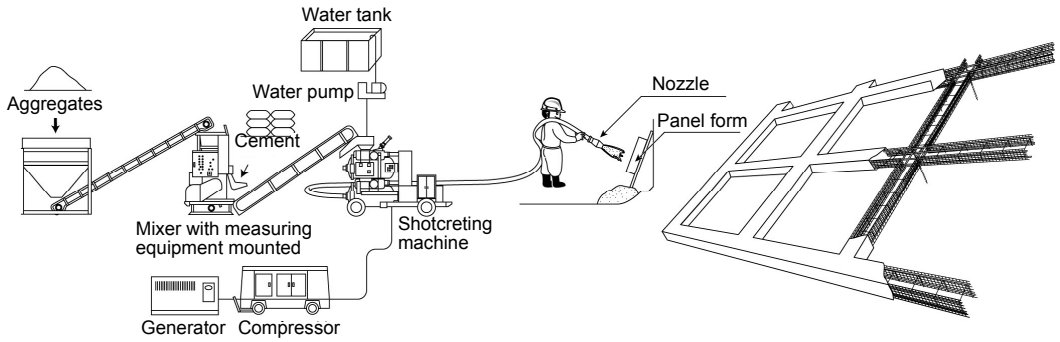

Fig. 2 Example of Spraying Test for Slope Stabilization

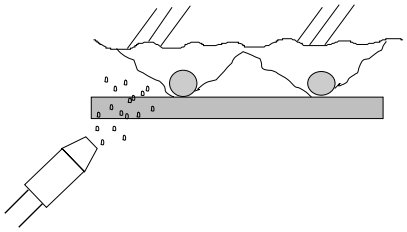

Fig. 3 Example of Spraying Test for for Repairing and Strengthening (Bar Arrangement Simulating Actual Structure)

7. Test Items

Table 1 shows an example of a set of test items for shotcreting by usage.

Table 1 Example of Test Items for Spraying by Usage

Usage	Mechanical properties				Spraying performance				Durability
	Compressive strength	Initial strength	Flexural toughness	Bond strength	Pumpability	Rebound ratio	Dust concentration	Filling performance	
Tunneling	○	△	△	–	△	△	△	–	△
Slope stabilization	○	–	△	–	△	△	–	–	△
Repair and strengthening	○	△	△	○	△	△	△	△	△

(○: mandatory, △: if necessary)

8. Testing Methods

The methods of preparing specimens and testing shall be as follows.

8.1 Tests for Mechanical Performance of Sprayed Concrete

a) The compressive strength of shotcrete shall be determined through tests under JIS A 1107, using specimens of a specified age [5] prepared as specified in JSCE-F 561.

Note 5: Generally, 28-day specimens shall be used.

b) The initial strength of shotcrete shall be determined through tests defined in JSCE-G 561 or JSCE-G 562, JSCE-G 563.

c) The bending toughness of shotcrete shall be determined through tests defined in JSCE-G 552 or JSCE-K 561, section 5.6, using specimens of specified age prepared according to JSCE-F 553 or JSCE-K 561.

d) The bond strength of shotcrete for repair/strengthening shall be determined through tests defined in JSCE-K 561, using specimens of specified age prepared according to JSCE-F 566.

8.2 Tests for Spraying Performance of Sprayed Concrete

a) Pumpability of shotcrete shall be visually checked for notable pulsation and clogging of the delivery hose.

b) The rebound percentage of shotcrete shall be obtained through tests according to JSCE-F 563.

c) The dust concentration of shotcrete shall be obtained through tests according to JSCE-F 564.

d) The filling performance of concrete for repair/strengthening shall be checked for unfilled voids in the cross-section of specimens prepared by applying shotcrete on the object modeling the actual layout of reinforcing bars.

8.3 Tests for Durability of Sprayed Concrete

a) The durability of shotcrete shall be determined through various durability tests on specimens of a specific age prepared according to JSCE-F 562.

b) Changes in length of concrete for repair/strengthening shall be determined through tests according to JSCE-G 564.

9. Reporting

The following items shall be reported.

9.1 Items That Must Be Reported

a) Test date

b) Types of tests (shotcrete tests simulating the actual construction site or shotcrete tests on actual construction)

c) Plant machinery used (types and performance of construction equipment including a concrete production plant, delivery equipment, shotcreting machine, compressor, accelerator feeder and nozzle etc.)

d) Shotcreting conditions (pumping distance, shotcreting method, shotcreting direction, distance of the nozzle to the target surface, discharge pressure, set discharge rate, compressed air volume

or opening of the valve of pumping pipe, target of shotcreting)

e) Types and quality of materials used

f) Mix formula of concrete

g) Temperature and humidity on the test day

9.2 Items to Be Reported for Performance to Be Verified

a) Mechanical properties (compressive strength, initial strength, bending toughness, bond strength, etc.)

b) Spraying performance (pulsation or clogging during pumping, rebound percentage, dust concentration, filling capability)

c) Durability (items subject to reporting stipulated in the respective durability test procedures)

9.3 Items to Be Reported as Needed

a) Difference in height between the shotcreting machine (gun) and the gunning position

b) Ventilation equipment

JSCE-F 566-2005

Method of Making Specimens of Bond Strength Tests of Sprayed Concrete (Mortar) for Repairing and Strengthening (Draft)

1. Scope

This specification stipulates the method of making specimens of bond strength of sprayed concrete (mortar) (also referred to as shotcrete) for repairing and strengthening.

2. Referenced Standards

The following standards are referenced in this specification to constitute part of its provisions.

The latest versions are referenced for the respective standards.

JSCE-K 561 *Test method of patching repair materials in concrete structures (draft)*

JIS R 6252 *Abrasive paper*

3. Base Plate for Testing

The base plate for testing (hereafter referred to as base plate) shall be handled as follows.

a) The base plate shall comply with section 5.8 of JSCE-K 561 (bond strength).

b) The base plate surface on which shotcrete is to be applied shall be carefully polished [(1)] and cleaned using abrasion paper Type 150 defined in JIS R 6252.

c) Prior to making specimens, the base plate shall be cured for seven days or more at a temperature of 20 ± 2°C and a relative humidity of 60 ± 10%.

Note 1: Depending on bond strength tests to be conducted, water jetting or blast application, or primer coating may be used to prepare the base plate.

4. Making Specimens

Specimens shall be prepared as described below.

a) Use a shotcreting machine to shotcrete the base plate. Hold the nozzle at right angles to the target surface at an appropriate distance, and then finish so that the shotcreted surface is smooth.[(2)]

b) Shotcreting direction shall be established as needed, including upward, downward, or horizontal, according to the purpose of the bond strength tests.

Note 2: Shotcrete which does not have accelerator may be smoothed with a trowel.

5. Curing

A specimen treated with shotcrete shall be allowed to stand for 24 hours, and then cured at a temperature of 20 ± 2°C and a relative humidity not lower than 50%.

6. Preparation for Tests

Test preparation shall be according to JSCE-K 561.

7. Reporting

The following items shall be reported.

a) Shotcreting method (equipment and conditions)

b) Types of materials used

c) Mix proportion of shotcrete (sprayed concrete or mortar)

(For pre-mixed type, mix proportion of powder materials, polymer solution and water shall be described.)

d) Bending strength of the base plate

e) Preparation of the base plate

f) Temperature and humidity at the time specimens were made

g) Number of specimens

h) Curing method of specimens