

JSCE TEST METHOD FOR SURFACE COATING MATERIALS

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Test Method for Surface Coating Materials, which has been drafted for the first time in Japan, is presented. Surface coating materials are mainly used in repairing work on existing concrete structures under various environmental conditions. Therefore, required characteristics of these materials are widely ranged depending on the condition of structures. Test methods described herein include, weathering test methods, oxygen permeability test methods, water vapor permeability test methods, water Permeability test methods, chloride ion permeability test methods, adhesive strength test methods and crack bridging test methods.

**Keywords** : test method, surface coating material, concrete repair, permeability, weatherability, adhesive strength, crack bridging

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## PREFACE

As the number of deteriorated concrete structures increases in Japan, the demand for use of concrete surface coating materials is also drastically increasing. Many kinds of surface coating materials are developed and commercially available. However, the testing standard for their physical and chemical characteristics is not established. Therefore, it still contains great difficulties to obtain best performance of surface coating materials, used in repairing work of deteriorated concrete Structures.

Under these circumstances, the Concrete Committee of the Japan Society of Civil Engineers established a Working Group on "Standard for Repairing Materials" chaired by Prof. Eiichi Tazawa of Hiroshima University in 1989. This WG was continued until 1991, followed by newly organized WG on "Repairing Materials" chaired also by Prof. Tazawa, which was continued until 1994. In this WG, first draft on testing standard of surface coating materials, including weatherability, oxygen permeability, adhesive strength and crack bridging ability, was proposed. In 1996, a new WG on "Repairing Materials" (chaired by Prof. Toyoaki Miyagawa of Kyoto University) was organized aiming to establish the JSCE standard on test methods for concrete surface coating materials. Based on the proposal on testing standard by former WG, and through one years' activity, this newly organized WG proposed the JSCE standard on testing method for surface coating materials. It includes weathering test methods, oxygen permeability test methods, water vapor permeability test methods, water permeability test methods, chloride ion permeability test methods, adhesive strength test methods and crack bridging test methods.

This Concrete Library contains these test methods. Hopefully, this proposed standard is read and executed in many countries and by many research engineers and field engineers. Also, I Strongly hope that the standard described herein will lead the repairing work of concrete structures with surface coating materials to be technically effective and economically reasonable. Finally, it will contribute to social development not only in Japan, but also an over the world.

Finally, I wish to express my gratitude to Prof. Etsuo Sakai, Vice-chairman, Mr. Kazuo Eguchi, Secretary, for their dedications to the working group's work from the beginning until the publication of the Concrete Library. My sincere appreciation also goes to other working group members whose contributions led to the success of the committee.

Toyoaki MIYAGAWA

Chairman of the Research Working Group on Test Method for Surface Coating Materials

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# 1. Weathering Test Methods for Surface Coating Materials(JSCE-511-1999)

## 1.1 Scope

This JSCE standard describes the procedure for the determination of weatherability of surface coating materials for use in repair of concrete structures.

Note 1 : The weathering test methods include an accelerated weathering test as a main test, and an outdoor exposure test, if necessary.

Note 2 : Concrete structures, such as water and sewerage facilities and water tanks which surfaces are always touched by water, are excluded in this standard.

## 1.2 Normative reference

This standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at appropriate places in the text and the publications are listed hereafter.

- JIS B 7753 Light exposure and Light-water-exposure apparatus (Sunshine Carbon-arc lamp type),
- JIS B 7754 Light exposure and Light-water-exposure apparatus (Xenon-arc lamp type),
- JIS K 5400 Testing Methods for Paints,
- JIS K 6266 Testing Methods of Weatherability for rubber, vulcanized or thermoplastic,
- JIS R 5201 Physical Testing Methods for Cement,
- JIS Z 6252 Abrasive Papers,
- JIS Z 8703 Standard Atmospheric Conditions for Testing,

## 1.3 Definitions

For the purposes of this standard the following definitions apply.

Surface coating materials : Synthetic resin and polymer modified cement coating materials which are coated on concrete surfaces for use in repair of concrete structures. surface coating materials are generally consisted of surface preparation material(primer), leveling material(putty), main and finish coating materials.

Note 1: The surface preparation material is used to improve the adhesion of concrete and leveling material, and to prevent the penetration of main coating material into the base concrete. This material is also called primer.

Note 2 : The leveling material is used to fill in air voids of concrete surface and to prepare the smooth surfaces for coating. This is also called putty.

Note 3 : The main coating material forms film or coating that stops the penetration of water, oxygen and carbon dioxide into concrete through its surface or cracks in order to prevent the deterioration of concrete or Steel bar in concrete. This coating material is also called second coating.

Note 4 : The finishing material is coated to give colors and luster to a finished face, and to improve the weatherability and water proofing of surface. The term of top coating material is also used.

## 1.4 Preparation of specimens

### 1.4.1 Experimental base plates

Experimental base plates, referred to as the “base plates” hereinafter, are prepared as follows:

- a) The base plates, based on JIS R 5201 10.4 (Preparation of specimen), with a water cement ratio of 50% and an sand cement ratio of 3, are cast in steel moulds of 70×70×20 mm in size.
- b) The plates are stored at a temperature of  $20 \pm 2^{\circ}\text{C}$  and a relative humidity of 80% for 24 hours. Then, the moulds are removed and the base plates are cured in water at  $20 \pm 2^{\circ}\text{C}$  for 6 days. And the base plates are stored at a temperature of  $23 \pm 2^{\circ}\text{C}$  and a relative humidity of  $50 \pm 5\%$  for 7 days or more.
- c) The bottom surfaces of base plates are thoroughly polished using abrasive paper #150 which is provided in JIS R 6252.

### 1.4.2 Types of tests

The types of tests, the item number applying tests and the number of specimens are given in **Table-1**.

**Table- 1 Types of Specimens**

types of Tests	Item number of Applying tests	Number of outdoor Exposure test Specimens	Number of original specimens
Accelerated Weathering Test	1.5.1 - 1.5.2	3	1
Outdoor Exposure Test	1.5.3 - 1.5.4	3	1

Note 5 : Original specimens are used for comparison with outdoor exposure specimens. after being prepared, they are kept in a dark room at normal humidity and temperature(1) until the comparison.

Comment (1) : The normal humidity and temperature are, as provided in JIS Z 8703 (Standard Atmospheric Conditions for Testing), Class 15 temperature of  $20 \pm 15^{\circ}\text{C}$  and Class 20 humidity of  $65 \pm 20\%$ .

### 1.4.3 Specimens

- a) Specimens are prepared as follows: The base plates and sample materials of base preparation, leveling, main and finish coatings are stored at a temperature of  $23 \pm 2^{\circ}\text{C}$  and a relative humidity of  $50 \pm 5\%$  for 24 hours.
- b) The base plate surfaces are coated according to the way and specifications specified by the manufacturer, and are stored for 28 days at a temperature of  $23 \pm 2^{\circ}\text{C}$  and a relative humidity of  $50 \pm 5\%$ .

## 1.5 Test Methods

### 1.5.1 Accelerated weathering

Using a light exposure and light-water-exposure apparatus (sunshine carbon-arc lamp type, or xenon-arc lamp type) provided in JIS B 7753 and JIS B 7754 respectively, the test is carried out under the conditions given in **Table-2**.

**Table-2 Operational Conditions**

	Sunshine carbon arc lamp system	Xenon arc lamp system
Types of glass filter	Type A	Combination of quartz glass Ultraviolet intercepting filter, and infrared intercepting filter
Using time of glass filter	Not exceed 2,000 hours	
Black panel temperature	63 ± 3 °C	
Water Spraying Conditions	Pressure	0.08-0.13 MPa
	Quantity of Water	2000 ± 100ml/min
	Quality of Water	After lighting of 102 minutes, 18 minutes of lighting or Water spraying
		Water with pH of 6.0 to 8.0, conductivity of 5μS/cm or Below, and total solids of 1 ppm or below(2) is Recommended.
Water Temperature	16 ± 5 °C	

Comment (2) : The recommended quality of water can be prepared by the combination of a distillation and an ion exchange or the combination of a distillation, an ion exchange and a reverse osmosis treatment.

### 1.5.2 Evaluation of accelerated weathering test

- After a specified time of lighting, the specimens are taken out from the machine. If the specimens are wetted, they are dried by shaking water from the surfaces and storing in room for an hour. Then, by comparing with the original specimen, the changes of the weathering test specimens in the coat surfaces effected by the lighting, such as chalking, heaving, cracking and peeling will be visually inspected.
- The luster and color differences are measured in accordance with JIS K 5400.
- Fixing marks and a 10-mm rim of each of the coated surfaces Should be excluded from this evaluation.

### 1.5.3 Outdoor outdoor exposure test

- The test is carried out as per the procedure provided in JIS K 5400 9.9 (Weatherability)
- For an exposure angle of  $\theta$  in the weathering test machine, 0 degree is recommended.

### 1.5.4 Evaluation of outdoor exposure test

- After a specified time of exposure, the specimens are removed from the exposure equipment. Then, by comparison with the original specimens, the changes in the coat surfaces affected by the exposure, such as chalking, heaving, cracking and peeling, will be visually inspected.
- The luster and color differences are measured in accordance with JIS K 5400.
- Fixing marks and a 10-mm rim of each of the coated surfaces should be excluded from this evaluation.
- Preprocessing, such as cleaning, for the evaluation is carried out in accordance with the method provided by the manufacturer.



## **1.6 Report**

The following items will be reported.

### **1.6.1 Results of the accelerated weathering test**

- a) Types and coating specifications of the surface coating materials, given based on **Table-3**.
- b) Types of accelerated weathering test machines, and the operating conditions and test duration.
- c) Surface coating material's visual evaluations. If preprocessing such as cleaning is carried out, the method is also given.
- d) Luster and color differences of the surface coating materials. If preprocessing such as cleaning is carried out, the method is also given.
- e) The testing organization.

### **1.6.2 Results of the outdoor exposure test**

- a) Types and coating specifications of the surface coating materials, given based on **Table-3**.
- b) The location of the test site.
- c) The exposure angle.
- d) The starting time and term of the test and observation.
- e) Weather observation data.
- f) Surface coating material's visual evaluations. If preprocessing such as cleaning is carried out, the method is also given.
- g) Luster and color differences of the surface coating materials. If preprocessing such as cleaning is carried out, the method is also given.
- h) The testing organization.

**Table-3 Types of Surface Coating Materials and Coating Specifications**

Stage of Work.	Types of Surface coating materials	Preparation of surface coating materials		Conditions for Coating					
		Names of Materials Mixing ratio	types of dilution materials and dosage (%)	Coating method	Quantity used (kg/m <sup>3</sup> ) (3)	Working life (4)	Thickness of Coating (μm) (5)		Coating Interval (6)
							Dry	Wet	
Pre-Processing	Base preparation material (Primer)								
	Leveling material (putty)								
Second Coating Material	Main coating material (7) (Second coating material) Number of coating)								
Top Coating	Finish coating material (Top coating material) Number of coating)								

Comment (3) : Quantity used before dilution

Comment (4) : In accordance with the method provided in JIS K 5400 4.9 (Pot life)

Comment (5) : Measured thickness of coat put onto a steel plate

Dry : In accordance with the method provided in JIS K 5400 3.5 (measurement of coating film thickness)

Wet : In accordance with the method provided in JIS K 5400 3.4 (measurement of coating layer thickness)

Comment (6) : The period of time between a coatings and next coating when preparing specimens

Comment (7) : When reinforcing materials such as glass fiber are used, their types are given

## **2.Oxygen Permeability Test Methods of Surface Coating Materials (JSCE-K 521-1999)**

### **2.1 Scope and Field of Application**

This JSCE standard describes the method for determining oxygen permeability of surface coating materials for use in repairing concrete structures.

### **2.2 Normative References**

This standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at appropriate places in the text and the publications are listed hereafter..

- JSCE-K 511 Weathering Test Methods of Surface Coating Materials
- JIS K 5400 Testing Methods for Paints
- JIS K 7100 Standard Atmospheres for Conditioning and Testing of Plastics
- JIS K 7126 Testing Method for Gas Transmission Rate through Plastic Film and Sheetting
- JIS Z 0208 Testing Methods for Determination of the Water Vapor Transmission Rate of Moisture Proof Packaging Materials Dish Method)
- JIS Z 8401 Rules for Rounding off of Numerical Values

### **2.3 Definitions**

Terms used in this standard are defied as follows.

Free films : Surface coating materials coated on tin plates or glass plates with mould release paper or film as same specification as coating to real concrete structures, and peeled in a certain way. Main and finish materials are included, surface preparations and leveling materials are excluded.

### **2.4 Adjustments of specimens and test temperature**

#### **2.4.1 Adjustments of condition**

Dry specimens are kept at same temperature as test temperature over 48 hours using calcium chloride or other desiccants in a desiccator before test.

#### **2.4.2 Test temperature**

Generally, the test is carried out in a room, which temperature is, as provided in JIS K 7100 Standard Atmospheric Conditions for Testing, Class 2 temperature of  $23 \pm 2^{\circ}\text{C}$ .

Types of specimens

Standard specimens and Specimens after accelerated weathering test, are prepared as follows.

#### **2.5.1 Preparation of standard specimens**

Specimens are free films, prepared in the following procedures.

##### **2.5.1.1 Preparation of films**

The surface coating materials are coated on tin plates as real specification, and cured at a temperature of  $23 \pm 2^{\circ}\text{C}$  and a relative humidity, of  $50 \pm 5\%$  for 28 days. At the time of coating, three points of film thickness are measured with a wet mm gauge as provided in SIS K 5400 3.4 (measurement of coating film

thickness). In case of using Japanese paper, it is difficult to measure mm thickness by wet film gauge, therefore only specimen's thickness is measured as provided in 2.5.1.4.

### **2.5.1.2 Free films**

Free films from the coated tin plates are obtained by amalgam method.

Note 1 : Mercury used in this test possesses toxicity, so it requires careful treatment. Therefore, if there is no problem in the property of free films, testing coating materials are coated on glass plates covered with mould release papers or mms, according to same specification as surface coating materials, as provided in JIS a 5400 8.8, 8.17 and 8.18. As mould release papers or films, tack papers, polyethylene terephthalate (PET) and fluorine resin film is usable.

Note 2 : In case of PET films, solvent type surface coating materials Ewe difficult to be peeled in some Cases.

Note 3 : Mould release paper has a surface treatment with silicon resin, so it is better to use fluorine film for silicon type surface coating materials.

Note 4 : If smooth free film cannot be obtained because repelling occurs on the mould release paper or film, use both mould release paper and Japanese paper (100 $\mu$ m: paper mulberry 60%, pulp 40%, machine made) together.

### **2.5.1.3 The number of specimens**

It is confirmed that free mms have no deformations such as curves or bends, and pinholes are not appearing by seeing through the natural light. The required number of specimens are obtained from one coated plate. The number of specimens is three. Specimens should be larger than permeable area of cell that is used for measurement, and attached to the cell with complete sealing.

### **2.5.1.4 Thickness of specimens**

Three points of thickness evenly with no influences on the surface of specimens are measured, and the mean value is obtained as provided in JIS K 5400 3.5.

## **2.5.2 Preparation of specimens after accelerated weathering test**

### **2.5.2.1 Accelerated weathering test**

Using specimens that are prepared by the method of 2.5.1, accelerated weathering test for specified time is carried out, as provided in JSCE-K511. In order to prevent deformation of specimens, an adhesive tape is used to attach specimens on stainless plates.

### **2.5.2.2 The number of specimens**

The specimens from 2.5.2.1 are used as the specimens after accelerated weathering test. The number of specimens is three.

## **2.6 Oxygen permeability test**

Using above specimens, the oxygen permeability test is carried out, as provided in JIS K 7126 the method A (differential pressure method) or the method B (isobaric method), and oxygen permeability, ( $\text{mol}/\text{m}^2 \cdot \text{s} \times \text{Pa}$ ) and oxygen permeability coefficient ( $\text{mol} \times \text{m}/\text{m}^2 \times \text{s} \times \text{Pa}$ ) are obtained.

## 2.7 Test results

The data is calculated individually, and the data rounding off to two significant figures as provided in JIS Z 8401 is obtained.

## 2.8 Report

The following items are reported.

- 1) Type and coating specification of the surface coating material, based on JSCE-511 **Table-3**
- 2) Preparation method of free films
- 3) Names of test instruments
- 4) Permeability area of cell
- 5) Type of specimen
- 6) Type of accelerated weathering test machine, operating conditions and test duration. The operating Conditions shall be based on JSCE-K 511 **Table-2**.
- 7) Type of pressure sensor (differential pressure method) or Type of oxygen sensor (isobaric method)
- 8) Thickness of specimens (each specimen's value and the mean value)
- 9) Oxygen permeability, and/or oxygen permeability coefficient
- 10) Date of test
- 11) The testing organization

### 3. Water Vapor Permeability Test Methods of Surface Coating Materials (JSCE-K 522-1999)

#### 3.1 Scope

This JSCE standard describes the method for determining water vapor permeability of surface coating materials for use in repairing concrete structures.

#### 3.2 Normative References

This standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at appropriate places in the text and the publications are listed hereafter.

- JSCE-K 511 Weathering Test Methods of Surface Coating Materials
- JSCE-K 521 Oxygen Permeability Test Methods of surface Coating Materials
- JIS A 6203 Polymer dispersions and redispersible polymer powders for cement modifiers
- JIS K 5400 Testing Methods for Paints
- JIS K 7100 Standard Atmospheres for Conditioning and Testing of Plastics
- JIS K 7126 Testing Method for Gas Transmission Rate through Plastic Film and Sheeting
- JIS Z 0208 Testing Methods for Determination of the Water Vapor Transmission Rate of Moisture-Proof Packaging Materials (Dish Method)
- JIS Z 8401 Rules for Rounding off of Numerical Values

#### 3.3 Adjustments of specimens

Dry specimens are kept at same temperature as test temperature over 48 hours using calcium chloride or other desiccants in a desiccator before test.

#### 3.4 Specimens

Specimens used in this standard are standard specimens and/or specimens after accelerated weathering test based on JSCE K521 5. (Types of specimens). The number of specimens is three.

#### 3.5 Water Vapor Permeability test method

Using above specimens, the test is carried out based on JSCE K511-5 (types of specimens) and water vapor permeability using the following equation is obtained. Test condition is  $40 \pm 1$  °C (90 ± 2) %, based on JIS A 6203 8.15 (water vapor permeability).

$$\text{Water Vapor permeability (g/m}^2 \times 24\text{h)} = (240 \times M) / (T \times S)$$

S : area of water vapor permeability'

M : mass increment between final measurement and pre-anal measurement (mg)

T : time interval between final measurement and pre-anal measurement (h)

Note : The, size of dishes and the amount of moisture-proof agent based on JIS A 6203 8.15 (water vapor permeability) are also usable. In this case, the equation for calculating the water vapor permeability should be based on JIS A 6203 8.15 (water vapor permeability).

#### 3.6 Test results

The data is calculated individually, and the data rounding off to two significant figures as provided in JIS Z 8401 is obtained.

### 3.7 Report

The following items are reported.

- 1) Type and coating specifications of the surface coating materials, based on JSCE-511 **Table-3**
- 2) Preparation method of free films
- 3) Types of specimens
- 4) Size of specimens
- 5) Size of dishes ( measurement area )
- 6) Thickness of specimens
- 7) Type of accelerated weathering test machine, operating conditions and test duration. The operating conditions shall be based on JSCE-K 511 **Table-2**.
- 8) Water vapor permeability (each specimen's value and the mean value)
- 9) Date of test
- 10) The testing organization

## 4 . Water Permeability Test Methods for Surface Coating Materials (JSCE-K 523-1999)

### 4.1 Scope

This JSCE standard describes the methods for determining water permeability of surface coating materials for use in repairing concrete structures.

### 4.2 Normative references

This standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at appropriate places in the text and the publications are listed.

- JSCE\_K 511 Weathering Test Methods of Surface Coating Materials
- JISA 1404 Method of test for waterproof agent of cement for concrete construction
- JIS A 6203 Polymer dispersions and redispersible polymer powders for cement modifiers
- JIS R 5201 Physical Testing Methods for Cement
- JIS R 6252 Abrasive Papers
- JIS Z 8401 Standard Atmospheric Conditions for Testing

### 4.3 Specimens

#### 4.3.1 Experimental base plates

Experimental base plates, referred to as the "base plates' hereinafter, are prepared as follows:

- a) The preparation of base plates is based on JSCE-K 511 1.4.1 (Experimental base Plates)
- b) The mould used is steel made, and the size is 150mm in diameter, 40mm in height.

#### 4.3.2 Preparation of specimens

- a) The preparation of specimens is based on JSCE-K 511 1.4.3 (Specimens).

### 4.4 Test Methods

- a) The test is based on JISA 1404 11.5.
- b) Weight ( $W_0$ ) of specimen, prepared based on 4.3.2, is measured. Then water pressure of 98kPa is applied to the specimen for 1 hour followed by weight ( $W_1$ ) measurement of the specimen.
- c) Based on JIS A 6203, the volume of permeated water ( $W_p$ ) is calculated by using following equation. The average value of three data is obtained.

$$W_p = W_1 - W_0$$

$W_p$  : Volume of permeated water

$W_1$  : Weight of specimen before application of water pressure

$W_0$  : weight of specimen after application of water pressure

### 4.5 Calculation

Based on JIS Z 8401, the test data is expressed in three decimals of significant digits.



## 4.6 Report

The following items are reported.

- a) Types and coating specifications of the Surface coating materials (based on **Table-3** in JSCE K511)
- b) Permeated volume (individual datum and their average value)
- c) The tested date
- d) The testing organization

## 5 Chloride Ion Permeability Test Methods for Surface Coating Materials (JSCE-K 524-1999)

### 5.1 Scope

This JSCE. standard describes the methods for determining chloride ion permeability of surface coating materials for use in repairing concrete structures.

### 5.2 Normative references

This standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at appropriate places in the text and the publications are listed.

- JSCE-K 511 Weathering Test Methods of Surface Coating Materials
- JIS A 6203 Polymer dispersions and redispersible polymer powders for cement modifiers
- JIS K 5664 Tar epoxy resin paint
- JIS R 5201 Physical Testing Methods for Cement
- JIS R 6252 Abrasive Papers
- JCI-SC4 Test Method for Chloride Content in Hardened Concrete
- JCI-SC5 Test Method for Total Chloride Content in Hardened Concrete

### 5.3 Specimens

#### 5.3.1 Experimental base plates

- a) The preparation of base plates is based on JSCE-a 511 1.4.1 (Experimental base plates).
- b) The mould used is steel made, and the size is 150×150×150mm.
- c) Mortar is placed into mould with three layers. The thickness of each layer is under 40mm, and each layer is well compacted with mechanical vibrator.

#### 5.3.2 Preparation of specimens

- a) Preparation of specimens is based on JSCE-K 511 1.4.3 (Specimens).
- b) Edge surfaces, bottom surface and mortar placing surface of the specimen are sealed with epoxy resin coating materials in conformity with first grade material specified in JIS K 5664. The specimen was stored at temperature of  $23 \pm 2^{\circ}\text{C}$  and a relative humidity of  $50 \pm 5\%$  for one day. Then, remained two un-coated Surfaces of the specimen are coated with coating materials in accordance with the specification of its manufacturer. Furthermore, the specimen was stored at temperature of  $23 \pm 2^{\circ}\text{C}$  and a relative humidity of  $50 \pm 5\%$  for 28 days.

### 5.4 Penetrating Depth of Chloride Ion

Penetrating depth of chloride ion is measured as follows.

- a) With the specimen made in accordance with 5.3.2, chloride penetrating depth is tested in conformity with JIS A 6203 8.12 (Chloride ion penetrating depth).
- b) Test specimen is split into two pieces and it is necessary that its split surface cross the coated Surface in tested samples.
- c) Measuring of chloride ion penetrating depth is carried out at three points, one is center of split. edge, and other two points are 25mm apart from center point. Three data are obtained in one split piece, therefore, all together six data are obtained in one specimen, and each datum is obtained at minimum order of 1mm.
- d) If required, chloride content in hardened concrete is tested according to JCI-SC4 Test Method for Chloride Content in Hardened Concrete, or JCI-SC5 Test Method for Total Chloride Content in Hardened Concrete.
- e) For chloride ion content measurement, the ion chromatography is also used.

## 5.5 Calculation

Based on JIS Z 8401, by rounding off the first decimal number, the test data is expressed in whole number.

## 5.6 Report

The following items will be reported.

- a) Types and coating specifications of the surface coating materials (based on **Table-3** in JSCE K511)
- b) Chloride ion intrusion depth (individual datum and their average value)
- c) The tested date
- d) The testing organization

## 6. Adhesive Strength Test Methods of Surface Coating Materials (JSCE-K531-1999)

### 6.1 Scope and Field of Application

This JSCE standard describes the methods for determining adhesive strength of surface coating materials for use in repairing concrete structures.

### 6.2 Normative reference

This standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at appropriate places in the text and the publications are listed.

JSCE-K 511	Weathering Test Methods of Surface Coating Materials
JIS A 6909	Coating Materials for Textured Finishes of Buildings
JIS a 5400	Testing Methods for Paints
JIS A 5201	Physical Testing Methods for Cement
JIS A 6252	Abrasive Papers
JIS Z 8401	Rules for Rounding Off of Numerical Values

### 6.3 Specimens

Specimens used in this standard are prepared as follows:

- The preparation of base plates is based on JSCE-K 511 1.4.1 (Experimental base plates).
- Types of specimens, item number of applying tests and number of specimens are given in **Table 1**.
- The preparation of specimens is based on JSCE-K 511 1.4.3 (Specimens).

**Table-1 Type of Specimens**

Type of Tests	Type of Specimens	Item number of applying tests	Number of specimens
Adhesive Strength Test	Standard specimens	6.4.1	3
	Specimens after alkali resistance test	6.4.2	3
	Specimens after accelerated weathering test	6.4.3	6

### 6.4 Test methods

#### 6.4.1 Test for standard specimens

Test for standard specimens is carried out as follows.

- At  $23 \pm 2^\circ\text{C}$  and  $50 \pm 5\%$  R.H., by spreading the adhesive agent on the surface of the faced-upwards specimen and slightly polishing the contact surfaces of the specimen and the upper steel jig (ref. **Figure 1**), the specimen is attached to the upper steel jig to make the jig stand still on the specimen (ref. **Figure 2**). In addition, a weight about 1 kg is placed on the upper steel jig and wiped off the pressed-out adhesive agent around the contact surfaces of the specimen and the upper steel jig. This setting is kept for 24 hours.
- As shown in **Figure 2**, the weight is removed and the cuts along the 4 sides of the upper steel jig until the base plate is made, the depth of which are around 1mm.
- In addition, by combing the lower steel jig for tension (ref. **Figure 3**) and the bearing plate (ref. **Figure 4**), the tension force vertical to the surface of the specimen is applied to and out the maximum tensile load T (N), as indicated in **Figure 5**.
- The loading rate until the failure of the specimen should be kept around 1500 - 2000 N/min.

- e) If the displacement-controlled test machine is utilized, the loading rate is necessary to be adjusted to the above range.
- f) The gripping device for tension test machine should be the type of self-centering device.

#### **6.4.2 Test for specimens after alkali resistance test**

Test for specimens after alkali resistance test is carried out as follows.

- a) As shown in **Figure 7**, the specimen face is kept upwards on the sand in the vessel containing saturated calcium hydroxide solution and water is poured into the vessel until 5 mm gap between the top surface of the base plate and the water surface. This setting is kept for 28 days.
- b) Then, the specimens are taken out from the solution and the test is carried out under the steps given in **6.4.1 (1)-(6)**.

#### **6.4.3 Test for specimens after accelerated weathering**

Test for specimens after accelerated weathering test is carried out as follows:

- a) Accelerated weathering test is carried out in accordance with JSCE-K 111.
- b) Then, the specimens are taken out from the machine and the test is carried out under the steps given in **6.4.1 (1)-(6)**.

### **6.5 Calculation**

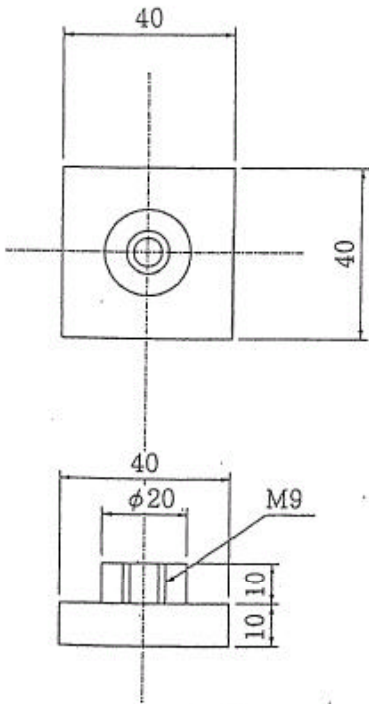
The calculation is presented below.

In accordance with JIS Z 8401, the adhesive strength is calculated by rounding off to two decimal digits. Besides, the evaluation on state of failure is expressed by the area ratio of failed part to the original part, as illustrated in **Figure 6**.

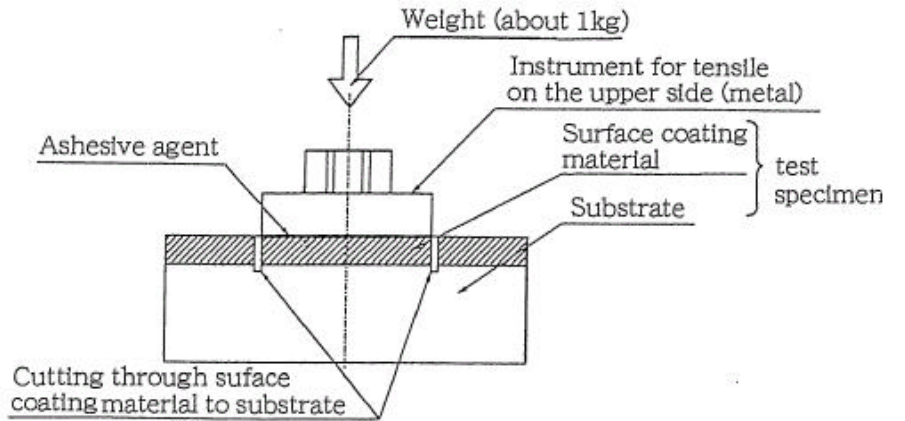
### **6.6 Report**

The following items are reported.

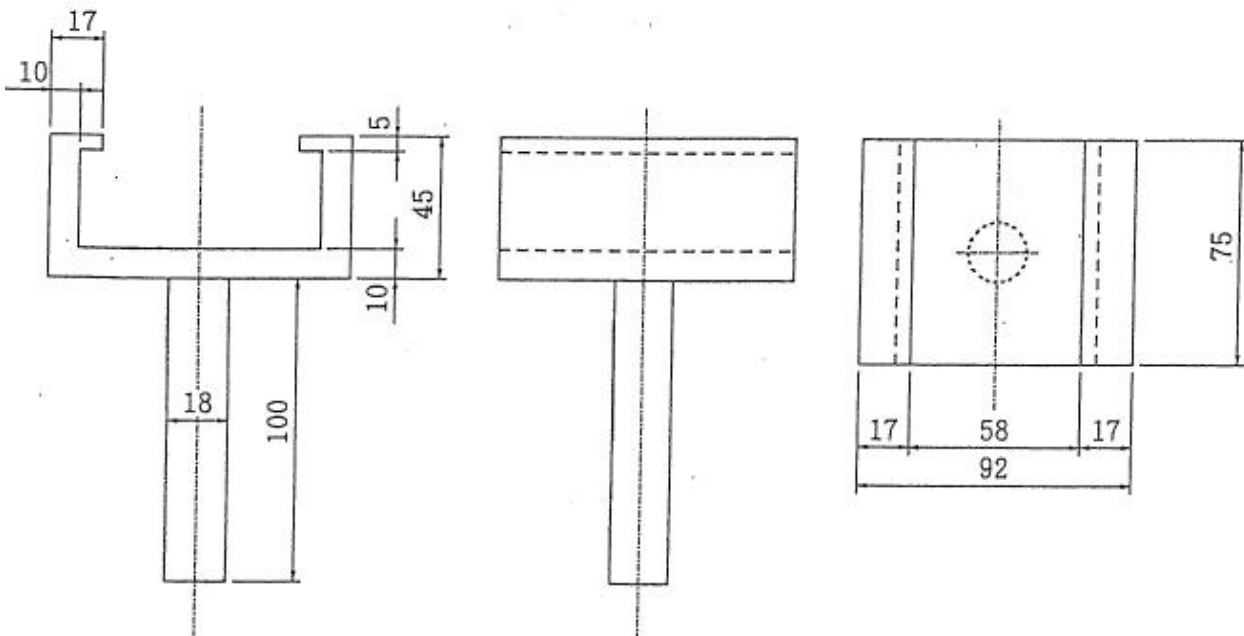
- a) Types and coating specifications of the surface coating materials (aged on **Table-3** in JSCE K511)
- b) Types of specimens
- c) Maximum tensile load (N)
- d) Adhesive strength (N/mm<sup>2</sup>)
- e) Failure state of each test piece (area ratio)
- f) Type of accelerated weathering test machine, test condition and test period
- g) The testing organization
- h) Date of test



**Figure 1 Instrument for tensile on the upper side**



**Figure 2 Test assembly installed in instrument for tensile on the upper side**



**Figure 3 Instrument for tensile on the lower side**

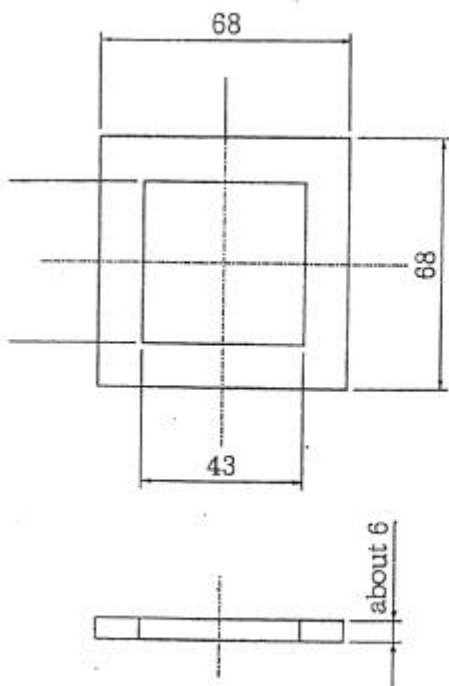


Figure 4 Metal spacer.

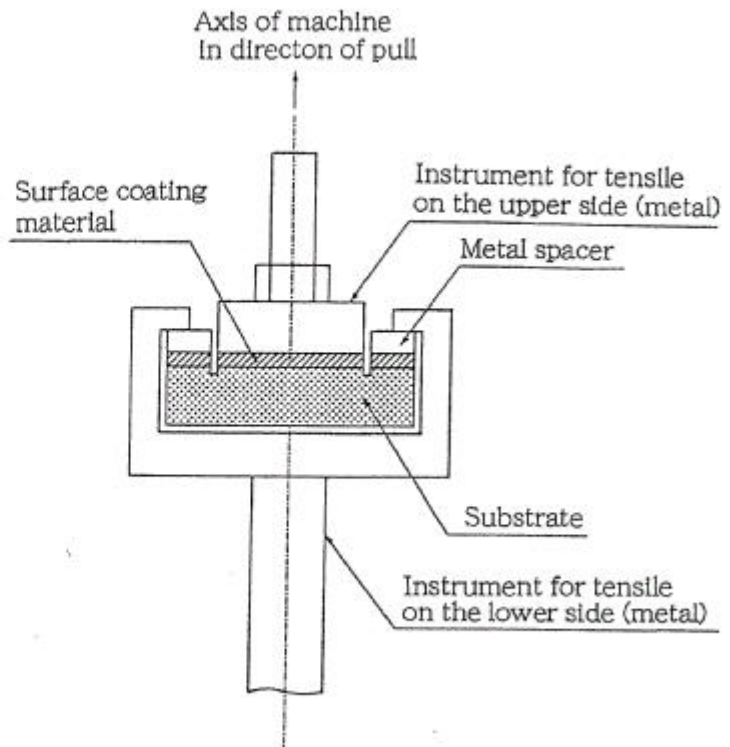
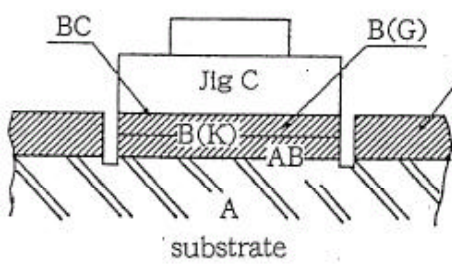


Figure 5 Test assembly installed in testing machine



Surface coating material

A : Destruction of substrate

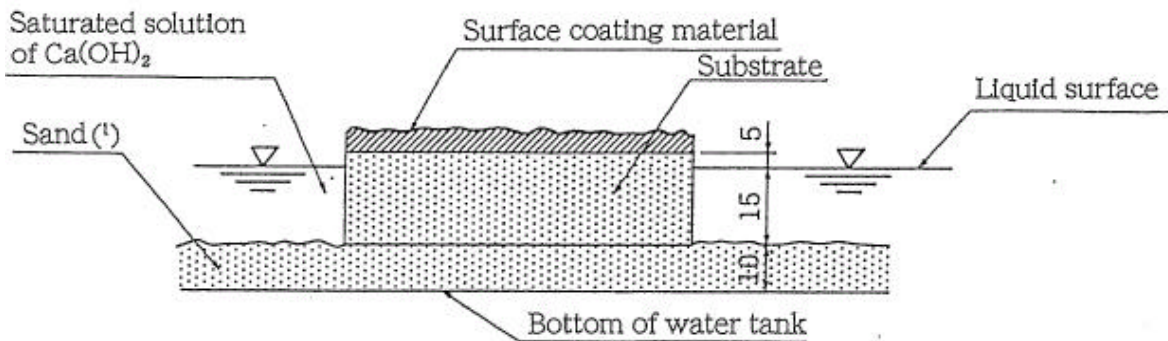
AB : Destruction between substrate and coating material

B(G) : Destruction of coating material

B(K) : Destruction between coating material

BC : Destruction between jig and coating material

Figure 6 Position of destruction



Note<sup>(1)</sup> standard sand or quartz sand

Figure 7 Test method of submergence

## 7. Crack Bridging Test Methods of Surface Coating Materials (JSCE-K532-1999)

### 7.1 Scope and Field of Application

This JSCE standard describes the test methods for crack bridging of surface coating materials for use in repairing concrete structures.

### 7.2 Normative references

This standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at appropriate places in the text and the publications are listed.

JSCE-K 511	Weathering Test Methods of Surface Coating Materials
JIS K 5400	Testing Methods for Paints
JIS R 5201	Physical Testing Methods for Cement
JIS R 6252	Abrasive Papers
JIS Z 8401	Rules for Rounding Off of Numerical Values

### 7.3 Definitions

Terms used in this standard are defined as follows.

- a) Crack bridging performance: based on its extensibility, the performance of surface coating materials on its coating ability, which is regardless of the existence of cracks.

### 7.4 Specimens

#### 7.4.1 Experimental base

Experimental base plates, referred to as the "base plates" hereinafter, are prepared as follows.

- a) Based on JIS R 5201, the base plates are formed in metal forms with the dimension by 40×120×10mm.
- b) The plates are cured for 24 hours at  $20 \pm 2^\circ\text{C}$  and above 80% R.H.. Then, the forms are removed and the plates are water cured at  $20 \pm 2^\circ\text{C}$  for 6 days.
- c) After water cure, the plates are cured for 7 days or more at  $23 \pm 2^\circ\text{C}$  and 50±5% R.H.. Then, as shown in **Figure 1**, 5mm depth cut is made by diamond-cutter on the upwards-faced surface of the molded specimen (i.e. the opposite surface of the surface spread with surface coating material). By bending, the plates are disunited into two parts.
- d) On steel or stainless plate, the disunited plates are joined by adhesive tape attached on the lateral surface of the plates. If the specimens are used for accelerated weathering test, stainless plate and the adhesive tape(1) with weatherability and durability should be used.

Note 1: the specification of the adhesive tape is based on JIS C 2338.

#### 7.4.2 Preparation of specimens

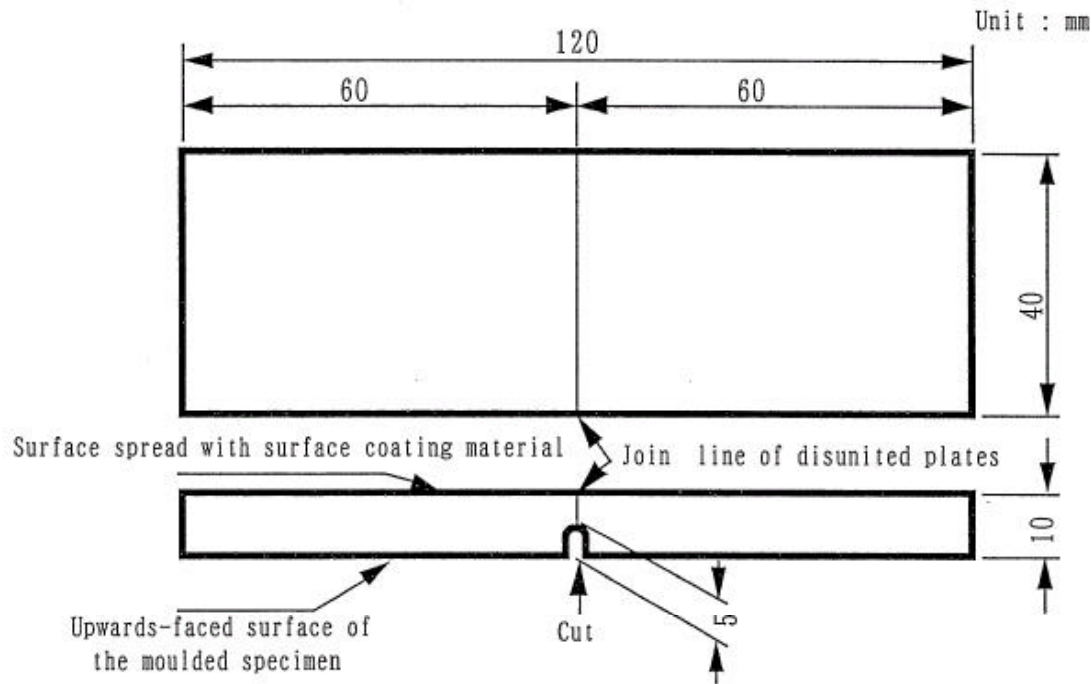
Specimens are prepared as follows.

- a) The regulating agent for leveling provided by the manufacturer is rubbed on the plates along the join line of the disunited plates by spatula, the width of which should be controlled within 20 mm. After the regulating agent for leveling is hardened, the part rubbed with regulating agent for leveling is polished using abrasive paper No.150 Specified in JIS R 6252 to remove the excessive regulating agent for leveling.
- b) By following the specification provided by the manufacturer, with special care taken for avoiding the



inflow of the regulating agent for leveling along the join plane between the disunited plates and for remaining 30 mm margin of the joined plate at both sides, the surface coating material is spread on the surface of the joined plates. Then, the plates used for specimens are cured for 28 days at  $23 \pm 2^\circ\text{C}$  and  $50 \pm 5\%$  R.H...

- c) The number of the specimens is explained in 7.4.3, where the number for the specimens, specimens at low temperature and specimens after alkali resistance test are three while six for the specimens after accelerated weathering test.



**Figure 1** Layout of the specimen

### 7.4.3 Type of specimens

The type of specimens, item number of applying tests and number of specimens are given in **Table- 1**.

**Table- 1** Type of Specimens

Type of tests	Type of specimens	Item number of Applying tests	Number of specimens
Crack Bridging Test	Standard specimens	7.4.3.1	3
	Specimens at low temperature	7.4.3.2	3
	Specimens after accelerated weathering test	7.4.3.3	6
	Specimens after alkali resistance test	7.4.3.4	3

#### 7.4.3.1 Standard Specimens

Without detaching the specimens from the steel plate, the specimens are cured for 8 days or more at  $23 \pm 2^\circ\text{C}$  and  $50 \pm 5\%$  RH. Then, the specimens detached from the steel plate are tested at  $23 \pm 2^\circ\text{C}$ .

### 7.4.3.2 Specimens at low temperature

Without detaching the specimens from the steel plate, the specimens are exposed in the low-temperature cabin for 30 minutes or more at  $-20 \pm 3^\circ\text{C}$ . Then, the specimens detached from the steel plate are tested at  $-20 \pm 3^\circ\text{C}$ .

### 7.4.3.3 Specimens after alkali resistance test

Without detaching the specimens from the stainless plate, the specimens are tested by following the steps of JIS K 5400, in accordance with JSCE-K 511 "Weathering Test Methods for Surface Coating Materials". After the required duration for accelerated weathering test is expired, the specimens are kept at  $23 \pm 2^\circ\text{C}$  and  $50 \pm 5\%$  R.H. for 24 hours. Then, the specimens detached from the stainless plate are tested at  $23 \pm 2^\circ\text{C}$ .

### 7.4.3.4 Specimens after alkali resistance test

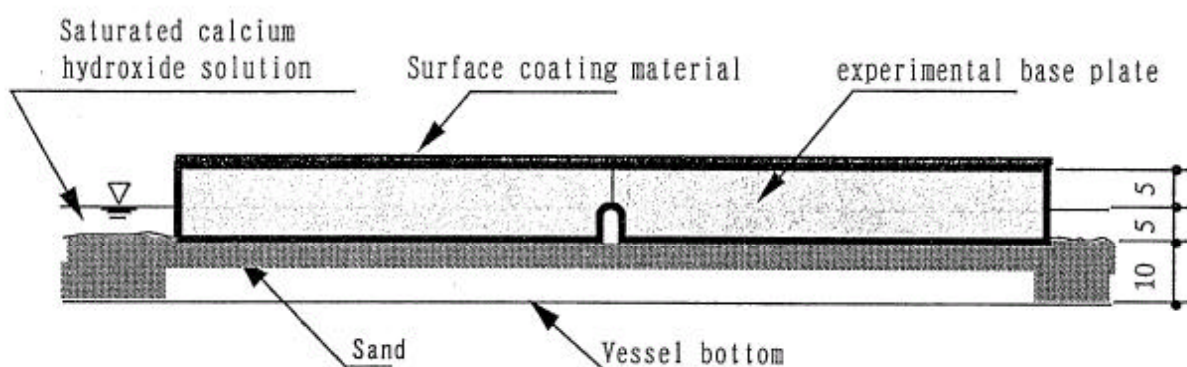
As shown in **Figure 2**, the specimen face is kept upwards On the sand(2) in the vessel containing saturated calcium hydroxide solution and water is poured into the vessel until 5 mm left between the top surface of the base plate and the water surface. This setting is kept at  $23 \pm 2^\circ\text{C}$  for 28 days. Then, the specimens are kept at  $23 \pm 2^\circ\text{C}$  and  $50 \pm 5\%$  R.H. for 24 hours. Then, the specimens detached from the stainless plate are tested at  $23 \pm 2^\circ\text{C}$ .

Note 2 : standard sand or silica sand is required.

## 7.5 Teat method

By detaching the specimens from the steel plate or stainless plate, the specimens are fastened to tension test machine by keeping the existence of clearance between zippers. The specimens are pulled at uniform loading ratio at 5mm/min. When the state of surface coating material is close to the following state, the elongation (mm) is measured from the chart based on **Figure 3**.

- Failure of surface coating material
- Partial failure of surface coating material is observed by visual observation.
- The maximum tensile strengths of main coating material or finish material is indicated in the chart.



**Figure 2 Configuration of immersion in saturated calcium hydroxide solution**

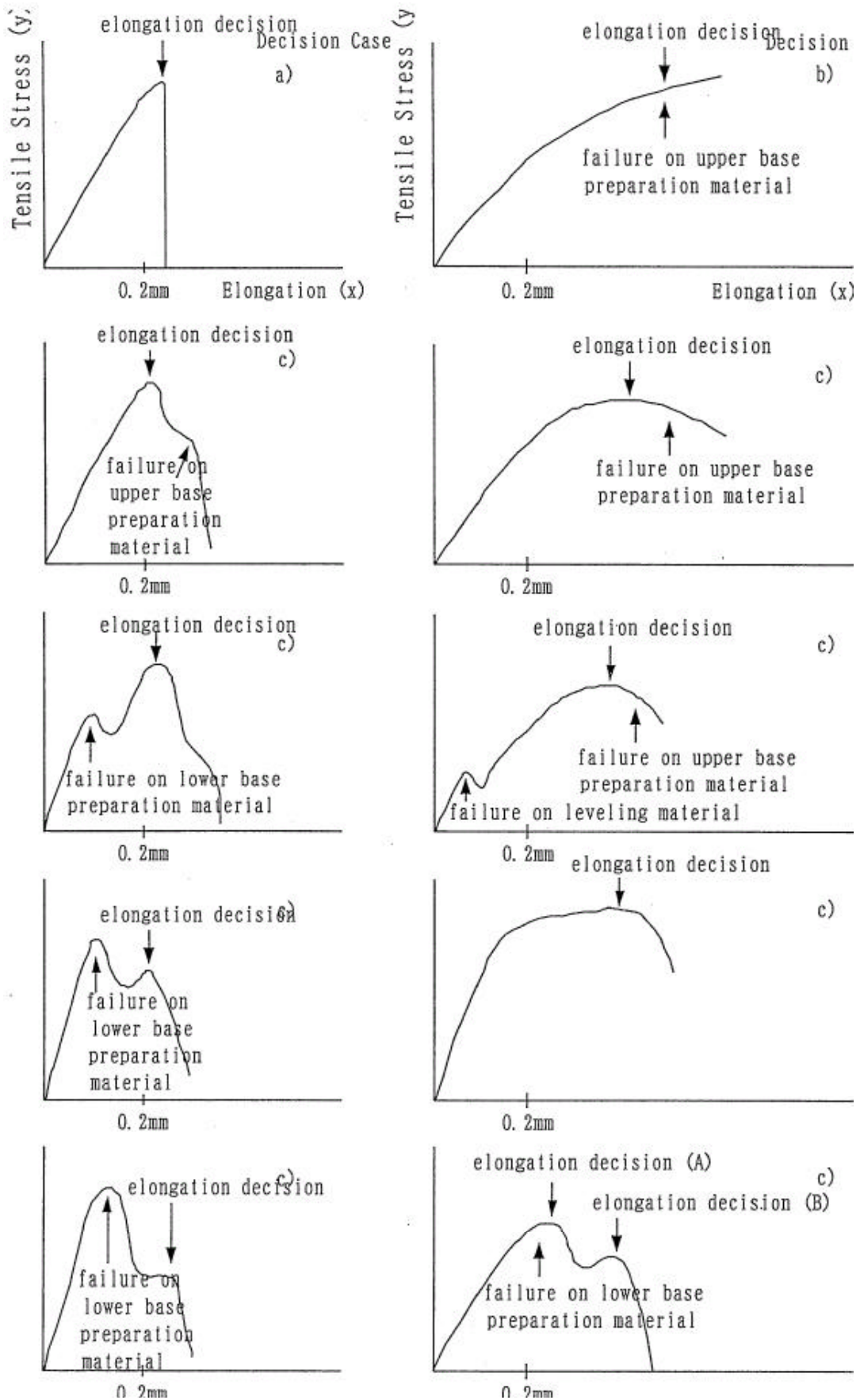
## 7.6 Calculation

The result of each specimen is calculated. In accordance with JSI Z 8401, the result of each specimen is rounded off to two decimal digits.

## 7.7 Report

The following items are reported.

- a) Types and coating specifications of the surface coating materials (based on **Table-3** in JSCE K511)
- b) Types of Specimens
- c) Elongation (mm) (besides measured value of each specimen and the average value, the chart for deciding crack bridging performance of each specimen)
- d) State of coating mm under measuring the elongation
- e) Type of accelerated weathering test machine, test condition and test period
- f) The testing organization
- g) Date of test



**Figure 3 Decision for Crack Bridging Performance**