
**Test methods for repair materials for
water-leakage cracks in underground
concrete structures —**

**Part 4:
Test method for adhesion on wet
concrete surface**

*Méthodes d'essai pour matériaux de réparation pour fissures dues à
l'eau dans les structures en béton souterraines —*

Partie 4: Méthode d'essai de l'adhésion sur un substrat humide

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 7, *Maintenance and repair of concrete structures*.

ISO/TS 16774 consists of the following parts, under the general title *Test methods for repair materials for water-leakage cracks in underground concrete structures*:

- *Part 2: Test method for chemical resistance*
- *Part 3: Test method for water (wash out) resistance*
- *Part 4: Test method for adhesion on wet concrete surface*

The following parts are under preparation:

- *Part 1: Test method for thermal stability*
- *Part 5: Test method for watertightness*
- *Part 6: Test method for response to the substrate movement*

Introduction

This Technical Specification is linked to ISO/TR 16475. ISO/TR 16475 outlines 6 basic properties and the required performance levels of water-leakage repair materials, and ISO/TS 16774 proposes a tentative, sample test methods that are capable of evaluating the respective properties of the repair materials.

The test methods in this Technical Specification are intended to serve as references for nations that have not yet developed a test method on the 6 proposed required performance properties of water-leakage repair materials. If other forms of test methods that are simpler, more accurate or more organized are available, such methods are recommended for use instead. Many of the dependent variables outlined in the reference test methods of this Technical Specification are subject to change in accordance to the environmental conditions (temperature and humidity, chemical solution and concentration, width of movement activity, water pressure or water flow velocity, etc.) outlined in the standards used in respective countries.

For ISO/TS 16774-1, ISO/TS 16774-5 and ISO/TS 16774-6, for the purpose of objectively comparing the performance of injected repair materials, artificial cracks of same width, height, and volume were used to control the usage of repair materials for each testing cycle and enable repetition of the same test methods under the same conditions.

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Test methods for repair materials for water-leakage cracks in underground concrete structures —

Part 4:

Test method for adhesion on wet concrete surface

1 Scope

This part of ISO/TS 16774 specifies a laboratory test method for indirectly measuring the adhesion performance of repair material to wet concrete crack surfaces by qualitatively, as a pass/fail at predetermined time, against predetermined amount of weight exerted on the repair material adhesion.

NOTE This part of ISO/TS 16774 classifies and categorizes materials that are tested into families of similar properties for the purpose of making relative comparisons with the data results.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/TR 16475, *Guidelines for the repair of water-leakage cracks in concrete structures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 16475 and the following apply.

3.1

repair material for water-leakage cracks

grouting materials used for prevent water-leakage at crack in concrete

Note 1 to entry: In this Technical Specification, target ingredients are limited to injection materials outlined in ISO/TR 16475.

Note 2 to entry: [SOURCE: ISO/TS 16774-2:—, 3.1]

4 Principle

A repair material's ability to adhere to a wet leakage crack surface is one of the fundamental properties that water-leakage repair materials should possess. Focus areas of repair material application are most often on concrete surfaces that are constantly wet and humid. During and after application, repair materials should be able to remain firm adhesion to concrete surface and should not fall off. This test method proposes that observing whether repair materials can retain adhesion on wet concrete surface against a constantly exerted weight can determine a repair material's adhesion performance on wet concrete surface. An example test method is provided in [Annex A](#).

Repair materials are injected in an artificially produced wet crack space formed by two separate concrete (or mortar) specimens, a top part that serves as an anchor, and another that serves as the any constant weight that pulls on the material adhesion surface. The concrete specimen is then lifted and held in mid-air by the clamp (anchor) of adhesion tester to see if the material can maintain adhesion past the failure margin time against the weight of the bottom concrete specimen.

5 Apparatus

5.1 Adhesion tester.

Adhesion tester should have 3 main parts: frame, clamp, and mobile support plate/mechanism.

5.2.1 Frame, used for levelling the specimen horizontally that can be set immobile during the progress of the test.

5.2.2 Clamp, can anchor the test specimen securely and hold it suspended in mid-air during the test.

5.2.3 Mobile support plate/mechanism, used to initially secure the specimen prior to the testing.

Once the testing starts, it shall be removable (left, right, top, down, in any direction) to allow the specimen to stay mid-air.

Any apparatus can be used, but it should allow the bottom concrete specimen that serves as the weight to pull against the material adhesion the wet surface during the testing.

5.2 Others.

5.2.1 Stop watch, used for testing the duration of adhesion of the material.

5.2.2 Injector, testing material injecting apparatus.

5.2.3 Water container.

6 Preparation

6.1 Test specimen assembly as artificial water-leakage crack

- a) A water-leakage crack test specimen is prepared using two separate concrete or mortar parts (upper and bottom part) placed horizontally parallel to one another. One part (upper) is placed over the other (bottom) with spacers in between, forming the test specimen with an artificial crack.

NOTE The space height between the two concrete parts represents the width of the concrete crack. The height can vary according to different national standards.

- b) The crack space along the side is covered with silicon sealants, tape or other applicable materials along the exterior side of the artificial crack space to prevent leakage during injection.

Any supplementary material can be used to hold the two parts together with a crack space in between, but should leave an inlet for material injection.

- c) The assembled specimen is placed underwater for a predetermined period (time subject to vary according to the different national standards applied to this test method).
- d) After taking the specimen out of the water, the repair material is injected into the space while the surface is still wet.

Injection method varies according different national standards. If manufacturer's instructions are available, employment of such method is recommended.

6.2 Ambient conditions

Keep the test room at temperature $(20 \pm 3) ^\circ\text{C}$ and humidity at $(65 \pm 5) \%$ during the experiment unless specifically required otherwise.

NOTE Temperature values are subject to change according to different national standards.

Examples may include warmer countries with ranges that can reach up to $(27 \pm 2) ^\circ\text{C}$ and colder countries at $(16 \pm 3) ^\circ\text{C}$, etc. The same applied to humidity conditions.

7 Procedure

- a) Place the test specimen on the support plate located at the adhesion tester.

Raise the support plate up to the clamp located at the top of the adhesion tester and fix the upper concrete part on to the clamp (refer to procedure note).

- b) To begin testing, remove the support plate, letting the whole specimen suspend in mid-air and letting the weight of the bottom concrete part pull on the repair material adhesion on concrete surfaces.

NOTE One of the two concrete parts adhered together by the injected repair material is fixed onto the clamp of adhesion tester and the other concrete part alone acts as the weight to pull on the adhesion of the repair material.

- c) Observe the specimen to see if it maintains adhesion for a given period of time to pass the test method (adhesion maintenance time subject to change in accordance to different national standards) and record the adhesion time.
- d) If the material fails adhesion and falls off, end the test and record the results (the time at which material adhesion fails).

Photos of the specimen and equipment conditions shall be taken at every stage possible during the each and every test procedure for recording and information purposes. For detailed and clearer explanation, refer to [Annex A](#).

8 Expression of results

In this test method, repair materials are evaluated for their performance on wet concrete surface adhesion. The weight of the bottom concrete part of the specimen will exert a natural pulling force on the repair material adhesion. For all repair materials, the results of this test on whether the adhesion holds for the given period against the predetermined mass can be used to evaluate the repair material performance on wet surface adhesion. These results can be used as a data base for an evaluation guideline in future cases of selecting appropriate repair materials with the required properties of adhesion on leakage crack surfaces of underground concrete structures.

9 Test report

9.1 Information on the repair material of the test target

9.1.1 General

The test report should record the following information on repair material of the test target:

- a) manufactured date, time, place of the repair material;
- b) manufacturer (name, address, phone number);
- c) type, storage method and authentication of the repair material;

- d) guideline and manual on how to use and apply the repair material;
- e) data on chemical composition of repair material as indicated in manufacturer's data sheet.

9.1.2 Other information

The following information is recorded on demand if required:

- 1) objective of the testing and related;
- 2) applicable areas in construction sites using the test specimen;
- 3) result of eco-toxicological performance tests to account for the release of hazardous substance and the subsequent effects on health and safety.

9.2 Information on the test

The test report should record the following information on the test:

- a) test manager;
- b) name, purpose of the test;
- c) ambient condition of the lab (temperature, humidity, safety conditions etc.);
- d) production time and place of the specimens;
- e) shape and size of the specimens;
- f) identification of the specimens (Lot No. etc);
- g) curing and storage conditions;
- h) information on the test repair material (name, producer, validity etc.);
- i) test data (production, measurement, test period etc.);
- k) type of facilities, equipment, tools;
- k) status of test equipment, tools;
- l) test results;
- m) details on other test programs and procedures.

Annex A (informative)

Example test method

A.1 Principle

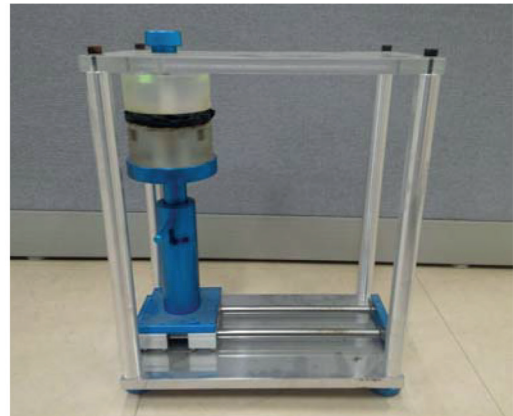
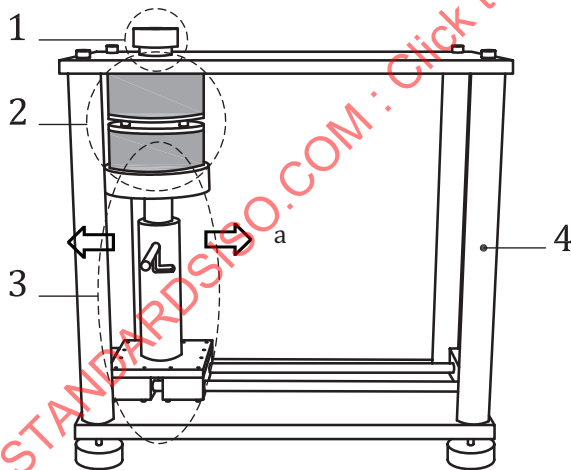
This example test method evaluates the adhesiveness performance of repair material on wet leakage crack surface. The test repair material is injected in the gap between the upper and bottom parts in wet condition. The specimen is then lifted and clamped to be held in mid-air. In this state, bottom part (weight $550\text{ g} \pm 50\text{ g}$) will act as the weight that pulls on the repair material adhesion. If the repair material adhesion fails against this predetermined weight of the bottom part, the repair material is considered to have inadequate adhesive properties on wet leakage crack surface.

This test method requires the usage of fabricated and simulated artificial cracks as illustrated with the specimen used in this test method. Using concrete specimens with natural cracks will be difficult to reproduce data and thus make the test method more difficult.

A.2 Apparatus

A.2.1 Adhesion tester (refer to [Figure A.1](#)).

The adhesion test apparatus for repair material on the wet substrate (concrete surface) has 3 main sections: frame, clamp (anchor), and base support mechanism. The height of the tester shall be at least 1 m.



Key

- 1 clamp (fixing bolt $\varnothing 30\text{ mm}$)
- 2 test specimen
- 3 base support mechanism
- 4 frame
- a Sideways motion.

Figure A.1 — Diagram of the adhesion tester

A.2.1.1 Frame, should always maintain horizontal level and stable during the testing.

A.2.1.2 Clamp (for anchoring the specimen in place), should be able to fasten the test specimen securely in mid-air.

A.2.1.3 Base support mechanism, (attached to the frame) should be able to move sideways, up and down. Sideways motion should be unhindered and frictionless.

A.2.2 Test specimen (Refer to the [Figures A.2](#) and [A.3](#)).

A.2.2.1 Upper part of the specimen with fixing hole in the middle (acrylic, $\varnothing$ 100 mm $\times$ 30 mm).

A.2.2.2 Acrylic band (acrylic, $\varnothing$ 110 mm $\times$ 20 mm), for preventing material leakage during injection.

A.2.2.3 Spacer (STS 304, $\varnothing$ 10 mm $\times$ 15 mm), used for controlling the width of the crack space.

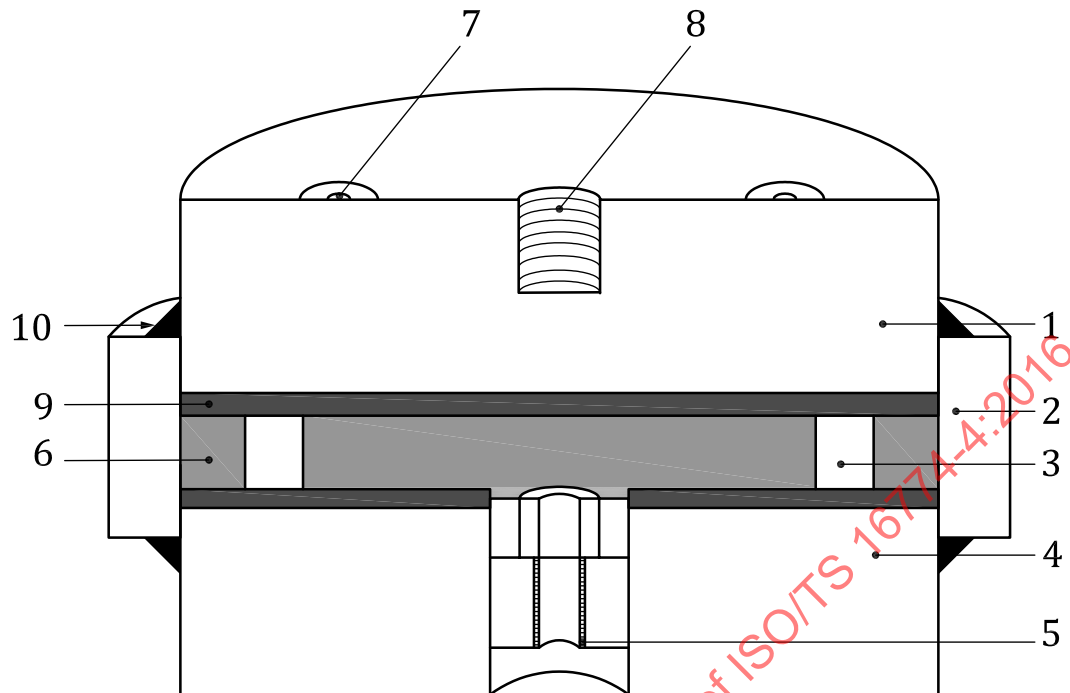
A.2.2.4 Bottom part of the specimen with inlet hole in the middle (acrylic, $\varnothing$ 100 mm $\times$ 30 mm).

Used to serve as a weight to pull against the material adhesion on the concrete surface. Recommended mass is approximately 550 g $\pm$ 50 g.

A.2.2.5 Inlet (hole) and cover for injection (STS 304, $\varnothing$ 10 mm $\times$ 15 mm).

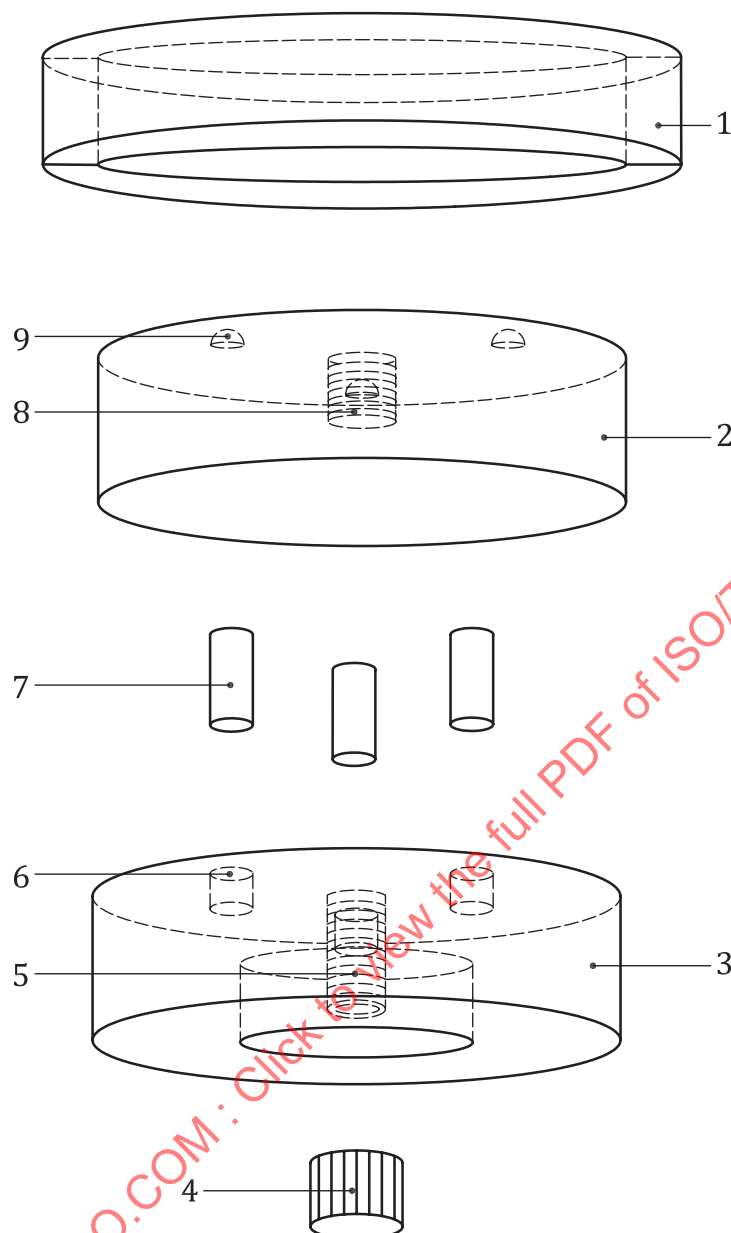
A.2.2.6 Silicon sealer (in case of optional sealing to prevent leaking of repair material during injection).

NOTE Upper and lower acrylic substrate parts used in this test method were pre-made with the following design specifically for use in this test method.

**Key**

- 1 upper part (anchor)
- 2 acyclic band
- 3 spacer
- 4 bottom part (weight)
- 5 inlet for material injection
- 6 repair material
- 7 leveling instrument
- 8 fixing hole ($\varnothing$ 30 mm)
- 9 mortar layer
- 10 sealant

Figure A.2 — Diagram of test specimen



Key

- 1 acrylic band
- 2 upper part (anchor)
- 3 bottom part
- 4 inlet cover
- 5 inlet bar for injection
- 6 spacer slots (ø 10 mm)
- 7 spacer
- 8 fixing hole (ø 6 mm)
- 9 leveling instrument

Figure A.3 — Assembly of the adhesion test specimen

A.2.3 Others.**A.2.3.1 Stop watch.****A.2.3.2 Repair material injector.****A.2.3.3 Water container.****A.3 Preparation****A.3.1 Test specimen assembly**

- a) A thin layer of mortar is cast on both surfaces of the acrylic substrate parts. For the bottom substrate part, record the total mass of the bottom part and the mortar cast on the surface.

NOTE The mortar layer represents the concrete leakage crack surface.

- b) Place the upper substrate part on the bottom substrate. Control the height of the crack space by selecting appropriate height of the spacers (recommended to be at least 20 mm).
- c) Seal the space between the upper and bottom substrate parts by using the acrylic band to prevent leak or flow out during injection with repair material around the specimen. Silicon sealant or taping can be used over the seams between the acrylic band and the substrate parts for reinforcement sealing.

If manufacturer instructions are available for the injection method, such method should be employed. Prepare the required number of test specimens according to above instructions for repeat testing.

A.3.2 Injection of repair material

- a) After specimen assembly, immerse the test specimens in water for approximately 1 h for applying the wet condition found in leakage cracks of concrete structures.
- b) After 1 h, take the specimens out of the water and begin preparations for repair material injection and material injector. Place repair material in the injector.
- c) Inject the repair material through the inlet hole on the bottom substrate part of the test specimen by using the injector. If manufacturer instruction can be used in this stage, it should be used instead.
- d) Once the material injection is finished, close the inlet hole.

NOTE Observation of material injection process through the acrylic band is possible as the band is semi-transparent. Once the material seems to have reached and filled up the sides of the acrylic band, stop the injection process.

- e) Place the test specimen underwater again for 24 h.

A.3.3 Ambient conditions

Keep the test room at temperature $(20 \pm 3) ^\circ\text{C}$ and humidity at $(65 \pm 5) \%$ during the experiment unless specifically required otherwise (example temperature and humidity ranges).

A.4 Procedure (refer to [Figure A.4](#))

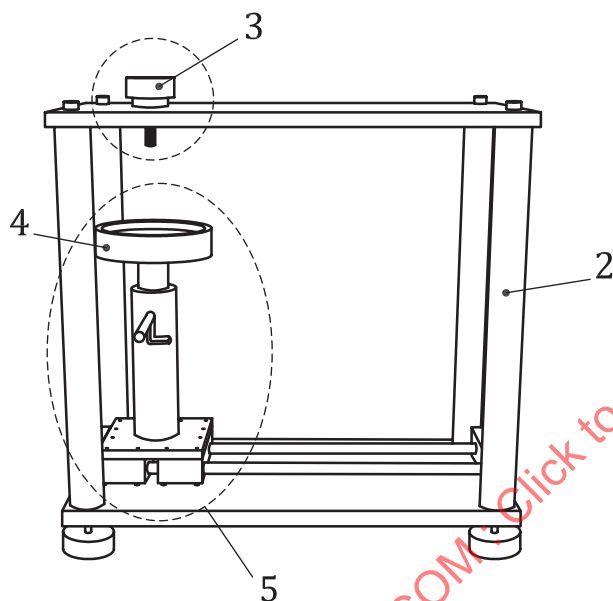
- a) Take the test specimen out of the water. Remove the acrylic band any other supplementary forms of sealing if used.

- b) Prepare the adhesion tester. Place the test specimen on the base support mechanism located at the adhesion tester. Raise the plate on the support mechanism up to the clamp of adhesion tester and screw it into the fixing hole on the upper substrate part.
- c) To begin testing, lower the support plate and slide the base support mechanism to the right, letting the whole specimen suspend in mid-air and the weight of the bottom acrylic part pull on the repair material adhesion on both upper and bottom part mortar surfaces.
- d) Observe the specimen to see if it maintains adhesion for the given period of time to pass the test method and record the adhesion time.

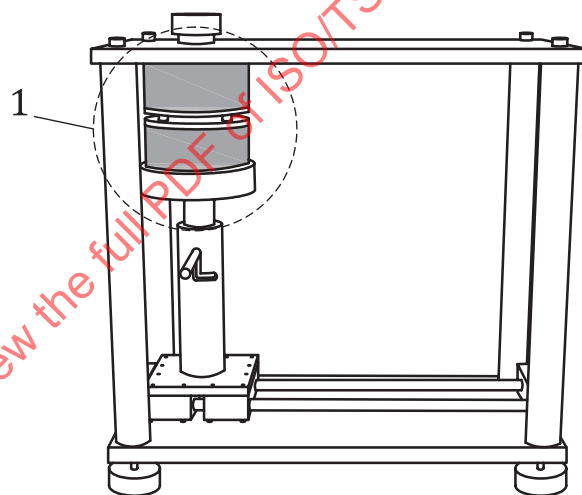
Recommended test duration is 60 sec to 120 sec.

- e) If the material fails adhesion and falls off, end the test and record the results (the time at which material adhesion fails).

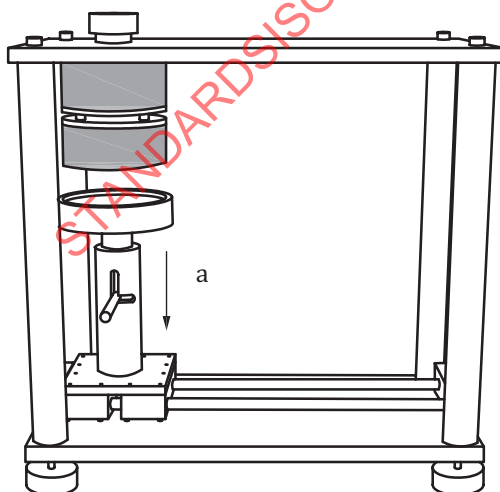
Photos of the specimen and equipment conditions shall be taken at every stage possible during the each and every test procedure for recording and information purposes.



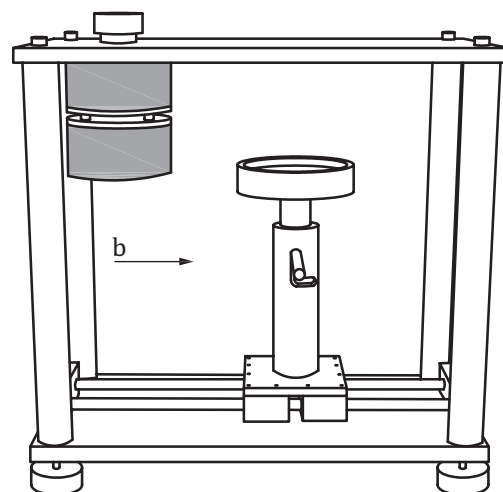
a) Step 1 Adhesion tester apparatus



b) Step 2 Anchor the upper part to the clamp



c) Step 3 Lower the supporting plate



d) Step 4 Move the support mechanism and record the adhesion time