TECHNICAL REPORT

ISO/TR 16475

Second edition
2020-03

General practices for the repair of water-leakage cracks in concrete structures

Pratiques générales pour la répartition des fissures dues à l'eau dans les structures en béton

Reference number
ISO/TR 16475:2020(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 7, *Maintenance and repair of concrete structures.*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is intended to provide an informative outline of practice for the repair of water-leakage cracks of concrete structures. There are two types of cracks that can form in a concrete structure; dry cracks and water-leakage (wet) cracks. Cracks normally form when the structural element is subject to phenomena such as dry-shrinkage and formation of joints. In the typical above grade sections of the concrete structure, dry cracks are more easily controlled and repaired with a well-defined maintenance method. When cracks are formed by the effect of hydrostatic pressure and the interface of the crack is subject to constant wetness, these cracks are designated as water-leakage cracks. The ingress of water through cracks often leads to increase of humidity in the building interior and this can result in a drastically accelerated degradation of durability for the concrete structure. In extreme cases, the presence of water can generate harmful effects that cause health problems to the users, rendering the building completely uninhabitable.

In the current state, it is difficult to secure a proper repair method of water-leakage cracks because of insufficient knowledge and understanding of the degradation factors (i.e. environmental conditions, the influences of various human activities, etc.), at an institutional level. There are already a number of repair techniques and application methods that are commonly used in application, but the required conditions for properly repairing and sealing the water-leakage cracks have often been proven to be difficult. Even in some cases where the repair procedures have been followed through properly with skilled workmanship, the performance level of the repair method may be insufficient and lead to reopening of the leakage crack. This can in turn lead to increase in maintenance and labour costs and decrease in the property value of the building structures.

Past records of remedial actions for cracks and damage in concrete structures have shown varying degrees of results; some have shown failure, some have had minor success and, in some cases, an adequate solution was implemented. However, the cases of successful repair methods cannot serve as a universal model for all cases of cracks and leakage due to the diversity of environmental degradation factors existing in the construction field. In this regard, a standardized practice for selecting appropriate leakage repair materials and methods in construction sites can be used. It is highly anticipated that a newly proposed awareness and understanding of these issues will prevent further unnecessary increase in maintenance costs, expenditures and results in improved durability performance of concrete structures.

General practices for the repair of water-leakage cracks in concrete structures

1 Scope

This document provides a guideline for the selection of a proper grout material to repair water leakage through cracks and other deformities in concrete structures. The factors relevant to the quality control of maintenance and repair of water-leakage cracks are as the following;

a) conditions of water-leakage cracks;

b) performance requirements for repair materials;

c) different types of repair materials (grouts);

d) procedures followed to select the appropriate repair materials;

e) execution of different types of repair methods;

f) performance assessments of applied materials and methods;

g) data collection.

This document does not include any details on the repair of dry cracks and the causes of cracks. The details on dry crack repair are covered in ISO 16311-4.

A flow chart for maintenance of water-leakage cracks is shown in Figure 1.

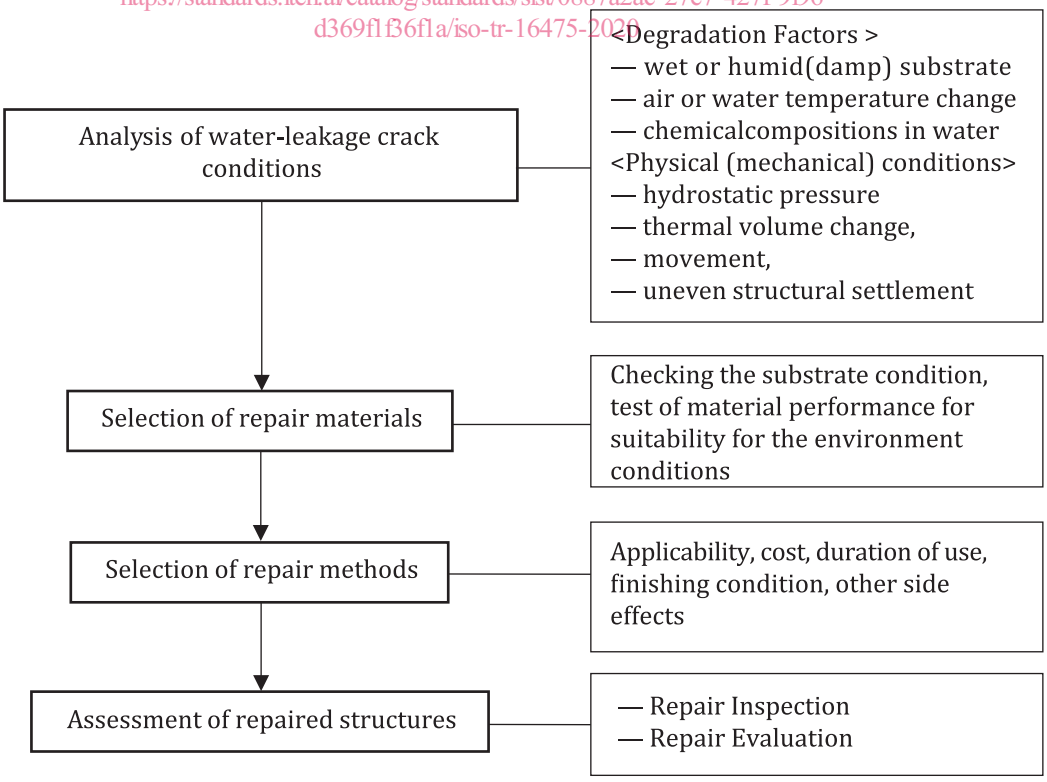

Figure 1 — Flow chart for maintenance of water-leakage chart

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 16311-2, *Maintenance and repair of concrete structures — Part 2: Assessment of existing concrete structures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16311-2 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
water-leakage crack
gap or split in a concrete substrate accompanied by intermittent or continuous contact of water present across the interface of the gap/split surface

3.2
leakage
amount or flowing state of liquid(water) that is entering into the interior of the concrete structure by means of a crack, hole, joint or other structural fault

3.3
thermal stability
ability to withstand long time exposure to elevated temperature

[SOURCE: IEC 60050:2010, 212-12-32]

3.4
washout resistance
property of the water-leakage crack (3.1) repair material related to the ability to withstand quantitative and qualitative loss of materials produced by the pressure and flow velocity of water

3.5
watertightness
repair material's waterproofing performance in consideration to its impermeability, adhesion strength to the concrete substrate surface and cohesive strength, while being subject to the influence of hydrostatic pressure

4 Conditions of water-leakage cracks

4.1 Types of water-leakage cracks

Leakage type and degree, and crack size (width) classification can be difficult as there are variances in leakage crack control methods with different repair material and methods. Leakage types can be classified as damp, seepage and flow, but specific amount of water leakage for the corresponding leakage types also varies. Optimal grout injection method and material selection through evaluation and testing can be applied for the respective classification of cracks (fine, medium and large cracks) in relation to different leakage types and degrees (damp, seepage and flow). In this document, a leakage type and degree classification system from ICRI 340.1-2006 is provided. The reference also provides an information on the possible crack size classification (crack width) that corresponds to the leakage types and degrees. This information is provided in Table 1.

Table 1 — Classification of cracks in relation to repair of water-leakage (example)

Type of crack	Patterns of leakage
Non-moving crack	—
Fine cracks ≤2 mm (≤1/13 in) Medium cracks >2 mm to 6 mm (>1/13 in to 1/4 in) Large cracks >6 mm to 20 mm (>1/4 in to 10/13 in)	Damp surface
	Light seepage <1 l/min (<1/4 gal/min)
	Medium seepage >1 l/min to 5 l/min (>1/4 gal/min to 1 1/4 gal/min)
	Heavy seepage >5 l/min to 10 l/min (>1 1/4 gal/min to 2 1/2 gal/min)
	Light flow >10 l/min to 15 l/min (>2 1/2 gal/min to 4 gal/min)
	Medium flow >15 l/mm to 25 l/min (>4 gal/min to 6 1/2 gal/min)
	Heavy flow >25 l/min (>6 1/2 gal/min)
NOTE 1 Each and every crack width in the left column corresponds to the leakage amount conditions specified in the right-side column.	
NOTE 2 Leakage types and degrees, and crack sizes (width) can differ in national standards.	

4.2 Environmental degradation factors that cause water-leakage cracks

4.2.1 General

Unlike dry cracks, water-leakage cracks are often caused by exposure to certain environmental-related (chemical and physical) degradation factors that are caused by nature. These factors are: temperature and humidity in the atmosphere and concrete surface, water pressure, flow velocity, chemical reactions of the water and various forms of mechanical loads (e.g. vibration caused by passing vehicles). When in the presence of one or more these environmental factors in a concrete structure, structural degradation accelerates and negatively affects performance level of repair (see Figure 2).

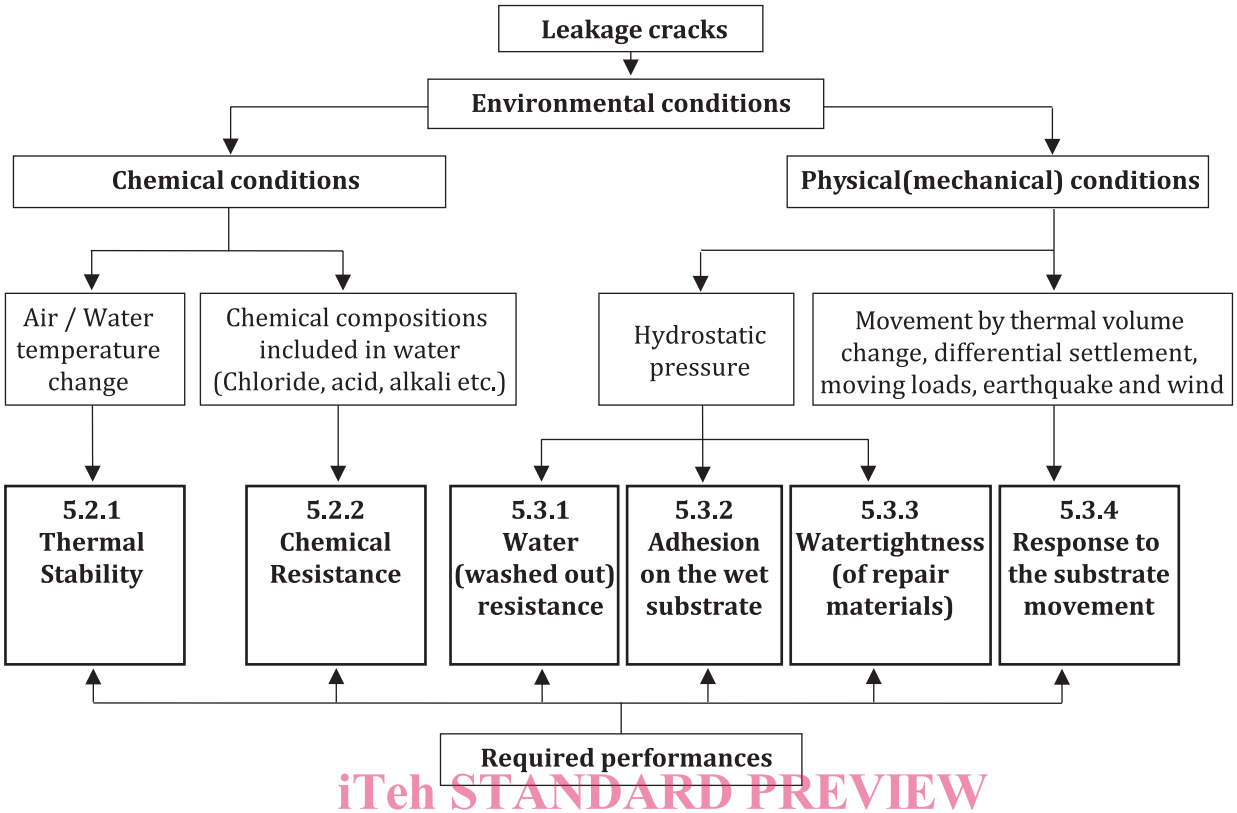

Figure 2 — Environmental conditions and required performance for water-leakage crack repairs

Water-leakage cracks are constantly subject to a variety of environmental degradation factors. In order to establish a proper response to degradation factors that exist in the surrounding environment, it is important to select the appropriate repair materials and methods.

Based on the types of environmental factors found in the concrete structure surroundings, the types of possible defects such as material adhesion failure, waterproofing layer delamination or material cracking can be estimated. Potential sources of degradation can be clearly identified and repair materials with the required performance level that can respond to these degradation factors is selected accordingly. Finally, the installation process can be observed and evaluated to determine that the repair material can maintain a long-term quality performance while subject to constant exposure to the given environmental degradation condition.

Figure 2 categorizes the environmental degradation factors into the relevant categories and outlines the required material properties.

4.2.2 Chemical conditions

Chemical factors that affect the performance of repair materials in water-leakage cracks include temperature changes and ambient conditions of the water-leakage cracks and the chemical composition of the water (e.g. underground water, salt water, sewage water and acid rain). These factors affect thermal stability, resistance to chemical attack, watertightness and the adhesion performance of repair material on the concrete substrate surface.

4.2.3 Physical (mechanical) conditions

The physical (mechanical) factors that affect the performance of repair materials in water-leakage cracks include the movement of the concrete substrate joints or cracks, shrinkage and expansion of concrete due to temperature change, structural settlement, surrounding loads caused by passing of vehicles and hydrostatic pressure.

These factors affect the repair material adhesion on the concrete substrate surface, the watertightness and the elongation of the repair materials.

5 Expected performance for repair materials

5.1 General

Materials used for repairing water-leakage cracks prevent water leakage by maintaining an adequate response performance to the environmental conditions. To this end, a thorough understanding of the expected performance of the repair materials can assist in selecting the appropriate material. The expected performance can be divided into the categories outlined in 5.2 and 5.3.

5.2 Expected performance for chemical conditions

5.2.1 Thermal stability

Under a high degree of temperature change, the concrete substrate is subject to direct or indirect effects of dry-shrinkage, structural movement and joint movement of the concrete substrate. Repair materials can seem to maintain a cohesive bond when installed in concrete substrate surface based on the results of empirical data of standard testing. However, it is advised that a qualitative delamination resistance property testing be conducted to conclusively ensure that the selected water leakage repair material can maintain an integral structure while subject to a variety of degradation factors.

5.2.2 Chemical resistance

Concrete structures are constructed under various chemical environmental conditions. Waterproofing membranes are often exposed to contact to water or soil in underground structures. In cases where the concrete structures are located near industrial areas or seashores, corrosion caused by chemical substances (e.g. acid, alkali, salt water or calcium hydroxide and carbon dioxide) can occur more frequently. In addition, chemical corrosion decreases the performance of the injected repair materials by hindering normal chemical reactions caused by mixing different admixtures.

5.3 Expected performance for physical (mechanical) conditions

5.3.1 Water (wash out) resistance

Water-leakage cracks are subject to intermittent or continuous hydrostatic pressure. For non-grout injection type repair materials that require curing period (liquid/semiliquid state) and have low concentration gradient, the material can be discharged or washed out of the crack due to water flow before the material reaction can fully form a waterproof layer. For some types of materials, this can lead to environmental pollution. For grout type and cementitious repair materials, long-term exposure to water flow can also lead to material erosion, with some materials remaining whole inside the crack longer than others.

Manufacturers and architects/engineers can be consulted to find out all the information pertaining to the specific properties and limitations of the repair material when concerning the washout resistance performance of the repair materials.

5.3.2 Adhesion on wet substrate surface

In most cases, repair materials are injected into water-leakage cracks while moisture is still present at the interface of the crack surface. By conducting proper surface treatment prior to injection, elected repair material can secure a sufficiently strong adhesive bond to surfaces with moisture. Necessary information on the injection amount and speed is to be obtained from manufacturer instructions. An evenly distributed application of the repair material can ensure a more durable and stable waterproofing membrane structure within the water-leakage crack.