TECHNICAL REPORT

ISO/TR 16475

First edition
2011-08-01

Guidelines for the repair of water-leakage cracks in concrete structures

Lignes directrices pour la réparation des fissures dues à l'eau dans les structures en béton

Reference number
ISO/TR 16475:2011(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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.

ISO/TR 16475 was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 7, *Maintenance and repair of concrete structures.*

Introduction

This Technical Report attempts to draw out a successful and effective plan for repairing water-leakage cracks. In general, there are two types of cracks that form within a concrete structure: dry cracks and water-leakage cracks. Dry cracks vary in their depth and width, and are known to cause instability to the foundation and durability of concrete structures. Water-leakage cracks arise from a combination of several environmental factors (chemical and physical or mechanical influences) that surround the buildings or concrete structures. They not only further the negative effects of dry cracks, but also cause additional problems, such as lingering humidity and wetness in building operations, which sometimes renders the buildings and the structures unable to carry out their designated performance, purposes and duties.

It has been assumed that the reason why it is difficult to find a proper method for repairing water leakage cracks is an insufficient knowledge and understanding of the negative factors (i.e. environmental conditions, the influences of various human activities, etc.) that cause the formation of the cracks and also in the selection of the repair materials and methods. Various types of repair techniques have been carried out in order to mend these different types of cracks, mainly the water-leakage types. However, the required conditions for sealing the water-leakage cracks have often proven to be extremely difficult to satisfy due to the wet and humid environment (which in most cases is the initial reason why the cracks have formed in the first place). This lack of a reliable and stable source of information regarding the water leakage cracks has caused unnecessarily high costs of repair in the field of construction and architecture and still continues to be a problem today.

Past records related to remedial action taken for these cracks have shown numerous results; some have shown failure, some have had minor success and some have managed to find an adequate solution that met the structures' needs so that they are able to continue performing their designed purposes. But rarely has a global, standardized and consistent solution been implemented for these problems. When all the aforementioned problems are taken into consideration, it is evident that there is a strong need for a standardized guideline on how to select the appropriate materials and methods in accordance with the different types of environmental conditions and factors that lead to water-leakage cracks. It is highly anticipated that a newly proposed awareness and understanding of these issues will prevent further unnecessary use of high budgets and expensive repair materials that do not serve its intended purpose and additionally will help avoid manual and possibly dangerous repair projects when dealing with water leakage cracks.

This Technical Report attempts to create a reliable consistency for future cases of water-leakage cracks so that there will no longer be a need for obscure and insecure solutions that rarely remedy these types of problems with concrete structures. This Technical Report was developed for countries that do not currently have existing general guidelines on this subject and for local regulatory authorities worldwide. It is eagerly anticipated that there will be further development and cooperation by the authorities in each country for the principle of further augmenting knowledge about concrete and the understanding of concrete structures and architectural construction.

Guidelines for the repair of water-leakage cracks in concrete structures

1 Scope

This Technical Report gives guidelines for the selection of a proper grout material to repair water leakage through cracks and other discontinuities in concrete structures including the following:

— conditions of water-leakage cracks;

— performance requirements for repair materials;

— different types of repair materials (grouts);

— procedures followed to select the appropriate repair materials;

— execution of different types of repair methods;

— performance assessments of applied materials and methods;

— data collection.

This Technical Report does not include a focused section about the repair of dry cracks and the causes or the origins of cracks. The details on dry crack repairs are covered in ISO 16311-4[1)].

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

1) To be published.

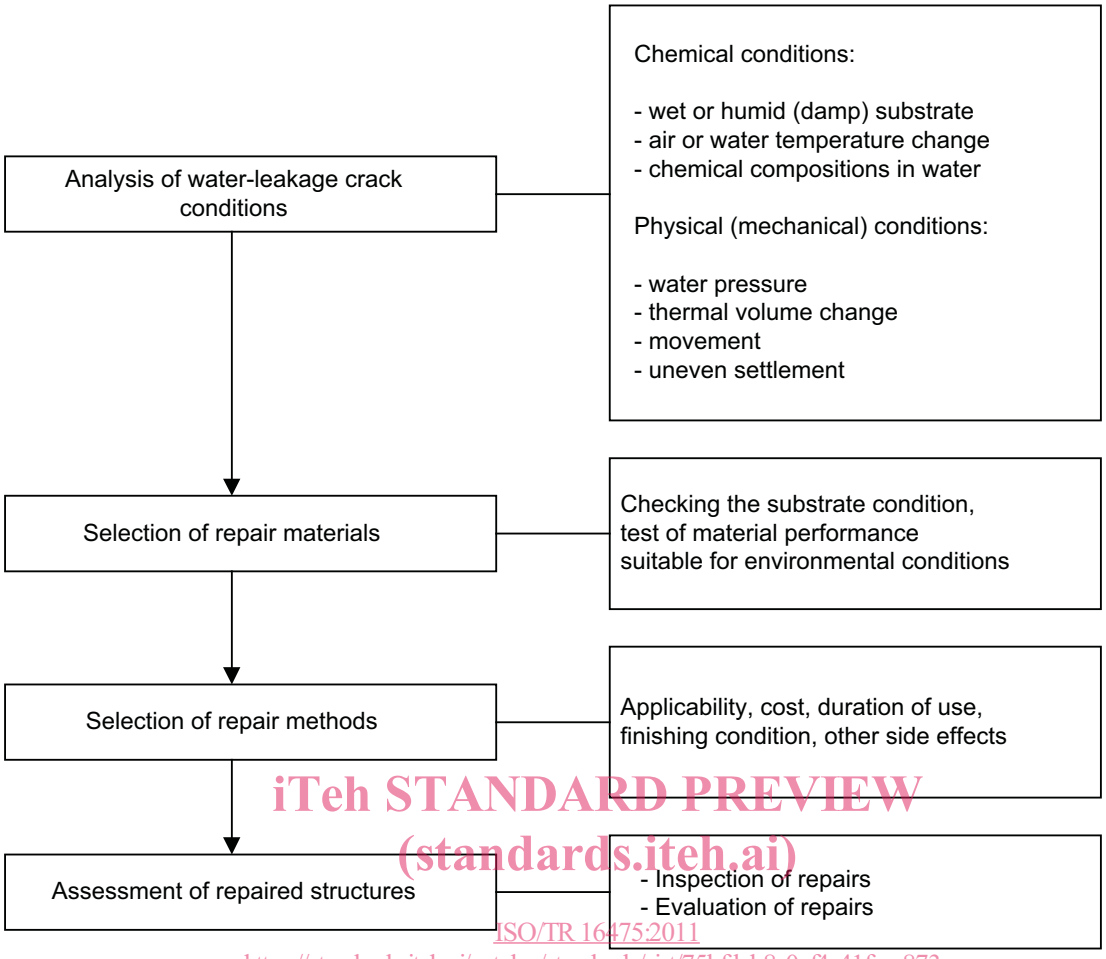

Figure 1 — Flow chart for maintenance of water-leakage cracks

2 Normative references

The following referenced documents are indispensable for the application 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)] (all parts), *Maintenance and repair of concrete structures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16311 (all parts) and the following apply.

3.1
water-leakage cracks
concrete fissures that accompany water leakage intermittently or continuously

2) To be published.

3.2
leakage
amount or flowing state of liquid (water) that escapes from inside or outside a concrete substrate by means of a crack, hole, joint or other fault

3.3
thermal compatibility
chemical and physical stability of repair materials in response to temperature fluctuations in the atmosphere or under water

3.4
water resistance
ability to withstand quantitative and qualitative loss of materials produced by the pressure and flow velocity of water

4 Conditions of water-leakage cracks

4.1 Types of water-leakage cracks

Various types of cracks under conditions ranging from dry to flowing water are given in Table 1. This includes both non-moving or static cracks which are stable and moving or dynamic cracks which are not growing. Table 1 also provides information about leakage cracks with varying ranges of width and water flow.

4.2 Environmental conditions of water-leakage cracks

Unlike dry cracks, when water-leakage cracks are exposed to various conditions, there are several environmentally-related (chemical and physical or mechanical) factors which must be taken into consideration, including temperature and humidity in the atmosphere, water pressure, flow velocity, chemical reactions of the water, and the vibration caused by passing vehicles. Such factors have negative effects not only on the water-leakage cracks themselves, but also on the efficiency and effectiveness of repair materials and methods that may be used on the cracks (see Figure 2).

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

Crack width	Leakage amount
Stationary or dormant crack	—
Fine cracks ≤2 mm (≤1/13 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)
Medium cracks >2 mm to 6 mm (>1/13 in to 1/4 in)	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)
Large cracks >6 mm to 20 mm (>1/4 in to 10/13 in)	Medium flow >15 l/min to 25 l/min (>4 gal/min to 6 1/2 gal/min)
	Heavy flow >25 l/min (>6 1/2 gal/min)
NOTE Each and every crack width in the left column corresponds to all seven leakage amounts in the right column.	

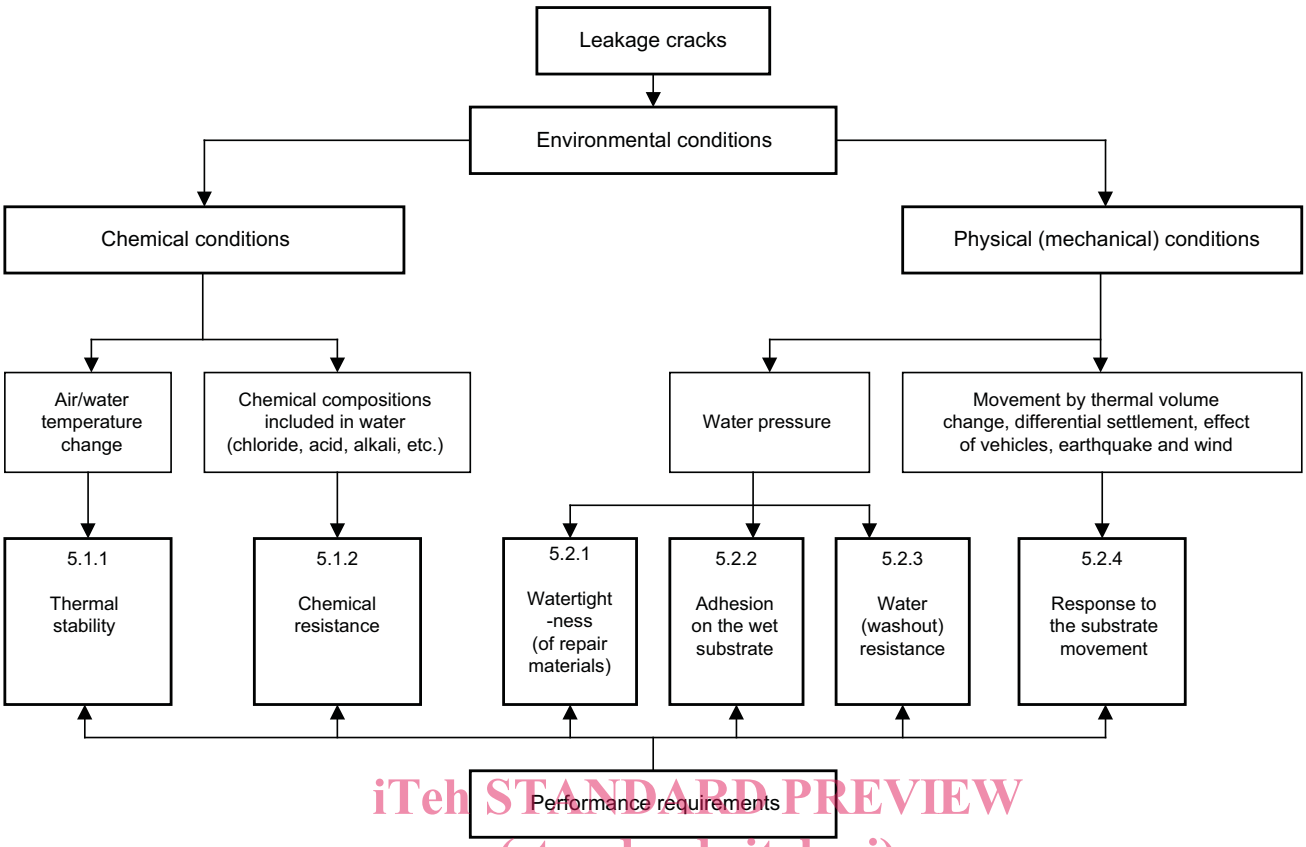

Figure 2 — Environmental conditions and performance requirements for the repair of water-leakage cracks

Because water-leakage cracks are constantly affected by a variety of environmental conditions and factors, repair materials and proper methods must also be designed to address these environmental factors.

An understanding of the environmental conditions pertaining to water-leakage cracks is a priority for remedying them. When selecting the correct repair materials and proper methods, the appropriate response to environmental factors must be considered. Finally, evaluating the appropriate materials and the application method of these materials to determine the response method to environmental factors is obligatory.

Figure 2 categorizes the environmental factors and illustrates the required performance responses to each factor. It also provides evaluation items for each repair material.

4.2.1 Chemical conditions

Chemical factors in the environmental condition that affect the efficiency of repair materials for water-leakage cracks include temperature changes in the air or water surrounding the 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 of repair materials on the substrate. The selection of appropriate materials for the given chemical condition is therefore very important.

4.2.2 Physical (mechanical) conditions

The physical (mechanical) factors in the environmental condition that affect the efficiency of repair materials include the movement of volume change by the shrinkage and expansion of concrete due to temperature change, the movement due to unevenness in the settlement of the structure, the vibration movement caused by passing of vehicles, and water pressure surrounding the crack.

These factors affect the adhesion on the substrate, the watertightness, and the responsiveness of repair materials to the substrate movement. The selection of appropriate materials for the given physical (mechanical) condition is very important with regards to these factors as well.

5 Performance requirements for repair materials

Materials used for repairing water-leakage cracks should perform in response to the environmental conditions. The performance requirements can be divided into the categories described in 5.1 and 5.2.

5.1 Performance requirements for chemical conditions

5.1.1 Thermal stability

These repair materials are made up of highly polymerized or inorganic compounds, thus they undergo constant shrinkage and expansion depending on temperature changes. Due to these continuous changes, the performance of injected repair materials can deteriorate.

In other words, repair materials used to seal water-leakage cracks should maintain their thermal dependence, even in the case of repeated temperature change, and should remain intact for a long period of time.

5.1.2 Chemical resistance

Concrete structures are constructed under various chemical environmental conditions. They are often bordered by water or soil in underground structures, and are located near industrial areas or seashores so that chemical corrosion caused by chemical substances (e.g. acid, alkali, salt water or calcium hydroxide, and carbon dioxide) occurs more frequently. In addition, chemical corrosion decreases the performance of the injected repair materials.

Therefore, repair materials should maintain their chemical attack resistance performance, even in the case of chemical corrosion, and satisfy the need to resist chemical attacks over a long period of time.

5.2 Performance requirements for physical (mechanical) conditions

5.2.1 Watertightness

Watertightness of repair material is the ability of a material to block the penetration of water. The watertightness of repair material is a crucial performance factor in environments where the substrate concrete is vulnerable to moisture-related deterioration. It must, therefore, be made certain that injected repair materials have bonded well, so as not to allow water passage.

Therefore, repair materials should be able to maintain their watertightness performance by withstanding constant changes in the surrounding water pressure or water volume and remain permeable to water over a long period of time.

5.2.2 Adhesion on the wet substrate

Water-leakage cracks often occur in wet or underwater conditions. In this case, the injected repair materials should not only be capable of withstanding strong water currents, but should also have strong adhesion to wet concrete substrate and other waterproofing layers. These characteristics can be obtained by maintaining the