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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

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Foreword

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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.

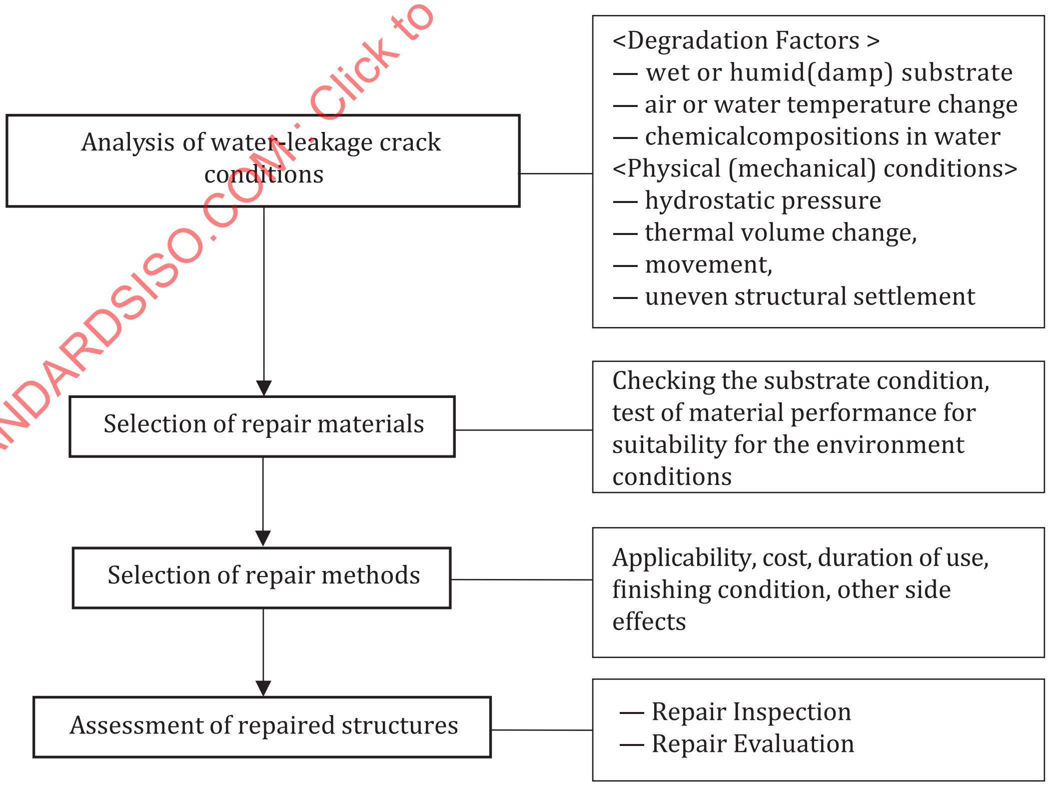

Figure 1 — Flow chart for maintenance of water-leakage chart

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).

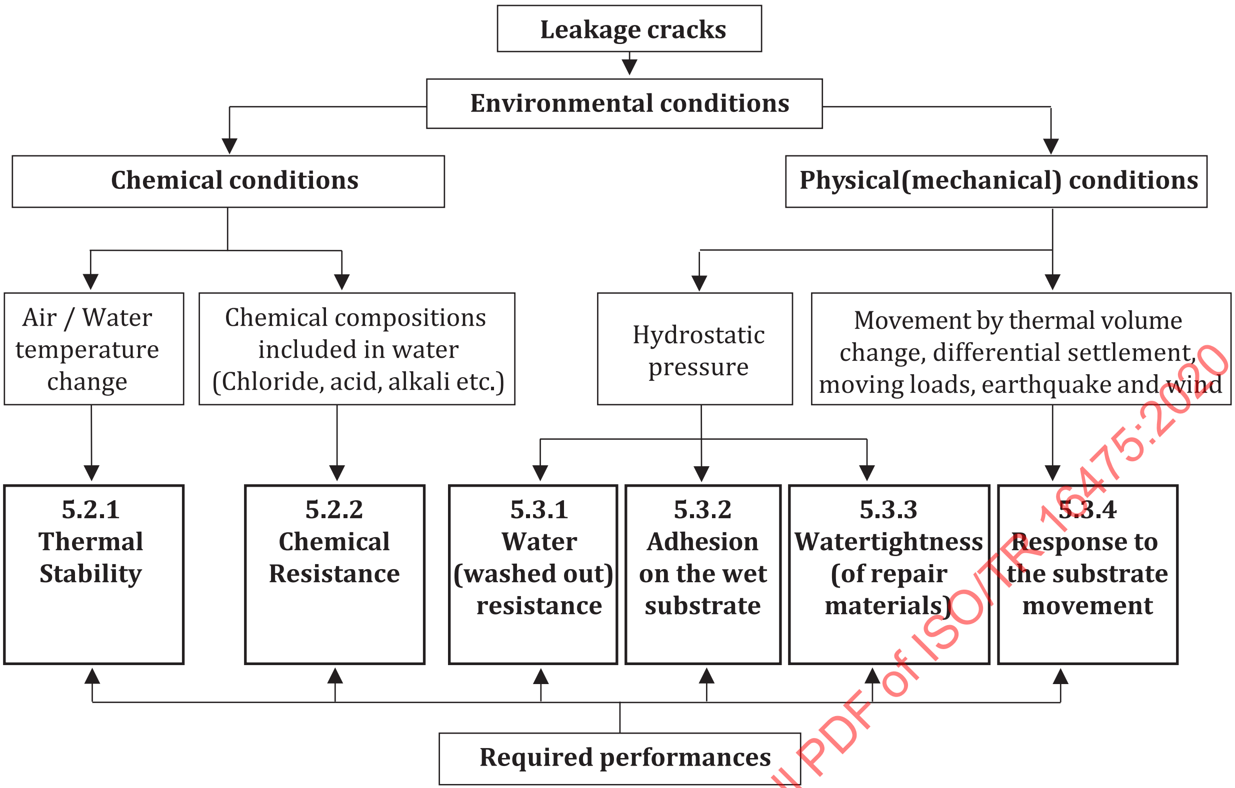

Figure 2 — Environmental conditions and required performance for water-leakage crack repairs

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.

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 adhesion performance on wet substrate surface of the repair materials.

5.3.3 Watertightness

Watertightness refers to the integral waterproofing performance of the repair material system installed in the concrete structure. Under the parameters of this document, watertightness is defined with the following criteria:

1) impermeability of the repair material to hydrostatic pressure;

2) the adhesive bond of the repair material to the concrete substrate surface to prevent ingress of water through leakage paths formed in the interface of material adhesion failure; and

3) the cohesive bond of the repair material to prevent delamination or breakage due to structural movement.

When repairing water-leakage cracks, repair materials with the correct performance properties can satisfy the required watertight performance standard. The installation procedure is conducted correctly in accordance to manufacturer instructions to ensure that the repair material can secure a proper adhesion onto the wet concrete surface. Lastly, it is to select repair materials that will not delaminate or permanently deform under hydrostatic pressure and repeated structural movement.

5.3.4 Response to the substrate movement

Water-leakage cracks or construction joints are subject to constant micro movements caused by drying shrinkage and expansion due to changes in the capillary water amount, temperature, hydrostatic pressure, structural settlement and various types of loads from surrounding sources. Repair material membranes bonded onto the interface of the water-leakage crack surface are subject to strain which can results in cohesive and/or adhesive failure. Regarding substrate movement resistance performance of repair materials, it is important to ensure that the selected injected repair material has sufficient elasticity and substrate movement response performance.

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 performance response to the substrate movement of the repair materials.

6 Grout materials for repair

6.1 General

Injection type grout repair materials are commonly used in today's market for repair water-leakage cracks. Among these, some of the most common types include acrylics grout, water-based cementitious grout, hydrophilic epoxy resin grout, polyurethane foam grout, synthetic rubberized gel grout and others. For most repair material products, details on the ingredient components, optimal mixture ratios and empirical data on physical properties are available in manufacturer guidelines.

However, in construction sites there are numerous factors that can differ from manufacturer directions for proper installation. The ambient condition and duration of storage, mixture time and degree of different components, quality of workmanship and environmental conditions are all factors that can influence the quality of the repair work. In cases where conditions outlined in the manufacturer guidelines cannot be met, repair materials can be designed to satisfy certain basic requirements to compensate for the possibilities of early failure and re-opening of cracks due to improper installation.

There have been numerous attempts to classify grouts according to their properties, but simplest classification to date is that of "particulate" and "non-particulate" grouts as outlined in Figure 3.

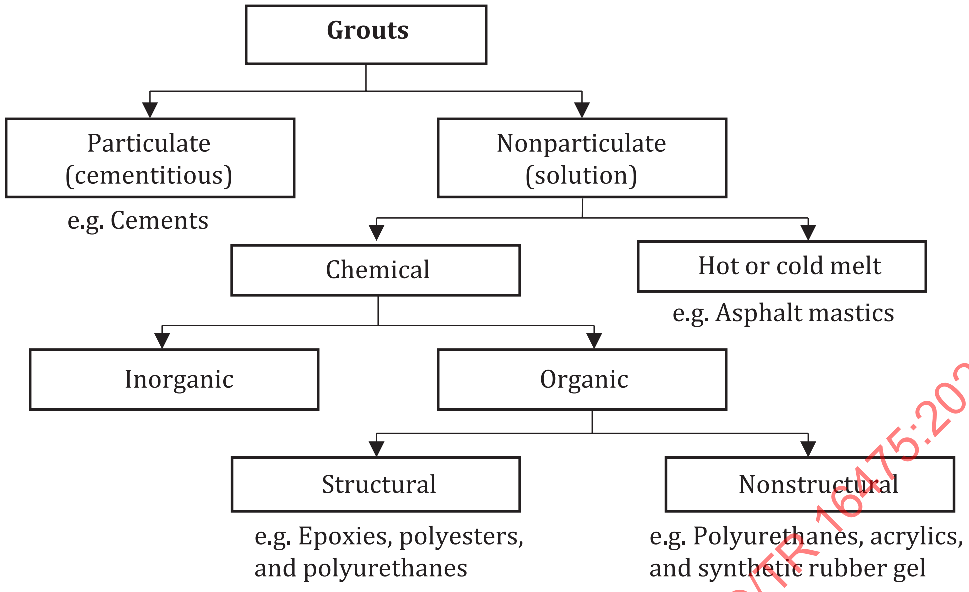

Figure 3 — Classification of grout material types

6.2 Acrylic grouts (water-based acrylic gel grout)

Types of acrylics grout material include acrylics, acrylates and acrylate ester. Water-based acrylic gel grout is composed of acrylic acid polymer.

Acrylic acid polymer (resin) and curing agents are usually requested to be prepared in accurate proportions in accordance to manufacturer instructions. The materials are normally injected or applied on the leakage crack immediately after mixing in order to prevent premature hydration and/or curing outside of the crack. Most water based acrylic grout repair materials attain gel-like state with low viscosity and provide temporary protection against water penetration.

Acrylate gel grout also has low elasticity and tensile strength as it is a water-based grout material. Poor tensile capacity of the gel can result in the grout layer fracturing inside the crack due to structural movement. Due to the material's weak durability and lack of adhesion on wet substrates, there is a possibility that the injected acrylic grout can be damaged and result in re-opening of the leakage crack.

6.3 Cementitious grouts (water-based mixture of cement grout)

Cementitious grout material are composite mixtures that can include cement grout, bentonite grout, acrylamide grout, micro fine grout, polyurethane grout or silicate grout. The thermal expansion coefficient of cementitious materials tends to be very similar to that of the substrate concrete. Under the effect of localized movement at the crack caused by structural settlement or drying shrinkage, the repair material becomes just as easily susceptible to cracking as well, resulting in a re-opening of the leakage crack. They are widely used due to their efficient bonding strength to wet substrate concretes.

Polymer-cement slurry, a mixture of super particle cement (maximum grain size: less than 16 μm) and inorganic compound is also often used. Mixture ratios of cement, polymer and water components and the mixing procedure can be conducted in accordance to manufacturer instructions in order to secure the optimal performance level of the repair material. When polymer-cement slurries are used, it is possible to inject materials into cracks that are less than 0,05 mm in width.

Generally, the site at which the injection will be applied are wet or are subject to high level of humidity. If the crack is dry, it is possible that cementitious material may not undergo proper hydration and fail to adhere to the interface of the crack surface. Decision to use this type of product can be made after a thorough understanding of the existing environmental conditions have been sufficiently made.

6.4 Epoxy resin grout

Epoxy always requires thorough mixing with a hardener and a curing compound, such as an amine or a polyamide compound. Mixture ratios of epoxy resin and other admixtures and the mixing procedure can be conducted in accordance to manufacturer instructions. The materials are normally injected or applied on the leakage crack immediately after mixing in order to prevent premature hydration and/or curing outside of the crack.

Due to the high adhesive strength, epoxies are used for dry crack repairs for widths greater than 0,05 mm. However, epoxy resin grouts are prone to hardening during the curing process, sometimes to the point that they have higher tensile strength than concrete on which they are applied. In such cases, localized cracking adjacent to the repaired crack can occur due to the stress caused by structural movement. Epoxies also have high thermal expansion modulus and the rigid resin grouts are most subject to adhesion failure at the interface when subjected to high tensile stress.

6.5 Polyurethane grouts

Polyurethane grouts consist of a polyurethane resin that reacts with water to form a closed-cell foam or gel layer inside the water-leakage crack when injected. During injection into water-leakage crack, it is important to determine the optimal injection speed and amount for two reasons:

1) the total reaction time to reach full expansion after contact with water is short for most polyurethane foam (from few seconds to several minutes); and

2) most polyurethane grouts expand to a volume of approximately 30 to 40 times.

The performance of polyurethane foam repair material depends heavily on the interval it takes to form inside the water-leakage crack. The importance of following the manufacturer instructions for proper management of mixing time and injection method is stressed.

Polyurethane grouts are conventionally classified into either hydrophobic or hydrophilic types and, in today's market, it is difficult to make a clear distinction due to the current state of polyurethane grout chemistry. Most polyurethane foams used as water leakage repair materials retain some degree of rigidity (key trait of hydrophobic types) and flexibility (key trait of hydrophilic types), which allows them to have some tolerance to concrete joint or crack movement. Polyurethane grouts are mainly used as a temporary measure to stop water leakage. This is because the porous structure used to trap the leakage water allows the polyurethane foam layer to deform easily under the influence of concrete joint movement. The pores also affect the adhesion onto the interface of the crack surfaces and cohesive and adhesive bond failure easily occur when the foam layer is subject to continued tension in cases where reinforcing layers or further repair works are required, constant surveillance of the leakage and/or defect site is required to respond to any reopening of water-leakage crack.

6.6 Synthetic rubber polymer gel grout

Synthetic rubber polymer gel grout is a mixture of a specialized macromolecular resin, such as rubber asphalt, and an inorganic component, such as bentonite. This grout can be used directly without other admixtures or components at the work site. These types of materials have a strong adhesive bond to wet substrate surface because of the expanding property of the bentonite component. This repair material also has a high response property to the concrete joint or crack movement due to the natural high elastic property of the rubberized gel component. They display high performance in both low and high temperature and humidity-conditions.

6.7 Other materials

The other types of grout material are products such as asphalt-emulsion, asphalt and mastics, quick setting mortars, silicate (liquid) and vinyl ester etc.

7 Appropriate repair material selection procedure

7.1 Selection process of repair materials (injection grouts)

When choosing a repair material (grout) for water-leakage cracks, a variety of materials are available. Cost optimization is an important factor during the selection process, but if in attempt to reduce labour cost and construction time, the appropriate property and method is neglected, securing a successful repair work can become difficult.

Water-leakage repair materials need to be selected based on their properties that respond accordingly to the environmental deterioration conditions of the water-leakage cracks. Figure 4 provides a model for the selection process of repair materials based on key conditions and objectives of repairing water-leakage cracks. The cracks that occur in concrete structures may require a combination of material properties based on the types of deterioration conditions present near the water-leakage crack and the selection of such materials can be planned out and executed accordingly.

In these situations, construction workers, site overseers, contractors need to ensure the following requirements:

1) accurately assessing all the potential degradation factors that affect the performance of water-leakage crack repair materials;

2) selecting the proper material(s) and application methods to ensure that the repair material can successfully seal the water-leakage crack while being subject to the degradation conditions.

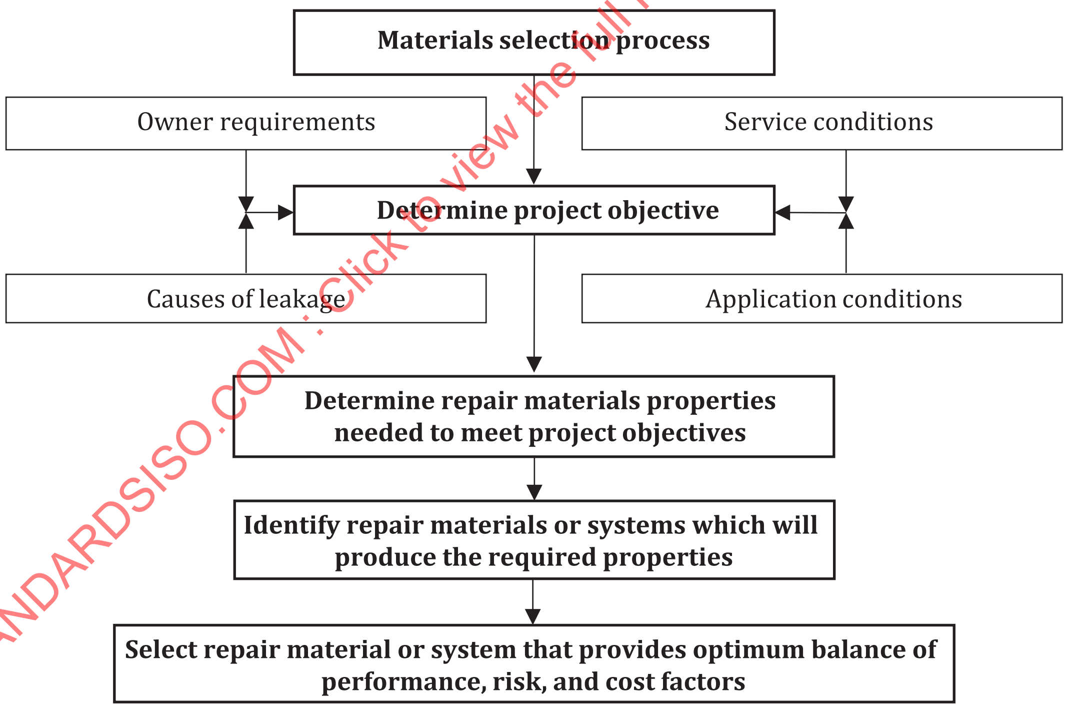

Figure 4 — Process of repair material selection

7.2 Test for performance requirements

7.2.1 General

Numerous standard test methods are available for comparing the physical properties of grouts. However, the empirical data obtained from these test methods cannot easily translate to an assessment of durability performance and workmanship when subject to multiple environmental degradation. In order to ensure that the repair material being considered for use has the correct properties to provide a durable protection to leakage, new testing methods can be used. The objectives and the scopes involved in each of these hypothetical test methods are listed in 7.2.2 to 7.2.7. The following test methods are specific, but not limited, to grout repair materials applied though injection in water-leakage cracks.

7.2.2 Test for thermal stability

Thermal stability testing assesses adhesive bond of injection type repair materials on the concrete substrate surface, elasticity and impermeability after being subject to thermal variation. The duration of which the repair material can maintain waterproofing performance is tested against temperature change in the surrounding environment of leakage cracks on underground structures or roof slabs.

One method used to evaluate thermal stability is to assess the repair material's permeability to hydrostatic pressure immediately after the material is subject to thermal stress. To perform this evaluation, the repair material to be tested first undergoes a predetermined number of cycles alternating between low and high temperatures (i.e. artificial fluctuations in temperature) in a temperature cycle chamber. Hydrostatic pressure is then immediately exerted on the test material for a given interval of time. The results of this testing can be used to estimate the expected thermal stability performance from the repair material (refer to ISO/TS 16774-1).

7.2.3 Test for chemical resistance

Chemical resistance testing assesses if the injected repair materials can maintain an integral structure while subject to chemical attack. The duration of which the repair material can maintain waterproofing performance is tested when corrosive compounds are found in the surrounding environment of leakage cracks on underground structures or roof slabs.

One method used to evaluate chemical resistance is to measure the change in the mass of the repair material after exposure. To perform this evaluation, a sample of the repair material comes in contact with solutions containing various chemicals (e.g., acid, alkali and sodium chloride, or sea water). The rate of change in the mass can be used to estimate the duration of which the repair material retains its structure inside the crack while under exposure to corrosive substance (refer to ISO/TS 16774-2).

7.2.4 Test for water flow (wash out) resistance

Washout resistance testing assesses the repair materials' resistance to erosion or physical wear due to contact with water flow when installed in cracks of underground structures or on roof slabs. This test method estimates whether the material would physical remain inside the crack all the while being subject to continuous hydrostatic pressure or water flow without wearing away.

One method used to evaluate the washout resistance is to measure the rate of decrease in mass before and after being exposed to long term water flow. A sample of the repair material would be placed at the bottom of water flow chamber, where the specimen will be subject to contact with continuously flowing water. Once the predetermined duration of exposure is concluded, a rate of mass reduction can be used to estimate the duration of which the repair material will be able to remain structurally integral inside a water-leakage crack after installation (refer to ISO/TS 16774-3).

7.2.5 Test for adhesion on wet substrate surface

Adhesion on wet substrate surface testing assesses the duration of which water-leakage crack repair materials can maintain adhesive bond on wet concrete substrate surface. For most grout type repair materials, observing the first few seconds up to a minute of contact with wet concrete surface is sufficient to determine whether the material has sufficient wet surface adhesion property or not.

One method used to evaluate the wet substrate surface adhesion of water-leakage crack repair material is to conduct a simple adhesion testing; the repair material is installed in between two concrete substrate pieces of a predetermined surface area and mass. The entire specimen is held up in mid-air by clamping one of the concrete substrate pieces in mid-air. During the interval of the moment the specimen is held up in mid-air to end of a predetermined duration, the specimen is checked to see if an adhesion failure will occur across the interface of either concrete substrate pieces (upper or bottom).

The results of such testing can provide a reference data to estimate the wet substrate surface adhesion performance of various water leakage repair materials (refer to ISO/TS 16774-4).

7.2.6 Test for watertightness

Watertightness testing assesses the ability of repair materials to prevent the ingress of water into the interior of a concrete structure when subject to continuous or intermittent hydrostatic pressure. The duration of which the repair material can maintain waterproofing performance is tested against hydrostatic pressure originating from the surrounding environment of leakage cracks on underground structures or roof slabs.

One method used to evaluate the watertightness of water-leakage crack repair material is to conduct a hydrostatic pressure resistance testing. The repair material is installed in between the interface of two concrete substrate pieces and is subject to predetermined hydrostatic pressure. The results from such testing can provide a reference data to estimate the watertight performance of various water leakage repair materials (refer to ISO/TS 16774-5).

7.2.7 Test for response to the substrate movement

Substrate movement response testing assesses the elastic and cohesive bonding of the repair material when injected into a water-leakage crack. Concrete joints and cracks are subject to continuous cycles of thermal shrinkage and expansion, loads and vibrations (from nearby passing vehicles), and structural settlement. The evaluation involves assessing if the repair materials installed inside the cracks of concretes can maintain adhesive and cohesive bond while being subject to continuous micro movement and tensile stress.

One method used to evaluate the substrate movement response is to determine whether repair material is able to maintain the required waterproofing performance after the material installed inside a concrete crack has been subject to cyclic stress caused by repeated movement. By subjecting the material to hydrostatic pressure resistance testing after substrate movement stress, an estimation of the durability performance of the repair material can be determined (refer to ISO/TS 16774-6).

8 Execution of different types of repair methods

8.1 General

An optimal method for effectively sealing water-leakage cracks can be selected and be made aware of by fully understanding the requirements concerning environmental degradation factors, installation cost, durability, finishing condition and other conditions related to repair methods. Methods that can provide an effective response measure against water leakage and continuous hydrostatic pressure can be used. The methods for repairing water-leakage cracks can be categorized as listed in 8.1 and 8.2.

8.2 Grouting injection methods

Figure 5 illustrates the injection repair methods using urethane foam grout, acrylate grout, cementitious grout and epoxy resin grout. There are three main types of grouting injection methods for water-leakage cracks.

1) The first method is called intercept injection [Figure 5 a)]. At a certain distance away from the crack, a hole is drilled diagonally through the concrete until it intercepts the crack at its midpoint. An injection nozzle is then inserted through the drilled hole. The repair material being prepared or mixed inside the injection apparatus flows through the injection hose and fills up the crack in both negative and positive directions from the midpoint of the crack until the crack is completely sealed up.

2) The second method is called negative side injection [Figure 5 b)]. Injection ports are installed directly on the mouth of the concrete crack, set at an interval of short distance and the repair material is directly injected into the ports from the negative side. The repair material flow through the crack toward the positive side, filling up the entire backside space of the concrete substrate.