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Structural intervention of existing concrete structures using cementitious materials —

Part 3:
Bottom-surface (soffit) underlaying

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Foreword

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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 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 Organisation (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*.

A list of all parts in the ISO 5091 series can be found on the ISO website.

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

As a repairing and strengthening method, attaching of cementitious material layer to surface of existing concrete structures has been widely accepted. Since the cementitious layer does not have enough tensile strength, tension reinforcement is generally placed in the cementitious layer. There are two types of attaching way. For the first way, the cementitious layer is attached either on top surface or bottom surface of horizontal concrete members, especially slabs, while, for the second way, the cementitious layer is attached to jacket vertical concrete members, especially columns. There has not been ISO standard on design, execution and maintenance for this method with attaching cementitious layer. This ISO 5091 serves as the first ISO standard for the intervention by attaching cementitious material layer with tension reinforcement inside.

At the same time, this ISO 5091 is the first ISO standard developed for a specific intervention method, which conforms to the umbrella code, ISO 16311 Maintenance and repair of concrete structures, especially ISO 16311-3 – Part 3: Design of repairs and prevention and ISO 16311-4 – Part 4: Execution of repairs and prevention.

ISO 5091 Structural intervention of existing concrete structures using cementitious materials consists of four parts; ISO 5091-1 – Part 1: General principles, ISO 5091-2 – Part 2: Top-surface overlaying, ISO 5091-3 – Part 3: Bottom-surface (soffit) underlaying, and ISO 5091-4 – Part 4: Jacketing. ISO 5091-1 provides the issues common to all three parts, while ISO 5091-2, 3 and 4 provide the issues specific to each attaching way of cementitious material layers.

It is expected that this ISO 5091 could serve as a practical standard for construction industry, such as client, design consultant and general contractor, to apply the structural intervention with externally attached cementitious layer. Additional technical information, which is not provided explicitly in ISO 5091, needs to be provided in each application case with consideration of the provisions of ISO 5091.

Structural intervention of existing concrete structures using cementitious materials —

Part 3:
Bottom-surface (soffit) underlaying

1 Scope

These guidelines specify the standards for design and construction using the bottom-surface (soffit) underlaying method. Bottom-surface (soffit) underlaying is a method whereby reinforcing materials are placed on the bottom surface of the slabs or beams whose performance is lower than required and the improvement of durability, serviceability, safety and other performance of the members is achieved by the integrity between the reinforcing materials and existing members.

Generally, polymer hydraulic cement mortar (hereinafter PCM) is used as the underlaying material. This is because PCM bonds well with the existing members and has large tensile strain at cracking, and making the penetration of degradation factors less likely. As reinforcing materials, reinforcing steel, welded wire mesh, FRP grid are used.

Bottom-surface (soffit) underlaying has evolved as a strengthening method for fatigue of RC decks, drawing attention because of examples of applications like the one shown in Figure 1. The members that are currently repaired or strengthened using this method include RC decks, tunnel linings, box culverts, waterways and beams. In these guidelines, the latest information about the design and construction of the bottom-surface (soffit) underlaying method using underlaying materials has been collected and the best possible standards are presented. Matters not mentioned herein shall be as set forth in ISO /NP 5091-1.

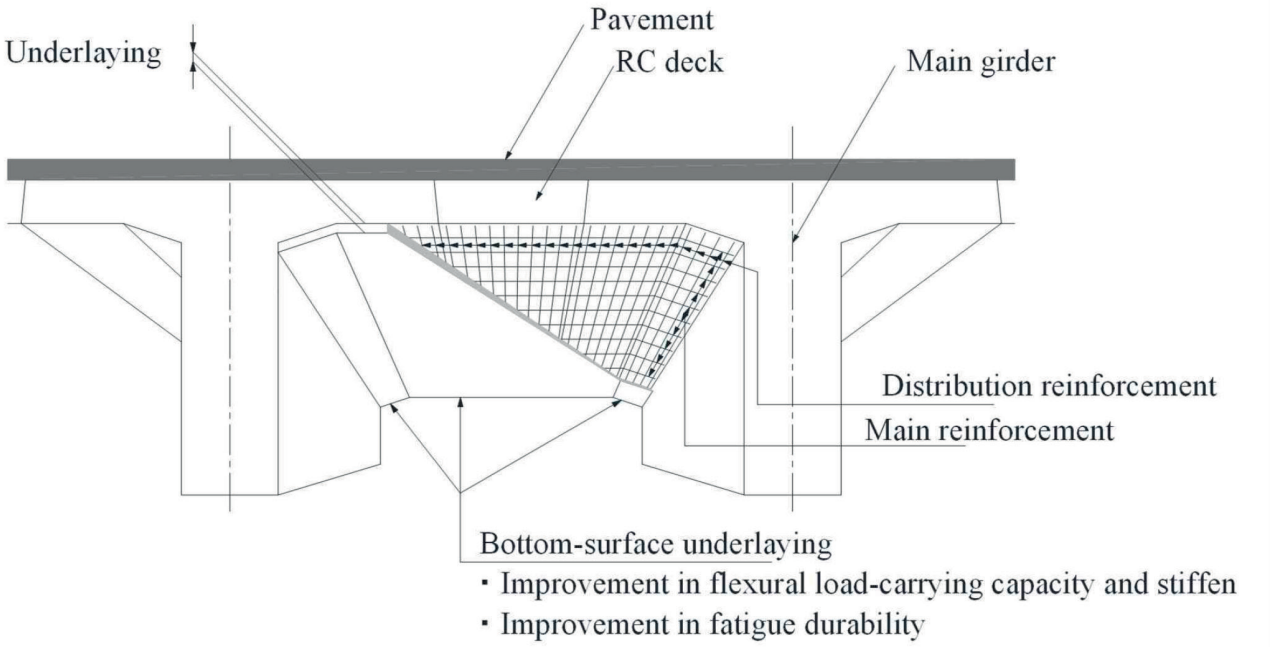

Figure 1 — Example of application of bottom-surface (soffit) underlaying for deck strengthening

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 16311-1:2014, *Maintenance and repair of concrete structures — Part 1: General principles*

ISO 16311-2:2014, *Maintenance and repair of concrete structures — Part 2: Assessment of existing concrete structures*

ISO 16311-3:2014, *Maintenance and repair of concrete structures — Part 3: Design of repairs and prevention*

ISO 16311-4:2014, *Maintenance and repair of concrete structures — Part 4: Execution of repairs and prevention*

ISO 22966:2009, *Execution of concrete structures*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1 General

The definitions of the terms used in the Bottom-surface (soffit) underlaying section shall be as defined in Clause 3 of ISO / NP 5091-1.

4 Investigation of existing structure

4.1 General

The study of the existing structure for which to consider intervention using the bottom-surface (soffit) underlaying method shall be as set forth in Clause 4 of ISO /NP 5091-1.

4.2 Investigation

4.2.1 Investigation using documents, records, etc.

When the climatic conditions, environmental conditions and geographical conditions of the local site are studied using documents, records, etc., the study shall be conducted in accordance with 4.2.1 of ISO /NP 5091-1.

4.2.2 On-site investigation

The on-site study on degradation, damage and initial defects of the existing concrete structure shall be conducted in accordance with 4.2.2 of ISO /NP 5091-1.

NOTE It is necessary to check that the shape, size and other characteristics of the existing members subject to bottom-surface (soffit) underlaying are consistent with the documents and records. In the investigation, the steel materials of the existing members need to be checked in terms of size, arrangement, etc. through a non-destructive inspection, chipping inspection or the like as necessary. Also, the degree of degradation and the progress of damage of the existing members subject to bottom-surface (soffit) underlaying shall be grasped through checking for changes in appearance (cracks, water leaks, efflorescence, rust staining flaking and peeling of cover concrete, and exposed reinforcing bar, etc.), measurement of chloride-ion concentration, checking of the carbonation depth, covering depth and degree of steel corrosion, etc. At the same time, the causes of degradation and damage shall be presumed based on the surrounding environment (coastal lines, traffic conditions, climatic conditions, etc.), the characteristics of damage, the flow of rainwater, water leaks, vibration generated when heavy vehicles pass and so forth.

The work environment and other relevant conditions of the site shall be checked in advance.

NOTE It is necessary to check the status of the approach route for work vehicles, work machines, etc. as well as whether the storage space and temporary structures such as scaffoldings can be set up.

5 Intervention design

5.1 General

When repairing or strengthening a concrete structure using bottom-surface (soffit) underlaying, it shall be verified by means of an appropriate method that the structure fulfills the required performance for the required period. Also, the environment for the intervention construction, constructability, post-intervention maintainability and economy shall be taken into consideration.

NOTE Bottom-surface (soffit) underlaying is applied for purposes such as flexural strengthening and shear strengthening of structural members by providing thin reinforcing underlaying layers. One feature of this method is that the increase in weight due to intervention is small. When it is used for box culverts, tunnels, waterways, etc., there is only a small reduction in the inner section. When structural members such as bridge decks are repaired or strengthened using bottom-surface (soffit) underlaying, a verification related to the punching shear failure of the decks needs to be performed. In the case of waterways or box culverts, it is necessary to verify ordinary design loads such as earth pressure and water pressure. Even for tunnels and water channels, a verification related to level 2 ground motions may be required. While the verification methods described in these guidelines do not cover all kinds of verification, the currently available latest technologies are presented herein.

NOTE An example of the construction section observed when bottom-surface (soffit) underlaying is applied to bridge decks is shown in Annex.

NOTE Bottom-surface (soffit) underlaying requires that underlaying materials protect reinforcing materials from corrosion as well. With the bottom-surface (soffit) underlaying method using PCM, the thickness of underlaying parts is 30 mm or so in many cases. Therefore, underlaying materials can be applied to underlaying parts by either spraying or trowelling. A rational method should be selected taking into consideration the application environment and quantity.

5.2 Structural plan

The structural plan for a structure repaired or strengthened with bottom-surface (soffit) underlaying shall be as set forth in 5.2 of ISO /NP 5091-1.

NOTE The repaired or strengthened structure shall fulfill the required levels of durability, safety, serviceability and restorability throughout the design service life. The performance requirements differ depending on the structure repaired or strengthened with bottom-surface (soffit) underlaying. In flexural strengthening of existing members, the verification is mainly intended for serviceability, safety, etc. In fatigue strengthening of bridge decks, the punching shear capacity of the decks is required to be improved. In seismic strengthening of box culverts and tunnels, the verification is intended for restorability. Also, the intervention shall be planned taking into consideration the causes of degradation and damage of the existing members subject to bottom-surface (soffit) underlaying.

NOTE Since thin members are used as underlaying materials in bottom-surface (soffit) underlaying, the covering of reinforcing materials becomes relatively thin. This makes it possible for degradation factors to intrude more quickly in a severe corrosion environment. Therefore, durability verification is a key point in maintenance and necessary measures shall be considered.

5.3 Structural details

The structure of bottom-surface (soffit) underlaying shall ensure the integrity between the existing and underlaying parts in the repaired or strengthened members.

NOTE In bottom-surface (soffit) underlaying, the loss of the integrity between the existing and underlaying parts in the repaired or strengthened members may result in the limit state of safety. This failure is brittle, which shall be avoided.

The structure of bottom-surface (soffit) underlaying shall ensure that reinforcing materials are securely anchored to the existing parts to reduce the risk of peeling.

The structure of bottom-surface (soffit) underlaying shall prevent retention of water in the interface between the existing and underlaying parts.

NOTE The retention of water near the interface between the existing and underlaying parts in the members repaired or strengthened with bottom-surface (soffit) underlaying may cause the degradation of the interface or a decrease in adhesion. Therefore, a measure to prevent such retention of water shall be taken.

The reinforcing materials used for bottom-surface (soffit) underlaying shall have a certain level of tensile stiffness that allows the reinforcing materials to behave with the existing parts as one.

NOTE The reinforcing materials used for bottom-surface (soffit) underlaying shall not have excessive tensile stiffness against the existing parts. If the tensile stiffness of the reinforcing materials is excessive, care needs to be exercised because the forces transferred through the interface between the existing and underlaying parts as well as the anchoring parts of the reinforcing materials become great, potentially leading to peeling or some other problem. It is desirable that the reinforcing materials be arranged as uniformly as possible so that they behave with the existing parts as one. Therefore, it is advisable to use reinforcing materials having a small diameter and arrange them as densely as allowed for construction. For example, small-diameter reinforcing steel may be used as reinforcing materials and arranged at the pitch of 50 mm.

6 Materials

6.1 General

The materials used for bottom-surface (soffit) underlaying shall be of proven quality to ensure that the required performance is fulfilled for a necessary period

6.2 Materials in existing structure

The characteristic values of material strength, partial safety factor for materials and design values of the materials in the existing structure that are used for the design shall be determined in accordance with 6.2 of ISO /NP 5091-1.

6.3 Materials used in repairing or strengthening parts

6.3.1 General

The quality of the materials used in the parts repaired or strengthened with bottom-surface (soffit) underlaying shall be as set forth in 6.3 of ISO /NP 5091-1.

6.3.2 Cementitious materials

The underlaying materials used for bottom-surface (soffit) underlaying shall have a bonding property and durability sufficient to integrate the existing parts with added reinforcing materials.

NOTE The underlaying materials used for bottom-surface (soffit) underlaying are required to achieve excellent bonding between the existing parts and reinforcing materials and have sufficient adhesion, gap filling property, etc. to guarantee the integrity between the existing parts and reinforcing materials. Generally, they need to be excellent in bond strength, tensile strength and flexural strength and ensure the transfer of stress between the existing parts and reinforcing materials. Materials having Young's modulus and compressive strength that are the same as or similar to those of the existing members are suitable.

The underlaying materials shall have performance equal to or greater than the resistance against permeation of the existing members against environmental factors.

NOTE In many cases, the covering of underlaying materials is thin relative to reinforcing materials and, therefore, the underlaying materials need to be impermeable to degradation factors that affect the underlaying parts and existing parts. Particularly, those having a low chloride diffusion coefficient, a low carbonation rate and high resistance to freezing and thawing are preferred. Considering these performance requirements as well as uniform quality and economy, premixed PCM is often used as the underlaying material.

6.3.3 Reinforcing materials

Considering the performance requirements, reinforcing materials having appropriate tensile stiffness, design tensile strength and durability shall be selected.

NOTE Reinforcing steel, welded reinforcing steel, FRP reinforcement and the like are used as reinforcing materials, and they are available in shapes of bars and grids.

6.3.4 Bonding products

The bonding products used in the interface between the existing and underlaying parts shall ensure the specified bonding property.

NOTE The bonding products include polymer dispersion, polymer hydraulic cement mortar and resin adhesive selected for each method (material). They are used to improve the bonding property of the existing and underlaying parts.

The bonding products shall prevent the degradation in the bonding property of the underlaying and existing parts.

NOTE The bonding products shall be those proven to be compatible with the materials used in both the underlaying and existing parts and have sufficient durability.

6.4 Characteristic values and design values of materials for repaired or strengthened parts

6.4.1 General

The characteristic values and design values of the materials used for bottom-surface (soffit) underlaying shall be as set forth in 6.4 of ISO /NP 5091-1.

6.4.2 Cementitious materials

The cementitious materials used for bottom-surface (soffit) underlaying shall be as set forth in 6.4.2 of ISO /NP 5091-1.

NOTE If the strength and other mechanical properties of a material change depending on temperature even in the temperature range under the normal usage environment of the structure, as with PCM, the characteristic values of strength and other properties need to be determined under the temperature condition appropriate for the usage environment.

6.4.3 Reinforcing materials

The reinforcing materials used for bottom-surface (soffit) underlaying shall be as set forth in 6.4.3 of ISO /NP 5091-1.

6.4.4 Bonding products

As the design value of the bonding product, the characteristic value of the bond strength obtained after integrating interfaces between the existing part and the underlaying part and between underlaying parts shall be used, instead of the characteristic value of the strength of the bonding product itself.

NOTE The bonding product shall have material properties that ensure that the existing parts and underlaying parts are integrated throughout the design service life. The bonding product is used to integrate the existing parts, underlaying parts and interface between underlaying members through intervention. Therefore, the characteristic value of the strength obtained after integrating the old and new materials is necessary for the design. The characteristic value of the bonding product shall be determined through testing as necessary.

7 Actions

7.1 General

The actions used for performance verification of intervention using the bottom-surface (soffit) underlaying method shall be as set forth in Clause 7 of ISO /NP 5091-1.

7.2 Actions for intervention design

In the intervention design, the actions that may occur on the existing structure and repaired or strengthened parts shall be considered in accordance with 7.2 of ISO /NP 5091-1.

8 Performance verification for repaired or strengthened structure

8.1 General

The items to be verified for the concrete members repaired or strengthened with bottom-surface (soffit) underlaying shall be established appropriately so as to fulfill the required performance of the repaired or strengthened structure.