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Structural intervention of existing concrete structures using cementitious materials —

Part 2:
Top-surface overlaying

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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 2:
Top-surface overlaying

1 Scope

These guidelines specify the standards for design and construction using the top-surface overlaying method, which increases the thickness of existing concrete members by integrating cementitious materials onto the top surface of the members so as to improve the safety, serviceability, durability and other properties of a concrete structure. The requirements not mentioned in the Top-Surface Overlaying section shall be as set forth in the ISO/NP 5091-1 and relevant standard specifications for concrete structures.

NOTE Top-surface overlaying is a construction method that increases the thickness of existing concrete members by placing and integrating cementitious materials onto the top surface of the members so as to improve the safety, serviceability, durability and other properties of a concrete structure.

NOTE Typical structures to which top-surface overlaying is applied as an intervention method are highway bridge reinforced concrete decks (hereinafter decks) that are subject to the repeated action of relatively large variable loads. The method is mainly applied to improve the safety and other properties of decks that have degraded due to fatigue resulting from the repeated action of traffic loads. It may also be applied to improve durability and utility for such purposes as to respond to design load changes taking place as vehicles become larger and protect the top surface of decks against degradation due to de-icing substance. Examples of applications other than those for decks include overlaying reinforcement of the top surface of footings aimed at improving the seismic performance of bridge piers whose existing footings have an insufficient flexural load-carrying capacity for ground motions. While the Top-Surface Overlaying section is not necessarily confined to a specific type of structure, it mainly covers the standard design and construction methods for top-surface overlaying of decks.

NOTE For top-surface overlaying to produce the specified effect, it is indispensable to integrate the existing members with the cementitious materials of the overlaying parts. In some cases, after the top surface of decks is cut and cleaned, fiber-reinforced concrete is placed while adhesive is applied in order to achieve integrity. The primary reason for using fiber-reinforced concrete on the overlaying parts is to improve the flexural resistance, tensile resistance, shear resistance and cracking resistance of the concrete. For example, since the cross-section layer of the top-surface overlaying parts is relatively thin, there is possibility of cracking occurring due to initial drying or occurring and progressing due to active loads. Mixing fiber is expected to suppress the progress of cracking. Also, in intermediate support points and overhanging decks of continuous girder bridges, reinforcing materials such as reinforcing steel and FRP reinforcing materials are used to improve the negative flexural load-carrying capacity. In top-surface overlaying for footings, the thickness is greater than for decks. In the case of mass concrete, therefore, a measure needs to be taken to protect against thermal cracking due to hydration heat of cement.

NOTE These guidelines describe a specific method of verifying the performance of a structure repaired or strengthened by means of top-surface overlaying based on the currently available latest technologies. Note, however, that the verification method described herein does not cover all kinds of verification. For necessary information, reference shall be made to the relevant standard specifications and other documents. In the future, as purposes for intervention, diversify and advances in technology are made, many different methods are expected to be proposed.

NOTE Given that members subject to intervention are mostly decks at present, the standard methods are described herein that are considered the latest information on design and construction of top-surface overlaying using fiber-reinforced concrete on overlaying parts. As technology advances, new materials and design and construction methods are developed and methods for evaluating the post-intervention structural performance with sufficient accuracy are established, making it possible to apply top-surface overlaying for intervention parts and members other than decks, use materials other than fiber-reinforced concrete, employ interface treatment methods other than cutting, cleaning and adhesive, etc., it is not necessarily required to adhere to what is set forth in these guidelines.

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 19338:2014, *Performance and assessment requirements for design standards on structural concrete*

ISO 1920-8, *Testing of concrete — Part 8: Determination of drying shrinkage of concrete for samples prepared in the field or in the laboratory*

ISO 10406-2, *Fibre-reinforced polymer (FRP) reinforcement of concrete — Test methods — Part 2: FRP sheets*

ISO 10406-3, *Fibre-reinforced polymer (FRP) reinforcement of concrete — Test methods — Part 3: CFRP strips*

ISO 12473, *General principles of cathodic protection in seawater*

ISO 13823, *General principles on the design of structures for durability*

ISO 14484, *Performance guidelines for design of concrete structures using fibre-reinforced polymer (FRP) materials*

ISO 22966, *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 Top-surface overlaying section shall be as defined in Clause 3 of ISO / NP 5091-1.

4 Investigation of existing structure

4.1 General

The investigation of the existing structure for intervention using the top-surface overlaying method shall be as set forth in Clause 4 of the ISO/NP 5091-1.

NOTE Intervention using the top-surface overlaying method needs to be designed by understanding the condition of the existing structure through a prior investigation, and plans for construction, construction management and inspections need to be formulated based on the results of the design. The investigation of the existing structure shall be as set forth in Clause 4 of the ISO/NP 5091-1 and involve an investigation using documents, records, etc. and an on-site investigation. It is necessary to check the condition of the structure, environmental conditions and conditions of use, as well as to understand the restrictions and problems on intervention, through these studies.

4.2 Investigation

4.2.1 Investigation using documents, records, etc.

The investigation of the existing structure using documents, records, etc. for top-surface overlaying shall be as set forth in Clause 4 of the ISO/NP 5091-1.

NOTE To check the performance that the existing structure possesses, it is necessary to understand such information as the dimensions of members, steel arrangement and materials used, based on design documents and as-built drawings. Information such as the traffic volume on the target road and the ratio of-heavy goods vehicles in traffic flow should also be obtained as needed. If the intervention has already been performed, maintenance records need to be inspected. It is important to check the location and environmental conditions of the structure in advance in order to identify construction restrictions and problems.

4.2.2 On-site investigation

The on-site investigation for considering the application of top-surface overlaying shall be as set forth in Clause 4 of the ISO/NP 5091-1.

NOTE If the existing structure has any physical degradation such as cracks, the integrity between the existing structure and cementitious materials may be impaired. Also, if the existing structure has steel corrosion due to intrusion of de-icing substance, scaling caused by freezing and thawing actions, cracking or very severe degradation of concrete disrupting the integrity of concrete resulting from alkali-aggregate reaction or the like, intervention using top-surface overlaying may not be fully effective unless the degraded parts are removed. It is, therefore, necessary to check changes in the existing structure in advance by means of periodical inspection records and other relevant information, as well as to check the necessary items on the site. It is good practice to judge whether the existing structure needs intervention or not, the scale of intervention and so on by taking into consideration the performance level and design service life of the structure required to be achieved by the intervention based on results of the on-site investigation. To ensure smooth construction work with top-surface overlaying on the site, it is important to check the storage space and arrangement of construction machines and materials, traffic restrictions and so forth in the prior investigation phase.

5 Intervention design

5.1 General

The intervention plan for considering the application of top-surface overlaying shall be as set forth in Clause 5 of the ISO/NP 5091-1.

NOTE With top-surface overlaying, the effect of the intervention is greatly influenced by the degradation status of the existing structure. Therefore, the structural plan for degraded part removal, patching repair, concrete replacement, etc. needs to be formulated based on the correct judgment of the degradation status to ensure that the performance level and design service life of the structure required from the intervention are achieved.

NOTE In structural details, a bonding method shall be established that ensures the integrity between the existing parts and overlaying parts so that the intervention effect of top-surface overlaying is obtained. Specifically, an appropriate surface treatment method and, if necessary, a method of maintaining integrity for a specified period by means of adhesive or other bonding products shall be considered. Also, when asphalt pavement is placed on top of the overlaying parts, it is important from the perspective of post-intervention durability to provide a water-resistant layer and consider a plan for blocking and draining water intruding into decks.

5.2 Structural plan

The structural plan for considering the application of top-surface overlaying shall be as set forth in Clause 5 of the ISO/NP 5091-1.

NOTE When top-surface overlaying is selected, it is necessary to consider economy in addition to the impact of construction work on the surrounding environment,maintainability after intervention and so forth. The intervention method by top-surface overlaying is often adopted for decks, and it is common to strengthen decks with fiber-reinforced concrete after appropriate treatment of a placement interface on the top surface of the existing decks. When the method is used for decks, a understand shall be gained in advance as to the cracking and efflorescence in the existing reinforced concrete decks, the degradation of concrete due to traffic loads, repeated freezing and thawing, alkali-aggregate reaction, etc., the status of concrete cover peeling resulting from reinforcing steel corrosion caused by salt attack mainly due to sprayed de-icing substance, the status of the concrete cover very severe degradation of concrete disrupting the integrity of concrete as a result of water intruding into such corroded parts, and so on. In designing intervention work, appropriate decisions shall be made on the method to remove degraded concrete, the materials and method for patching repair, whether partial concrete replacement is necessary and the range of replacement, the construction method of top-surface overlaying, etc. before starting construction with top-surface overlaying, considering these circumstances. Materials for patching repair for the top surface of decks are required to shrink little, be excellent in crack resistance and deformation-following capability and Young's modulus equal to or smaller than that of the existing concrete, etc.

NOTE In the top-surface overlaying plan, it is necessary to consider specific intervention measures according to the performance requirements specified for the structure. Based on the evaluation of the impact of the degradation and damage of the existing structure on its structural performance, specific measures need to be planned according to structural conditions to ensure that the purpose and required performance of the target structure are fulfilled throughout the design service life.

NOTE In intervention, the location and environmental conditions of the target structure have a significant impact on the construction work. For example, when top-surface overlaying is applied to decks, intervention involves prolonged traffic restrictions and, therefore, the range of construction needs to be planned considering this.

NOTE In recent years, there have been reports of post-intervention peeling and re-degradation of overlaying parts of decks reinforced with the top-surface overlaying method. The reason for such peeling and re-degradation is considered to be that the bonding between the existing decks and overlaying parts is impaired by rainwater intruding from construction joints, cracks, etc. thereby making it impossible for them to resist loads together. Therefore, the intrusion of water into the inside of decks needs to be completely prevented and it is important to apply waterproofing and ensure water drainage on the waterproof top surface. In order to ensure that the repaired or strengthened structure sustains its performance as mentioned above, it is necessary to take measures to prevent re-degradation while taking into consideration the maintenance folllowing completion of intervention as well.

5.3 Structural details

The structural details for considering the application of top-surface overlaying shall be as set forth in Clause 5 of the ISO/NP 5091-1. An increase in the self-weight due to the overlay shall also be considered appropriately.

NOTE For a structure repaired or strengthened with top-surface overlaying to fulfill the required performance, the existing parts and overlaying parts need to function together as a composite structure. Figure 1 shows examples of the cross-section of decks to which top-surface overlaying is applied. Generally, after the existing deck is cut by 10 mm, its top surface is shot-blasted and steel fiber-reinforced concrete is placed while applying adhesive as necessary in order to bond the existing deck and overlaying part. Regarding the treatment of overlay placement interface, whether to use adhesive and how to apply it shall be decided rationally taking into consideration the circumstances of the construction site. Generally, asphalt pavement is placed on top of the steel fiber-reinforced concrete of the overlaying part and a water-resistant layer needs to be provided between the overlaying part and pavement. This is particularly important for preventing the degradation of decks from occurring or accelerating in the presence of water. For example, water accumulating in decks accelerates fatigue-damage or degradation, and chloride ions that penetrate decks with water promote steel corrosion.

NOTE If the stiffness of the existing part is vastly different from that of the overlaying part, the strength, Young's modulus and other properties of the existing concrete and overlaying materials need to be considered fully because a sufficient strengthening effect may not be obtained depending on the bonding method. Also, since the layer of the overlaying part is as thin as 50 mm, the constraint from the existing member is great in terms of shrinkage and creep deformation. It is, therefore, necessary to thoroughly consider the volume change characteristics of fiber-reinforced concrete and the suppression effect of the progress of cracking.

NOTE If overlaying results in the entire cross-section of the member becoming thicker, an increase in dead loads due to the self-weight needs to be considered as well.

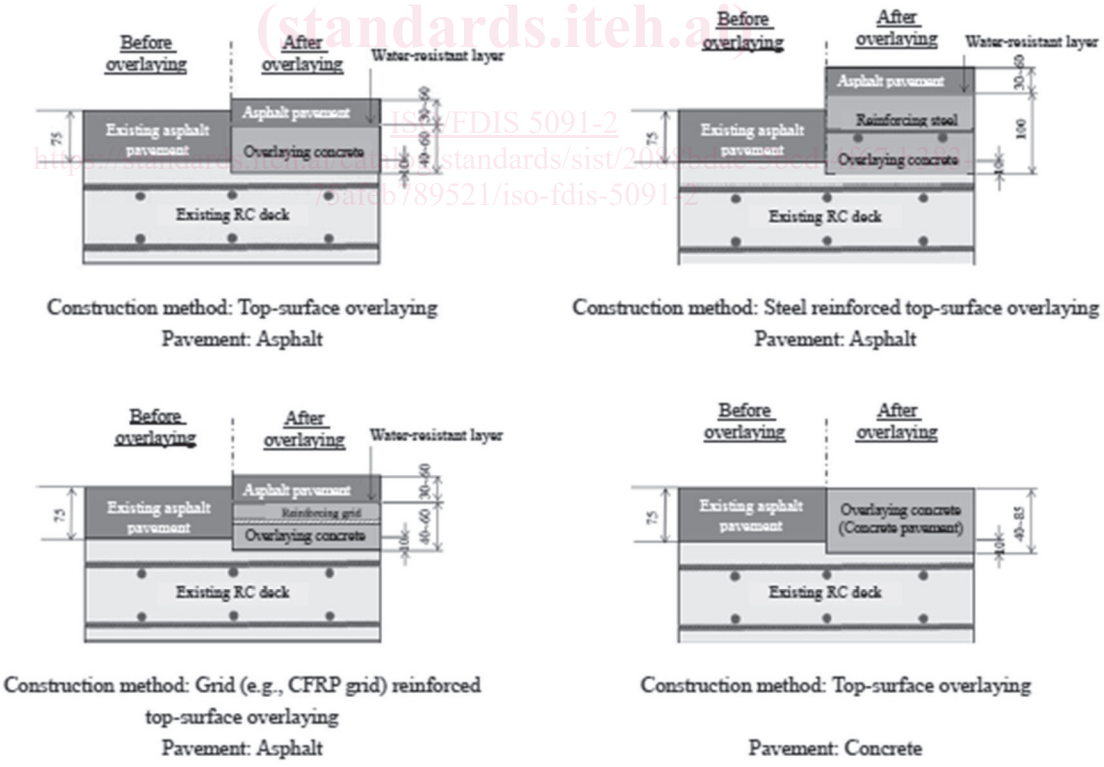

Figure 1 — Examples of the cross-section of decks to which top-surface overlaying is applied