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Structural intervention of existing concrete structures using cementitious materials —

Part 2: Top-surface overlaying

Intervention structurelle sur les structures en béton existantes utilisant des matériaux cimentaires —

Partie 2: Recouvrement de la surface supérieure

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

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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*.

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 any ISO standard on design, execution, and maintenance for this method with attaching cementitious layer. The ISO 5091 series serves as the first ISO standard for the intervention by attaching cementitious material layer with tension reinforcement inside.

At the same time, the ISO 5091 series is the first ISO standard developed for a specific intervention method, which conforms to the umbrella code, ISO 16311, especially ISO 16311-3 and ISO 16311-4.

The ISO 5091 series consists of four parts. 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.

ISO 5091-2 describes 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 need to be made to the relevant standard specifications and other documents.

Given that members subject to intervention are mostly decks, the standard methods described herein are considered the latest information on design and construction of top-surface overlaying using fibre-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 fibre-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 ISO 5091.

The ISO 5091 series can 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 series, needs to be provided in each application case with consideration of the provisions of ISO 5091 series.

Structural intervention of existing concrete structures using cementitious materials —

Part 2:
Top-surface overlaying

1 Scope

This document specifies 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.

This document specifies structural intervention of existing concrete structures using cementitious materials design and execution principles, and strategies for defects and on-going deterioration including, but not limited to:

a) mechanical actions, e.g. fatigue, impact, overloading, movement caused by settlement, blast, vibration, and seismic actions;

b) chemical and biological actions from environments, e.g. sulfate attack, alkali-aggregate reaction;

c) physical actions, e.g. freeze–thaw, thermal cracking, moisture movement, salt crystallization, fire, and erosion;

d) reinforcement corrosion;

e) original construction defects that remained unaddressed from the time of construction.

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 5091-1:2023, *Structural intervention of existing concrete structures using cementitious materials — Part 1: General principles*

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

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

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
top-surface overlaying
method in which the thickness of the structural element associated with the top surface of the existing concrete members is increased using cementitious materials, which will generally be reinforced

Note 1 to entry: The technique enhances the performance (e.g. strength, stiffness) of the existing concrete structure and is applicable to highway bridge decks, etc.

3.2
bonding product
material, such as a primer or adhesive, that is applied to bond concrete and mortar

Note 1 to entry: The grouting material for bonding concrete and reinforcing material is also included in this term.

3.3
filling material
material injected to fill the gap between a reinforcing material, such as intermediate penetrating tie, and concrete

3.4
filling property
degree of filling of cracks and adhesion of crack filling material to substrate

3.5
very high early strength cement
type of cement with a typical mix proportion that develops a compressive strength as high as 20 N/mm^2 to 30 N/mm^2 within 2 h to 3 h of placement

3.6
reinforcing material
steel or FRP material used to sustain, restore or improve the mechanical performance of a structure

3.7
polymer hydraulic cement mortar
hydraulic composition made cementitious materials and fine aggregate modified by the addition of a polymer

3.8
overlaying material
cementitious material, potentially reinforced, added on the top surface of an existing concrete structure for the purpose of making an intervention to enhance the performance of that structure

3.9
FRP grid
resin-impregnated FRP reinforcing materials formed into a grid shape

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 ISO 5091-1:2023, Clause 4.

4.2 Investigation

4.2.1 Investigation using documents, records

The investigation of the existing structure using documents, records, etc. for top-surface overlaying shall be as set forth in ISO 5091-1:2023, Clause 4.

If the intervention has already been performed, maintenance records need to be inspected.

4.2.2 On-site investigation

The on-site investigation for considering the application of top-surface overlaying shall be as set forth in ISO 5091-1:2023, Clause 4.

To ensure smooth construction work with top-surface overlaying on the site, the storage space and arrangement of construction machines and materials, traffic restrictions and so forth should be checked 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 ISO 5091-1:2023, Clause 5.

The structural plan for degraded part removal, patching repair, concrete replacement, etc. shall 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.

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.

5.2 Structural plan

The structural plan for considering the application of top-surface overlaying shall be as set forth in ISO 5091-1:2023, Clause 5.

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.

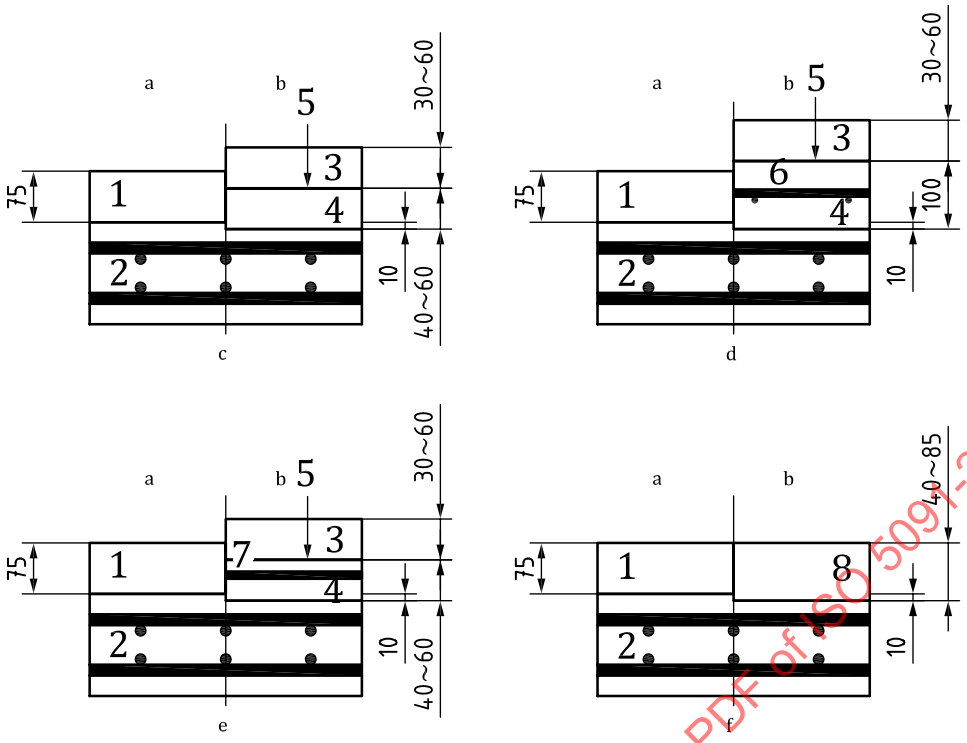
The intrusion of water into the inside of decks needs to be completely prevented and it is important to apply waterproofing and ensure water drainage on the waterproof top surface. In order to ensure that the repaired or strengthened structure sustains its performance as mentioned above, it is necessary to take measures to prevent re-degradation while taking into consideration the maintenance following 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 ISO 5091-1:2023, Clause 5. An increase in the self-weight due to the overlay shall also be considered appropriately.

For a structure repaired or strengthened with top-surface overlaying to fulfil 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.

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.



Key

1 existing asphalt pavement
2 existing RC deck
3 asphalt pavement
4 overlaying concrete
5 water resistant layer
6 reinforcing steel
7 reinforcing FRP grid
8 overlaying concrete (concrete pavement)
a Before overlaying.
b After overlaying.
c Top-surface overlaying with asphalt pavement.
d Steel-reinforced top-surface overlaying with asphalt pavement.
e FRP grid reinforced top-surface overlaying with asphalt pavement.
f Top surface overlaying.

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

6 Materials

6.1 General

The materials used for top-surface overlaying 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 and design values of the materials in the existing structure shall be as set forth in ISO 5091-1:2023, Clause 6.

When setting the material properties of the existing structure based on documents, records, etc. according to ISO 16311-2, the partial safety factor for materials should be determined taking into consideration the impact of degradation. On the other hand, when the functionality of the existing structure is restored using patching repair materials or the like prior to top-surface overlaying, the material properties of the repair materials should be considered appropriately according to their impact.

6.3 Materials used in repairing or strengthening parts

6.3.1 Cementitious materials

The cementitious materials used for top-surface overlaying shall be as set forth in ISO 5091-1:2023, 4.3.2. Water, cement, aggregate, fibre, mineral admixture and chemical admixture, polymeric resins mixed with cement and others used for the cementitious materials shall be those compliant with the relevant standards or those proven to have the required levels of quality based on existing test results or through confirmation tests.

If shrinkage cracking of cementitious materials presents a problem, an expansive additive, which expands upon setting and hardening may be used as a mineral admixture. When very high early strength cement is combined with an expansive additive, the skeleton of the cement hardened body is formed early and, therefore, there are cases in which an expansive additive generates expansive hydration early is used.

It is necessary to use an appropriate material according to the required performance.

6.3.2 Reinforcing materials

The reinforcing materials used for top-surface overlaying shall be as set forth in ISO 5091-1:2023, Clause 6. In top-surface overlaying for decks, grid-shaped steel and FRP reinforcing materials may be used as reinforcements in addition to reinforcing steel.

6.3.3 Bonding products

The bonding products used for top-surface overlaying shall be as set forth in ISO 5091-1:2023, Clause 6.

In top-surface overlaying for decks, adhesive may be used on the placement interface to achieve integrity between cementitious materials and existing decks.

6.3.4 Waterproof materials

The waterproof material to be used for top-surface overlaying shall be selected so as to fulfil the required performance, taking into consideration the construction conditions and environment, variations in quality, etc.

6.3.5 Pavement materials

With regard to the pavement material to be placed after top-surface overlaying for highway bridge decks, its performance of bonding with the waterproof material shall be taken into consideration.

If the bonding between the pavement material and waterproof material is insufficient, it is possible that the required waterproof performance will not be obtained.

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 top-surface overlaying shall be as set forth in ISO 5091-1:2023, Clause 6.

6.4.2 Cementitious materials

The characteristic values and design values of the cementitious materials used for top-surface overlaying shall be as set forth in ISO 5091-1:2023, Clause 6.

6.4.3 Reinforcing materials

The characteristic values and design values of the reinforcing materials used for top-surface overlaying shall be as set forth in ISO 5091-1:2023, Clause 6.

6.4.4 Bonding products

A bonding product that ensures the integrity between the existing and overlaying parts for a necessary period shall be selected and used appropriately based on a full understanding of its properties.

The bonding product is required to have material properties that ensure the overlaying parts are bonded throughout the design service life. It is therefore necessary to check through appropriate testing that the integrity between the existing and overlaying parts can be achieved with the bonding product. The placement interface of the actual structure is likely to be in a complex stress status because of loads, surrounding environmental actions, condition of the existing structure, etc. Also, there can be combined actions of degradation factors. In the evaluation, the performance of the bonding product should be checked by means of a technique whereby the influence of these factors can be taken into consideration appropriately.

7 Actions

7.1 General

The actions used for performance verification of the intervention method using top-surface overlaying shall be as set forth in ISO 5091-1:2023, Clause 7.

7.2 Actions for intervention design

The actions for intervention design that are used for performance verification of the intervention method using top-surface overlaying shall be as set forth in ISO 5091-1:2023, Clause 7.

8 Performance verification for repaired or strengthened structure

8.1 General

The performance of a structure repaired or strengthened with top-surface overlaying shall be verified by means of the method specified in this clause.

8.2 Calculation of response

8.2.1 General

The response values of a structure repaired or strengthened with top-surface overlaying shall be calculated as set forth in ISO 5091-1:2023, Clause 8.

8.2.2 Modelling of structure

A structure repaired or strengthened with top-surface overlaying shall be modelled as set forth in ISO 5091-1:2023, Clause 8.

8.2.3 Structural analysis

The structural analysis of a structure repaired or strengthened with top-surface overlaying shall be performed as set forth in ISO 5091-1:2023, Clause 8.

8.2.4 Calculation of response values

The response values of a structure repaired or strengthened with top-surface overlaying shall be calculated as set forth in ISO 5091-1:2023, Clause 8.

8.3 Durability verification

8.3.1 General

The durability of a structure repaired or strengthened with top-surface overlaying shall be verified as set forth in ISO 5091-1:2023, Clause 8.

8.3.2 Verification related to steel corrosion

When a structure repaired or strengthened with top-surface overlaying is verified to check for steel corrosion due to salt attack, an appropriate value of chloride ion concentration on the concrete surface shall be established if salt attack due to de-icing substance has an impact as an environmental action.

8.4 Safety verification

8.4.1 General

The safety of a structure repaired or strengthened with top-surface overlaying shall be verified as set forth in ISO 5091-1:2023, Clause 8.

8.4.2 Verification related to failure

8.4.2.1 General

The verification of failure shall be performed in accordance with ISO 5091-1:2023, 6.4, while the verification method specific to top-surface overlaying shall be as set forth in Clause 8.

8.4.2.2 Verification related to bending moment and axial force

The verification related to bending moment and axial force shall be performed as set forth in ISO 5091-1:2023, Clause 8.

When the flexural load-carrying capacity of repaired or strengthened concrete members is calculated, it is assumed that the existing members and overlaying members behave as one without peeling away

from each other. Therefore, when the overlaying parts to be bent are located in the tension zone, the tension-side concrete shall be ignored.

When the existing parts are located in the compression zone, the flexural load-carrying capacity needs to be calculated using the design strength of the existing concrete. When the overlaying parts are located in the compression zone, the strength and Young's modulus of the overlaying parts do not match those of the existing concrete and, therefore, it is desirable to calculate the flexural load-carrying capacity using the design strength of the cementitious materials of the overlaying parts obtained in accordance with 6.4.

8.4.2.3 Verification related to shear force

The safety verification related to shear force shall be performed as set forth in ISO 5091-1:2023, Clause 8. This verification assumes that the existing members and overlaying members are integrated. The design shear capacity of beams shall be as set forth in ISO 16311-3, appropriately taking into consideration the effect of reinforcing materials used in top-surface overlaying. When the loaded surface is separated from the free end or the opening of the member and the eccentricity of the load is small, the punching shear capacity shall be as set forth in ISO 16311-3, appropriately taking into consideration the effect of reinforcing materials used in top-surface overlaying. Calculation example is shown in Annex A.

When there is shear reinforcement in the existing members, the design shear capacity V_{yd} should be expressed as the sum of the contribution of the shear reinforcement V_{sd} and V_{cd} in accordance with ISO 16311-3.

If the strength level considerably differs between the existing parts and overlaying parts, the verification needs to be performed carefully by making checks through experiments or by other means.

8.4.2.4 Verification related to torsional moment

If the action of the torsional moment is not negligible, a safety verification shall be performed by means of an appropriate method in accordance with ISO 16311-3. However, there is almost no research on the behaviour of torsional moment of members repaired or strengthened with top-surface overlaying, performance should be checked through appropriate experiments.

8.4.3 Verification related to fatigue failure

8.4.3.1 Verification related to flexural fatigue capacity

It shall be verified that the members repaired or strengthened with top-surface overlaying are safe against flexural fatigue under load and environmental actions. The fatigue strength of concrete and steel may be calculated in accordance with ISO 16311-3. It is desirable to perform a flexural fatigue verification for the overlaying parts on an as-needed basis in such cases as when negative bending moment acts on top-surface overlaying decks.

If no data is available about the fatigue strength of the cementitious materials used for top-surface overlaying, the flexural fatigue capacity needs to be calculated by means of an appropriate method such as experiments, an experiment-based evaluation method or non-linear finite element analysis.

Since a fatigue test generally takes time, it is allowed to perform the verification using an S-N curve created from existing research data. In that case, however, care shall be taken by assuming a life with a survival probability of 95 %, defining the point of time when the progress of cracking suddenly accelerates as the service limit life.

8.4.3.2 Verification related to punching shear fatigue capacity of slabs

It shall be verified that the surface members repaired or strengthened with top-surface overlaying are safe against punching shear fatigue under load and environmental actions.

When the punching shear fatigue capacity of repaired or strengthened surface members is calculated, it is assumed that the existing members and overlaying members behave as one without peeling away from each other.

When top-surface overlaying is applied to bridge decks, the punching shear fatigue capacity is reduced significantly as the decks are subject to the repeated action of moving wheel loads, compared to the case where the load point is fixed. Therefore, the capacity needs to be estimated by means of an appropriate method such as experiments, an experiment-based evaluation method or non-linear finite element analysis. The estimation of fatigue life in a dry condition or in a water-filled condition is shown in Annex A.

8.5 Serviceability verification

8.5.1 General

The serviceability of a structure repaired or strengthened with top-surface overlaying shall be verified as set forth in ISO 5091-1:2023, Clause 8.

8.5.2 Stress level limit

The stress level limit of a structure repaired or strengthened with top-surface overlaying shall be as set forth in ISO 5091-1:2023, Clause 8.

8.5.3 Verification related to appearance

The appearance verification of a structure repaired or strengthened with top-surface overlaying shall use the crack width as the verification and check that the calculated response values resulting from load and environmental actions satisfy the designated limit values determined from serviceability in accordance with ISO 5091-1:2023, Clause 8.

The flexural crack width of members repaired or strengthened with top-surface overlaying shall be calculated, using the stress level calculated for the composite section formed as the existing and overlaying parts are integrated, according to ISO 16311-3. Since there is little knowledge, the crack width should be checked through appropriate experiments.

8.6 Restorability verification

8.6.1 General

The restorability of a structure repaired or strengthened with top-surface overlaying shall be verified as set forth in ISO 5091-1:2023, 6.6.

When top-surface overlaying is applied to decks, it is necessary to ensure the functionality required after an earthquake and check that the structure can prevent the falling of the superstructure.

8.7 Structural details

8.7.1 Thickness of top-surface overlaying parts

The top-surface overlaying parts shall have a sufficient covering thickness to achieve the specified durability within a range that ensures the necessary intervention effect and constructability.

The thickness of overlaying cementitious materials shall be determined, taking into consideration the maximum size of coarse aggregate and construction accuracy, in order to ensure constructability and integrity with the existing members. Also, the overlaying parts shall have a covering thickness that takes into consideration drying shrinkage and intrusion of degradation factors such as chloride ions.

If the overlaying member thickness is thinner than 50 mm, concrete or mortar with coarse aggregate whose maximum size is 13 mm can be used. In such a case, the use of admixture should be considered to improve the bonding property and following-deformation capability of polymer and other materials. When reinforcing steel is used for the overlaying parts, the design thickness of the overlaying parts shall be 100 mm in principle, combining the space between the existing concrete and reinforcing steel (30 mm), the thickness of the upper surface covering of reinforcing steel (30 mm) and reinforcing steel diameter.

When FRP reinforcing materials are used for the overlaying parts, the cover can be reduced because there will be no corrosion due to chloride ion penetration or some other factor. Therefore, the thickness is the same as that employed for the top-surface overlaying method that does not involve the placement of reinforcing steel.

8.7.2 Cover

The cover for top-surface overlaying shall be determined taking into consideration the bonding strength of cementitious materials and reinforcing materials, construction error and the durability of the structure.

A cover shall be provided whose thickness is more than the value obtained by adding construction error to the diameter of reinforcing steel, and the thickness shall be determined taking into consideration the existing records and whether fibre is mixed among other things. Also, the unevenness on the surface of the existing concrete members resulting from surface treatment should be taken into consideration.

8.7.3 Placement of reinforcing materials

In top-surface overlaying, reinforcing materials shall be placed taking into consideration the space between reinforcing materials and the space between the existing concrete surface and reinforcing materials in order to ensure that the reinforcing materials achieve the specified strengthening performance and constructability.

The space between the existing concrete surface and reinforcing steel and the space between reinforcing steels need to be determined taking into consideration the maximum size of coarse aggregate and the length of the fibre. These spaces shall be more than four-thirds times the maximum size of coarse aggregate and more than the length of the fibre.

In top-surface overlaying for decks, the space between the existing concrete and reinforcing materials can be set to 30 mm based on the assumption that it should be more than four-thirds times the maximum size of coarse aggregate as well as the filling property of concrete and the length of the fibre.

8.7.4 Joints for reinforcing materials

Joints for the reinforcing materials used in the overlaying parts shall ensure the transfer of stress without failure at the joint part.

In top-surface overlaying for decks, lap splices can be used as joints for steel materials. If divided construction is affected, the construction work can be performed using joints whose length is 20 times or more the reinforcing steel diameter. This is based on the assumption that the confinement effect of steel fibre-reinforced concrete used in top-surface overlaying contributes to the integrity of lap splices. If lap splices of the specified length are not available, mechanical joints shall be used.

8.7.5 Structural details related to seismic performance

Structural details related to seismic performance shall be as set forth in ISO 5091-1:2023, Clause 8.

9 Construction

9.1 General

The construction for top-surface overlaying shall be performed according to a construction plan.

Engineers with sufficient knowledge and experience in the construction for top-surface overlaying shall be present at the site and the construction work shall be performed under the direction of those engineers.

If any troubles disable working along the construction plan in the actual construction for top-surface overlaying, appropriate measures shall be taken to ensure the performance required at the time of design under the direction of the responsible engineer.

The example of the construction procedure for bridge deck is shown in Annex A.

9.2 Prior investigation and construction plan

The existing concrete structure, to which top-surface overlaying is applied, shall be fully investigated in advance to check differences from design documents, the status of damage and so on.

When decks are the target, the investigation involves visually checking for cracking and efflorescence from under the decks. Also, core samples shall be collected from the road surface to measure the pavement thickness, reinforcing steel covering, etc.

A construction plan shall be formulated, and a construction plan document shall be created to perform the construction for top-surface overlaying appropriately. When formulating a construction plan, the structural conditions of the existing structure, environmental conditions of the site, construction conditions and other relevant factors shall be taken into consideration.

When formulating a construction plan for top-surface overlaying, it is important to create an appropriate construction plan according to the conditions of the site. When decks are the target, an example of the construction procedure is shown in Figure A.2. The items to note are described below.

a) Cutting

b) Cleaning

c) Assembly of reinforcing material

d) Manufacturing

e) Execution of overlaying

f) Curing

g) Pavement

9.3 Mix proportion of cementitious materials

The mix proportion of cementitious materials shall be designed, taking into consideration the construction conditions and environment, variations in the quality of the materials used, etc., so that the materials fulfil the required performance.

The points to note regarding how to design a mix proportion necessary to ensure the integrity between the existing and overlaying parts when cementitious materials are placed on the top-surface overlaying parts of certain members are described as follows.

a) Design material age and strength: Since the design strength of cementitious materials in top-surface overlaying assumes the integrity between the existing and overlaying parts, a strength equal to or greater than that of the concrete of the existing parts is required. The material age at

which the design strength is established is often set to 3 h when very high early strength cement is used or 7 d when high early strength Portland cement is used. When determining the water-cement ratio that satisfies the design strength at the specified material age, trial mixing needs to be performed using the cementitious materials that are actually used for top-surface overlaying in order to find the relationship between the water-cement ratio and strength. Polymer hydraulic cement mortar is premixed in many cases. By mixing it with an amount of water proven to ensure performance, polymer hydraulic cement mortar having the specified performance can be obtained.

b) Maximum size of coarse aggregate: It is common to use coarse aggregate whose maximum size is 20 mm. If there are restrictions on the thickness of the top-surface overlaying work or the covering of or space between reinforcing materials, the maximum size of coarse aggregate can be set to a value smaller than 20 mm.

c) Slump: When top-surface overlaying is applied to decks, construction is performed mainly by machines and, therefore, stiff-consistency concrete with a slump of 5 cm is used. By contrast, when construction is performed through manpower, the slump is often set to 8 cm or so.

d) Air content: Generally, air content is often set to 2 % to 3 % when very high early strength cement is used at the site plant or around 4,5 % when high early strength Portland cement is prepared by a mixer at a ready mixed concrete plant is used.

e) Mineral admixture and supplementary cementitious materials quantity: When an expansive additive is used for shrinkage compensation or crack prevention, the unit quantity shall be established so as to achieve the required performance.

f) Chemical admixture quantity: The quantity of high-performance water reducing agents to be used needs to be checked through trial mixing. To determine the polymer-cement ratio when using polymer, premixed polymer hydraulic cement mortar with proven performance needs to be used. If the polymer is added, the appropriate quantity of polymer to be used needs to be determined separately through testing. When fibre is used, the fibre mix ratio needs to be determined taking into consideration the strengthening effect and constructability of fibre. The fibre mix ratio of steel fibre-reinforced concrete is often set to 1,0 to 1,3 vol. %.

9.4 Preparation

Before intervention is performed with top-surface overlaying, preparation work shall be done as necessary.

When top-surface overlaying is applied to decks, the pavement materials such as asphalt, water-resistant layer and tack coat shall be cut and removed in advance because they impair the integrity between the existing members and overlaying members. Examples of the preparation work applied to decks are as follows.

a) Removal of degraded parts of concrete.

b) Carry-in and accumulation of raw cement materials (when mixing is performed at the site).

c) Building of a site plant (when mixing is performed at the site).

d) Consideration of the method of transporting concrete at the site.

e) Carry-in, installation, etc. of machines and facilities such as dedicated concrete finishing machines.

9.5 Surface treatment

In surface treatment for top-surface overlaying, dirt oil and fat on the surface of the existing members and vulnerable layers shall be removed so that the existing concrete and overlaying parts are integrated. Also, harmful cracks, floating, peeling and water leaks shall be treated appropriately.

In principle, surface treatment shall be performed using water jetting, vacuum blasting, sandblasting, chipping or other appropriate method and involve removing oil, grease and other dirt, vulnerable

layers and cement paste and exposing the sound surface. If the surface of the existing members has construction defects such as honeycombs, noticeable degradation, cracks, water leaks, the existing members shall be repaired using an appropriate method such as patching repair, crack injection or water leak prevention.

9.6 Assembly of reinforcing materials

Individual reinforcing materials shall be jointed and anchored by means of the method specified according to the type of reinforcing material.

9.7 Manufacture of cementitious materials

Cementitious materials shall be manufactured so as to achieve the required quality in principle in accordance with ISO 16311-4.

9.8 Transportation, placement, compaction and finish

For the transportation of cementitious materials, a method that considers the separation of materials and a drop-in fluidity shall be selected.

Cementitious materials shall be unloaded and placed such that the separation of the materials does not occur.

Compaction shall be performed using a vibrator promptly after cementitious materials are placed. Prior to compaction using a vibrator, the areas around the mold and construction joints shall be compacted fully by means of a simple device or other tools.

The surface shall be finished so that the specified shape, size and quality are achieved. It is important to plan these processes so that they can be performed consecutively. Appropriate methods for placement, compaction and finish shall be selected in principle based on an understanding of the properties of the materials and the characteristics of the structure.

Cementitious materials shall be transported, placed, compacted and finished in principle in accordance with ISO 16311-4. In top-surface overlaying for decks, when an adhesive is used to increase the bond strength between the existing decks and the fibre-reinforced concrete of the overlaying parts, the concrete shall be placed while adhesive is applied to the surface of the existing parts.

A dedicated concrete finishing machine should be used for compaction. At the start and end of compaction with the dedicated concrete finishing machine, the compaction work needs to be done through manpower using a mold vibrator. The dedicated concrete finishing machine is required to have a vibration property that ensures the integrity between the existing members and cementitious materials, in addition to proper flatness of the finished surface. A machine with proven performance should be used.

9.9 Curing

The mortar or concrete applied for overlaying shall be cured such that it is not subject to sudden temperature changes, drying or other detrimental action, such as vibration and deformation.

9.10 Pavement

Since waterproofing have a great impact on durability, materials shall be selected, based on an understanding of the structure, construction time, compatibility with cementitious materials and other relevant conditions, so that the specified waterproof performance is achieved.

Care shall be taken because, depending on the combination of the curing agent used when placing cementitious materials and the waterproof materials, the required bonding performance cannot be achieved.

As for asphalt pavement, care shall be taken in determining the transportation time of materials and selecting the machines to be used in order to ensure the specified quality at various outside air temperatures.

When the surface of the overlaying members is used as concrete pavement, it shall meet the performance requirements of pavement.

9.11 Quality control

Quality control shall be implemented for specified items in each phase of construction so as to check that the structure repaired or strengthened through top-surface overlaying has the required level of quality. Quality control shall involve not only controlling the quality of reinforcing materials but, in the case of mortar overlay or concrete overlay, managing the mixing and accomplishing mix proportion management.

a) Quality control of reinforcing materials

b) Mixing management

c) Mix proportion management

d) Strength management

The quality of mortar overlay or concrete overlay shall be checked before being carried in, based on the quality records created during production at the plant. At the site, the compressive strength and bond strength of the mortar or concrete shall be checked in appropriate construction quantities.

9.12 Inspection

A structure constructed with top-surface overlaying shall be in principle inspected according to an inspection plan under the responsibility of the ordering party of the structure. Destructive tests should be conducted such as a bonding strength test and non-destructive tests using the impact echo method, tapping sound, etc. as inspections for the repaired or strengthened structure in order to check for gaps and other anomalies between the existing and overlaying members.

10 Records

Information concerning the intervention of a structure shall be recorded by means of an appropriate method and retained for a necessary period. The method of recording shall be as set forth in ISO 5091-1:2023, Clause 10.

11 Maintenance

The maintenance of a structure repaired or strengthened with top-surface overlaying shall be as set forth in ISO 5091-1:2023, Clause 11.

Particularly, if there is water intrusion after completion, there is concern of early degradation occurring on the bond interface and the water should therefore be drained promptly.

Maintenance shall be performed to prevent re-degradation, taking into consideration the post-intervention environment and the condition of the structure.