
**Structural intervention of
existing concrete structures using
cementitious materials —**

**Part 4:
Jacketing**

*Intervention structurelle sur les structures en béton existantes
utilisant des matériaux cimentaires —
Partie 4: Chemisage*

[ISO 5091-4:2023](https://standards.iso.org/iso/5091-4:2023)

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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 document 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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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.

The jacketing is cases of intervention in which the jacketing method is used to repair or strengthen concrete structures such as reinforced concrete bridge piers damaged by seismic actions. When a damaged concrete structure is repaired or strengthened using the jacketing method, the status of damage such as concrete cracking and spalling are grasped through a prior investigation and crack injection or sealing, patching repair and other measures are taken in advance as necessary.

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

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Structural intervention of existing concrete structures using cementitious materials —

Part 4: Jacketing

1 Scope

This document specifies the standard requirements regarding design, construction and maintenance to be applied for structural intervention using the jacketing method, which places reinforcing materials such as reinforcing steel or fibre-reinforced polymer (FRP) grids around the periphery of existing concrete column or beam and jackets these members with cementitious materials.

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 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
jacketing**

method in which additional cementitious materials and associated reinforcement are added to the periphery of the existing concrete member to increase its strength, stiffness and/or ductility

Note 1 to entry: It is applicable to columns, bridge piers, rigid-frame pier beams, 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
intermediate penetrating tie**

reinforcing member, generally made of steel or fibre-reinforced polymer (FRP), that is installed inside the drilled hole and glued into the concrete substrate to improve the ductility and shear strength of bridge piers

**3.5
reinforcing material**

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

**3.6
polymer hydraulic cement mortar**

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

**3.7
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 which to consider intervention using the jacketing method shall be conducted as set forth in ISO 5091-1:2023, Clause 4.

When an earthquake-affected structure is repaired or strengthened using the jacketing method, the status of damage to that structure shall be studied in detail.

4.2 Investigation

4.2.1 Investigation using documents, records

An investigation using documents, records, etc. shall be conducted in accordance with ISO 5091-1:2023, 4.2.1.

Details of the materials used in the target existing structure and the structural specifications shall be understood from the design documents created at the time of construction, the design documents for the intervention work performed before the consideration of intervention.

4.2.2 On-site investigation

The on-site investigation on the existing structure shall be conducted in accordance with ISO 5091-1:2023, 4.2.2. Specifically, an earthquake-affected structure shall involve studying the status of damage caused by the earthquake in detail.

In the structural performance evaluation based on the appearance changes, the grades of structural performance shall be established on mechanical grounds taking into full consideration the degree of each graded appearance change and the impact of the changed region on structural performance. Appearance changes can be classified into the following three grades.

- Grade I: No or minor damage
- Grade II: Moderate damage
- Grade III: Severe damage

The mechanical resistance of the change region should be classified into the following four levels.

- Level a: Resistance remaining intact
- Level b: Slightly degraded resistance
- Level c: Significantly degraded resistance
- Level d: No resistance

5 Intervention design

5.1 General

In the intervention design using the jacketing method, a rational structural plan shall be formulated, and structural details shall be established based on that plan so that the structure after intervention fulfils the required performance throughout the remaining design service life.

When an earthquake-affected structure is repaired or strengthened using the jacketing method, it is necessary to take appropriate measures for the members damaged by the earthquake first. The intervention plan shall be considered.

5.2 Structural plan

In the intervention plan using the jacketing method, the intervention method shall be selected, taking into consideration the structural properties, materials, construction method and restrictions, maintenance method, economy to ensure that the required performance is fulfilled under the environmental conditions of the structure, factoring in the structure's importance.

In the design phase, it can be considered that the public safety requirements regarding the spalling off of the jacketing part and other public disaster risks for users of the structure, third parties, etc. are met if the requirements set forth in [8.3](#) are met.

5.3 Structural details

In intervention using the jacketing method, structural details shall be determined so as to ensure the integrity between the existing members and jacketing parts.

The members to be repaired or strengthened using the jacketing method, the range of intervention, the arrangement of reinforcing materials around the periphery of the existing members, the thicknesses of reinforcing material covering and jacketing material, etc. shall be established appropriately so that the performance requirements of the structure are met.

If the flexural load-carrying capacity needs to be improved, the reinforcement placed around the periphery shall be anchored securely enough to the existing parts.

If the ductility needs to be improved, it is advisable to consider placing intermediate penetrating tie according to the cross-sectional shape of the existing structure.

6 Materials

6.1 General

The materials used for jacketing shall be of proven quality to ensure that the required performance is fulfilled for a necessary period. Specifically, for jacketing for the seismic strengthening of an existing structure, materials shall be selected to ensure the integrity between the existing parts and jacketing parts so that the structure repaired or strengthened through jacketing fulfils the seismic performance.

6.2 Materials in existing structure

The characteristic values of material strength, design values and material factors of the materials in an existing and earthquake-affected structure shall be determined in accordance with ISO 5091-1:2023, 6.2.

When intervention is targeted at an earthquake-affected structure, the materials in the existing structure can have incurred severe damage, such as yielding or buckling of reinforcing steel, cracking of concrete or crushing of core concrete, and the impact of that damage shall be evaluated appropriately. If any measure such as cracking repair or patching repair has been taken for such damage prior to intervention through jacketing, the characteristic values, design values and material factors of the materials in the existing part shall be determined, appropriately taking into consideration the influence of that measure as necessary.

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 through jacketing shall be as set forth in ISO 5091-1:2023, 6.3.

[Table 1](#) shows the classification of the materials used for jacketing. In this document, they refer to the following materials.

- Primer used to improve the bond strength of the existing concrete and mortar.
- Anchor grouting material used to anchor longitudinal reinforcement or other reinforcing materials to footings.
- Adhesive used to bond reinforcing materials and existing concrete. It is mainly used for a construction method that requires a bond for reinforcing materials placed in grooves on existing concrete cover or for bonding intermediate penetrating tie.

Table 1 — Types of materials used for jacketing

Construction method	Cementitious materials	Reinforcing materials	Bonding products	Filling materials
Concrete jacketing	— Concrete	— Reinforcing steel — Prestressing steel — FRP reinforcing materials	— Primer — Anchor grouting material	— Non-shrink grout
Mortar jacketing	— Mortar	— Reinforcing steel — FRP reinforcing materials	— Adhesive	— Mortar

6.3.2 Cementitious materials

The cementitious materials used for jacketing shall be selected in accordance with ISO 5091-1:2023, 6.3.2.

In principle, as the concrete used for concrete jacketing, high-quality materials having the required level of workability appropriate for construction through jacketing shall be selected and an appropriate mix proportion shall be established by performing trial mixing so as to minimize the change in quality over time after hardening.

When appropriate testing and analysis have confirmed that the compressive strength and other material properties of the concrete, which have been created with an appropriate mixing design through the use of materials of proven quality, will exhibit almost no change over time, the material properties at the time of verification may be used as those for intervention construction.

With the jacketing method, reinforcing materials, such as reinforcing steel, are placed on the outer surface of the existing structure. It is therefore advisable to make the reinforcement covering of the jacketing concrete sufficiently thick or, if necessary, provide the jacketing parts with surface protection so as to ensure that the reinforcing materials deteriorate as little as possible over time. When deterioration in the material properties over time can be prevented through appropriate protection, the material properties at the time of verification may be used as those for intervention construction.

As the mortar used for mortar jacketing, materials with proven quality and safety for which an appropriate mix proportion is established shall be used according to the type of spraying or trowelling work.

As the materials for dry or wet spraying, those proven to meet the quality and safety requirements for spraying mortar shall be used. [Table 2](#) shows typical examples of the composition of the materials used in spraying mortar.

Table 2 — Typical examples of the composition of the materials used in spraying mortar

Materials		Materials for dry spraying	Materials for wet spraying
Cement		Ultrarapid hardening cement (high early strength Portland cement or normal Portland cement to be used depending on circumstances)	Portland cement, Portland blast-furnace slag cement, Portland fly ash cement and calcium-aluminate cement
Fine aggregate		Dry natural fine aggregate ^a	Dry natural fine aggregate and lightweight Aggregate
Fibre		Steel fibre and organic fibre	Mainly organic fibre
Admixture	Cement mixing polymer ^b	Polymer dispersion	Polymer dispersion and redispersible polymer powder
	Water reducing agent	-	Can be used.
	Water retention agent	-	Used in many cases.
	Accelerant	-	Can be used when thickening is required for construction in cold weather.
	Retarder	-	Can be used for construction in hot weather.
	Quick setting agent	Can be used. ^c	Can be used.
	Expansive additive	-	Used in many cases.
	Fine powder	Can be used.	Used in many cases.
Water		Tap water is used normally.	
^a Mainly mechanically stabilized prepacked aggregate. ^b In the case of polymer hydraulic cement mortar. ISO 5091-4:2023 ^c When high early strength Portland cement or ordinary Portland cement is used. 94b-1b87-4882-bcd0-863561ef91a8/iso-5091-4-2023			

6.3.3 Reinforcing materials

The reinforcing materials used for jacketing shall be selected in accordance with ISO 5091-1:2023, 6.3.3.

The reinforcing steel and FRP materials shall be checked to confirm that they possess mechanically reliable material properties including strength, elongation capacity, Young's modulus and coefficient of linear thermal expansion. Steel materials that fulfil the quality requirements set forth in the relevant national standards should be used.

The durability of an FRP reinforcing material varies depending on the types of continuous fibre and matrix resin. It is necessary to check the durability of the composite material after molding.

6.3.4 Bonding products

The bonding products used for jacketing shall be selected in accordance with ISO 5091-1:2023, 4.3.5.

A primer that meets the performance requirements shall be selected so that stress is transferred between the existing concrete and the cementitious materials of the jacketing parts.

With the mortar jacketing method, a primer is generally applied before the jacketing of mortar to ensure the transfer of stress between the existing concrete and mortar. A primer of proven quality that ensures the bonding property of the existing concrete and mortar shall be selected according to the type of mortar used.

An anchor grouting material that has the required strength and ensures the anchorage strength between the existing concrete and reinforcement shall be selected.