

Recommendations for Design and Construction of Prestressed
Concrete Structures Using Advanced Prestressing Steel Coated
with Epoxy Resin

– Draft –

– Epoxy Coated and Filled Strand –

– Pre-grouted Tendon –

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Japan Society of Civil Engineers

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[Part 1: Common]

Chapter 1 General Rules

1.1 Scope of Application

- (1) The Recommendations (draft) provide guidelines for the design, construction, and inspection of prestressed concrete structures using advanced prestressing steel with epoxy resin, as defined in Section 1.2, as the prestressing tendons.
- (2) Construction and design details not covered in the Recommendations (draft) shall be implemented in accordance with the Japan Society of Civil Engineers (JSCE) Standard Specifications for Concrete Structures (hereafter referred to as the Specifications). Although the Recommendations (draft) are consistent with the 2007 version of the Specifications, any later amendments to the Specifications shall be appropriately taken into account when following the Recommendations (draft).

1.2 Advanced Prestressing Steel Using Epoxy Resin Covered by the Recommendations (draft)

- (1) The Recommendations (draft) cover two types of advanced prestressing steel fabricated with epoxy resin: epoxy coated and filled strand (ECF strand) and pre-grouted tendon.
- (2) ECF strand complies with JSCE standard JSCE-E 141 (draft) and is coated and impregnated to fill the interstices between the wires with epoxy resin.
- (3) Pre-grouted tendon complies with JSCE standard JSCE-E 145 (draft) and is coated with unhardened epoxy resin and then enclosed in a sheath for further protection.

1.3 Design Life and Maintenance

- (1) The design life of prestressed concrete structures using advanced prestressing steel with epoxy resin shall be 100 years.
- (2) When carrying out maintenance of prestressed concrete structures using advanced prestressing steel coated with epoxy resin, the characteristics of respective prestressing steel must be taken into consideration.

1.4 Environment and Economics

The planning, design, construction, maintenance, demolition and disposal or reuse of prestressed concrete structures using advanced prestressing steel coated with epoxy resin shall be carried out with sufficient consideration of the effective use of resources, reduction of environmental load, and economics, etc.

1.5 Definitions

The main terms used in the Recommendations (draft) are defined as follows.

Normal prestressing steel:	Prestressing strand or prestressing bar without corrosion resistant covering.
Epoxy resin:	A resin obtained by polymerizing a compound containing two or more epoxy radicals in the molecule.
Epoxy coated and filled strand (ECF strand):	Coated prestressing strand complying with JSCE standard JSCE-E-141 (draft), in which the surface of the prestressing strand is cleaned, then heated and coated with epoxy resin so that the resin impregnates interstices between the wires.
Grit:	Inactive particles such as silica sand that are embedded in the surface of the epoxy resin coating.
Standard ECF strand:	ECF strand in which the corrosion-resistant covering is provided by the epoxy resin coating only.
Bonded-type ECF strand:	ECF strand with grit embedded in the surface of the epoxy resin coating to improve the bondability with concrete.
PE-coated ECF strand:	ECF strand in which the surface of each standard ECF strand is protected with polyethylene.
Coating continuity:	Continuity of the resin coating on an ECF strand, such that the steel surface is not exposed by pin holes, splits, etc.
Repair paint:	Paint used to repair damage to the epoxy resin coating or the cut end of an ECF strand.
Crown:	The part of the covering at the point of intersection of the line joining the center of the core wire and the center of the outer wire with the outside periphery of the outer wire.
Coil:	The smallest unit of ECF strand product manufactured as a single continuous length by the process of coating an uncoated prestressing strand with epoxy resin.
Pre-grouted prestressing strand:	Coated prestressing strand complying with JSCE standard JSCE-E 145 (draft), in which the prestressing strand is coated with unhardened epoxy resin and then a continuous covering of polyethylene is given by the extrusion method, forming surface irregularities on the internal and external surfaces.
Pre-grouted prestressing bar (using resin sheath):	Coated prestressing bar complying with JSCE standard JSCE-E 145 (draft), in which the prestressing bar is coated with unhardened epoxy resin and then a continuous covering of polyethylene is given by the extrusion method, forming surface irregularities on the internal and external surfaces.
Pre-grouted prestressing bar (using steel sheath):	Coated prestressing bar complying with JSCE standard JSCE-E 145 (draft), in which the prestressing bar is inserted into a steel sheath that satisfies the performance specified in the JSCE Specifications [Construction: Special Concrete Chapter 12 Prestressed Concrete], and the sheath is filled with unhardened thermo-hardening epoxy resin for pre-grouting.
Moisture-hardening epoxy resin for pre-grouted tendon:	Epoxy resin that gradually hardens with time using hardening agent (ketimine) that is activated by reacting with moisture; hardening has low temperature dependence.

Thermo-hardening epoxy resin for pre-grouted tendon:	Epoxy resin that gradually hardens with time using latent hardening agent that melts when heated and hardening promoting agent.
Complete hardening:	Indicates the state of complete hardening of resin in the hardening process of pre-grout resin. For pre-grout resin subject to the Recommendations (draft), this indicates the state when the hardness is 80D or higher when measured in a durometer D hardness test in accordance with JIS K 7215.
Effective bond strength:	The bond strength between the pre-grouted tendon and concrete that is equivalent to the bond strength between the prestressing tendon and the concrete in case of cement grout under the same conditions of tendon diameter, concrete strength, etc.
Unhardened pre-grout resin:	The state before the bond strength between pre-grouted tendon and the concrete member reaches the effective bond strength.

[Part 2: Epoxy Coated and Filled Prestressing Strand]

Chapter 1 ECF Strand

1.1 General

- (1) The types of ECF strand that are the subject of the Recommendations (draft) are as specified in Table 1.1.1.

Table 1.1.1 ECF strands as used in the Recommendations (draft)

Types	Standard type, Bonded type, PE-coated type
Steel type	Prestressing strand (7-wire strand)
Nominal diameter (steel portion)	12.7mm, 15.2mm

- (2) Apart from the PE-coated type, the types of ECF strand that are the subject of the Recommendations (draft) shall not be used in an environment where they are permanently outdoors and exposed to direct ultraviolet light.
- (3) If an ECF strand that is the subject of the Recommendations (draft) is used as the prestressing tendon for pretensioning, it shall be used in an environment where fire resistance is not required as standard.

1.2 Quality of ECF Strand

- (1) ECF strand shall comply with JSCE-E 141 “Specification for epoxy coated and filled strand for prestressed concrete (draft)”.
- (2) In case that the epoxy resin covering of the ECF strand is damaged, appropriate repair shall be carried out using repair paint complying with JSCE-E 143 “Specification for repair paint of epoxy coated and filled strand for prestressed concrete (draft)”.

1.3 Handling, Storage, and Transport of ECF Strand at Manufacturing Plant

- (1) ECF strand shall be handled with care so as to avoid damaging the covering.
- (2) Standard and bonded-type ECF strands shall be packaged by winding onto a drum as standard.
- (3) When storing standard and bonded-type ECF strands, care shall be taken to ensure that they are not exposed to direct sunlight.
- (4) When transporting ECF strand, measures shall be taken to ensure no damage occurs to the coating during transport.

Chapter 2 Design

2.1 General

This chapter describes particulars regarding the design of structures using ECF strand.

2.2 Prestressing Force

2.2.1 Friction loss

- (1) The decline in prestressing force due to friction between the ECF strand and the sheath shall be calculated in accordance with the Specifications [Design].
- (2) The friction coefficient between the ECF strand and the sheath shall be appropriately determined in accordance with the type of ECF strand and the location of use.

2.2.2 Seating loss

Specific anchors shall be used for tensioning and anchoring ECF strand. The recommended value for the respective method of anchoring can be used as the seating loss.

2.2.3 Relaxation

The decline in prestressing force resulting from relaxation of the ECF strand shall be calculated in accordance with the Specifications [Design].

2.2.4 Young's Modulus

Young's modulus of ECF strand may be the same as that of normal prestressing strand.

2.3 Bonding with Concrete

2.3.1 Bond anchorage length of pretensioning strand

In case that ECF strand is used as the prestressing tendon for pretensioning, bonded-type strand shall be used, the bond anchorage length may be the same as that of normal prestressing strand.

Chapter 3 Verification of Structure Durability

3.1 General

When ECF strand is used, a check shall be carried out to confirm that the structure will maintain the required performance over its design life.

3.2 Verification of Structural Durability due to the Degradation of ECF Strand

- (1) The verification of structural durability due to the degradation of ECF strand may be checked by verifying the durability of the ECF strand itself.
- (2) The verification of ECF strand durability may be omitted for structures that (i) use ECF strand complying with the specification in “JSCE Standard (Draft)”, (ii) satisfy the requirements of “Chapter 4 Structural Details”, and (iii) were constructed in accordance with the construction methods specified in “Chapter 5 Construction”.

Chapter 4 Structural Details

4.1 General

When ECF strand is used, structural details specified in this chapter shall be complied with.

4.2 Deviators

4.2.1 Radius of Curvature

The minimum radius of curvature in ECF strands at deviators along the center of the deviator tube shall be as given in Table 4.2.1.

Table 4.2.1 Minimum radius of curvature in ECF strands at deviators

Name	Minimum radius (m)
7S12.7, 7S15.2	3.0
12S12.7, 12S15.2	3.0
19S15.2	3.0
27S15.2	3.5
37S15.2	4.0

4.2.2 Protection Method for ECF Strand at Deviators

As a rule, ECF strand at deviators shall be protected using resin tubes.

4.3 Anchorages

4.3.1 Protection Method for Anchorages

As a rule, anchorages shall be protected using corrosion prevention treatment.

4.4 Protecting the Covering

4.4.1 ECF Strand Used as an External Cable

- (1) When ECF strand is used as an external cable, in principle, protection shall be provided to prevent degradation of the prestressing strand due to penetration of chloride ions and degradation of the epoxy resin covering due to ultraviolet.
- (2) Notwithstanding the provision in (1), when ECF strand is used as an external cable inside a box girder, protection against steel corrosion due to chloride ions and against degradation due to ultraviolet may be omitted.

4.4.2 ECF Strand Used as an Internal Cable

- (1) When ECF strand is used as an internal cable, the bonded-type of strand shall be used in principle, and protection of the ECF strand against penetration of chloride ions and degradation due to ultraviolet is unnecessary.
- (2) When ECF strand is used for pretensioning, a corrosion protection treatment shall be carried out on the cut surface using epoxy resin.
- (3) When ECF strand is used as an internal cable for post-tensioning, a polyethylene sheath shall be used in principle.

4.4.3 ECF Strand Used as a Stay Cable

When ECF cable is used as a stay cable, protection shall be provided in principle.

Chapter 5 Construction

5.1 General

- (1) In the usage of the ECF strand for construction, sufficient care shall be taken to prevent damage to the epoxy resin coating during transport, storage, installation and tensioning operations, and long-term direct exposure to ultraviolet shall be avoided.
- (2) The usage of the ECF strand for construction shall be carried out at an ambient temperature of -10°C or higher in principle.

5.2 Materials

5.2.1 ECF Strand

ECF strand that complies with “1.2 Quality of ECF Strand” shall be used.

5.2.2 Anchoring and Coupling Devices

Anchoring and coupling devices used with ECF strand shall comply with the Specifications [Construction: Special Concrete, Section 12.4.2]. In addition, if wedge-type

anchoring devices are used, the teeth of the wedges shall be designed such that they bite the epoxy resin covering through and anchor onto the steel surface. Also, in the application for external cables or stay cables, the prestressing tendons that are confirmed to have sufficient fatigue strength near the anchoring and coupling devices shall be used.

5.2.3 Corrosion Prevention Materials

- (1) For corrosion prevention of anchorages, materials that have sufficient corrosion prevention effect, such as cement grout, etc. shall be used.
- (2) Corrosion prevention materials shall be capable of filling the inside of anchorages and deviator tubes.
- (3) The corrosion prevention material used for filling the inside of sheaths for internal cables shall be cement grout as standard.

5.2.4 Sheaths and Protection Tubes

- (1) Polyethylene sheaths confirmed that its deformation does not easily occur during handling and during the casting of concrete shall be used.
- (2) Materials of tubes used to protect the epoxy resin coating during construction, such as when installing the cables, etc., shall be softer than epoxy resin.

5.3 Transport and Storage

5.3.1 Transport

- (1) Damage or harmful deformation of the epoxy resin coating due to rubbing or hitting, etc., during transport shall be avoided.
- (2) The packaging of ECF strand when shipped from the factory varies depending on the cable arrangement, etc. ECF strand shall be properly handled according to the respective type of packaging.

5.3.2 Storage

ECF strand shall not be stored directly on the ground. In principle it shall be stored in a warehouse or, in case kept outdoors, covered appropriately so as to avoid damage to the epoxy resin coating, adherence of dirt, and direct ultraviolet, etc.

5.4 Installation

- (1) Specific equipment suitable for each type of packaging shall be used to uncoil the ECF strand, so as to avoid damage to its epoxy resin coating.
- (2) The ECF strand shall be installed correctly according to the alignment and dimensions indicated by the design, and there shall be no tangling of the ECF strand.

- (3) When installing the strand, care shall be taken to ensure that the epoxy resin coating is not damaged by contact with concrete, reinforcement, steel members, metal parts of the installation equipment, or other objects that are harder than the epoxy resin. Also, when uncoiling the strand and inserting it into a beam, the work shall be visually monitored by a deployed staff.
- (4) When installing bonded-type ECF strand, it is desired to insert the bundled strands in a single operation.

5.5 Assembly and Installation of Anchoring Devices

- (1) Anchoring devices designed specifically for use with ECF strand and that comply with the performance specified in Section 5.2.2 shall be used. They shall be installed such that the position of each component is properly maintained.
- (2) Anchoring devices shall be installed such that no partial bending of the ECF strand arises as a result of improper placement.
- (3) Inlet holes and outlet holes shall be provided at appropriate positions of a head cap to ensure that voids do not form in the corrosion prevention material injected into the anchoring devices.

5.6 Assembly and Installation of Deviators

- (1) Deviators shall be installed such that no partial bending of the ECF strand arises as a result of improper placement.
- (2) Resin tubes to protect the ECF strand shall be installed on the deviators at specific locations, and it shall be checked whether they are properly located after the tensioning operation.

5.7 Tensioning Operations

- (1) Tensioning shall be carried out using tensioning equipment specifically designed for ECF strand cables, so that the specified tension force is obtained.
- (2) Tensioning shall be controlled in the same way as for normal prestressing steel in accordance with the Specifications [Construction: Special Concrete, Section 12.6.4]. Tensioning shall be controlled such that the tensioning force applied to the cable is not less than the designed value.
- (3) After tensioning, the excess length of prestressing strands shall not be removed using a gas cutter.
- (4) When injecting corrosion prevention material into the anchoring devices with fitting protective caps, the planning and execution shall be made taking particular properties of the corrosion prevention material into consideration.

5.8 Use of ECF Strand in Stay Cables

5.8.1 Installation of Pre-fabricated Cables

When using pre-fabricated stay cables, specific suspension equipment suitable for the cable installation method shall be used and care shall be taken not to damage the high-density polyethylene covering, etc.

5.8.2 Assembly and Installation of Saddles, etc.

- (1) Saddles, etc., shall be installed such that the partial bending does not arise in stay cables as a result of improper placement.
- (2) When filling saddles with cement grout, inlet holes and outlet holes shall be planned to be able to fill them certainly.

5.9 Use of ECF Strand in Internal Cables

5.9.1 Use for Post-tensioning

5.9.1.1 Installation of Internal Cables

When installing cables, necessary measures shall be taken to prevent contact with concrete or metal, etc., the work shall be visually monitored by a deployed staff, and damage to the epoxy resin covering of the ECF strand shall be avoided.

5.9.1.2 Assembly and Installation of Sheaths

When fixing the polyethylene sheath covering the ECF strand, a method that does not damage the sheath shall be used.

5.9.2 Use for Pretensioning

5.9.2.1 Installation

- (1) Equipment specifically designed for use with ECF strand shall be used when installing the cable so as to prevent damage to the epoxy resin coating.
- (2) When installing the ECF strand, any substances that might damage the bond with the concrete shall be removed.
- (3) If reinforcement having a corrosion prevention treatment is present near the bonded-type ECF strand, care shall be taken to prevent damage to the corrosion protection layer of reinforcement.

5.9.2.2 Assembly and Installation of Anchoring Devices and Coupling Devices

- (1) If ECF strand is directly anchored to an anchoring platform, anchoring devices specifically designed for use with ECF strand and having the performance specified

in Section 5.2.2 shall be used. Each component shall be installed to maintain its correct position.

- (2) When connecting ECF strand to the lead strand, special coupling devices shall be used and tensioning shall be carried out until the designed tension force is obtained.

5.9.2.3 Bending Up Equipment

Bending support devices or rollers used for bending up (or bending down) ECF strand shall be specifically designed for use with ECF strand.

5.9.2.4 Tensioning Operations

- (1) Tensioning control shall be carried out in the same way as for normal pretension steel in compliance with the Specifications [Construction: Special Concrete, Section 12.6.4], and tensioning control shall be carried out such that the tension force applied to the prestressing strands is not less than the designed value. Also, in principle, the anchoring force shall be released once the temperature of the concrete near the prestressing strands has fallen to 65°C or less.
- (2) After tensioning, corrosion prevention treatment shall be applied to the cut surface of the ECF strand using repair paint as specified in Section 5.10.2.

5.10 Repairs

5.10.1 General

If damage to the epoxy resin coating is observed by inspections carried out at any of the stages of construction, either repairs shall be carried out by an appropriate method using the materials specified in Section 5.10.2 or ECF strand shall be replaced.

5.10.2 Repair Materials

- (1) Materials complying with JSCE-E 143 “Specification for repair paint of epoxy coated and filled strand for prestressed concrete (draft)” shall be used for repairs.
- (2) Since the material used for repair of the epoxy resin coating contains harmful chemicals, construction shall be carried out in strict compliance with relevant laws and regulations, and appropriate safety measures shall be taken.

5.10.3 Repair Methods

Damage to the epoxy resin coating in general parts shall be repaired by applying the repair material to a thickness such that it visibly bulges above the surrounding coating. Damage to the epoxy resin coating near an anchorage shall be repaired to the same thickness as the surrounding coating, and tensioning shall be carried out only after the repair has hardened. The thickness of the coating at repair locations should be checked visually.

Chapter 6 Inspections

6.1 General

A rational and economic inspection plan shall be established to make it possible to check that a structure using ECF strand has the specified performance. The necessary inspections shall be carried out at each stage of construction. For inspection items not covered here, refer to the Specifications [Construction].

6.2 Acceptance Inspections for Materials

- (1) Acceptance inspections for ECF strand shall comply with Table 6.2.1. When opening a package of ECF strand, a visual inspection for damage to the epoxy resin coating shall be carried out and, if damage is found, appropriate repair by the method specified in Section 5.10 shall be carried out or the ECF strand shall be replaced.

Table 6.2.1 Acceptance Inspections for ECF strand

Item	Test or inspection method	Timing; number	Judgment criterion
Quality standard	Confirmation of manufacturer's test results table	Upon receipt	Compliance with JSCE-E 141 (Draft)
Damage to epoxy resin covering	Visual inspection	Upon opening a package; every package	No visible damage

- (2) The acceptance inspection for anchoring devices and coupling devices shall confirm that they are items specifically designed for ECF strand as specified in Section 5.2.2.

6.3 Construction Inspections

- (1) Inspection of the installation of ECF strand shall be carried out in accordance with Table 6.3.1. It shall be visually confirmed that no damage occurs to the epoxy resin coating either during installation of the ECF strand or afterwards. If damage is found, appropriate repair shall be carried out by the method specified in Section 5.10 or the ECF strand shall be replaced. Repair locations shall be inspected visually or by touch to confirm that the repair has been appropriately carried out.

Table 6.3.1 Inspection of ECF strand installation

Item	Test or inspection method	Timing; number	Judgment criterion
Damage to epoxy resin coating	Visual inspection	During and after installation	No visible damage
Epoxy resin repair locations	Visual or tactile inspection	After repair; all repair locations	Repairs have been appropriately carried out

- (2) In the inspection of the anchoring devices and coupling devices, it shall be confirmed that the devices are designed specifically for ECF strand.

Chapter 7 Construction Records

7.1 General

Construction records shall be produced and filed in accordance with the Specifications [Construction].

[Part 3: Pre-grouted Tendons]

Chapter 1 Pre-grouted tendons

1.1 General

- (1) The types of pre-grouted tendons that are the subject of the Recommendations (draft) are as specified in Table 1.1.1 as standard.

Table 1.1.1 Pre-grouted tendons as used in the Recommendations (draft)

Types	Moisture-hardening type*, thermo-hardening type		
Sheath material	Polyethylene sheath, steel sheath**		
Steel type	Prestressing strand (7-wire strand)	Prestressing strand (19-wire strand)	Prestressing bar
Nominal diameter (steel)	15.2mm	17.8mm, 19.3mm, 21.8mm, 28.6mm	32mm

* Moisture-hardening type pre-grouted tendons shall be of the polyethylene sheath type only.

** Steel sheaths are for the prestressing bar type only.

- (2) The types of pre-grouted tendons that are the subject of the Recommendations (draft) shall in principle be used in environments where the temperature does not exceed the upper limit shown in Table 1.1.2.

Table 1.1.2 Upper limit of temperature for pre-grouted tendons

State	Control item	Upper limit of temperature
After casting concrete	Concrete temperature	Maximum temperature 95°C
Two weeks after casting	Concrete temperature	75°C
One month after casting	Concrete temperature	45°C

1.2 Quality of Pre-grouted Tendon

- (1) ECF strand shall comply with JSCE-E 145 “Specification for pre-grouted tendons installed in prestressed concrete (draft)”.
- (2) The epoxy resin used in pre-grouted tendons shall comply with JSCE-E 146 “Specification for epoxy resin for pre-grouted tendons installed in prestressed concrete (draft)”.
- (3) The sheath material for pre-grouted tendons shall comply with JSCE-E 147 “Specification for sheath for pre-grouted tendons installed in prestressed concrete (draft)”.

1.3 Selection of Epoxy Resin for Pre-grouted Tendons

- (1) The epoxy resin for pre-grouted tendons shall be selected taking into consideration the member in which it is to be used and the construction environment, the starting period of operation of the structure, and the components of epoxy resin shall satisfy the applicable conditions.
- (2) Selection of the resin shall be carried out appropriately at each stage of design and construction.

1.4 Handling, Storage, and Transport of Pre-grouted Tendons at Manufacturing Plant

- (1) Pre-grouted tendons shall be handled with care so as to avoid damaging the sheath surface.
- (2) When transporting pre-grouted tendons, resin leak-prevention caps shall be fitted to the ends of the pre-grouted tendon.
- (3) When storing pre-grouted tendons, care shall be taken to ensure that they are not exposed to long-term direct sunlight. They shall be stored in a location that does not reach high temperatures and in circumstances that do not cause damage to the sheath.
- (4) When transporting pre-grouted tendons, necessary measures shall be taken to ensure that there is no damage to the sheath during transport, and it shall be transported in such a manner that it will not collapse, etc.

Chapter 2 Design

2.1 General

This chapter describes particulars regarding the design of prestressed concrete structures or structural members using pre-grouted tendons.

2.2 Consideration of Bond between Concrete and Pre-grouted Tendon

- (1) As a rule the bending resistance of members fabricated with pre-grouted tendons once the effective bond strength has been reached shall be evaluated in the same way as for a member that uses a bonded internal cable.
- (2) The bending resistance of members fabricated with pre-grouted tendons before the effective bond strength being reached may be evaluated from the design bending strength of members using unbonded prestressing steel or external cables in accordance with the Specifications [Design: Section 15.6.3].

2.3 Coefficient of Friction

- (1) As a rule the coefficient of friction of pre-grouted tendons shall be appropriately determined based on test results, etc.
- (2) Where (1) above is not applied, the values given in Table 2.3.1 may be used.

Table 2.3.1 Coefficient of friction of pre-grouted tendons

Type of pre-grouted tendon	Alignment conditions	μ (1/rad)	λ (1/m)
Prestressing strand	Almost straight; short lengths	0.10	0.003
	Other than the above	0.30	0.004
Prestressing bar	Straight	-	0.003

2.4 Verification of Structural Durability

- (1) The durability of a concrete structure that uses pre-grouted tendon may be checked by verifying the durability of the pre-grouted tendon itself.
- (2) The above verification of durability may be omitted for structures that (i) use pre-grouted tendons complying with the specification in “JSCE Standard (Draft)”, (ii) satisfy the requirements of “Section 2.5 Structural Details”, and (iii) were constructed in accordance with the construction methods specified in “Chapter 3 Construction”.

2.5 Structural Details

When pre-grouted tendons are used, structural details of their use shall comply with the Specifications [Design].

Chapter 3 Construction

3.1 General

- (1) When carrying out construction with pre-grouted tendons, an appropriate construction plan shall be established to enable the pre-grouted tendons to achieve the expected performance. The plan shall be managed and the records shall be kept throughout the work.
- (2) The design shall specify the period during which the pre-grout resin is in a state suitable for tensioning of the tendon and the time at which the effective bond strength is achieved. These times shall be checked before commencement of construction to ensure that they coincide with those calculated based on the actual construction procedure. If there is any discrepancy, the period in which the pre-grout resin can be tensioned and the time at which the effective bond strength is achieved shall, in principle, be reviewed based on the actual construction procedure as determined prior to construction.
- (3) In its unhardened state, since pre-grout resin contains harmful chemicals, construction shall be carried out in strict compliance with the applicable laws and regulations, and appropriate safety measures shall be taken.

3.2 Transport and Storage

3.2.1 Transport

When transporting pre-grouted tendons, an appropriate method shall be used to ensure that no damage is caused to the sheath.

3.2.2 Storage

- (1) Pre-grouted tendons shall be appropriately stored to ensure that no damage is caused to the sheath.
- (2) Since the hardening rate of the pre-grout resin is greatly affected by storage temperature, care shall be taken with temperature control. Also, pre-grouted tendons shall be stored out of direct sunlight.
- (3) If the period in which a pre-grouted tendon can be tensioned is predicted to expire, then in principle the tendon should not be used.
- (4) The resin leak-prevention cap fitted to the ends of a pre-grouted tendon shall be removed immediately before tensioning.

3.3 Installation and Coupling

3.3.1 Installation

When fixing a pre-grouted tendon in the specified location, no damage shall be caused to the sheath.

3.3.2 Coupling

Coupling between pre-grouted tendons shall be properly carried out using coupling devices suitable for the prestressing steel used.

3.4 Concrete Casting

- (1) When casting the concrete, checks shall be carried out to ensure that the temperature conditions of the selected pre-grout resin are satisfied.
- (2) Casting and compaction of the concrete shall be carried out so that no damage is caused to the sheath.

3.5 Tensioning Operations

3.5.1 Control of Tensioning Period

- (1) Tensioning of a pre-grouted tendon shall be completed within the period in which the pre-grout resin can be tensioned.

- (2) If the external temperature falls below freezing point, measures such as adjusting the tensioning period or maintaining the curing temperature, etc., shall be considered.

3.5.2 Preparations for Tensioning

- (1) Immediately prior to tensioning, the sheath of the pre-grouted tendon shall be cut and removed to the front surface of the anchor plate.
- (2) For pre-grouted tendons where the prestressing strand is used, the pre-grout resin on excess length inserted into the tensioning jack shall be removed prior to tensioning.
- (3) The wedges of the tensioning jack shall be checked prior to tensioning so that the pre-grout resin is not bonded or hardened.

3.5.3 Tension Control

The tensioning operation shall be controlled so that the designed tension force is applied to the pre-grouted tendon.

3.5.4 Protection of Anchoring Devices

- (1) Immediately after tensioning, corrosion prevention and resin leak-prevention measures shall be taken for the prestressing steel in the anchoring devices.
- (2) After tensioning, the excess length of prestressing steel shall not be cut using a gas cutter.

3.6 Repairs

- (1) A pre-grouted tendon in which sheath damage is found to be accompanied by resin leakage shall be replaced. If there is sheath damage but no resin leak is detected, the pre-grouted tendon shall be properly repaired using the appropriate material.
- (2) A material used for sheath repair shall be one that will reliably prevent the penetration of moisture, etc., from outside.

Chapter 4 Inspections

4.1 General

- (1) This chapter provides the criteria for inspections to be carried out during construction of concrete structures using pre-grouted tendons. For inspection items not covered here, refer to the Specifications [Construction].
- (2) Inspections necessary to confirm that a pre-grouted tendon has the specified performance shall be carried out at each stage of construction.

4.2 Acceptance Inspections at Construction Site

- (1) Acceptance inspections for pre-grouted tendons at the construction site shall comply with Table 4.2.1 as standard.

Table 4.2.1 Acceptance inspections for pre-grouted tendons at construction site

Item	Test or inspection method	Timing	Judgment criterion
JSCE-E 145 (draft) quality standard	Confirmation of manufacturer's test results table	Upon receipt	Compliance with JSCE-E 145 (draft)
Standard, length, number, strand diameter, sheath diameter, pre-grout resin processing date (date of manufacture)	Confirmation using delivery notes, product tags, and test results table	Upon receipt	As per order
External appearance Resin leakage, damage, adhesion of substances, sheath deformation, resin leak-prevention cap, method of packing, coil diameter	Visual inspection	Upon receipt	No defects found by visual inspection

- (2) If resin leakage or sheath damage is detected in a pre-grouted tendon, it shall be repaired in accordance with "3.6 Repairs" or replaced.

4.3 Construction Inspections

- (1) Pre-grouted tendons shall be inspected during construction work in accordance with Table 4.3.1.

Table 4.3.1 Inspections of pre-grouted tendons during construction

Item	Test or inspection method	Timing	Judgment criterion
Sheath damage	Visual inspection	Before and after installation	No damage
Resin leakage	Visual inspection	Before and after installation	No leakage
Repaired locations	Visual inspection	After repair	Repair has been appropriately completed
Temperature	Temperature measurement	Period between receipt and tensioning	Storage temperature and maximum concrete temperature shall satisfy the design values

- (2) If resin leakage or sheath damage is detected in a pre-grouted tendon, it shall be repaired in accordance with "3.6 Repairs" or replaced.

Chapter 5 Construction Records

5.1 General

Construction records shall be produced and filed in accordance with the Specifications [Construction].