

CARES MODEL SPECIFICATION



**For Bonded and Unbonded
Post-Tensioned Floors in
Non-Highway Structures**

4th Edition

GUIDANCE

For organisations for the use / installation of bonded and unbonded post-tensioned floor slabs and beams containing monostrand or flat multistrand tendons





Model Specification for Bonded and Unbonded Post-Tensioned Floors in Non-Highway Structures

4th Edition

This model specification offers guidance to organisations for the use / installation of bonded and unbonded post-tensioned floor slabs and beams containing monostrand or flat multistrand tendons.

Notes for designers are given (where appropriate) in italics and do not form part of the specification.

It is the specifier's responsibility to ensure that the contract specification is suitable for and meets the requirements of the contract.

The images throughout this Model Specification are courtesy of CCL, Cleartech and Structural Systems.



Contents

1. Post-tensioning contractor

2. Quality plan

3. Health and safety

4. Materials and products

4.1 Tensile element

4.2 Coating material (unbonded tendons)

4.3 Anchorages

4.4 Ducts and vents (bonded tendons)

4.5 Grout

4.6 Storage and handling of materials

5. Workmanship

5.1 Tendon installation

5.1.1 Marking of tendon position

5.1.2 Tendon installation records

5.2 Stressing

5.2.1 Stressing equipment

5.2.2 Stressing records

5.3 Sealing of anchorage components

5.4 Grouting

5.4.1 Preparation of ducts

5.4.2 Grouting equipment

5.4.3 Grouting procedure

5.4.4 Grout testing

5.4.5 Grout records

5.4.6 Calibration

STANDARDS AND DESIGN GUIDES

Design shall be in accordance with:

BS EN 1992-1-1 Eurocode 2 Design of concrete structures.

Concrete Society Technical Report (TR43) 2nd edition Post-Tensioned Concrete Floors.

All relevant post-tensioning design documentation should cross reference to this CARES Model Specification 4th edition and in particular to the requirements of Clause 1(a).

Note: Further guidance can be found in Concrete Society Technical Report No.72 Durable Post-tensioned Concrete Structures.

1 Post-tensioning contractors

- a) Post-tensioning systems shall only be installed by specialist post-tensioning contractors that have the necessary experience, knowledge, resources, materials and equipment. Post-tensioned contractors shall have CARES certification for the installation of post-tensioning systems in concrete structures against CARES Appendix PT2 or equivalent accredited product certification.
- b) Access to the works shall be granted to CARES for the purpose of quality auditing and maintenance of certification by arrangement with the post-tensioning contractor and/or Contract Administrator (CA).
- c) The CA may nevertheless request an additional surveillance audit on a CARES approved post-tensioning contractor by CARES (at their own cost). If a quality audit is required by the CA during the contract then this shall be clearly stated in the project specification.
- d) All post-tensioning operations shall be carried out by operatives with appropriate knowledge, training and proven experience in carrying out similar operations. Supervisors and operators shall be trained and certified to meet the requirements given in CARES Appendix PT9.
- e) Trainee post-tensioning personnel shall be adequately supervised when performing post-tensioning activities.

Note: The number of trainees should be limited and the ratio of trainees to experienced trained staff should be balanced according to circumstances and normally not exceed 50% of the post-tensioning personnel.

- f) All site post-tensioning duct fixing, tendon installation, stressing and grouting shall be undertaken by suitably trained and experienced staff under the direct supervision of the post-tensioning contractor. Site operatives employed by other contractors on the site shall not be used for post-tensioning work.
- g) Where required by the CA the names of all post-tensioning operatives to be employed on the site shall be submitted, with their training records before commencement of the subcontract works.

2 Quality plan

The post-tensioning contractor shall provide the CA with a quality plan giving details of all the proposed materials, equipment and method statements relating to site activities, including work instructions quality procedures, records inspection and test arrangements and work acceptance procedures.

Note: The quality plan may comprise a single document or series of linked documents.

3 Health and safety

All post-tensioning contractors should submit full risk assessments, method statements and safe systems of work to cover the full scope of works prior to starting work on site.

All post-tensioning contractors should operate health and safety management systems to OHSAS18001:2007 or an equivalent system.

4 Materials and products

4.1 Tensile element

- a) Strand shall comply with BS 5896.
The grade and diameter shall be specified by the post-tensioning designer and shall be obtained from firm(s) holding a valid CARES certificate of approval and shall be of a type that is compatible with the anchorage testing or approval.
- b) Tensioned bar shall comply with BS 4486.
The grade and diameter shall be specified and shall be obtained from firm(s) holding a valid CARES certificate of approval.

Note: Confirmation of the strand or bar supplier's approval status can be obtained from CARES web site: www.ukcares.com

4.2 Coating materials (unbonded tendons)

The coating to unbonded strand shall be either high density polyethylene (HDPE) or high density polypropylene (HDPP). The coating thickness shall be at least 1.0mm unless otherwise stated in the project specification and the friction between the coating and the strand shall not exceed 60N/metre. The friction shall be determined in accordance with the test methods defined in ETAG 013 Annex C clause "C.1.3.2.2 Friction test".

Note: High density polyethylene is more flexible and less liable to embrittlement at extremely low temperatures, while polypropylene is more stable at high temperatures. Both materials have high resistance to abrasion and creep, although polypropylene is slightly superior in these respects. In all cases grease is injected into the strand to reduce friction and provide corrosion protection.

4.3 Anchorages

Anchorage for post-tensioning systems shall be CE marked and comply with the minimum performance requirements of BS EN 13391 as defined in CARES Appendix PT3 or the post tensioning kit shall hold a European Technical Approval (ETA) against ETAG 013 or EAD 16-0004. Documentary evidence of product conformity shall be provided if requested on site.

Note: BS EN 13391 is a supplementary standard to BS EN 1992-1-1, BS EN 1992-2 and ETAG 013.

Evidence of compliance with the above post-tensioning kit / post-tensioning anchorage qualification should be obtained at tender stage if possible.

4.4 Ducts and vents (bonded tendons)

Duct, vent and connection material shall be robust enough to resist damage during construction; for example smooth galvanised steel with a minimum wall thickness of 0.35mm, corrugated galvanised steel with a minimum wall thickness of 0.30mm or high density polyethylene or polypropylene with a minimum wall thickness of 2.0mm. Plastic ducting should conform to the requirements of fib bulletin 75.

Ducting shall prevent the entrance of paste from the concrete, and shall not cause harmful electrolytic action or any deterioration of the tendon or tendon components. The internal cross-sectional area of the duct shall be at least twice the net area of the tendon's prestressing steel. Ducting shall be capable of transmitting forces from grout to the surrounding concrete.

A water-resistant, fabric-based adhesive tape should effectively seal any ducts. It should be suitable for application to wet galvanised steel/plastic ducts and to be inert and non-reactive to anything in the concrete, grout or the steel (duct or strand).

Note: For bonded tendons the designer should clearly specify the type of duct required to meet the required bond and durability requirements.

Ducts are usually steel with a folded seam and are not leaktight. Where a higher level of protection is required such as in car parks, plastic duct systems should be considered.

The use of PVC is not recommended since it is known that chloride ions can be released in certain conditions.

4.5 Grout

Suitability tests shall be carried out with materials, plant and personnel proposed for use on site, to verify the properties are as per the criteria in 5.4.4. The tests shall be sufficiently in advance of grouting operations to enable adjustments to be made to the materials, plant or personnel.

Grout shall consist of pre-bagged material requiring only the addition of a measured amount of water and shall be CARES approved to Appendix PT10.

Grout shall be stored in accordance with the manufacturer's instructions.

Note: Bagged grout materials have a specified shelf life and the bags are normally date marked. The material must be used by the specified date.

Bleed water is excess water in the grout that is not chemically bound and can lead to low density grout, grout cracking, grout shrinkage and porosity, therefore the w/c ratio must be kept as low as possible. The necessary grout properties can be achieved with properly formulated grout materials and the addition of specified quantities of water.

4.6 Storage and handling of materials

All materials and components are to be stored in a safe and careful manner to ensure no damage occurs to the wires or anchors. Strand is to be stored in large diameter coils prior to installation and kept away from welding and other dangerous operations and protected from extreme changes in temperature.

Strand is to be delivered to site clean and free from permanent bends, kinks, pitting, scale or other damage and to be stored in such a way as to protect it in this condition until it is installed.

If the strand is shown to have excessive corrosion it should not be used. For clarification, unacceptable corrosion is regarded as that which cannot easily be removed by hand and permanently marks the surface of the part (such as surface pitting)



5 Workmanship

5.1 Tendon installation

- a) Vertical accuracy shall be +/- 5mm or greater at the discretion of the PT slab designer.
- b) Horizontal accuracy shall be 50mm in beams or 150mm in floor slabs.
- c) Unbonded tendons may be deviated to avoid obstructions such as openings and columns with the agreement of the CA. The change of direction of the tendon should occur away from the opening and trimmer bars should be provided to avoid any possible cracking at the corners in accordance with TR43 Clause 6.7.

Note: Tendon profiles which require a curve in plan may be provided by faceting straight lengths of flat duct down to a minimum radius of 50m and a 7 degree maximum facet angle. The length of each straight facet of duct shall not be less than 6m. For tighter radii, circular ducts should be used.

Alterations to PT designers drawings should be authorised by the PT designer prior to pouring concrete.

- d) Tendons shall be fixed and supported at centres not exceeding 1m and shall be securely fixed to prevent movement and flotation during the construction process.

Note: Flat ducts are quite flexible in the vertical direction and it is common to install the strand within the duct and then profile the tendon, which increases the stiffness and aids the achievement of a smooth tendon profile.

- e) Vents shall be fixed at injection and exit points and, where tendon drape exceeds 500mm, intermediate vents shall be fixed at tendon high points. Vents shall extend approximately 500mm above the slab surface.
- f) All inlets and outlets shall be suitably marked to identify the tendon and their location along the tendon.

Note: Consideration should be given to the use of intermediate vents on tendons over 20m in length. Vent spacing should not exceed 30m.

5.1.1 Marking of tendon position

Unless otherwise stated in the project specification, the actual position of the tendons shall be marked on the slab soffit to indicate the location in plan within the slab. The system of marking shall be agreed with the CA.

Note: Where services etc., are to be fixed to a slab, it is important that the slab is clearly identified as post-tensioned construction on all drawings and relevant documents.

All details relating to tendon positioning for potential alterations or demolition are to be available in the O & M manual as supplied by the PT designer.

Where the tendon position is not accurately and authoritatively documented, reinforcement detection equipment should be utilised to locate tendon positions prior to any cutting or drilling work on the slab.

5.1.2 Tendon installation records

Tendon installation shall be recorded. Records shall include:

- a. Date of installation
- b. Strand source
- c. Coil number
- d. Heat number (or Cast number)
- e. Anchorage batch number
- f. Wedge batch number
- g. Duct batch number
- h. Supervisor
- i. Operatives
- j. Location of the products within the structure
- k. Drawing number and revision status

5.2 Stressing

- a) The post-tensioning designer shall calculate the theoretical tendon extension. All relevant system data shall be stated e.g. μ , k , strand E value and area, wedge draw-in on lock off and any assumed movement of dead end etc.
- b) The PT contractor shall make available for review by the CA/Structural Engineer the actual extensions. Stressing shall not commence before the concrete has achieved the transfer strength specified by the PT Designer.
- c) The concrete transfer strength shall be based on match cured cubes taken at the point of concrete placement.

Note: *There can be significant differences in concrete strength between the first and last loads to be poured, therefore the slab's concrete transfer strength should be based on cubes taken from the last concrete load.*

Match curing of cubes requires the cubes to be cured at the same temperature as the concrete element from which the cubes were taken.

- d) The designer shall specify any restrictions on stressing sequence and increments.
- e) The jacking force should not exceed those given in the appropriate design standard and should be provided by the PT Designer.
- f) Tendons shall be stressed in the specified sequence and load increments.
- g) For routine stressing, extensions shall be measured prior to commencement of stressing, and after stressing and locking off to an accuracy of 2% or 2mm whichever is greater. Measurements shall take into consideration the possible strand movement at the dead end anchor.

- h) The actual extensions shall be within the limits specified in BS EN 13670 Clause 7 5.3.
- i) Tendons are not to be cut and sealed, until the PT Designer has checked and signed off the actual extensions.

Note: *Theoretical extensions are used as an indication that tendons have the correct load applied during stressing. The accuracy of extension calculations will depend on the accuracy of inter alia: the tendon profile and the assumptions made for movement at the anchorages, friction and wobble coefficients.*

- j) In the event that any failures occur during stressing (system components or concrete) the cause shall be thoroughly investigated and a formal report presented to the CA. No further stressing on that element shall be undertaken until the proposed corrective action has been approved by the CA.

5.2.1 Stressing equipment

Stressing jacks and their load measuring system should have an appropriate and current calibration certificate, which is traceable to national standards, and no more than 6 months old at the time of stressing. The calibration shall be undertaken by a UKAS accredited company. The stressing equipment shall be capable of establishing a tendon load to a maximum tolerance of +/-2%.

Tendons shall be cropped using mechanical means.

Note: *Flame cutting is not acceptable for cutting strand, as heat will adversely affect the properties of the strand.*

5.2.2 Stressing records

Stressing operations shall record:

- a. Date of stressing.
- b. Strength and age of concrete cubes.
- c. The minimum age of concrete at transfer.
- d. Stressing equipment.
- e. Calibration date.
- f. Supervisor and operators.
- g. Serial numbers of gauges and jacks.
- h. Tendon identification.
- i. Theoretical extension, actual extensions and corresponding, loads (where required), initial and final jacking loads.
- j. Drawing number and revision status.

Completed stressing records shall be made available to the CA not more than one week after stressing.

5.3 Sealing of anchorage components

Anchorage components shall be sealed against the ingress of water or aggressive agents likely to cause corrosion of the steel or anchorage. The method of anchorage sealing shall be stated in the project specification.

In the case of grouted tendons, the chosen method of sealing shall be capable of resisting the specified grout pressure.

Note: In the case of grouted tendons, proprietary non-shrink mortars and bonding agents are recommended.

Anchors are usually cast into pockets in edge beams and the pockets sealed with mortar/ render. The detailing of this area requires some attention, as mortar/render can be permeable and subject to shrinkage.

For exposed anchors higher levels of protection should be considered such as end caps.

For unbonded tendons it is recommended that anchorage components are coated with grease of similar specification to that used in the tendon and that a watertight cap be applied over the coated area. The minimum concrete end cover to the cap shall be 25mm.

Data sheets and method statements for anchorage sealing shall be submitted to the CA.

5.4 Grouting

- a) Grouting of the ducts shall normally be shown to leave no void which has a radial dimension greater than 5% of the maximum duct sectional dimension or which poses a risk to the integrity of the tendon. Particular attention shall be given to avoiding bleed collection or void formation at high points in the ducts or anchorages.
- b) Grouting trials are typically not considered unless tendons are longer than 50m or have particularly severe profiles. (For example on slabs less than 350mm or a profile range with a high point to low point of more than 300mm).
- c) "Grout trials should be considered for structures in Exposure Classes XD1 to XD3 and XS1 to XS3.

5.4.1 Preparation of ducts

Where necessary, all grouting and venting points shall be suitably marked to enable identification of the duct to which they are connected.

Note: In many slabs the duct layout is simple and repetitive and vent labelling may not be necessary. However with more complex duct / vent configurations where it is possible to confuse vents from different ducts, it is important to mark and identify the vents.

The ducts shall be kept free from contamination at all stages from storage to installation and shall be thoroughly clean before grouting.

Ducts should be blown through with oil free compressed air prior to grouting (not water). Blowing through of tendons should be recorded for each tendon individually. No grout shall be placed if the temperature of the structure adjacent to the tendons is expected to be below 5°C during the following 24 hours.

5.4.2 Grouting equipment

Grouting equipment shall comply with BS EN 446 Clause 7.

5.4.3 Grouting procedure

Grout injection shall be continuous and shall be slow enough to avoid segregation of the grout and shall comply with BS EN 446 Clause 8.

There shall be a procedure for corrective action in the event of blockage or breakdown such as backup equipment or flushing out of ducts.

All vents shall be closed one after another in the direction of the flow. The injection tubes shall then be sealed off under positive pressure of not greater than 0.1MPa.

The filled ducts shall be protected to the satisfaction of the CA to ensure that there is no damage to the grout due to shock or vibration for 24 hours after injection of the grout and that the temperature in the ducts does not fall below 5°C for 24 hours after injection of the grout.

There shall be a procedure for corrective action in the event of blockage or breakdown such as back up equipment or flushing out of ducts.

Note: *the tendon encapsulation (i.e. the ducts and anchorage system enclosing the tendon) for bonded flat slabs cannot usually be sealed to the same degree as that used for civil engineering structures designed to TR72 as steel ducts are often used and the anchors are usually sealed with render instead of grout caps. Additionally flat slabs are thinner in section and contain significantly less reinforcement and can be damaged by high grout pressure.*

The CA or the Contractors representative shall be invited to witness a representative sample of the grouting operation and countersign the grouting record sheet prepared by the Post-tensioning Contractor.

Grouting to take place as soon as practicable after the tendons have been stressed, extensions approved and the strands cropped but no longer than 28 days from stressing without the approval of the Contract Administrator.

Note: *Bonded tendons cannot achieve their full ultimate design capacity until the grouting operations have been completed. PT Designer may therefore need to consider the reduced slab capacity in the temporary condition.*

5.4.4 Grout testing

Grout shall comply with the performance requirements of BS EN447 Clause 6 as follows:

Grout properties	
Fluidity	BS EN 447 clause 6.3 using the cone method
Bleeding	BS EN 447 Clause 6.4 wick induced test
Volume change*	BS EN 447 Clause 6.5 wick induced test $\geq -0.5\%$ and $\leq 2.5\%$
Strength*	BS EN 447 Clause 6.6 but 100mm cubes may be used
Sieve test	BS EN 447 Clause 6.2.
w/c ratio*	≤ 0.35
Grout temperature*	As specified by the grout manufacturer
Density	From cube tests

Table 1

Note: *Items marked with an “*” denote an additional or enhanced requirement over and above BS EN 447 requirements.*

The frequency of grout testing shall be in accordance with table 2 below.

Frequency of grout testing	
Test	Frequency
Fluidity**	One set of tests per grout mix (at t_0 and t_{30})
Bleeding**	One wick induced test per day
Volume change**	One wick induced test per day
Strength**	3 cubes per grouting session taken at mixer
Density**	Recorded from cube tests above

Table 2

Note: Items marked with an “**” denote a departure from BS EN 446 Table 3 Inspection Class 3 requirements and represent current best practice.

Grout shall be batched in accordance with the manufacturer’s instructions.

The source of materials and procedures approved as a result of satisfactory trials shall not be departed from without the approval of the CA.



5.4.5 Grout Records

Records of each grouting operation shall be kept detailing:

- The materials used, including batch numbers.
- The date, time and conditions under which the grouting operations were carried out.
- Ambient and structure temperatures and weather conditions.
- Grout properties including temperatures, bleed, volume change and fluidity.
- Details of any interruptions and any problems encountered during the grouting process e.g. blockages, loss of grout or loss of grout pressure.
- Supervisor and operatives undertaking the grouting operation.
- Grout manufacturer’s Technical and Safety data sheet.

5.4.6 Calibration

Calibration records shall be available and retained for all measuring equipment used on site during the PT installation. Such equipment includes:-

- Pressure gauges used in the grouting operation
- Pressure gauges and associated jacks in the stressing operation
- Temperature probes.

In the case of the latter certificates of conformity / Manufacturer statements of accuracy are acceptable. These are typically supplied with the instrument on purchase.

In all cases the devices should have a clear identification which can be referenced against the calibration records and dates.

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