



Building and Construction Authority

**REQUIREMENTS FOR  
CERTIFICATION OF SPECIALIST BUILDERS  
(IN-SITU POST TENSIONING WORKS)**

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**TECHNICAL REQUIREMENTS FOR  
CERTIFICATION OF SPECIALIST BUILDERS  
(IN-SITU POST TENSIONING WORKS)**

## INTRODUCTION

- 1.1 This assessment schedule relates to the quality system requirements for the supply and installation of post-tensioning systems in cast-in-situ concrete structures using bonded or unbonded tendons in accordance with the relevant product standard and execution specification.

## 1. ABBREVIATIONS

The following abbreviations are used in this document:

BS EN	British Standard adoption of European Standard
CARES	UK CARES (UK Certification Authority for Reinforcing Steel)
CB	Certification Body
CoC	Certificate of Conformity
SB	Specialist Builder
EXC	Execution Class
ETA	European Technical Assessment
EAD	European Assessment Document
FPC	Factory Production Control
PT	Post Tensioning
PT Kit	Post Tensioning System
SS EN	Singapore Standard of European Standard
TRCSB	Technical Requirements for Certification of Specialist Builders (In-Situ Post Tensioning Works)

## 2. DEFINITIONS

*Anchorage.* A mechanical device, usually consisting of several components designed to retain the force in the stressed tendon and to transmit it to the concrete.

*Anchorage zone.* The local zone in the structure through which the prestressing force is introduced into the concrete via the anchorage.

*Attendance.* The services to be provided by or through the SB e.g. water, power, lifting equipment, access, etc.

*Batching.* The mixing of grout from prescribed constituents to an agreed formulation and procedure

*Bonded tendon.* A tendon bonded to the structural element by cementitious grout injection.

*Local anchorage zone/Bursting reinforcement.* The reinforcement in the anchorage zone to resist transverse tensile forces due to the introduction of prestressing force.

*Client.* The body for which the works are being carried out.

*Coupler.* A device to splice tendons.

*Customer.* The body engaging the SB to carry out the work described in the specification according to this schedule (this would usually be the main contractor).

*Duct (sheathing).* An enclosure in which the prestressing steel is placed, and which temporarily or permanently allows relative movement between the prestressing steel and the surrounding concrete.

*EAD. European Technical Assessment Document.* A document, which defines criteria for the assessment of a PT Kit.

*ETA.* European Technical Assessment. A document, which assesses a PT Kit according to assessment criteria defined by EAD160004-00-0301. This document not only defines the outer geometry of the assembled PT Kit, but also defines equipment needed for installation and the correct installation methods. The PT Kit's ETA is verified and issued by the TAB.

*Execution specification.* The documents covering all drawings, technical data and requirements necessary for the execution of a particular project.

*External Post-Tensioning Tendon.* The tendon is located outside of the prestressed structural member for most of its free length and is only embedded in the concrete at its anchorages and internal deviation points.

*FPC.* Factory Production Control. A system by which the consistency of quality of manufactured items are controlled.

*Grout.* Grout comprising a mixture of cement, admixture and additives, mixed with water and injected into the duct and anchorage to fill the space in the tendon's duct around the strands to protect the strands from corrosion and to provide structural bond between the strands and the structure.

*Harmonised Products.* Products, whose material properties and geometry including tolerances are covered by a harmonised standard (e.g. strands). Post-tensioning Kits or Systems as a product assembled from PT Kit Components are not covered by harmonised standards.

*Hold points.* Defined points in the post-tensioning installation process which require inspection or verification, by the SB, customer or client, of the satisfactory completion of all of the necessary processes up to that point and prior to the commencement of the next stage of the process.

*Inspection Test Plan.* The document defining what checks have to be performed during what stage of installation and to what acceptance criteria including format of check lists. This document is supplementary to the Method Statement.

*Internal Post-Tensioning,* the tendon is over its full length embedded in the concrete of the prestressed structural member.

*Method Statement.* The document setting out the specific details, resources and sequence of activities relevant to the installation of post-tensioning systems and shall be specific to each project / site.

*Main Tensile Element (MTE).* The structural component of a tendon which is stressed and transfers the tendon's prestressing force from anchorage to anchorage. In context of these requirements MTEs are seven wire strands. MTEs are harmonized products.

*Prebagged Grout.* Grout comprising an offsite prebagged blended mixture of cement admixture and additives, mixed on site with defined amount of water and injected into the duct and anchorage to fill the space in the tendon's duct around the strands. Prebagged grout have a shelf life, which may shorten as a function of storage conditions.

*Prestressing.* Structural concept to control deformation in a member arising from dead and imposed loads by the superposition of a favourable internal stress state through stressing of straight or profiled tendons\.

*Post-tensioning (PT) Kit.* Post-Tensioning System. It consists at least of main tensile element, anchorages, ducts and filling material (the PT Kit Components). Its design and detailing is defined on PT Kit Manufacturer's fabrication drawings and through material specifications, which are confidential and proprietary documents. Performance of PT Kits cannot be verified by calculation but only by full scale testing as defined in EAD160004-00-0301, ETAG013 or BS EN 13391.

*Post-tensioning Kit Manufacturer.* Company, which owns the intellectual property for the Post-Tensioning Kit and manages its fabrication. It assesses and approves PT Kit Component manufacturers and defines the FPC for the fabrication of the PT Kit Components. It is the responsibility of the Manufacturer to ensure the constancy of performance of the PT kit as defined in chapter 3 of EAD160004-00-0301 or chapter 8 of ETAG013 which is independently audited by a CB or equivalent assessment and verification of constancy of performance.

*Quality plan.* The document setting out the specific quality practices, procedures, resources and sequence of activities relevant to the project.

*Supplier.* A body approved by the SB for the fabrication of PT Kit Components, and the supply of equipment or services.

*TAB.* An approved Technical Assessment Body designated in accordance with the Construction Products Regulation.

*Tendon.* One or a number of structural elements used to prestress a member, comprising of MTE, duct, duct filler material and pair of anchorages. A tendon can either be bonded or unbonded.

*Tendon-anchorage assembly.* A connection between tendon and anchorage.

### **3. SCOPE**

This Schedule describes the minimum quality and operations requirements for the post-tensioning of cast-in-situ concrete structures using bonded or unbonded tendons comprising steel strands placed within or externally to the structural member. It relates to the use of the following:

- a) Prestressing strands manufactured to BS 5896 or EN10138-3.
- b) Anchorages for post tensioned systems approved to BS EN 13391 or EAD160004-00-0301, sections 2.2.1, 2.2.2. and 2.2.3 respectively.
- c) Duct systems for post-tensioned tendons complying with the requirements of *fib* bulletin 75 or EN 523 to 524.
- d) Cement grout complying with BS EN 445 to 447.
- e) The organisational and procedural requirements of BS EN ISO 9001.
- f) Guidance on the Post Tensioning Operation may also be found in TR72 and BS EN13670.
- g) CARES Model Specification for Bonded and Unbonded Post-Tensioned Floors in Non-Highway Structures, 4th Edition
- h) Any requirements as detailed in Building and Construction Authority Approved Document
- i) BS EN 13670-2009 Execution of Concrete Structures, Chapter 7 Prestressing

#### **3.1 Schedule of Operations**

The SB shall document the manufacturing and installation processes, materials, equipment, the names and grades of site operational personnel relevant to this schedule in Schedule of Operations.

Where the SB has off-site storage facilities for PT materials and equipment other than their Head Office address these should be included in the Schedule of Operations.

The Schedule of Operations shall be maintained in an updated form and used by CB in the assessment and, where appropriate, subsequent surveillance inspections.



## **4. OPERATION OF THE SCHEME**

The Scheme will operate as follows:

### **5.1 Certification of the SB**

Certification of the SB will be granted after a satisfactory assessment of all office and site operations relevant to on-site post tensioning activities by CB in accordance with all parts of this Schedule, the SB's quality plan, method statement & inspection test plan, training and certification scheme of site crews and BS EN ISO 9001.

### **5.2 Notification of Contracts**

The SB shall notify CB of each site when it has been awarded that particular contract. Assessments and surveillance inspections shall be carried out by CB at selected sites to ensure satisfactory operational control against this schedule.

The SB shall notify CB at the beginning of each month the details of ALL SITES where they are actively installing PT using the CB Notification of Contracts form (Appendix 2).

Failure to provide this information will result in a minor NCR being issued. Further failures will result in the issue of a major NCR.

## **5. QUALITY MANAGEMENT SYSTEM REQUIREMENTS**

The SB shall operate a quality management system that complies with ISO 9001 and this schedule. This Schedule interprets those elements that are particularly relevant to the installation of post-tensioning systems in cast-in-situ concrete structures to ensure consistent product quality and continued compliance with this schedule.

If the Quality Management System of the SB has been certified to ISO 9001 by a CB accredited by SAC or an IAF Multilateral Recognition Arrangement (MLA) partner, the SB may use the accredited certificate in support of the certification for specialist builders (in-situ post tensioning works).

### **6.1 Documentation Requirements, Control of Records**

The SB shall establish and maintain records to show conformity with this schedule and shall define their retention period and their disposition.

Inspection records, including those records relating to the technical details of post-tensioning contracts shall be retained for a minimum period of 5 years or longer if defined by the contract and a copy of these shall, when required, be sent to the client.

## **6.2 Management Responsibility**

Top management shall provide evidence of its commitment to the development and implementation of the quality management system and continually improving its effectiveness by:

- a) Communicating to the organization the importance of meeting customer as well as statutory and regulatory requirements.
- b) Establishing the quality policy.
- c) Ensuring that quality objectives are established.
- d) Conducting management reviews.
- e) Ensuring the availability of resources.

## **6.3 Quality Management System Planning**

The SB shall produce a quality plan for each structure, contract or project as appropriate and identifying specific details on which it is contracted to operate.

This plan shall include method statements & inspection test plans for all key post-tensioning activities e.g. duct installation, tendon installation, tendon tensioning, anchorage installation, tendon protection, grouting and testing. The minimum scope for a quality plan and inspection test plan is given in Section 6.3.1 and 6.3.2.

The quality plan shall identify the: human resources including training and certification for site crews, responsibilities, hold points (and release authorities), processes, materials, equipment, controls, inspection, measuring and test equipment, reference standards and levels of acceptability required to meet the contract requirements.

### **6.3.1 Quality Plan**

The organisation shall produce a documented quality plan, which covers general post-tensioning operations and specific site requirements. To ensure a degree of consistency between organisations, the quality plans shall include the following:

1. The requirements of this schedule, ISO 9001.
2. The definition and identification of contract specific requirements and related documents including internal and external audit reporting requirements.
3. A definition of the organisational responsibilities and authorities, particularly those pertaining to verification activities.
4. The resource requirements including processes, materials and equipment.
5. The identification and status of site personnel.
6. The approval and verification requirements of purchased services and material.
7. A procedure for reviewing the work programme, adjustments to the work programme and records of programme review.
8. Procedures for office activities including communication between the office and site.

9. Method statements relating to site activities, including work instructions, quality procedures, records, inspection and test arrangements and work acceptance procedures.
10. Procedures for the control of site documentation.
11. Procedure for dealing with non-conformances.
12. Procedures to train and certify the site crews and keep records to demonstrate that all personnel working on site are adequately and appropriately trained and certified.
13. Procedures for quality audit and management review of the implementation of the quality plan.
14. The identification of hold points, the verification required, the verification responsibilities and the authority for release.
15. The selection and employment of suppliers.
16. A review of the completed contract including an analysis of defects.

### **6.3.2 Inspection Test Plan (ITP)**

The organisation shall produce a documented inspection and test plan for each project. The minimum requirements of such a document should include:

1. The various stages of installation, referencing the control/inspection records and clearly defining acceptance criteria
2. Responsibilities for completion of the records (Job title/position)
3. Responsibilities for checking of the records (Job title/position), if applicable
4. The identification of "hold points" where applicable at each installation stage
5. The identification of the responsible individuals to release to the next stage
6. The identification of the records necessary to allow release to the next stage
7. The method of release (signature, email etc)

Such information may be provided in tabular form or in a flow diagram but shall provide sufficient clarity to ensure the requirements of this schedule are met.

Documents used for recording of the installation shall be controlled with appropriate document reference numbers and version control where necessary.

All records of the installation and release signatures shall be made available for inspection on site or during office audits (in cases of completed projects) and stored appropriately in line with requirements of this schedule.

### **6.4. Provision of Resources**

The SB shall identify the resource requirements in the quality plan and provide adequate resources, including materials, equipment, inspection, measuring and test equipment and trained and certified personnel for the management, supervision and site execution of the work and verification activities.

The SB shall have a documented procedure which details the minimum attendance and qualification required to supervise, execute and verify the post-

tensioning operations. The level of qualification and the provision of attendance shall be agreed between the client, the customer, and the SB.

## **6.5 Competence, Awareness and Training**

The SB shall ensure that all post-tensioning personnel are familiar with the operation of the post-tensioning equipment and post-tensioning operations. All post-tensioning operations shall be carried out by operatives with appropriate knowledge, training & certification and proven experience in carrying out similar operations.

Supervisors and operators shall be trained and certified. Trainee post-tensioning personnel shall be adequately supervised when performing post-tensioning activities. All post-tensioning personnel shall carry an identification card stating the certified skill or scope of works which they are trained for.

The SB shall:

- a) Define the necessary knowledge, experience and vocational competence for post-tensioning personnel performing work affecting health & safety and product quality, including inspection and verification activities.
- b) Determine the training needs and the training syllabus to meet requirements from 6.5.2 and 6.5.3.
- c) Provide the necessary training
- d) Evaluate the effectiveness of the training and certify successfully trained individuals.
- e) Issue the successfully trained individuals with their identification card containing the certified skill or scope of works which they are trained for.
- f) Ensure that its personnel are aware of the relevance and importance of their activities and how they contribute to the achievement of the health & safety and quality objectives.
- g) Maintain appropriate records of certificate issued for education, training, and skills, ensuring these are available for review during each CB audit.
- h) Keep records of the projects sites which the trained personnel are deployed to and to ensure personnel are deployed to the required site based on relevant experience.
- i) Ensure that on all site installation work is only performed by trained & certified crews.

### **6.5.1 Training Requirements**

The SB shall maintain a training and certification scheme for all personnel performing site activities that have an effect on health & safety and quality in accordance with the requirements of BS EN ISO 9001. The procedures shall:

- a) Define the categories of on-site personnel, e.g. trainee, operative, supervisor, engineer.

- b) Define the knowledge, skill and experience required for each personnel category.
- c) Evaluate and endorse experience of personnel based on objective evidence such as verifiable training records.
- d) Provide relevant theoretical and practical training.
- e) Evaluate the level of knowledge and skill attained during training.
- f) Issue certifications with statements of achievement, which identify the level of training achieved, the date of issue and the date of expiry.

### 6.5.2 Site Training Requirements

The SB shall have a documented procedure that ensures that on-site personnel are trained with respect to their post-tensioning capability.

The procedure shall ensure:

- a) Engineer(s) are familiar with the on-site post-tensioning procedures and operation of equipment in relation to duct installation, tendon installation, tendon stressing and grouting and are familiar with the post-tension design criteria.
- b) All on-site post-tensioning personnel are familiar with the procedures and operation of equipment in relation to duct installation, tendon installation, tendon stressing and grouting.
- c) All on-site operations shall only be carried out by personnel with appropriate knowledge, training & certification and proven experience in carrying out the specific operations on the specific post-tension system.
- d) Post-tensioning trainees shall not carry out any post-tensioning activities unless adequately supervised by suitably trained personnel.
- e) Ensure that critical aspects of the installation such as stressing and grouting are carried out under the direct supervision of the fully trained supervisor

As a minimum, all post-tensioning personnel shall have an appropriate level of training and experience of:

*Ducts and anchorages (bearing plates):* Installation of ducts including profiling, splicing of ducts, correct positioning of anchorages (bearing plates) and local zone reinforcement, positioning of vents, identification of ducts, cleaning of ducts.

*Tendon Stressing:* Installation of strand and anchorages (anchor blocks and wedges), setting up jacks, stressing procedure, site safety, recognition of load/elongation relationship, de-tensioning, assembly of dead-end anchors and couplers.

*Duct grouting:* Grouting procedures, installation of grout caps, verification of tendon's leak tightness by pressure testing, grout mixing, w/c ratio, production grout testing, use of admixtures, dealing with blockages, temperature constraints, grouting records, post grout inspections.

Additionally, post-tensioning supervisors shall have an appropriate level of training and experience of:

*Post-tensioning system:* Anchorages, strand types and grades, duct sizes and types.

*Grouting:* Suitability testing

## **6.6 Purchasing**

The SB components, grout components and post-tensioning equipment. Post-tensioning stressing equipment shall comply with the requirements of the post-tensioning kit manufacturer.

The SB shall have a documented procedure for purchasing prestressing strands, PT Kit Components from the PT Kit Manufacturer or from PT Kit Component manufactures, which have been approved by the PT Kit Manufacturer. FPC systems shall cover fabrication plants for all related processes, production lines and/or departments, including those outsourced or operated by SB and those managed through the supply chain of the licensor of the PT Kit (the PT Kit manufacturer).

### **6.6.1 Purchasing Information**

The purchase orders shall include all aspects of the prestressing strands, PT Kit Components or service specification, which are important in ensuring satisfactory product quality, traceability and identification.

### **6.6.2 Evaluation of Suppliers**

The SB or its PT Kit Manufacturer, if this is not the same company, shall have a documented procedure for the evaluation and selection of prestressing strands and PT Kit Component manufacturers. Records of approved manufacturers shall be maintained.

## **6.7 Product Identification and Traceability**

The SB shall have documented procedures that ensure product identification and traceability during all stages of production, delivery, receipt and installation into the structure and shall include the following as appropriate:

- a) The strand source, majority heat number and coil/batch identities.
- b) The source and specification of post-tensioning anchorage components (including the appropriate ETA Certification No. if applicable)
- c) The appropriate ETA or equivalent documentation should be readily accessible with appropriate drawings available to ensure receipt of the correct PT system on site (if direct supply) or off site (if off – site storage is used by the company prior to delivery to site)
- d) The source and specification of ducts, grout, grout components and admixtures.

The SB shall record:

- a) The location of the above components within the structure.
- b) Details of the time and condition under which the operations were carried out.
- c) Details of any interruptions to site operations.

The site records shall be included in the traceability procedure and be incorporated into the quality records.

## **6.8 Determination of Requirements Relating to the Product**

The SB shall ensure that all contract responsibilities and relevant design details e.g. post-tensioning system, tendon configuration, tensioning sequence, tensioning increments, grout, grout mixing, grout injection, grout testing, resource requirements and attendance are clearly, adequately and unambiguously defined.

The Specialist Builder shall review the requirements related to the product. This review shall be conducted prior to the Specialist Builder's commitment to the customer to supply and install a product and shall ensure that:

- a) Product meets the requirements in this document.
- b) The internal and external audit reporting requirements.
- c) Contract or order requirements differing from those previously expressed are resolved.
- d) The Specialist Builder has the ability to meet the defined requirements.

Records of the results of the review and actions arising from the review shall be maintained.

## **7 PRODUCTION AND SERVICE PROVISION**

### **7.1 Preservation of the Product**

#### **7.1.1 Receipt**

The Specialist Builder shall have a documented procedure for the receipt of incoming material that includes inspection of material and, where appropriate, correlation of advice notes and test certificates. Inspection needs to include condition of the materials, quantities, specification and ensuring that heat/batch numbers match delivery documentation/certification.

The procedure shall incorporate the receipt of customer property.

#### **7.1.2 Storage**

Storage may be off site or on site but in each case the SB shall have a prescribed procedure, which ensures that materials are stored and segregated in a manner, which prevents their corrosion, damage, deterioration and contamination. 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).

- a) Where applicable, the SB shall have a documented procedure for recording and identifying all materials held in stock and subsequently processed. The procedure shall ensure materials are identified to the original heat or batch information, as applicable. This system shall include material supplied by the customer.
- b) All test and inspection information shall be maintained as specified in the appropriate standard. Material shall not be released from storage until verification of conformity to specified requirements has been received.
- c) The procedure shall include all material sent to site and subsequently installed.

### **7.1.3 Handling**

The SB shall have a documented procedure for handling materials and equipment that prevents them from becoming damaged, contaminated or corroded.

### **7.1.4 Delivery**

The SB shall ensure that products are protected up to and including installation on site.

## **7.2 Control of Monitoring and Measuring Devices**

The SB shall have a documented procedure which ensures that all equipment that is used for processing, measuring and testing is identified, defined and regularly calibrated and maintained in accordance with a prescribed calibration and maintenance programme. The calibration and maintenance programme shall include any contract-specific requirements. The re-calibration period for equipment used in PT installation shall not exceed 6 months.

## **7.3 Internal and External Audits**

The SB shall have a documented procedure for the planning, implementing and objective reporting of internal quality audits in order to verify the effectiveness of the quality system, including site activities. The level of inspection shall comply with BS EN13670 inspection class 3.

The internal audit shall include both the Quality Management System (QMS) and also site PT activities / processes and:

- a) Verify that quality activities comply with requirements specified in the SB's quality management system.
- b) Determine the effectiveness of the quality management system.

The results of the audit shall be recorded and shall include:



- a) Objective evidence of audit findings.
- b) Recommendations for corrective actions.
- c) Verification of corrective actions.

The results of internal and external audits shall be included in the management review and shall be made available to the client where required by the execution specification.

#### **7.4 Monitoring and Measuring of Processes and Product**

The SB shall have a documented procedure that ensures inspection and testing is conducted in accordance with the quality plan, appropriate reference standards and execution specifications.

Records of inspection and test information shall be maintained as specified by the customer and the appropriate standard or specification.

#### **7.5 Control of Nonconforming Product**

The SB shall have a documented procedure for processing nonconforming work and materials, which shall include:

- a) Adequate product segregation and identification of nonconforming product.
- b) Review of nonconforming work and appropriate corrective action.

All nonconforming product shall be notified to the customer, client and supplier.

#### **7.6 Improvement**

The Specialist Builder shall continually improve the effectiveness of the quality management system through the use of the quality policy, quality objectives, audit results, analysis of data, corrective actions and management review.

Corrective action procedures shall provide for dealing with customer complaints relating to product. Records of all complaints received, and action taken shall be retained.

#### **7.7 Corrective Action**

The SB shall have documented procedures for corrective action to eliminate the cause and potential cause of nonconformities. The procedures shall include complaints to the SB and complaints from customers relating to the installation, workmanship and materials. Records of all complaints and the corrective action taken shall be maintained.

#### **7.8 Technical Service**

When requested by a customer or client, the SB shall provide technical advice to customers regarding the processing and application of products and operations which are the subject of this schedule where required.

## **8. PRODUCT REQUIREMENTS**

### **8.1 Post-tensioning Kits**

The PT Kit have to comply with the requirements of BS EN13391 or EAD 160004-00-0301 section 2.2.1 (Resistance to static load), 2.2.2 (resistance to fatigue) and 2.2.3 (Load transfer to the structure) or to EAD's predecessor ETAG013. In both cases the anchorages' performance must have been verified by full scale testing witnessed by an independent third party.

For PT Kits which have a valid ETA complying with EAD160004-00-0301 paragraphs 8.1.1 and 8.1.2 will be assumed to be complied with.

For PT Kits which have a CE marking paragraph 8.1.3 will be assumed to be complied with.

#### **8.1.1 Qualification Testing**

For the initial approval and changes in product design, the prestressing anchorages shall be subject to the initial assessment test programme defined in paragraph 8.1.2.

#### **8.1.2 Assessment Test Programme**

Each mechanical prestressing anchorage type shall be subject to the following tests.

- a) Assessment of resistance to static load shall be based on EAD 160004-00-0301 Annex C.2.1. Three sizes are required to be tested: largest, intermediate and small sizes. Largest size is always tested twice. Out of the small and intermediate size, the one with the higher stresses shall be tested twice, the other once.
- b) Assessment of resistance to fatigue shall be based EAD 160004-00-0301 Annex C.3.1. Three sizes are required to be tested: One of the smallest sizes, one intermediate size and two of the largest size.
- c) Assessment of load transfer to structure shall be based on EAD 160004-00-0301 Annex C.4.1. Three sizes are required to be tested: largest, intermediate and small sizes. Largest size is always tested twice. Out of the small and intermediate size, the one with the higher stresses shall be tested twice, the other once.

The above tests originate from EAD160004-00-0301 (ETAG013) and therefore those anchorages that have previously been tested according to the relevant clauses in EAD160004-00-0301(ETAG013) will be deemed acceptable.

### **8.1.3 Periodic Test Programme (Assessment and Verification of Constancy of Performance)**

The SB shall have a periodic test programme that ensures that the anchorage components comply with the audit test requirements of EAD 160004 -00-0301 clause 3.3.4. and table 4.

The samples to be tested shall be representative of those used in practice and shall be of the same type and size and selected at random from the same batches of anchorage components. The tests shall be witnessed by an independent third party proposed by the PT Kit Manufacturer and carried out in.

### **8.1.4 Components of the PT kit and amendment control**

PT Kit components used in the installation shall be from the same design (geometry, geometrical tolerances, material properties, fabrication process) as those which have been used for the assessment testing as detailed in 8.1.2. Any subsequent changes to the kit may require further testing for compliance. Examples of such changes are detailed below, but not limited to:

- a) Change to design of any component
- b) Change to material properties
- c) Change in manufacturing process

Warning of such changes should be made to the CB for their review as to whether further testing may be necessary.

All PT Kit Component fabrication drawings and material properties should be document controlled and suitable for assessment of any changes to the above by the CB.

## **8.2 Ducts**

The SB shall have a documented procedure for the installation and testing of the duct system which comprises ducts, duct connectors, grouting connections, vents, vent connections, drains, transitions to anchorages and anchorages caps.

The procedure shall ensure that:

- a) The duct system complies with EC2 and the execution specification with regard to protection levels (PL1 to PL3) and is produced from suitable materials and components complying to EN 523 or *fib* bulletin 75.
- b) The duct system is correctly assembled, accurately installed and adequately fixed to resist movement and floatation during concrete placement.
- c) The position of vents complies with execution specifications.
- d) The ducts are kept free from standing water and contamination at all times and shall be thoroughly cleaned before strand installation by compressed air.
- e) The duct system is protected from damage during assembly and installation and concrete placement.

### **8.3 Strands and Strand Installation**

The prestressing strands shall comply with the requirements of BS 5896 or EN10138-3 and execution specification.

Strands can only be procured from suppliers, which have factory production certification scheme which is audited by an independent and accredited CB. This certification scheme shall demonstrate that the supplier has production methods with frequency of testing and sampling for FPC, which ensure long-term quality level testing of strand and special properties such as stress relaxation, fatigue and corrosion resistance adhere to the requirements of BS5896 or EN10138-3.

The CB may conduct independent testing, inspect production and materials at source if circumstances arise which may affect the confidence of the reliability of the material or lack of available information to quantify the above requirements.

The SB shall have a documented procedure for the installation of strands that ensures strands are installed safely and without degradation, contamination or damage to the strands or the duct where applicable. The SB shall record details of the time and condition under which the strand installation operations were carried out and details of any interruptions and any problems encountered during the installation process, e.g. blockages or the use of excessive force.

### **8.4 Tensioning**

The SB shall have a documented procedure for tensioning tendons which shall comply with the requirements of the PT Kit's and BS EN13670 clause 7.5 and the execution specification. The procedure shall include the measurement and recording of tendon force and tendon extension for verification purposes.

The SB shall have a documented procedure which ensures that tendons are adequately anchored and that the anchors and strands are protected from corrosion and mechanical damage.

Anchorage including local anchorage zone reinforcement, shall comply with the performance requirements of EAD160004-00-0301 (or ETAG013) and the PT Kit shall hold a valid ETA or with the performance requirements in accordance with BS EN 13391 and the execution specification.

### **8.5 Protection of Post-tensioning System Components**

The SB shall have a documented procedure for the protection of the post-tensioning system components against corrosion, contamination and mechanical damage during and after installation, prior to grouting (where applicable).

When selecting the method and type of protection, the SB shall give due consideration to the duration and type of exposure to which the post-tensioning system components are likely to be subjected.

## 8.6 Grout

Where grouting is required, the SB shall have a documented procedure for assessing the suitability of grout. The grout shall comply with BS EN 445 to 447 and execution specification. Grout shall only be produced using fresh materials from the same source as those used in the suitability testing.

### 8.6.1 Cement used for the grout

The supplied cement used as part of the grout mixture shall comply with the requirements of BS EN 197-1, and as such records of compliance are maintained for each batch received. Bagged constituent materials shall be bagged to an accuracy:  $\leq \pm 2\%$  by weight.

### 8.6.2 Instructions in use and subsequent batching on site of material

These should be clearly defined and supplied to the Specialist Builder with the certificate of conformity for each batch of materials supplied. The label of each constituent to be clearly indicated.

Procedures should be in place to ensure document control and version status of these instructions.

### 8.6.3 Site batched grout product requirements

Grout batched on site in accordance with the SB's recommendations / latest instructions shall achieve the following properties across the specified temperature range and specified w/c ratio.

Sieve test:	grout should contain no lumps (sieve aperture $\leq 1.5\text{mm}$ )
Fluidity:	$> 10$ secs and $< 25$ secs
(Fluidity should not change by more than 20% from immediately after mixing to 30 min after mixing or any later time specified by the grout manufacturer - per clause 6.3 of EN445)	
Bleed:	$\geq 0.0\%$ and $< 0.3\%$
Volume change:	$\geq -1\%$ and $\leq 5\%$
Characteristic strength:	$> 27\text{MPa}$ @ 7 days (cube test)
w/c ratio:	$\leq 0.35$

The addition of chlorides or sulphate is not permissible, and the batched grout should not contain more than:

Chloride (Cl)	$< 0.10\%$ by weight of cement;
Sulfate ( $\text{SO}_3$ )	$< 4.50\%$ by weight of cement;
Sulfide- ions ( $\text{S}^{2-}$ ) ions	$< 0.01 \%$ .

Evidence of the above limits should be made available by the retention of certificates of conformity for the cement / constituent materials received.

#### **8.6.4 Grout Suitability Testing**

Prior to use the SB shall design a grout mix whose properties shall be assessed by suitability testing in accordance with the methods specified in BS EN446, using the materials, material sources and plant proposed for use on site. Grout preparation shall be undertaken under the temperature conditions expected on site. The assessment shall be made sufficiently in advance, but not more than 12 months ahead of the grouting operations to allow controlled adjustments to the materials, procedures or equipment. A grout mix shall be proposed which does not rely on the use of chilled water but has still adequate flowability considering actual ambient temperature and temperature of structure duct is embedded into.

Whenever there is a change in mix design or change in cement supplier and/or properties, the SB shall undertake another series of suitability testing to verify the adequacy of the proposed mix.

#### **8.6.5 Grouting**

The SB shall have a documented procedure for the control of the grouting process, which ensures that the grouting operation complies with BS EN446 and execution specification. The procedure shall include:

- a) The design formula for the grout mix including product name of additives (plasticiser and stabilizer), quantities of constituents and time when to add to the mix, mixing time and target density.
- b) Type of mixer to be used.
- c) Date and evidence of successfully conducted suitability testing.
- d) The planning of resources, supervision, material and the attendance required, to ensure that the grouting process can be conducted without interruption.
- e) Methods for sealing of the anchorages and for testing of the duct's leak tightness by pressure testing Use of dry pack mortar for sealing of anchorages is not permitted.
- f) Definition of locations where grout is injected and where ducts are vented.
- g) Grout waste management
- h) An assessment of the amount of materials required and records of the amount of materials used.
- i) Corrective action in the event of blockage or breakdown.
- j) No grouting when ambient temperature and/or the temperature of the structure is outside the range for which the grout was verified by the suitability testing.
- k) Definition and provision of daily production quality testing (density, flowability, wick induced test, strength) in compliance with BS EN 445 with test frequency specified in EN446 table 3 for inspection class 3.
- l) Post grout inspection and sealing of grouting ports

### **8.6.6 Grouting Records**

The SB shall record details of:

- a) Initial type testing (qualification testing) according to EN447.
- b) Material properties including temperatures and suitability testing according to EN 446.
- c) Quantities of materials used, for how many mix batches and for which tendons per day of grouting with results of production testing.
- d) Location of each tendon that has been grouted.
- e) Confirmation that each tendon's leak tightness has been checked by pressure testing (with results of tests) and that each tendon has subsequently been grouted using grout from with mix batch
- f) The time and condition under which the grouting operations were carried out.
- g) Details of any interruptions and any problems encountered during the grouting process, e.g. extreme temperatures, blockages, loss of grout or loss of grout pressure. Grouting records shall be included in the quality records.
- h) Details of post grouting inspection and any remedial actions undertaken.

## 9 NORMATIVE REFERENCES

The following standards are relevant to the application of this scheme document. Unless agreed otherwise during the application process, the latest version of the product or management system standards will apply.

*ISO 9001: 2015* Quality Management Systems – Requirements.

*BS EN 445: 2007* Grout for prestressing tendons – Test methods.

*BS EN 446: 2007* Grout for prestressing tendons – Grouting procedures.

*BS EN 447: 2007* Grout for prestressing tendons – Basic requirements.

*BS 5896: 2012* Specification for high tensile steel wire and strand for the prestressing of concrete.

*BS EN 13670: 2009* Execution of concrete structures

*EN10138-3: 2005* Prestressing steels – part 3 strand

*ETAG013: Edition June 2002 Amended February 2013* Guideline for European technical approval of post-tensioning kits for prestressing of structures.

*EAD 160004-00-0301: 2005* Post-tensioning kits for prestressing of structures

*fib bulletin 75, 2004* Polymer duct systems for internal bonded post - tensioning

*ISO10012-1: 2003* Quality assurance requirements for measuring equipment.

*TR72: 2004* Durable post-tensioned concrete structures

*BS EN 523:2003* Steel strip sheath for pre-stressing tendons – Terminology, requirements, quality control.

*BS EN 524:1997 (parts 1 – 6): 2003* Steel strip sheath for pre-stressing tendons – Test methods

*BS EN 197-1: 2000* Cement – Part 1: Composition, specification and conformity criteria for common cements.

*BS EN 934-2: 2009+A1:2012* Admixtures for concrete, mortar and grout. Concrete admixtures. Definitions, requirements, conformity, marking and labelling

*BS EN 934-4: 2009* Admixtures for concrete, mortar and grout. Admixtures for grout for prestressing tendons. Definitions, requirements, conformity, marking and labelling



**ADMINISTRATIVE REQUIREMENTS FOR  
CERTIFICATION OF SPECIALIST BUILDERS  
(IN-SITU POST TENSIONING WORKS)**

## 1. OBJECTIVES

The objective of the Scheme is to give confidence to the purchaser of post tensioned concrete structures that the product complies with the appropriate specification without the need to undertake separate verification. It involves the application of quality assurance principles to assess the supplier's quality systems and, as appropriate to, product testing, to ensure conformity with the requirements contained in this Scheme.

The assessment and certification system employed in the Scheme has been developed around the following principles:

- a) The Scheme is concerned with ensuring that the installed post tension system complies with the relevant product Standards and customers' specifications.
- b) The responsibility for complying with the Standards rests absolutely with the Specialist Builder (SB).
- c) The means of providing assurance of consistent compliance with the Standards shall be the formal management system for quality, including process control, which the SB is required to have documented and to be operating to the satisfaction of CB. This system is subject to audit at periodic intervals.
- d) A key method of verifying compliance of the product is by independent assessment and surveillance of the SB's management system for quality, including as appropriate independent inspection and testing of the product. These activities are undertaken by CB.

Product certification is an assurance of product quality and thus the requirements of this certification Scheme are rigorous. Nevertheless, the legal responsibility for compliance with the relevant published standards remains with the SB.

As in the Approved Documents, post tensioning systems that are supplied and installed under the conditions of this Scheme, will ensure recognition of the Scheme as the appropriate method of assurance that post tensioning systems used in Singapore conform to the requirements of the relevant Standards.

The Scheme provides for assessment by CB, acting independently of supplier, of the Quality Assurance procedures to ensure conformity to the appropriate Standards thus eliminating the need for the purchaser to carry out separate testing. This does not preclude the right of the purchaser to carry out independent testing.

## **2. OPERATING PROCEDURES**

A SB who is able to satisfy the qualifying requirements may apply for the recognition of his ability to supply and install post-tensioning systems in accordance with the relevant Standards.

### **2.1 Applying for Certificate of Conformity**

Applications for a CoC are made to the CB. Applications must be accompanied by the appropriate application form and fee, giving details of the products/services for which certification is being sought. The Application form contains a legally binding undertaking to comply with all the requirements laid down by CB from time to time and not to use either of the CoC should approval be withheld or withdrawn.

The applicant is required to have and be able to demonstrate:

- a. The ability and resources required to supply and\ install post-tensioning systems to the relevant Standards.
- b. A quality management system which complies with the requirements of ISO 9001 and the relevant Quality and Operations Assessment Schedule. The system shall be described formally in the supplier's Quality Manual. When the applicant is approved, a Certificate Number will be issued.

### **2.2 Review of Application**

The purpose of the assessment is to establish that the SB has the capability to design, fabricate, supply and install post-tensioning systems to the relevant Standards.

The SB's application will be subjected to an initial review by the CB. This review will be based upon:

- a. The written description of the SB's quality system.
- b. Technical Requirements for Certification of Specialist Builders (TRCSB)

In order to confirm by explanation that the described arrangements are being implemented and are effective, a favourable review will be followed by the assessment of:

- a. The SB's office practice and procedures, including resources, interfaces, training & certification of site crews, site controls and records.
- b. Representative samples of the SB's site practice and procedures, including method statement & inspection test plans, resources, training & certification of site crews, site controls and records.

If at any stage the application does not in the view of CB justify the expense of proceeding further, the SB will be notified and given reasons.

### 2.3 Audit of the Specialist Builder

The audit will be conducted by CB's competent auditor and the programme will provide for:

- a) An introductory Stage 1 meeting with the Applicant during which the assessment procedures will be explained and an overview of their capabilities obtained.
- b) A timetable of activities so that arrangements can be made for appropriate staff to be available during the assessment.
- c) Full Stage 2 audit in accordance with TRCSB:

The office activities and site controls e.g., contract review, document control, requirements for and procurement of the PT Kit Components, calibration of equipment, method statements & inspection test plans and training & certification of site crews.

Examples of key site activities - grout trials, duct installation and testing, tendon installation, stressing, grouting and sealing of ducts vents and grout caps.

Table 1. No. of Audits and Mandays for Initial Assessment or Re-certification every 3 years in addition to Table 2.

Type of Audits	No of Audits / Mandays
Office	1 / 2
Sites	2 / 4

- d) A final meeting with CB's auditor to present its findings in the audit report to the Applicant.

For SB, whose office practice satisfies TRCSB's criteria, but where through lack of a suitable contract, it is not possible to undertake a satisfactory assessment of the SB's site practice a letter of pre-certification will be issued. The letter will detail the scope of the activities assessed: Office Activities in relation to ISO 9001 and technical requirement of the TRCSB as appropriate.

- a) The letter of pre-certification will only be issued when the SB has undertaken to inform CB when a suitable contract has been awarded to allow CB to assess representative samples of the SB's site practice and procedures, including method statements & inspection test plans, resources, training & certification of site crews, site controls and records.

The letter of precertification shall be valid for a period of 6 months but may be reissued for a further 6 months if necessary.

- b) When CB has been notified of a suitable contract, a site audit will be conducted in accordance with 2.4 (c) above.

A recommendation for conformity will be provided when both office and site practice have been assessed and the above criteria have been satisfied and all reported deficiencies have been addressed to the satisfaction of CB.

The CB reviews and approves if the SB meets the requirements of the Scheme and issues a CoC.

## 2.4 Continuous Surveillance

The task for a CB during the surveillance visits will be detailed in prepared audit itineraries based on previous audits and findings with a standard checklist for each installation procedure, including a vertical audit of inspected records for completed levels.

The frequency of surveillance visits shall be in accordance with Table 2.

Table 2. Frequency of Surveillance Audits

Audit Type	Contract tonnage per year		
	0-1000t	>1000t	>2000t
Office	1	1	1
Announced Site	0	1	2
Unannounced Site	1	2	3
Total	2	4	6

The CB may request for more frequent visits from that given in Table 2, subjected to non-conformities identified during the periodic site audits.

If major non-conformities are found, a follow up audit will be taken within 2 months of the date of the raised non-conformance and will not be counted as part of the frequency as detailed in table 2.

Examples of major non-conformance include, but not limited to:

- Nonconformities in PT installation procedures
- The use of non-approved PT Kit and/or kit components
- Incomplete or incorrect material inspection documents
- Lack of availability of necessary inspection records and signatures for each installed level
- Incomplete technical knowledge about the PT Kit's installation procedure by the SB's person in charge of the site installation
- Site installation by non-trained & certified people
- Significant defects in kit components and/or assembled Post Tensioning Tendons

An additional surveillance audit may be requirement for one of the following reasons:

- Different installed PT system to the original approved system
- Significant changes in personnel, identified by the receipt of training records or deployment of personnel without adequate or appropriate training & certification.

## **2.5 Duration and Frequency of Audits**

In determining the duration of an audit, a CB shall consider the complexity and duration of the project as detailed in their monthly project notification. Invariably each site or office audit will last no longer than 2 days.

## **2.6 Certificate of Conformity**

The CoC is valid for three years with renewal subject to continuing satisfactory performance.

The certificate will state

- a. The scope of the approval i.e. those products/services and relevant Standards which are within the assessed capability of the SB.
- b. The name of the SB.
- c. The certification number applicable to the SB.

SB granted with CoC are required to notify CB of all post-tension contracts on award of contract using the Notification of Contracts form provided by CB. This information together with the information derived from the Schedule of Operations will be used to determine the CB inspection regime. It is a condition of the granting of the Certificate that CB shall assess:

- a. The office activities once per year against the relevant assessment schedule including the training requirements in Section 6.5 of TRCSB.
- b. A representative sample of site practice at least one time per year.  
The representative sample of site practice should include each of the installation activities. Assessments of site practice may be conducted on an unannounced basis by direct agreement with the client.
- c. Where the SB has no PT contracts that fall within the scope of this scheme in one calendar year, CB shall assess the office activities at least once a year. The SB shall notify CB of the first suitable PT contract which shall be assessed.
- d. Where the SB has no PT contracts that fall within the scope of this scheme for a period of three calendar years, the CoC shall be withdrawn.
- e. The SB shall undergo a re-certification audit every 3 years of their quality management system by CB as required in Table 1. Depending on the

activities reviewed during the previous 3 year period in addition to the normal office audit this may also include a site audit to review those activities not observed during the previous 3 year period.

The CB reserves the right to request further assessments where deemed to be necessary. The results of the assessment shall be reported to the SB. If satisfactory a renewal certificate will be issued.

## **2.7 Withdrawal of the Certificate of Conformity**

The decision to withdraw a CoC is made by the CB. After the decision the SB in question has the right to appeal to the Appeals Panel.

Examples of the reasons for withdrawal of the CoC are:

- a) Frequent non-compliance with any of the specified properties or other criteria specified in the relevant Standard.
- b) Uncorrected deficiencies noted during a surveillance visit.
- c) Misuse of either of the CoC
- d) Refusal or hindrance to allow CB to verify inspection or testing records.
- e) Circumstances which may affect the confidence of the public or authorities on the reliability

## **2.8 Records**

CB will maintain confidential records relating to assessment, auditing and approval of applicant for 5 years. These records are not available for issue to third parties except due to legal requirements or with the expressed permission of the SB, which must be provided in writing to the CB.

## **2.9 Renewal of Specialist Builder Licence**

At point of SB license renewal, SB to submit CoC together with all audit reports for the past year.

# Appendix1

## Flowchart on Application Process

### Stage 1: Application

Complete application requires the following to be submitted to CB:

- Detail of the PT Kit with valid certification of qualification testing and assessment & verification of constancy of performance of the PT kit component fabrication
- A Quality Manual / Quality Plan, which satisfies the requirements of ISO9001:2015, Technical and Administrative Requirements for Certification of Specialist Builder (In-situ Post-tensioning Works)
- A completed application form to detail the scope of approval relevant to installation of the PT kit, and the type of kit(s)
- The application fee.



### Stage 2: Prelim Assessment by CB

On receipt of a completed application, CB will proceed as follows;

1. Confirm that the application is correct in all respects. A file will be opened to record the assessment process.
2. The PT Kit test certificate, the Quality Manual and / or PT installation Quality Plan / Method Statement and Inspection Test plan shall be reviewed for its adequacy in terms of ISO 9001 and Technical and Administrative Requirements for Certification of Specialist Builder (In-situ Post-tensioning Works) accordingly. Any deficiencies shall be discussed at the Preliminary Inspection (PI) Phase.
3. A Preliminary Inspection (PI) may be performed at the applicants company. This is to establish the technical resources of the applicant and to enable clarification of the application, requirements for the assessment and the maintenance of approval. In certain cases this may be performed at the time of the assessment.
4. As part of the PI an initial Assessment which will examine the company and its' installation procedures for compliance with the applicant's Quality System and Technical and Administrative Requirements for Certification of Specialist Builder (In-situ Post-tensioning Works).



### Stage 3 : Final Assessment

As an absolute minimum the following stages must be observed:

- a) Installation of the approved PT kit and components
- b) Stressing of the tendon(s)
- c) Grouting of the tendons(s), including grout testing

As part of the above there will be assessment of the adequacy of controls and records at each stage.



**Stage 4: Certification of Conformity Granted**

On satisfactory completion of all stages and approval by CB, a Certificate of Conformity will be issued. If any stage is unsatisfactory, there will be no progression to the next stage until all outstanding issues have been resolved.

**Stage 5: Application for Specialist Builder (In-situ post tensioning works)**

At point of SB license renewal, SB to submit Certificate of Conformity together with all audit reports for the past year.

**Stage 6: Ongoing Surveillance following approval for Renewal Specialist Builder (In-situ post tensioning works) license**

Ongoing surveillance audits each year will be undertaken according to the tonnage that the company is undertaking installation. Each month as part of the requirements of the scheme the approved company shall provide to the CB.

A minimum of 1 visits will be required to a maximum of 6 visits depending on the number of live contracts..

## Appendix 2

**Post-tensioning data: Quality records, logging and disposition of site information.**  
 [Name and address of CB]

### Certificate of Conformity

[Certificate Number]

<b>Construction product and its trade name</b>	e.g. <b>Structural components and kits according to TRCSB</b>  <i>produced by</i>
<b>Kit Manufacturer</b>	[Name of Fabricator Company] [Address of Fabricator Company]  <i>in the plant</i>
<b>PT Kit Component Manufacturers (Annex 3)</b>	[Address of Fabrication Plant]
<b>Specialist Builder</b>	[Name of Company] [Address of Company]
<b>Confirmation</b>	This certificate attests that for the PT Kit certified all provisions concerning the assessment and verification of constancy of performance described in TRCSB, with the addition of management system auditing applied, are met and that the PT Kit components are purchased from suppliers with factory production control which fulfils all the prescribed requirements stated therein.
<b>Start of validity</b>	[Original Issue Date]
<b>Next surveillance date</b>	[Date of Next Surveillance Audit] -1 year from date of issue
<b>Period of validity</b>	The certificate will remain valid for 3 years and/or the factory production requirements included of the declared characteristics do not change, and the product and the manufacturing conditions in the plant are not modified significantly.

[Signed by authorized CB person]

[Date of issue]

This Certificate remains the property of <name of CB> and shall be returned upon request. The fabricator is solely responsible for compliance of any product that has the same designation as the product type-tested. Persons relying on this Certificate should verify its validity by checking <name of CB>'s website at <CB website>.

## Appendix 3

[illegible]