



CERTIFICATION SCHEME FOR PERSONNEL

DOCUMENT No. CSWIP-FRP-06

**Requirements for the Certification of Installers and Supervisors of
FRP Plate Strengthening of Concrete Structures**

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Issued under the authority of the Governing Board for Certification
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CSWIP is administered by TWI Certification Ltd

FOREWORD

The Certification Scheme for Personnel (CSWIP) is a comprehensive scheme which provides for the examination and certification of individuals seeking to demonstrate their knowledge and/or competence in their field of operation. The scope of CSWIP includes Welding Inspectors, Welding Supervisors, Welding Instructors, Cathodic Inspection personnel, Bolting Technicians, Plant Inspectors, Underwater Inspection personnel, Plastics Welders and NDT personnel.

CSWIP is managed by the Certification Management Board, which acts as the Governing Board for Certification, in keeping with the requirements of the industries served by the scheme. The Certification Management Board, in turn, appoints specialist Management Committees to oversee specific parts of the scheme. All CSWIP Boards and Committees comprise member representatives of relevant industrial and other interests.

This document describes the requirements of a scheme for the examination and certification of personnel engaged in application and inspection of fibre composite plates in the strengthening of metallic and concrete buildings and civil engineering structures, see Appendix 1.

CSWIP Certificates are generally well recognised by many different national bodies, including authorities, owners of plant and structures, and purchasers.

Fibre-reinforced plastic (FRP) materials are used increasingly in a large range of civil infrastructure applications, in both new build and repair. The growth in the use of composite materials systems for structural applications, either as the sole material component or for applications that involve concrete and metallic materials, has highlighted the need for more rigorous training and competence assurance in the installation and approval processes.

The installation stage is summarised by the following three steps:

- Preparation for installation (including substrate surface preparation)
- Application of adhesive and composite reinforcement
- Quality control checks.

ACCESS TO CERTIFICATION

Access to certification schemes is not improperly restricted. The sole criteria for certification are given in this document (and any subsequent amendments) and no other criteria will be applied. Certification is not conditional on the candidate applying for other services or membership from TWI Certification Ltd, its parent, or any other group or associations.

1 General

This document specifies the examination and certification of personnel who are required to apply and inspect unidirectional fibre composite plates to strengthen existing structures, and in new build. Details of examinations are contained in Appendices 2, 3 and 4. The categories of certification described in this document relate to installer and supervisor levels.

Many of the details of the operations considered are given in:

- Concrete Society TR55 Design guidance for strengthening concrete structures using fibre composite materials
- Concrete Society TR57 Strengthening concrete structures using fibre composite materials: acceptance, inspection and monitoring.
- CIRIA C595 Strengthening of metallic structures using externally bonded fibre-reinforced plastics.
- FIB Externally bonded FRP reinforcement for RC structures.
- The following technical reports issued as formal outputs from the Classification and Assessment of Composite Materials Systems for use in Civil Infrastructure (CompClass)

project supported under the DTI Measurements for Materials Systems (MMS6) programme, and are available from Compclass project website: www.compclass.org.uk :

- Project Overview (2005)
- Technical Report 9 Application Guide
- Technical Report 5b Recommended QC Test Procedures and Specimen Fabrication Protocols
- Technical Report 6 Qualification and Classification Schemes

The competence of an installer or supervisor is an essential condition for the assurance of the quality of the installation work. The application of this document ensures that the examination is carried out according to a uniform procedure.

The scope of examination includes an understanding of the scope of a strengthening project, comprises of: initial work, surface preparation, mixing and application of adhesive, application of FRP plate and inspection during and after installation.

1.1 Requirements for Installer Prior to Taking an Approval Test

Only installers whose training and/or whose previous experience show that they are likely to pass the planned test may be admitted. Typically this is the case if one of the following conditions is met:

- At least 2 years' recognised experience in the relevant application technique by verified CV/employment records.
- Completed a CSWIP recognised training course, followed by at least 6 months on-the-job training supervised by an installer or supervisor with a certificate in the relevant application technique. See Appendices 1 and 2.

1.2 Requirements for Supervisor Prior to Taking an Approval Test

Only supervisors whose training and/or whose previous activities show that they are likely to pass the planned test may be admitted.

- Must have CSWIP Installer certificate with either:
 1. A completed CSWIP recognised training course, followed by at least 6 months on-the-job training in the relevant application technique.
 2. Experience of at least one year supervisory role in the relevant application technique.

2. Test Procedure

The assessment procedure consists of both theoretical and practical examinations.

2.1 Installer

2.1.1. Theoretical examinations, see Appendices 2 and 3

The installer's knowledge of the practical working rules for skilful and safe working shall be established in the theoretical test.

The theoretical written test is a closed book multiple choice paper (specific to the category of certification sought) covering the following:

- Health, safety and environmental aspects of materials, equipment used and their disposal
- Materials conformity before strengthening
- Adhesion, surface preparation and priming
- Awareness of environmental exposure on the materials used prior to application
- Aspects of mixing and application, and curing of adhesives

- Application of FRP material(s) to prepared surfaces
 - Post installation finish
 - QC tests
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- 20 multiple choice questions
 - Time allowed 30 minutes
 - Pass mark 80%.

2.1.2. Practical examination, see Appendix 4

The installer shall complete the test pieces specified in Appendix 4.

All materials, equipment and documents necessary to complete the test piece shall be available to the installer.

The time taken by the installer to complete the relevant test shall correspond to that taken under production conditions.

2.2 Supervisor

2.2.1. Theoretical examinations, see Appendices 2 and 3

- Method statement production
 - Inspection of materials prior to installation
 - Inspection of surface prior to strengthening application
 - Inspection of materials preparation
 - Inspection regimes during strengthening application
 - Inspection of fabricated joint post installation
 - Routine maintenance and repair
 - QC tests
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- 40 multiple choice questions
 - Time allowed 60 minutes
 - Pass mark 80%.

2.3 Application for examinations and fees

Candidates for assessment are required to submit an application form, an authenticated Curriculum Vitae and experience checklist and, if appropriate, evidence of successful completion of a recognised course of training. Applications will not be considered confirmed until correctly completed and authenticated documents are received. In the event of a false statement being discovered in the application documentation, any assessment will be declared null and void. A certificate is automatically invalidated if there are any outstanding fees in respects of that certificate.

Candidates who are found cheating during an examination will automatically be banned for a minimum of five years from taking any CSWIP examination.

3. CATEGORIES OF CERTIFICATION

Successful completion of the theoretical and practical assessments will lead to certification in one of the following categories:

- Installer of FRP plates for Structural Strengthening
- Supervisor of FRP plate installation for Structural Strengthening,

4. CERTIFICATION

4.1 Results notices

All candidates will be sent a results notice. This notice will also be sent to the organisation paying the examination fee, if not paid by the candidate.

4.2 Successful candidates

Two copies of a certificate of approval will be issued to the sponsoring organisation or person. Duplicate certificates to replace those lost or destroyed will be issued only after extensive enquiries.

4.3 Unsuccessful candidates

A standard results notice will be issued to all candidates and their sponsoring organisation. If applicable it will indicate those parts of the tests in which success has not been achieved.

Candidates who fail to obtain a certificate shall undertake further training before taking a new approval test. One retest in the part of the examination that was failed can be undertaken, providing this is done within four months from the date of the original examination. After this time, a new approval test, comprising both theoretical and practical parts, shall be undertaken.

4.4 Initial Approval

The validity of the installer or supervisor's approval begins from the date when the overall assessment pass is awarded. This date may be different to the date of issue marked on the certificate.

An installer or supervisor approval shall remain valid for a period of 2 years providing all the following conditions are fulfilled:

- The installer or supervisor shall be engaged with reasonable continuity on FRP strengthening work within the range of approval corresponding to the approval test certificate. An interruption period for longer than one year is not permitted.
- There shall be no specific reason to question the installer or supervisor's skill and knowledge.

The sponsoring organisation shall advise TWI Certification Ltd at twelve monthly intervals on each installer or supervisor's quality performance.

If any of these conditions are not fulfilled, the approval shall be withdrawn.

4.5 Prolongation

Prolongation is only allowed when TWI Certification Ltd is advised before expiry of the period of initial approval.

Prolongation is only allowed when proof of installation experience is made available to TWI Certification Ltd, who accept that this is the case. This may take the form of signed and dated log book entries for previous installations carried out.

The validity within the range of approval is extended under the original approval for a further two years provided the conditions according to Section 4.4 are fulfilled. Only one prolongation is allowed. When this expires, a new test is required.

An approval assessment taken within three months before the expiry of the period of validity shall commence from that date of expiry.

4.6 Validity of Certificates

Certificates are only valid provided:

- a) they are within date;
- b) they are on standard cream CSWIP paper bearing the CSWIP logo in black on gold signed by an officer of CSWIP and embossed with the CSWIP stamp;
- c) they have been signed by the individual to whom the certificate is awarded; and
- d) they are accompanied by a valid official CSWIP identity card.

Photocopies are unauthorised by CSWIP and should only be used for internal administrative purposes.

4.7 Complaints and Appeals

An aggrieved party in a dispute which considers to have reasonable grounds for questioning the competency of a CSWIP qualified person may petition the Governing Board for non-renewal of the certificate. Such a petition must be accompanied by relevant facts, and if in the opinion of the Board an adequate case has been presented, a full investigation of the circumstances under dispute will be initiated. If the petition is substantiated to the satisfaction of the Board, the certificate will not be renewed without further test.

Appeals against failure to certify or against non-renewal of the certificate may be made by the installer or supervisor upon application in writing to the Governing Board.

5. RECORDS

TWI Certification Ltd maintain records of successful and unsuccessful candidates. These records are accessible to the Governing Board or its nominees at all reasonable times.

6. REFERENCES

1. TR55 Design guidance for strengthening concrete structures using fibre composite materials (The Concrete Society, Camberley, 2nd Edition, 2004)
2. TR57 Strengthening concrete structures using fibre composite materials: acceptance, inspection and monitoring (The Concrete Society, Camberley, 2003)
3. CIRIA C595 Strengthening of metallic structures using externally bonded fibre-reinforced plastics (Construction Industry Research and Information Association, London, 2004)
4. FIB Externally bonded FRP reinforcement for RC structures (International Federation for Structural Concrete, Lausanne, 2001)
5. Classification and Assessment of Composite Materials Systems for use in the Civil Infrastructure (CompClass) project supported under the DTI Measurements for Materials Systems (MMS6) programme, available from Compclass Website:
www.compclass.org.uk:
 - a. Technical Report 9 Application Guide (2005)
 - b. QC Procedures
 - c. Procedures for sample preparation for off-site testing
 - d. Procedures for conducting on-site QC tests
 - e. Classification

7. Further Reading

1. Adhesives in Civil Engineering (Mays, G.C. and Hutchinson, A.R., Cambridge University Press, 1992)
2. Construction Materials Reference Book, (Doran, D.K. & Cather R. (eds.), Elsevier, 2006)
3. Strengthening of Reinforced Concrete Structures, (Hollaway, L. & Leeming, M.B. (eds.), Woodhead, 1999)

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APPENDIX 1

Tasks and Responsibilities of Installers and Supervisors for FRP Plates for Strengthening Structures

FRP Strengthening of Structures: identification of the different roles of installers and supervisors

OPERATIONAL STEP*	ACTIVITIES	SUPERVISOR	INSTALLER
Design and specification Materials Selection	<i>Design by Engineer in association with client</i>		
Method Statement(s)	<i>Contractor develops methods to satisfy requirements of specification documents</i>	✓	
Site activities prior to installation of strengthening system	<i>Install plant /equipment Erect access and sheeting Start bonding record Site inspection of materials and conformance with specification Site trials</i>	✓ ✓ ✓	✓ ✓ ✓ ✓
Surface preparation	<i>Prepare surface(s) Apply surface repair coatings (if applicable) QC tests – mechanical Assessment of surface condition</i>	✓ ✓	✓ ✓ ✓
Application of strengthening system	<i>Preparation of materials Application of primers, adhesives, etc. Application of composite material(s) Finishing QC test specimens Witness plates (if applicable) Provision of particular curing conditions Bonding records Inspection</i>	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
Final QA checks, inspection and approval	<i>Inspection Propose repair methods (if applicable)</i>	✓ ✓	
Remedial works (if applicable)	<i>Materials removal Materials reinstatement QC test specimens Bonding records Inspection</i>	✓ ✓ ✓ ✓	✓ ✓ ✓
Finishing, maintenance and monitoring	<i>Apply finishing coatings and paints Signage Inspection</i>	✓	✓ ✓

*Adapted from CompClass Project

1. Installer Role and Responsibilities

The installer, following the instructions provided in the method statement, is primarily responsible for initial substrate preparation prior to application of the strengthening system,

mixing and application of the adhesive and strengthening system, appropriate QC test specimen preparation and final finishing procedures.

2. Supervisor Role and Responsibilities

The supervisor is responsible for the production of the method statement, based on initial information provided by the designer, inspection and sign off of all materials and equipment to be used, supervising adequate substrate surface preparation prior to installation of the strengthening system, supervision of the application of the strengthening system, supervision of fabrication of QC specimens, sourcing a test house, setting acceptance criteria, and final inspection of the finished installation.

APPENDIX 2: EXAMINATION SYLLABUS

1. Installer

The content of the examination will cover the following technical topics:

- **Health, safety and environmental aspects of the materials, equipment used and their disposal**
 - Adhesive resin handling
 - Solvents, primers
 - Datasheets
 - Equipment and PPE
- **Materials conformity before strengthening**
 - FRP acceptance specification
 - Adhesive resin acceptance specification
 - QC testing
- **Adhesion and surface preparation**
 - Surface cleaning
 - Primers and refreshing of surfaces
 - QC test specimens
 - Repair coatings
- **Awareness of environmental exposure on the materials used prior to application**
 - Materials handling
 - Moisture and UV exposure
 - Temperature
 - Storage
- **Aspects of mixing, application and curing of adhesives and laminating resins**
 - Materials data sheets
 - Mixing specifications
 - Procedures and methods for application
 - Tools for application
 - Control of thickness
 - Finish
- **Application of pre-formed plate to bonded surface**
 - Application specifications
 - QC test specimens including awareness of how to prepare a lap shear test
 - Witness plates if appropriate
 - Cross-over plates, if appropriate
 - Finish
- **Remedial works**
 - Removal of reinforcement
 - Re-preparation of surfaces
 - Resin injection

- **Post installation finish**
 - Final coating painting
 - Fire protection intumescent coatings
 - Repair Coatings
 - Signage

2. Supervisor

The content of the examination will cover the following technical topics:

- **Method statement production**
 - Health, safety and environmental considerations
 - Key elements
 - Acceptance
 - Compatibility of materials
 - QC tests
- **Inspection of materials prior to installation**
 - Data sheet and batch information
 - Life and storage history
- **Inspection of surface prior to strengthening**
 - Methods of assessing cleanliness, coherence, wettability, roughness, topography
 - Recognition of substrate conditions that would make strengthening inappropriate
 - Requirements for surface repair prior to strengthening
- **Materials Preparation**
 - Health, safety and environmental aspects of the materials, equipment used and their disposal
 - Storage during job
 - Cutting
 - Cleaning
 - Mixing
 - Temp control/ dew point
 - QC testing
 - Lap shear tests
 - Bulk adhesive, on and off site
- **Inspection regimes during strengthening**
 - Maintaining records
 - Staff training
 - Site trials
 - Working environment (tenting etc)
 - H&S for job
 - Routine visual inspection
 - Detailed inspection
 - Control samples and QC tests
 - Pull-off test
 - Implication of QC results and failure modes
- **Inspection of fabricated joint post installation**
 - Maintaining records
 - Visual inspection and conformity

- Detailed inspection and conformity
- Inspection of QC tests
 - Pull-off test
- Implication of QC results and failure modes
- **Routine maintenance and repair**
 - Finish
 - Maintenance
 - Repair.

APPENDIX 3: SPECIMEN EXAMINATION QUESTIONS

1. What is the typical pot-life of 5kg of mixed epoxy resin for FRP plate bonding application at 15°C, in minutes?
 - a. 1 minute a. _____
 - b. 10 minutes b. _____
 - c. 2 hours c. _____
 - d. 12 hours d. _____

2. The term 'pot life' for adhesive systems is:
 - a. The time the adhesive is stored in a pot. a. _____
 - b. The time after which the adhesive is no longer active for use b. _____
 - c. The time an adhesive takes to cure c. _____
 - d. The time that an adhesive can be stored safely. d. _____

3. The purpose of a peel ply layer moulded into the surfaces of a composite material is:
 - a. To be removed and provide a clean surface upon which to apply adhesive a. _____
 - b. A layer to stop the composite sticking in the mould b. _____
 - c. A layer to be left in during installation c. _____
 - d. To keep the surface clean and dry d. _____

4. What is the main method for surface preparation of concrete?
 - a. Sand/grit blasting a. _____
 - b. Wipe down with a cleaning fluid b. _____
 - c. Rub with sand paper c. _____
 - d. Grit blast and apply a surface primer d. _____

5. What is the best way to cut CFRP?
 - a. Hack saw a. _____
 - b. Guillotine b. _____
 - c. Diamond saw c. _____
 - d. Circular saw d. _____

APPENDIX 4: PRACTICAL EXAMINATION TEST PIECES

The practical exam is in three parts and candidate has to pass all three parts in order to be accredited for the practical exam.

All specimens should be made in a simulated site condition.

1. Production of a set of QC test specimens selected by the examiner from one of the following three categories.

1.1. On site dumbbell/dynamic mechanical thermal analysis (DMTA) strip specimen (made by candidate, tested by examiner).

- Number of specimens to be made
 - 5 good specimens
- Criteria for Pass/Fail
 - Fully-filled moulded shape, void-free by visual inspection when cured
 - Specimens must exceed minimum mechanical values for modulus, and strength to failure according to the adhesive used when tested to destruction*. ISO 527-1
 - Minimum of three samples to pass the above criteria

1.2. Lap shear specimen using CFRP adherends (made by candidate, tested by examiner).

- Number of specimens to be made
 - 5 good specimens
- Criteria for Pass/Fail
 - Good alignment and uniform bondline by visual inspection
 - Joints must exceed a minimum mechanical strength value (typically 8 MPa*). ASTM D 3163 and
 - 75% cohesive failure in adhesive/substrates*
 - Minimum of three samples to pass the above criteria

1.3. Bulk adhesive state of cure hardness test (using a bulk prism specimen) (made by candidate, tested off side by examiner). BS EN ISO 868:2003

- Number of specimens to be made
 - 5 good specimens
- Number of tests to be carried out
 - 10 Shore D durometer readings (minimum of 2 tests per specimen)
- Criteria for Pass/Fail
 - Typically 77 Shore D at 24 hours*
 - Minimum of three specimens, 2 reading each to pass the above criteria

2. Production of a representative section of FRP strengthened substrate, including surface preparation, adhesive mixing, application, strengthening system application and finish. This will be carried out in the presence of the examiner with the candidate discussing the procedure and answering questions posed by the examiner during the test.

- Number of specimens to be made
 - 1 horizontal, and 1 vertical or overhead
- Criteria for Pass/Fail at each stage
 - Primarily visual inspection (free of visual defects, properly tooled bondline fillets, parallel substrates and tap-test)

- A pull-off test carried out by candidate to assess adhesion and strength, to compare with control data for the system involved*†. BS EN 1542:1999

3. Surface preparation and pull-off test specimen for concrete and metallic substrates, for horizontal, vertical or overhead surfaces (made on site, tested off site). BS EN 1542:1999

- Number of specimens to be made
 - 5 numbers 25mm diameter steel dollies bonded to metallic substrates or
 - 5 numbers 50mm diameter steel dollies bonded to concrete substrates
- Criteria for Pass/Fail
 - Evaluation of appropriate surface preparation for metallic or concrete substrates
 - Dollies must be parallel to substrates and the spew fillet removed

* : The examining body should provide the actual figures for minimum acceptance data for particular materials from the control data established from the Compclass Classification Scheme. www.compclass.org.uk

†: To establish candidates' competency to carry out pull-off test, the examining body will provide a pre-fabricated representative section of FRP strengthened substrate to enable on site testing. The sections made by the candidates shall be tested off site by examiner).