

Structures

Master Specification

ST-SC-C3 Fibre Reinforced Polymer Composite Strengthening of Concrete Structures

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ST-SC-C3 Fibre Reinforced Polymer Composite Strengthening Of Concrete Structures

1 General

- 1.1 This Part specifies the requirements for the supply of materials, surface preparation, installation, relevant inspection and testing and acceptance criteria for the strengthening of bridges using strengthening systems.
- 1.2 The application of ultra violet protection, anti-graffiti and anti-carbonation coatings and crack repairs which may be required also form part of the FRPC strengthening system installation work and is included in this Part.
- 1.3 Unless specified otherwise, all design and / or documentation must comply with the most recent revisions (including published amendments) of the following design standards and / or specifications:
 - a) AS 2313 Guide to the Protection of Structural Steel Against Atmospheric Corrosion by the use of Protective Coatings

2 Quality Requirements

- 2.1 At a minimum, the Contractor's Quality Plan shall include the following documents, procedures and / or instructions:
 - a) proposed methods of obtaining access to the work;
 - b) details and evidence of the performance of the materials to be used (refer Clause 3.1 "Material Properties"), including relevant test results and certificates of compliance, which shall not be more than 24 months old;
 - c) methodology for application of strengthening system, including information on the proposed substrate preparation, method of application, equipment, and operators; and
 - d) if resin is to be factory applied or applied onto the fabric on-site, additional procedural information (refer Clause 4.31 – 4.37 "Application of Fabric Sheets").
- 2.2 If not provided beforehand, this documentation shall be submitted at least 28 days prior to the commencement of site work.
- 2.3 Provision of the procedures listed in this Clause shall constitute a **Hold Point**.

3 Materials

Material Properties

- 3.1 The constituent materials used for the FRPC strengthening system (including all resins, primers, putties, saturants, adhesives and reinforcing fibres) shall comply with the following (in order of precedence):
 - a) any requirement specified in the design;
 - b) the manufacturer's instructions;
 - c) the Contractor; and
 - d) this Part.

Handling and Storage of Materials

- 3.2 Adhesives and other resins shall be stored in dry conditions not exposed to direct sunlight, in strict accordance with the material manufacturer's data sheet requirements and within the manufacturer's specified maximum and minimum temperature range. Materials shall remain in their original, sealed containers until time of use.

- 3.3 All material shall be brought to site in the original unopened cans clearly labelled with the appropriate manufacturer's name, product type, reference number and batch number. Materials stored beyond the manufacturer's recommended shelf life shall not be used.
- 3.4 The Contractor shall provide, for each batch of FRPC system material, a copy of the manufacturer's information as specified below:
- a) manufacturer's name and address;
 - b) product reference;
 - c) batch number of identification;
 - d) quantity manufactured in the batch; and
 - e) certificate of date of manufacture.
- 3.5 FRPC system materials including, adhesives and resins, shall be used in order of date of manufacture.
- 3.6 FRPC plates, laminates or strips shall be supplied and stored on site such that damage or contamination does not occur. Plates, laminates and strips shall be free from unintended curves, bows, wraps, undulations or twists.
- 3.7 Plates, laminates and strips shall be handled with clean gloves under dry conditions, and touching of ready for bonding surfaces without peel ply shall be avoided.
- 3.8 Where FRPC materials are fitted with protective peel ply to ensure a clean surface, the ply shall be removed immediately prior to application and touching of the surface shall be avoided.
- 3.9 FRPC fabric sheets or rolls shall be kept free from any contamination. The FRPC fabric sheets shall be handled carefully and shall be free from wraps, twists or fibre misalignment. Any protective peel ply shall be removed immediately prior to application. They shall be stored either by being rolled to a radius greater than 300 mm or by being dry stacked after cutting and shall be protected from dust and moisture.
- 3.10 Handling and preparation precautions shall be in accordance with the material manufacturer's recommendations and material data sheets.
- 3.11 The Contractor shall maintain records showing which elements were treated with each batch of FRPC system material.

Carbon Fibre Laminate (Carbon Fibre Reinforcement with Epoxy Matrix)

- 3.12 The carbon fibre laminate material shall be a pre-fabricated, pultruded section, specifically designed for adding tensile strength as part of a compatible, load transferring, bonded system.

Carbon Fibre Fabric (High Strength Carbon Fibres)

- 3.13 The carbon fibre fabric materials shall be pre-woven into sheets, specifically designed for adding strength as part of a compatible, load transferring, bonded system.

Adhesive for Carbon Fibre Laminate

- 3.14 The adhesives shall be a thixotropic paste used to bond procured FRPC laminate systems to the concrete substrate and provide the required shear load path between the concrete substrate and the FRPC reinforcing laminate. Adhesives shall also be used to bond together multiple layers of FRPC laminates where required.

Saturating Resin

- 3.15 The saturating resin shall be used to impregnate the reinforcing fibre fabric to fix it in place and shall be capable of providing a shear load path to effectively transfer the load between fibres. The saturating resin shall also serve as the adhesive for wet lay-up systems and shall be capable of providing a shear load path between the previously primed concrete substrate and the FRPC system.

General Resin Requirements

- 3.16 Resins used as part of FRPC strengthening systems (including primers, putty fillers, saturants and adhesives) shall also have the following characteristics:
- a) compatibility with and adhesion to the concrete substrate;
 - b) compatibility with and adhesion to the FRPC system;
 - c) resistance to in-service environmental effects, including but not limited to moisture, salt water, temperature extremes and chemicals normally associated with exposed concrete;
 - d) filling ability;
 - e) workability;
 - f) pot life consistent with the application;
 - g) compatibility with and adhesion to the reinforcing fibre; and
 - h) development of appropriate mechanical properties for the FRPC.

Primer

- 3.17 The primer shall be a very low viscosity resin used to penetrate the concrete surface and provide an improved adhesive bond for the adhesive.

Putty Filler

- 3.18 The putty filler shall be a thixotropic paste used to fill small voids, including bug holes, in the concrete substrate, to provide a smooth surface to which the FRPC system bonds and also prevent bubbles from forming during curing of the saturating resin.

4 System Installation

Concrete Surface and Preparation

- 4.1 Concrete surfaces shall be dry and shall be free from all bond-inhibiting materials. The concrete surface shall be prepared with an appropriate method to provide a clean sound surface.
- 4.2 Abrasive blast cleaning shall be carried out in accordance with AS 1627.4 and other WH&S and Environmental regulations imposed by the local government authority and the EPA. Waste material resulting from the surface preparation shall be removed by suitable means. The surface shall be vacuumed before the application of the FRPC laminate.
- 4.3 The surface layer of the concrete shall be removed to expose small particles of well-bound aggregate such that the roughness to be achieved lies between an amplitude of 0.5 mm to 1 mm, with a surface presenting similar to 60 grit sandpaper. The surface shall not be roughened excessively.
- 4.4 Prior to the commencement of full-scale surface preparation procedures, the Contractor shall first prepare a representative sample area in accordance with the requirements of this Part, which shall be used as a reference standard exhibiting a satisfactory prepared surface for the duration of the works.
- 4.5 Preparation of the sample area constitutes a **Hold Point**.
- 4.6 Any blow holes, areas of honeycombing, loose surface layers and weak concrete, shrinkage cracks of width less than 0.20 mm or other defects, either revealed by a grinding process or exposed by other surface preparation methods, shall be filled with a suitable putty filler, compatible with the FRPC strengthening system to be applied.
- 4.7 If the surface of the concrete is weak, more material shall be removed, and the amount removed and refilled shall be sufficient to result in a strong, sound substrate suitable for the intended FRPC strengthening system. Where necessary, projecting fins, rough spots, sudden steps or other surface irregularities shall be ground to less than 1 mm by light abrasion with an angle grinder or filled with a suitable putty filler to provide a smooth concrete surface.

- 4.8 Any breakouts or core holes shall be repaired with hand-applied polymer modified cementitious materials to the original surface profile and in accordance with the material manufacturer's recommendations. The polymer modified cementitious materials shall be compatible with the parent concrete, in terms of electrical resistivity and compressive strength.
- 4.9 Where fibre fabric is to be wrapped around corners, the corners shall be rounded to a minimum radius of 25 mm to avoid local damage to the fabric.
- 4.10 The unevenness of the concrete substrate surface shall be such that the gap under a 2 m straight edge does not exceed 4 mm. The general unevenness with respect to a 0.3 m straight edge shall not exceed 1 mm. Any out of tolerance areas shall be rectified with a suitable rapid setting putty filler.
- 4.11 Concrete cracks of width equal to or greater than 0.20 mm shall be sealed by resin injection compatible with the FRPC strengthening system. Cementitious repairs shall be cured for at least 14 days prior to undertaking any FRPC strengthening application.
- 4.12 A trial application of the overall FRPC system to check the suitability of the surface, the surface preparation method, method of application and other requirements shall be undertaken (refer Clause 5 "Trial System Application").

Primer and Putty Filler Requirements

- 4.13 Where the FRPC strengthening system requires the use of a primer to seal the surface, it shall be uniformly applied to all areas of the prepared concrete surface using brush or roller, in accordance with the manufacturer's recommendations and specified rate of coverage.
- 4.14 Compatible putty filler shall only be used to fill voids, smooth surface discontinuities and treat minor imperfections prior to the application of other materials.
- 4.15 Rough edges or lines of cured putty shall be ground smooth prior to proceeding with the installation.
- 4.16 The putty filler shall have rapid strength gain characteristics which enable over-bonding to be carried out after a short time and shall be capable of being applied in thin layers where required.
- 4.17 Prior to applying the adhesive or the saturating resin the primer and putty filler shall be allowed to cure for the required period in accordance with the material manufacturer's specified requirements, to ensure satisfactory adhesion at the interface of the two materials.
- 4.18 Where the primer and putty filler are completely cured, additional surface preparation may be required prior to the application of the saturating resin or adhesive consistent with the FRPC strengthening system compatibility requirements.

Mixing of Resins

- 4.19 The mixing of resins shall be in accordance with the FRPC system manufacturer's recommended procedures including recommended batch sizes, mix ratios, mixing methods, mixing times, current material safety data sheets, and as specified in this section. The ambient temperature of all resin components shall be between 10°C and 30°C at the time of mixing.
- 4.20 Resin and hardeners shall be mixed together in the correct proportions and required mixing times until there is a uniform, homogeneous mixing of components and colour streaks are eliminated. No excess material shall be left in the individual component containers.
- 4.21 Scales or volumetric equipment used shall be calibrated at 3 monthly intervals.

Drying and Curing Requirements

- 4.22 The Contractor shall adhere to the manufacturer's instructions regarding drying and curing requirements, reapplication time intervals for adhesives and other resins, and prevailing weather conditions.

Environmental Conditions

- 4.23 FRPC strengthening systems shall not be applied under any of the following conditions:
- windy conditions where over spray and / or spatter may be generated;

- b) when wind-borne debris is likely to contaminate the uncured surface of the freshly applied coating;
- c) when the ambient temperature exceeds 300°C or is below 50°C;
- d) when the concrete surface temperature exceeds 350°C or is below 80°C;
- e) when the relative humidity exceeds 85%;
- f) when rain spatter or run-off, including leakage through deck joints, contaminating the surface and adversely affecting the adhesion to the substrate, may occur;
- g) when the surface temperature of the substrate is less than 30°C above the dew point calculated in accordance with AS 2312 (Figure 8.1) or exceeds 350°C;
- h) when the moisture content of the concrete or cementitious repairs exceeds 8%; or
- i) when the surface moisture condition of the concrete is not dry and it does not satisfy the manufacturer's recommendations.

Application of Plates, Laminates or Strips

- 4.24 The bonding surface of the FRPC plate, laminate or strip shall be thoroughly cleaned and where required abraded lightly as per the manufacturer's recommendations prior to application.
- 4.25 The adhesive shall be applied to the prepared bonding concrete surface as a thin layer by means of a notched steel trowel or equivalent immediately after mixing. The adhesive shall cover the whole of the bonding area and shall be maintained at a thickness in the range of 1 to 2 mm. A further adhesive layer shall be applied to the cleaned and fully dried FRPC plate, laminate or strip to form a dome profile across the plate with 3 mm of adhesive material in the centre and 1 mm on the edges.
- 4.26 The FRPC plate, laminate or strip shall be brought into contact and lightly pressed with the fingers onto the prepared bonding area. The FRPC material shall be further pressed on with a hard rubber roller until the extra adhesive is squeezed out along the sides.
- 4.27 The roller pressure shall be applied from the centre going to the outer edge such that no voids are formed between the laminate and the concrete substrate surface. The excess adhesive shall be removed.
- 4.28 The layer thickness of the final adhesive along the bond line of the laminate shall be a minimum of 1.5 mm and a maximum of 3 mm.
- 4.29 Adhesive residues on the laminate surface shall be removed with a compatible chemical remover prior to hardening. Where required, additional parallel FRPC plates, laminates or strips shall be applied at a minimum distance of 5 mm from the adjacent FRPC material. Where FRPC plates, laminates or strips are lapped, the minimum overlap, in the longitudinal fibre direction, shall be 200 mm unless otherwise approved by the Superintendent.
- 4.30 If temporary shoring of the FRPC plate, laminate or strip is required to be retained in position then the FRPC system should be fully cured before removing the shoring.

Application of Fabric Sheets

- 4.31 The saturating resin or bonding adhesive shall be uniformly applied to saturate the concrete surface using hand-held foam roller, brush or scraper at the coverage rates specified in the material manufacturer's data sheet to ensure adhesion of the fabric material.
- 4.32 The FRPC sheets shall be applied to the resin-saturated concrete surface by pressing manually onto the adhesive such that it is stretched by avoiding any wrinkles or the introduction of voids.
- 4.33 The surface of the fabric shall be rolled over the backing paper to force the impregnation of the resin into the fabric material. Rolling shall be in the longitudinal direction of the fibres along the centreline and working outwards to expel excess adhesive at the edges to ensure the removal of any entrapped air and produce an even adhesive line. The backing paper shall then be peeled away.
- 4.34 Where subsequent layers of saturation resin are required as part of the FRPC strengthening system, the required time shall be allowed between the first and second coat of resin in accordance with the

- material manufacturer's data sheet. The time between mixing and application of the saturation resin shall be in accordance with the material manufacturer's data sheet.
- 4.35 Where FRPC fabric sheets or strips are lapped, the minimum overlap in the longitudinal fibre direction shall be 200 mm. Additional resin shall be applied to the outer surface of the fabric layer to be overlapped. No lapping in the lateral fibre direction shall be allowed. Any lifting or delamination that may occur during the application period shall be corrected by pressing the fabric sheet using a foam roller or spatula.
- 4.36 Where multiple layers of FRPC fabric sheet are required as part of the design of the FRPC strengthening system, these shall be applied in accordance with the material manufacturer's recommendations, data sheet and as specified in this Part.
- 4.37 Where the resin is factory applied or it is applied onto the fabric on site using hand held foam rollers, brushes or impregnation machines prior to application, additional procedures on how the installation shall be supported shall be included in the Quality Plan.

5 Trial System Application

- 5.1 A trial application on a test area nominated by the Superintendent of the actual substrate shall be completed 7 days prior to the commencement of FRPC strengthening work. The trial shall include the sampling and testing of epoxies and resins as outlined by the Principal. The test area shall be prepared and strengthened by the Contractor to satisfy all the requirements of the material manufacturer's recommendations, unless otherwise specified in this Part.
- 5.2 The trial FRPC strengthening application shall prove the adequacy of the Contractor's proposed materials. Actual coverage rates of adhesives and other resins shall be recorded, in order that due allowance may be made in the full-scale application for rough, irregular or highly absorbent concrete substrate. Additional requirements or observations shall be recorded and considered for the full-scale application. If the trial application is successful, the FRPC strengthening system shall be utilised in the works.
- 5.3 Completion of the trial area shall constitute a **Hold Point**.

6 Contractor Competency

- 6.1 The FRPC system installation Contractor or subcontractor shall have a minimum of 5 years' experience in the repair and rehabilitation of reinforced concrete structures and a demonstrated competency for surface preparation and application of the FRPC system to be installed. Such experience shall be supported with documented evidence of previous experience including previous projects and relevant references.
- 6.2 The Contractor shall also provide documented evidence from the FRPC system manufacturer demonstrating that Contractor's application personnel are adequately trained and skilled in the installation procedures of the FRPC system to be installed. The FRPC system installation supervisor shall be trained and qualified on all aspects of the applied techniques and shall be present during work at all times.

7 Inspection and Testing

General

- 7.1 The Contractor shall undertake all inspection and testing of the installed FRPC strengthening system as specified in this Clause. The Contractor shall maintain all required documentation and results as specified in this Part and PC-QA1 "Quality Management Requirements" for all stages of the work.
- 7.2 The work shall be inspected by the Contractor at each stage of the FRPC strengthening operation as a minimum, i.e. after surface preparations, mixing of materials, prior to and after adhesive and resin application and any touch-up that may be required and both during and after installation of FRPC plates, laminates, strips or fabric sheets.

- 7.3 The Contractor shall provide at least 5 days' written notification of its intention to carry out strengthening works. Provision of the notification shall constitute a **Hold Point**.

Testing for Drummy Areas

- 7.4 A visual inspection of the FRPC works shall be conducted immediately after installation is complete and any defects recorded. The cured FRPC strengthening system shall also be visually inspected and checked for delaminations, air voids, and bubbles between multiple layers or between the FRPC system and the concrete, 7 days after completion of installation.
- 7.5 The "drumyness" test shall be conducted along the whole length of each applied FRPC plate, laminate, strip or fabric sheet using a small hammer (or similar). Areas where the FRPC material has not bonded correctly to the concrete or to subsequent layers will be characterised by a "drummy" or hollow sound.
- 7.6 Delamination size, location, and quantity relative to the overall application area shall be recorded and evaluated with respect to structural integrity and durability of the FRPC system. Small delaminations less than 25 mm x 25 mm do not require corrective action provided the total delaminated area is less than 5% of the FRPC strengthened area and there are no more than 5 such delaminations per 1 m².
- 7.7 Where these requirements are not complied with, the effective delaminated area shall be considered as a large delamination area and repaired in accordance with the requirements of Clause 8 "System Repairs". Individual or isolated delaminations, air voids or bubbles larger than 25 mm x 25 mm shall be marked and repaired in accordance with the requirements (refer Clause 8 "System Repairs").

Testing for Flatness

- 7.8 The evenness for the FRPC plates, laminate, strip or fabric sheets shall not deviate by more than 4 mm when checked with a 2 m straight edge. In addition, evenness shall not deviate by more than 1 mm when checked with a 300 mm straight edge.

Adhesion (Pull-Off) Testing

- 7.9 The Contractor shall conduct partially cored direct pull-off tests of the fully cured FRPC system to verify the tensile bond between the FRPC material and the existing concrete substrate, 7 days after the completion of installation. The pull-off testing shall be undertaken in accordance with European Standard EN 1542 (CEN 1999c) except that reference to standard concrete test specimens shall be replaced by in-situ concrete substrate. Sub-sections 4.1, 4.2, 4.3, 4.4, 4.12 and Sections 5 and 6 of the test method EN 1542 shall not apply in the adhesion testing of the FRPC system.
- 7.10 Testing for FRPC plates, laminates or strips and testing for FRPC fabric sheets shall be carried out at the frequency stated specified by the Principal. The mean bond strength at 7 days shall be greater than 1.5 MPa, and no individual result shall be less than 1.35 MPa.
- 7.11 The mode of failure of the pull-off test shall be in the concrete substrate. Mean bond strengths less than 1.5 MPa or failure between the FRPC system and the concrete substrate or between layers of FRPC shall be raised, as a non-conformance and disposition shall be to the satisfaction of the Superintendent.
- 7.12 After the pull-off test is complete (and prior to anti-carbonation coating) the cored hole shall be filled and smoothed with a polymer modified cementitious material or the FRPC system putty. If a polymer modified cementitious material is used then it shall be cured for 7 days before application of the anti-carbonation coating.

Compressive Strength of Adhesives and Resins

- 7.13 The Contractor shall take three 75 mm test cubes from the first batch of material mixed, then three 75 mm cubes for every 100 kg of material used thereafter to test for compressive strength. The cubes shall be cured for 7 days as per the material manufacturer's recommendations. Two cubes shall be tested at 7 days and the third cube at 28 days, to confirm compliance with the minimum compressive cube strengths as specified (refer Clause 3.1 "Material Properties").

8 System Repairs

- 8.1 Should any of the FRPC strengthening system application work not comply with the provisions of this Specification then the areas concerned shall be repaired. Such repair work may include removal of the FRPC areas concerned, follow by surface preparation and application of new layer of FRPC. The provision of a procedure for any repair work shall constitute a **s**
- 8.2 **int.**
- 8.3 For the purpose of this Clause, non-complying work shall include delaminations, air voids or bubbles larger than 25 mm x 25 mm. Large delaminations greater than 300 mm x 300 mm shall be repaired by selectively cutting away the affected FRPC material, followed by surface preparation and application of overlapping FRPC layer. Determinations, air voids or bubble greater than 25 mm x 25 mm in size but less than 300 mm x 300 mm shall be repaired by either resin injection for FRPC layer replacement in accordance with this Clause.
- 8.4 Wrinkling of the FRPC material or broken fabric shall be repaired by the application of additional layers.

9 Sealing of Cracks

- 9.1 The Contractor shall effect epoxy injection of cracks of width equal to or greater than 0.20 mm to both the FRPC strengthened and non-strengthened surfaces of the specified works. The epoxy injection system shall be compatible with the FRPC system and applied in accordance with the Department's Bridge Repair manual, Standard Repair Number 5.

10 Application of Decorative / Anti-Carbonating Coating

- 10.1 Unless otherwise specified by the Principal, the Contractor shall apply 2 coats of a decorative / anti-carbonation coating to a total minimum dry film thickness of 150 microns, to both the FRPC strengthened and non-strengthened surfaces of the specified works on the underside and sides of the bridge superstructure only. The decorative / anti-carbonation coating shall be alkali resistant, be suitable for use on FRPC material surfaces and applied in accordance with the manufacturer's recommendations.
- 10.2 The appearances of the finished product has a high priority and the application of the coating system shall ensure a uniformity of colour with the surrounding concrete surfaces.

11 Application of Anti-Graffiti Coating

- 11.1 The Contractor shall apply a non-sacrificial anti-graffiti coating to the whole of the specified works in accordance with the requirements outlined by the Principal. The anti-graffiti coating shall be compatible with the decorative / anti-carbonation coating applied.

12 Protection of Works and Property and Clean Up

Protection of Works / Property

- 12.1 The Contractor shall protect already completed works during abrasive blasting operations or any other surface preparation process and during FRPC system application processes. The Contractor shall ensure that the FRPC works are protected from adverse conditions, dust and debris during the curing period of the FRPC system in accordance with the requirements (refer Clause 4.23 "Environmental Conditions").
- 12.2 The Contractor shall undertake suitable protective measures and methods during the installation of the FRPC system to ensure that vehicles and pedestrians are adequately protected from these works.

Environmental Requirements

- 12.3 The Contractor shall remove all adhesive residues, droppings and smudges from all surfaces, including surfaces not being treated. The Contractor shall remove from the site all spent abrasive and all other rubbish accumulated during the work on a daily basis.
- 12.4 The Contractor shall dispose of such wastes and adhere to EPA and other local, state and federal government requirements with respect to how waste generated during surface preparation, FRPC system application, and clean-up will be collected, segregated, handled, controlled and disposed of.

Disposal of Waste Materials

- 12.5 Waste materials including liquid wastes shall be deposited in suitable containers and disposed of at sites to be located by the Contractor that acceptable to the EPA and other relevant authorities. Liquid or other waste materials shall not contaminate creeks, waterways or the stormwater drainage systems.

13 Hold Points

- 13.1 The following is a summary of hold Points referenced in this Part:

Document Ref.	Hold Point	Response Time
2.3	Submission of Procedures (if not in Post Tender Submission)	7 days
4.5	Concrete Surface Preparation Sample Area	6 hours
5.3	Completion of the Trial System Application	1 day
7.3	Notification of Commencement of Work	1 day
8.1	Procedure of Repairs	2 days

14 Verification Requirements and Records

- 14.1 The Contractor shall supply written verification that the following requirements have been compiled with and supply the verification with the lot package.

Table ST-SC-C3 14-1 Verification Records

Document Ref.	Subject	Property	Test Procedure	Test Frequency	Acceptance Limits
2	FRPC System	Previous performance Relevant test results Certificates of compliance	-	Note more than 24 months	-
3.3	Material Batches	Product reference Batch number of identification Quality manufactured in batch Date of manufacture	-	Each batch	-
3.10	Concrete substrate	Surface evenness	2 m straight edge 300 mm straight edge	Each strip Each strip	Gap not greater than 4 mm Gap not greater than 1 mm
3.23	Environmental Conditions	Ambient temperature	Dew point AS 2312 (Fig 8)	At commencement of each	Not greater than 30°C, or less than 5°C

Document Ref.	Subject	Property	Test Procedure	Test Frequency	Acceptance Limits
		Concrete surface temperature		component of work	Not greater than 35°C, or less than 8°C, or, less than 3°C, above dew point
		Relative humidity			Not greater than 85%
		Moisture content of concrete or repairs			Less than 8%
5	Trial system application	All requirement for work	-		As required for work
7.3	Drummy areas	-	-	Each strip	-
7.8	FRPC Strips	Flatness	2 m straight edge	Each strip	Gap not greater than 4 mm
			300 mm straight edge	Each strip	Gap not greater than 1 mm
7.9	FRPC Strips	Adhesion (pull off) testing	European Standard EN1542 (CEN 199C)	2 per span on underside of bridges. One at each pier on bridge deck.	Mean greater than 1.5 MPa. No individual result less than 1.35 MPa
7.13	Adhesives / Resins	Compressive strength	-	3x75 mm cubes from first batch. 3x75 mm cubes from each 100 kg of each material thereafter	Not less than 60 MPa
10	Anti-carbonating coating	Dry film thickness	-	1 test per joint	Not less than 150 microns