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AUSTROADS TECHNICAL SPECIFICATION ATS 5880

Fibre Reinforced Polymer Bridge Members



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1. Scope

- 1.1 Austroads Technical Specification ATS 5880 sets out the requirements for to the manufacture of fibre reinforced polymer composite members for bridges ('FRP Members').
- 1.2 It covers modular solutions (formed by connecting standard pultrusions) or from utilising bespoke mouldings (formed by the vacuum infusion process).
- 1.3 The FRP Members may be used in hybrid (non-composite) forms of construction; for example, a FRP road deck placed on beams constructed from steel, concrete or timber.
- 1.4 This Specification does not apply to:
 - a) the strengthening of existing structural members to form a structural composite action between the FRP and non-FRP members (refer ATS 5380); or
 - b) the manufacture of fibre reinforced polymer composite reinforcing bar.

- 1.5 If the manufacturer of the FRP Members ('Manufacturer') and the Contractor are not the same entity, the Contractor must ensure that the Manufacturer complies with the requirements of this Specification.

2. Referenced Documents

- 2.1 The following documents are referenced in this specification:

Australian / New Zealand Standards

AS/NZS 1170.0	Structural design actions Part 0: General Principles
AS 3959	Construction of Buildings in Bushfire Prone Areas
AS 5100.2	Bridge Design – Part 2 Design Loads
AS/NZS ISO 9001	Quality management systems – Requirements

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ATS 5380	Fibre Reinforced Polymer Composite Strengthening
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International Standards

BS EN 13706	Reinforced plastics composites Specifications for pultruded profiles, Parts 1 to 3 (inclusive)
ISO/IEC 17025	General requirements for the competence of testing and calibration laboratories

ASTM International

ASTM D3917	Standard Specification for Dimensional Tolerance of Thermosetting Glass-Reinforced Plastic Pultruded Shapes
ASTM D4385	Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products
ASTM G154	Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

Highways England

CD 368	Design of fibre reinforced polymer bridges and highway structures
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American Society of Civil Engineers

ASCE LRFD	Pre-Standard for Load & Resistance Factor Design (LRFD) of Pultruded Fiber Reinforced Polymer (FRP) Structures
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3. Definitions

3.1 In addition to the definitions in CD 368, the following definitions apply to this Specification.

FRP Member:	Includes Full Scale Components, Sub-components and Structural Elements.
Manufacturer:	The company that manufactures the FRP Members and also satisfies the requirements of Clause 4.3.
Principal's Registration Scheme:	Any scheme for the prequalification, registration or approval of products, manufacturers, suppliers and/or Professional Engineers in operation in the jurisdiction where the structure is to be built.
Professional Engineer:	<p>A person who:</p> <ol style="list-style-type: none"> has at least 5 years of experience in the design and/or construction of FRP Members; is registered on any scheme of registration of engineers prescribed by legislation in the applicable jurisdiction; is appropriately registered or prequalified, if the Principal has implemented an applicable registration or prequalification scheme; and satisfies at least one of the following requirements: <ol style="list-style-type: none"> is a Chartered Professional Engineer; or holds a four-year civil engineering degree from a university that is accredited under the Washington Accord and is registered in a relevant area of practice on the National Engineering Register (in Australia) or the Register of Chartered Professional Engineers (in New Zealand).

4. Quality System Requirements

4.1 The Contractor must prepare and implement a Quality Plan that includes the documentation in Table 4.1 at a minimum.

Table 4.1 Quality Plan

Clause	Description of Document
4.2	Evidence of AS/NZS ISO 9001 certification.
5.4	Design Information, including calculations, drawings and certification where required.
6.2	Details of Materials.
7.2	Procedures and details for fabrication.
10.2	Details of testing.

HOLD POINT 1.	
Process Held	Commencement of manufacture of FRP Composite Members.
Submission Details	The Quality Plan must be provided at least 15 working days prior to the commencement of manufacture.

- 4.2 FRP Members must be manufactured under a quality management system certified to AS/NZS ISO 9001 by a by an organisation which is accredited by the Joint Accreditation System of Australia and New Zealand (JAS-ANZ) or a member of the International Accreditation Forum (IAF).
- 4.3 Where a Principal's Registration Scheme is in place for the manufacture of FRP Members, the Manufacturer must be approved under that scheme.

5. Design

- 5.1 Unless specified otherwise in the Contract documents, all FRP Members must be designed in accordance with this Clause 5.
- 5.2 The design must comply with CD 368, except that the design loads in AS 5100.2 apply. However, subject to the Principal's approval, the Contractor may nominate the ASCE LRFD as an alternative to CD 338 in the Quality Plan (for pultruded members only).
- 5.3 The Contractor must either:
 - a) prepare complete design calculations and Drawings which demonstrate compliance with this Clause 5; or
 - b) manufacture the FRP Members to a design which has been previously approved by the Principal.
- 5.4 The Contractor must submit the Drawings and details to the Principal with the Quality Plan. If the design has not been previously approved by the Principal, calculations and the certification required under Clause 5.6 must be included in the submission.
- 5.5 At a minimum, the Drawings must show:
 - a) profile dimensions and cross sections;
 - b) details of fixings and inserts;
 - c) materials to be used and their characteristic property values;
 - d) details of any hybrid construction (i.e. the FRP Member is used in conjunction with steel members);
 - e) the required level of UV resistance and the method of achieving it; and
 - f) details of the fire protection and the specified level of fire resistance.
- 5.6 The Contractor must submit certification from a Professional Engineer that the Drawings and calculations comply with this Specification.

6. Materials

General

6.1 All materials must comply with CD 368 and the additional requirements of this Clause 6.

6.2 The Quality Plan must include the following information:

- a) types and details of the proposed materials.
- b) the material properties, as listed in the following tables of CD 368 ⁽¹⁾:

Resin	Table 2.5N
Core:	Table 2.7.1 N2
Fibre	Table 2.8.1N
Laminate	Tables 2.11N3a and 2.11N3b

- c) a compliance certificate from the supplier of the resin stating that the mix design and mixing methodology is in accordance with the supplier's recommendations;
- d) Safety Data Sheets for each product;
- e) the material Manufacturer's instructions covering handling and storage requirements, including temperature, humidity and environmental conditions; and
- f) test certificates for each nominated property.

6.3 The glass transition temperature (T_g) of the resin must be at least 20°C above the maximum service temperature.

6.4 Materials must be suitable for the exposure environment and not degrade in aggressive environments, such as salt-rich arid areas, sea water (tidal or splash zone) and soft or running water.

6.5 All testing of materials must be undertaken by laboratory accredited in accordance with Clause 10.3.

6.6 If requested by the Principal, the Manufacturer must submit details of the complete resin mix (ingredients, quantities, and procedure for mixing, applying and curing) to the Principal. The Principal undertakes that it will maintain the confidentiality of this information and will sign a deed of confidentiality if requested by the Manufacturer.

Additives and Coatings

6.7 The FRP Members must be protected from degradation due to UV and sunlight exposure. Unless specified otherwise in the Contract documents, the protective system must include the following at a minimum:

- a) a UV stabiliser added to the resin mix;
- b) a suitable pigment be added to the exterior layer; and
- c) a physical barrier comprising of paint or gel coat applied in accordance with the manufacturer's instructions.

¹ If ASCE LRFD is used, the properties in Section 1.3 of ASCE LRFD are required.

- 6.8 If the required level of fire resistance is not specified in the Contract documents, the Contractor must determine the applicable BAL rating in accordance with AS 3959. At a minimum, a fire resistance additive must be included in the mix. An additional fire protection coating must be applied evenly around all faces of the FRP Members if specified in the Contract documents.
- 6.9 Any additives to the resin system that influence processing or curing, such as fillers, promoters, accelerators, inhibitors, UV agents, and pigments, must be compatible with the fibre and resin system.

7. Fabrication

General

- 7.1 FRP Members must be fabricated in accordance with Section 6 of CD 368.
- 7.2 The Quality Plan must include:
 - a) details of the manufacturing facility;
 - b) procedures describing the pultrusion process and / or vacuum infusion process (as applicable)
 - c) procedure for inspection, detection of defects and rectification / rejection of defective FRP Members
 - d) method for determining the traceability of the materials used.
 - e) if specified in the Contract documents, a program showing the key dates for the commencement / completion of manufacture, curing, testing and transportation of the FRP Members.
- 7.3 Unless the FRP Member has been previously approved by the Principal, a test report of the pre-production testing (refer Clause 10.5) must be submitted to the Principal at least 5 working days prior to the commencement of manufacture.

HOLD POINT 2.	
Process Held	Commencement of manufacture of FRP Members.
Submission Details	The Test Report of the pre-production testing must be submitted to the Principal at least 5 working days prior to the commencement of manufacture.

- 7.4 FRP Members must be produced by a controlled process in a factory environment with full temperature, humidity and dust control.
- 7.5 All materials must be handled, heated and cured in accordance with the manufacturer's instructions and the matrix mix design.
- 7.6 FRP Members must be dry fitted prior to applying adhesive to ensure proper fit of all components and compliance with finished dimensions.
- 7.7 If the Vacuum Assisted Resin Infusion process is used, the Manufacturer must ensure a vacuum drop test is carried out prior to resin infusion. During the test, the vacuum bags must be correctly fitted without bridging.

Conformance

- 7.8 The appearance and workmanship of all FRP Members must comply with Annexures A and C of BS EN 13706-2 and be free of wrinkles, voids and resin rich areas in tight radii curves. ASTM D4385 may be used as an alternative to BS EN 13706-2.
- 7.9 The dimensions of pultruded FRP Members sections must comply with the tolerances set out in ASTM D3917 and Annex B of BS EN 13706-2. In addition, the dimensions of pultruded girders must also comply with the tolerances in Table 7.9.

Table 7.9 Dimensional tolerances of Girders

Measurement	Tolerance
Overall Length of girder	+/- 5 mm
Squareness	Not greater than 1 degree out of square on any cross- section
Position of holes in girder	+/- 1 mm
Position of Hybrid Units in elevation	+/- 2 mm

- 7.10 The Manufacturer must inspect and measure each FRP Member and include the results in the manufacturing report (refer Clause 11).

WITNESS POINT 1.

Process	Inspection and measurement of FRP Members
Notification Period	At least two working days prior undertaking the measurement.

8. Provision for performance monitoring

- 8.1 Clause 8 applies if the installation of strain gauges and/or fibre optic sensors on selected FRP Members is specified in the Contract documents.
- 8.2 For pultruded girders, the strain gauges and/or fibre optic sensors must be attached at following locations:
- on the inside face of the web panel of the nominated FRP Member; and
 - at the mid span and at each end of the FRP Member - top and bottom (or other position specified in the Contract documents).
- 8.3 Two gauges must be installed at each location and in each direction to provide redundancy.
- 8.4 The strain gauges must cover the + 45° and - 45° directions. The strain gauges must remain in a functional condition for the performance monitoring life cycle specified in the Contract documents.
- 8.5 Electrical connections to strain gauges / fibre optic sensors must be durable and vandal resistant.
- 8.6 The location of sensors and gauges must be recorded on the 'as constructed' drawings of the FRP Member and the manufacturer's operating instructions must be submitted to the Principal.

9. Marking, handling, storage

- 9.1 Each FRP Member must be clearly and permanently marked, on a surface which is not visible to the public when erected, with the following information:
- the date of manufacture;
 - the FRP Member identification number;
 - the Manufacturer's name or registration mark;
 - the maximum mass of the FRP Member;
 - identification of any areas where it is permissible to cut and drill;
 - areas designated to support; and
 - the maximum service temperature that the FRP Member is designed for.
- 9.2 FRP Members must:
- be handled with adequate care to eliminate the potential for fracture by impact, undesirable bending, twisting and whipping;
 - only be lifted using soft slings and a spreader beam so that the soft slings are perpendicular to the beam centreline;
 - stored on ground which is not liable to subsidence under the weight of the elements;
 - stored clear of the ground on adequate supports (timber bearers) placed on a plane surface in a manner that avoids damage, twisting or warping; and
 - not rest on any location between the specified support points.

10. Testing of FRP Members

General

- 10.1 The Contractor must undertake testing of Full Scale Components, Sub-components, Structural Elements and Coupons in accordance with Section 4 of CD 368, except that Clause 10.3 applies.
- 10.2 The Quality Plan must include the following:
- details of all testing to be undertaken, both pre-production and during production, including the property, the test method, the test frequency and the acceptance criteria; and
 - for load testing, details of the load location, loading rate, serviceability load and other parameters to be measured.

Laboratory Accreditation

- 10.3 All sampling and testing must be performed by a laboratory that:
- is accredited to meet the requirements of AS ISO/IEC 17025; and
 - complies with the resource requirements for competent testing personnel and appropriate supervision as required by AS ISO/IEC 17025.
- 10.4 The laboratory's accreditation body must be a signatory to the International Laboratory Accreditation Cooperation Mutual Recognition Arrangement (ILAC MRA) for testing laboratories. The National Association of Testing Authorities (NATA) is a signatory to the ILAC MRA.

Pre-production Testing

- 10.5 The Contractor must carry out pre-production testing of a representative sample of the proposed FRP Members, which at a minimum, must include the following:
- load testing in accordance with Clause 10.9;
 - fatigue testing in accordance with Section 4 of CD 368 and Clause 7.9 of AS 5100.2; and
 - UV / accelerated weathering testing in accordance with ASTM G154, with a minimum of 20,000 cycles.
- 10.6 Additional testing may be specified in the Contract documents.

WITNESS POINT 2.	
Process	Pre-production testing
Notification	At least 3 working days prior to the commencement of the pre-production testing (unless testing undertaken previously is accepted by the Principal).

- 10.7 The Contractor may propose to use a previously tested FRP Member for the approval process, in which case the tested FRP Member must:
- have the same dimensions as the production FRP Member (in the case of pultruded girders, within 5% of the length of the production FRP Member is acceptable);
 - have been manufactured using the same materials; and
 - have been designed using the same process.
- 10.8 The Contractor must submit a Test Report of the Pre-production testing, which includes the relevant details listed in Clause 11, to the Principal at least 5 working days prior to the commencement of manufacture (refer Clause 7.3 and Hold Point 2).

Load testing

- 10.9 Load testing of FRP Members must be carried out in accordance with Section 4 of CD 368 and Appendix D of BS EN 13706-2.

WITNESS POINT 3.	
Process	Load Testing of FRP Members
Notification Period	At least 3 working days prior to the commencement of the load testing (unless pre-production Test Report has been previously submitted with the Quality Plan).

- 10.10 During production, at least 10% of pultruded Structural Elements (such as girders), with a minimum of one per batch, must be load tested.
- 10.11 Deflection and Stiffness for serviceability conditions from the load testing must satisfy the criteria outlined in CD 368 and the following criteria:
- the deflection versus applied load plot is linear in the SLS region;
 - outer fibre stresses match the calculated values;
 - residual deflection when the load is removed is less than 5% of the acceptable amount under short term loading (refer AS 1170.0 Clause B3.5 (b)) after allowing for “bedding in”;
 - creep at maximum load (load at target proof moment, 15 minutes duration or any other duration specified in the Contract documents) does not exceed 1 mm;
 - deflection is not larger than the calculated value; and

f) there is no sign of distress during testing.

10.12 FRP Members with deflection larger than specified must be rejected. FRP Members with deflection smaller than specified value may be accepted subject to ascertaining that the reason for the difference does not compromise the performance of the beam.

10.13 If excessive creep occurs, the reason for the creep must be determined and the issue resolved before preparing a new prototype.

Acceptance

10.14 FRP Members must not be incorporated into the Works unless it satisfies all testing requirements of this Specification.

10.15 If a tested FRP Member does not meet all of the criteria listed in this Specification, all of the FRP Members from the batch represented by the tested FRP Member are deemed to be non-conforming. However, the Contractor may individually test each remaining FRP Member from that batch for acceptance.

10.16 A FRP Member must not be transported from the manufacturing facility until all production testing has been successfully completed and approved for release under the Manufacturer's Quality Management System

11. Records

11.1 The Contractor must prepare a Manufacturing Report which includes the following records and provide the report to the Principal within 5 working days of the completion of the manufacture of the FRP Members:

- a) results of the materials tests required under Clause 6;
- b) all data recorded during manufacture, including temperature records and results of the vacuum drop test (where applicable);
- c) measurements of the completed FRP Member required to demonstrate compliance with Clause 7.9;
- a) if strain gauges / fibre optic sensors will be installed, details of the locations and the manufacturer's operating instructions;
- b) installation location of each FRP Member;
- c) limitation on drilling;
- d) limitation on cutting including cutting at an angle;
- e) permissible cutting device; and
- f) lifting restrictions / instructions.

11.2 For each FRP Member which is load tested, the Contractor must submit a Test Report to the Principal which includes the following records at a minimum:

- a) FRP Member identification and test location;
- b) list of all witness personnel to the test;
- c) date and time of test;
- d) details of test FRP Member;
- e) photographs taken of the test setup and during testing;
- f) details of the test setup;

- g) equipment calibration data; and
- h) test results including time, load cell readings, strain gauge readings and deflection for each load increment.

HOLD POINT 3.

Process Held	Installation of FRP Members at the construction site.
Submission Details	The Manufacturing Reports and Test Reports must be provided a within 5 working days of the completion of the manufacture of the FRP Members and prior to installation of the FRP Member.

Annexure A: Summary of Hold Points, Witness Points and Records

The following is a summary of the Witness Points / Hold Points that apply to this Specification and the Records that the Contractor must submit to the Principal to demonstrate compliance with this Specification.

Clause	Hold point	Witness point	Record
4.1	1. Commencement of manufacture of FRP Members.		Quality Plan
7.3	2. Commencement of manufacture of FRP Members.		Test report of the pre-production testing
7.9		1. Inspection and measurement of FRP Members	
10.6		2. Pre-production testing	
10.9		3. Load Testing	
11			Production Reports and Test Reports

Amendment Record

Amendment no.	Clauses amended	Action	Date
-	New specification	New	October 2023

Key

Format	Change in format
Substitution	Old clause removed and replaced with new clause
New	Insertion of new clause
Removed	Old clauses removed