Specification

Fibre Polymer Composite Specification

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Introduction

This Specification is for the design, supply and construction of fibre polymer composite (FPC) components for Sydney Water assets.

Sydney Water makes no warranties, express or implied, that compliance with the contents of this Specification shall be sufficient to ensure safe systems or work or operation.

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Acronyms

Abbreviation	Definition
FPC	Fibre polymer composite
FRP	Fibre reinforced polymer
GRP	Glass Reinforced Polymer
PU	Polyurethane

General terms and definitions

Term	Definition
Additives	The performance of resins can be improved or modified using additives (e.g., hardeners, fillers and catalysts). A combination of resins and additives is called a resin system.
Adherend	Component in an adhesively bonded connection or joint
Adhesion	State in which two surfaces are connected together at the interface by chemical forces
Adhesive	Substance which when applied on mating surfaces is capable of bonding the two adherends together.
Contact moulding or hand lay-up	Manual process in a single tool
Core	The central component of a sandwich structure
Cure	Transition of thermoset resins from liquid to solid via a chemical reaction
ECR-glass fibres	'Electrical- and chemical-resistant' glass fibres. These are suitable for aggressive chemical environments
E-glass fibres	'E' refers to a class of glass fibres with low electrical conductivity.

Filament winding and hoop winding	Processes that wind fibres and mats around a rotating circular section mandrel. Filament winding is more applicable to pressurised smaller diameters; hoop winding is appropriate for large storage tanks and pipes
Gelcoat	A formulation of polymer forming a moulded finished surface
Impregnation	Process of transferring resin into dry fibre
Infusion	A controlled process that uses a cavity tool created by a single-sided tool and vacuum bag. The polymer is impregnated by flow instigated under vacuum
Laminate	Layers of plies bonded together to form a single structure
Matrix	Cured resin or polymer material in which the fibre system is embedded in a ply or laminate
Phenolic resins	Also called phenol formaldehyde resin (PF resin), phenolic resins offer better fire, smoke and toxicity (FST) performance in addition to higher chemical, heat and electrical resistance. However, these resins are brittle
Polyester resins	One of many types of synthetic resins. Two main types of polyester resins are ‘unsaturated’ and ‘saturated’. Of these, unsaturated polyester resins (UPR) are relevant.
Ply	Building block of a laminate with orthotropic properties
Prepreg	Layers of fibre with resin pre-impregnated into them
Pultrusion	Analogous to extrusion. Pultrusion is the production of linear sections of any length using a continuous process. Fibres are typically oriented towards the longitudinal axis of the profile
Resin	A highly viscous material, which can be polymerised. There are many types of synthetic resins, e.g., polyester resins, epoxy resins and vinyl resins.
Roving	A collection of bundles of continuous glass fibre filaments, either as untwisted strands or as twisted yarn.
S-glass fibres	‘Silica’ or ‘strength’ glass fibres involve higher silica content, which enhances their mechanical performance over E-glass fibres
Thermoset	Polymers that are liquid until cured via a chemical reaction. Once cured, a thermoset cannot be returned to the uncured state.

1. General

1.1 Scope

This specification sets out the requirements for the materials, fabrication, inspection, design and construction of fibre polymer composite (FPC) components manufactured using pultrusion, wet layup or filament winding techniques.

This specification addresses the following applications:

- Structures constructed of pultruded FPC structural profiles with bolted connections such as walkways, platforms and stairs conforming to either ASCE 74-23 or BS EN 13706.
- GRP shafts of regular, cylindrical geometry conforming to BS EN 13121.
- GRP vent shafts conforming to ACMA/UCSC UP01-18.
- GRP maintenance holes and inspection chambers conforming to BS EN 15383 and access covers conforming to EPS 500.
- Structures constructed of sandwich panels conforming to CEN/TS 19101 such as covers for odour control.
- GRP grating conforming to ANSI/ACMA/FGMC FG01-17 and AS 1657.

1.2 Referenced documents

Sydney Water documents

CPDMS0023	Technical Specification – Civil
EPS 500	Engineering Product Specification for Standard Pipes and Fittings for Networks

Australian standards

AS 1657:2018	Fixed platforms, walkways, stairways and ladders – Design, construction and installation
AS/NZS 4020	Testing of products for use in contact with drinking water
AS/NZS 4586	Slip resistance classification of new pedestrian surface materials

International standards

ANSI/ACMA/FGMC	FG01-17	Grating Manual FG01-17 FRP Composites Grating Manual
ASCE/SEI 74-23		Load and Resistance Factor Design (LFRD) for Pultruded Fibre Reinforced Polymer (FRP) Structures
ASCE Manual of Practice No 104		Recommended Practice for Reinforced Polymer Products for Overhead Utility Line Structures
ACMA/UCSC UP01-18		Standard Specification for FRP Composite Utility Poles
ASTM C581-15		Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service
ASTM D578-18		Standard Specification for Glass Fiber Strands

ASTM D1781-98	Standard Test Method for Climbing Drum Peel for Adhesives
ASTM D3917-15	Standard Specification for Dimensional Tolerance of Thermosetting Glass-Reinforced Plastic Pultruded Shapes
ASTM D3983-98	Standard Test Method for Measuring Strength and Shear Modulus of Nonrigid Adhesives by the Thick-Adherend Tensile-Lap Specimen
ASTM D4329-21	Standard Practice for Fluorescent Ultraviolet (UV) Lamp Apparatus Exposure of Plastics
ASTM D4385-19	Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products
ASTM D5573-99	Standard Practice for Classifying Failure Modes in Fiber-Reinforced-Plastic (FRP) Joints
ASTM D5868-01	Standard Test Method for Lap Shear Adhesion for Fiber Reinforced Plastic (FRP) Bonding
ASTM D7792/D7792M-23	Standard Practice for Freeze/Thaw Conditioning of Pultruded Fiber Reinforced Polymer (FRP) Composites Used in Structural Designs
ASTM E1640-18	Standard Test Method for Assignment of the Glass Transition Temperature by Dynamic Mechanical Analysis
ASTM G85-19	Standard Practice for Modified Salt Spray (Fog) Testing
ASTM G154-23	Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Materials
BS EN 13121-1:2021	GRP tanks and vessels for use above ground — Part 1: Raw materials — Specification conditions and acceptance conditions
BS EN 13121-2:2003	GRP tanks and vessels for use above ground – Part 2: Composite materials - Chemical resistance
BS EN 13121-3:2016	GRP tanks and vessels for use above ground – Part 3: Design and workmanship
BS EN 13121-4:2005	GRP tanks and vessels for use above ground – Part 4: Delivery, installation and maintenance
BS EN 13706	Reinforced plastics composites
BS EN 15383	Plastics piping systems for drainage and sewerage – Glass-reinforced thermosetting plastics (GRP) based on polyester resin (UP) – Manholes and inspection chambers
BS EN 16245-1:2013	Fibre-reinforced plastic composites – Declaration of raw material characteristics – Part 1: General requirements
BS EN 16245-2:2013	Fibre-reinforced plastic composites – Declaration of raw material characteristics – Part 2: Specific requirements for resin, curing systems, additives and modifiers
BS EN 16245-3:2013	Fibre-reinforced plastic composites – Declaration of raw material characteristics – Part 3: Specific requirements for fibre

BS EN 16245-4:2013	Fibre-reinforced plastic composites – Declaration of raw material characteristics – Part 4: Specific requirements for fabrics
BS EN 16245-5:2013	Fibre-reinforced plastic composites – Declaration of raw material characteristics – Part 5: Specific requirements for core materials
CEN/TS 14632	Plastics piping systems for drainage, sewerage and water supply, pressure and non-pressure – Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) – Guidance for the assessment of conformity
CEN/TS 19101	Design of Fibre-Polymer Composite Structures
ISO 9001	Quality management systems – Requirements
ISO 9227	Corrosion tests in artificial atmospheres – Salt spray tests
ISO 10952	Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Determination of the resistance to chemical attack for the inside of a section in a deflected condition
ISO 11003-2	Adhesives – Determination of shear behaviour of structural adhesives – Part 2: Tensile test method using thick adherends
ISO/IEC 17025	Testing and Calibration Laboratories
ISO 20144	Fibre-reinforced plastic composites – Standard qualification plan (SQP) for composite materials, including reduced qualification plan (RQP) and extended qualification plan (EQP) schemes
ISO 23856	Plastics piping systems for pressure and non-pressure water supply, drainage or sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin.

2. Specification, Documentation and Traceability

2.1 Quality system

All supplied FPC laminates must be manufactured by companies using quality management systems certified to AS/NZS ISO 9001 by a third party accredited by the Joint Accreditation System of Australia and New Zealand (JAS-NZS) or an affiliated international accreditation organisation. The companies must provide documentation to this effect with each consignment of materials or components supplied under this specification.

Testing must be conducted in a testing laboratory accredited by a nationally recognized accreditation body that conforms with the requirements of ISO/IEC 17025. The testing laboratory's scope of accreditation must include the specific test methods required by this specification and the standards nominated herein.

2.1.1 Project Quality Plan

The manufacturer, fabricator and contractor must establish a quality management system to ensure that the installed FPC structures comply with the relevant standards and this specification. The contractor must submit in advance of the works, a project quality plan that covers all aspects of the works.

The submission of a quality plan constitutes a hold point (FPC 1, Table 7-1)

2.2 Traceability

All materials used in the constructed asset must have full traceability.

The contractor must provide documentation in accordance with BS EN 16245 and the this section as a minimum.

2.2.1 Documentation for design, installation and operation

Documentation for design and installation must be provided by the Contractor to Sydney Water as follows:

- Design calculations in accordance with this specification and a record of design verification
- Test results data demonstrating structural and durability performance in accordance with the design and this specification
- Durability assessment for the service conditions in accordance with CPDMS0023 and this specification
- Design drawings including a general arrangement, elevations, sections and details as appropriate
- Laminate specification and mechanical values of laminates for the used laminate types
- Operating instructions
- Installation and handling procedures

2.2.2 Declarations of raw material characteristics

Declarations of raw material characteristics must be provided to Sydney Water with the design documentation in accordance with the relevant parts of BS EN 16245 proving that all materials (fibre, resin, curing systems, additives, coatings, core materials, adhesives etc.) used in the works conform to this specification and the standards nominated herein.

2.2.3 Manufacturing documentation requirements

Documentation for manufacturing must be provided by the Contractor to Sydney Water as follows:

- Laminating procedures (including details of curing)
- Laminating operator qualifications
- Weld procedure (for thermoplastic linings)
- Welder certification (for thermoplastic linings)
- Drilling and cutting procedure
- Any repair procedures used

2.2.4 Quality documentation requirements

1. Inspection and test records / certificates must be supplied in accordance with table 2-1

Table 2-1 Inspection and test records/certificates required

Structure	Inspection and test records / certificates required
Structures constructed of pultruded components	Table 1 and Table 2 of BS EN 13706-3 or Table 1-1 and Table 1-2 of ASCE/SEI 74-23
Grating	In accordance with ANSI/ACMA/FGMC FG01-17
GRP shafts	In accordance with section 7 of BS EN 13121-3
GRP maintenance holes and inspection chambers	In accordance with sections 4.2 of BS EN 15383 for maintenance holes and inspection chambers. GRP access covers in accordance with EPS 500
Structures incorporating sandwich panels	Table 1 and Table 2 of EN 13706-3 or Table 1-1 and Table 1-2 of ASCE/SEI 74-23 for laminates Test certificates in accordance with sections 5.3 and 5.4 of CEN/TS 19101 for core materials and adhesives

Submission of documentation required in accordance with clause 2.2 constitutes a hold point (FPC 2, Table 7-1)

2.3 Surveillance and audit

The fabricator must provide reasonable assistance to Sydney Water to facilitate surveillance of the works.

Sydney Water may elect to conduct audits of the works at any stage of the works. Full access to the works and the required documentation must be provided to allow Sydney Water to effectively conduct the audit.

2.4 Marking

2.4.1 Pultruded profiles

Marking and designation of pultruded profiles must be in accordance with BS EN 13706-1.

2.4.2 Pultruded gratings

Marking must be in accordance with the ANSI/ACMA/FGMC-Grating Manual-FG01-17

2.4.3 GRP shafts

Each component designed and fabricated in accordance with this specification must be marked according to section 18 of BS EN 13121-3 with:

a) manufacturer's name

b) year of manufacture

c) manufacturer's serial number and inspection stamp

d) max allowable pressure

e) test pressure (as required)

f) max/min allowable temperature

g) capacity

h) contents

2.4.4 GRP maintenance holes and inspection chambers

Marking must be in accordance with section 8 of BS EN 15383.

2.5 Shop drawings

Shop drawings of all fabricated FPC components must be:

- Submitted to the designer for approval prior to commencing fabrication
- submitted to Sydney Water for acceptance.

Shop drawings must be prepared before fabrication and give complete information necessary to fabricate structural components and systems, including location, type and size of fasteners, cuts and copes, tolerances, and surface preparation requirements, if applicable.

Detailed shop drawings must include dimensions, sectional assembly, location and identification mark, fabric sequence and orientation.

The submission of approved shop drawings constitutes a hold point (FPC 3, Table 7-1)

3. Materials

3.1 General

The requirements of this specification apply to all components forming a composite structure including resin, fibres, laminate, core, additives, surface coatings and adhesives.

FPC components proposed for use on Sydney Water projects must be qualified in accordance with ISO 20144.

All materials must comply with the standards and specifications shown on the drawings, the relevant Australian standards and the requirements of this specification.

Material properties must be determined by testing in accordance with the standards nominated in this specification.

3.2 Glass transition temperature

The glass transition temperature of composite, polymeric core and adhesive materials must comply with Clause 5.1 of CEN/TS 19101.

3.3 Durability and environmental effects

3.3.1 General

Materials must be selected so that the performance of structural components and systems is not compromised by long-term exposure to environmental effects during the service life of the structure if they are not protected against such effects.

A consistent approach to design for durability such as the approach documented in CEN/TS 19101 must be documented as part of the design considering the effects of all relevant service conditions and combinations of service conditions that may occur.

When used in contact with drinking water, FPC components must be tested and comply with the requirements of AS 4020.

Gel coats and surface veils may be used to increase the durability or to achieve a particular surface finish. Gel coats and veils must be regarded as non-structural.

Where a protective system is used to protect a composite structure from environmental effects, the compatibility and durability of the composite system must be considered.

All finished surfaces must be cured, appropriately resin rich, free of voids and without dry spots, blisters, cracks, crazes, or unreinforced areas. All glass fibres must be well covered with resin to protect against their exposure due to wear and weathering.

All FPC products used in Sydney Water projects must cause no harm to the environment or to human health. Environmental aspects must be considered at all stages of the product life cycle.

3.3.2 Thermal effects

The potential degradation of composite structures when subjected to the following thermal effects must be considered:

- Service temperature conditions

- Thermal cycles
- Freeze thaw cycles (where required)
- Thermal gradient

In applications where composite surfaces are subjected to direct sunlight, the impact of the surface colour of the composite material on the temperature increase of the composite structure must be considered.

For applications subjected to freeze thaw cycles, specimens must be tested in accordance with the requirements of ASTM D7792.

Additionally, the following thermal effects must be considered by the designer and supplier for composite sandwich panels:

- Changes in core material mechanical properties
- The stability of the composite face sheets under compression and shear deformations when the core material has softened
- The thermal stresses induced by the difference in thermal expansion coefficients between the core material and the composite face sheet material, which may cause changes in interfacial bond between the composite face sheet material and the core material.

3.3.3 UV Radiation

All FPC structures and systems exposed in service to direct UV radiation must be protected through the material(s) either having appropriate additives (UV blockers / UV absorbers), or by means of additional surface protection (e.g. a surface veil or gel coat).

Specimens must be tested in accordance with the requirements of ASTM D4329 or ASTM G154 as a minimum. The duration of the test exposure time must be selected to provide confidence in the service life of the component and support the claims of the manufacturer. Exposure time and test duration must be in accordance with section 6.1.1 of ACMA/UCSC UP01-18. After the specimens have undergone weathering, they must be visually examined for damage. No evidence of damage including breaks, cracks, blistering, delaminating, or exposure of fibres, or combination thereof, must be present.

This requirement does not apply to structures that are permanently buried such as manholes.

3.3.4 Fire resistance

The flammability and the fire retardant properties of all FPC systems and components must be appropriate for the application.

FPC structural components and systems in buildings must be designed for fire, smoke and toxicity requirements in accordance with the applicable Building Code of Australia requirements and Australian standards.

FPC vent shafts potentially exposed to the risk of bush fire must be fire tested in accordance with section 5.4 of the ASCE Manual of Practice 104 .

3.3.5 Moisture

The potential degradation of mechanical and physical properties as a result of exposure to moisture over the design life must be considered and addressed in design.

FPC structures in contact with water must be protected from the effects of contact with moisture through the selection of appropriate materials and/or application of appropriate protective systems (e.g. corrosion barrier).

GRP shafts must be designed in accordance with 3.3.6 and BS EN 13121-3 to account for the effects of exposure to water in service and exposure to groundwater.

FPC components must be tested in accordance with ASTM G85 or ISO 9227 for salt spray exposure if they are located in atmospheric exposure within 1 km of the shoreline of large expanses of saltwater. The type and number of test specimens to be used, exposure duration and evaluation criteria must be agreed with Sydney Water.

Pultruded structural sections including gratings must be selected for the durability and environmental effects and tested in accordance with ASCE/SEI 74-23 or EN 13706-2.

Laminates for vent shafts must comply with the testing for hydrophobicity and water absorption as set out in section 5.4 of ASCE Manual of Practice 104.

3.3.6 Chemicals

The potential degradation of FPC structures when exposed to one or more chemical environments must be considered.

Changes in physical and mechanical properties of the structure must be determined by testing, representative of the actual exposure conditions in accordance with the requirements of ASTM C581.

Performance under chemical exposure of laminates for GRP shafts must be verified based on in-service exposure or physical testing in accordance with BS EN 13121-2. The duration of the physical testing is to be agreed with Sydney Water.

If glass fibres are proposed for chemical or wastewater applications, E-CR glass fibres must be adopted.

GRP laminates for shafts for wastewater applications must conform to the requirements of ISO 23856 including testing to ISO 10952.

3.3.7 Abrasion

The potential degradation of FPC structures caused by abrasion when exposed to wastewater and stormwater flows must be considered and protective measures applied as appropriate.

GRP shafts in wastewater applications must be designed and fabricated to resist abrasion.

3.4 Physical and mechanical properties of pultruded FPC components

3.4.1 General

FPC material systems used in pultruded FPC components must conform to the requirements of ASCE/SEI 74-23 or BS EN 13706-3.

Glass fibres must be appropriate for the application and conform to ASTM D578 as a minimum.

GRP grating must be designed in accordance with ANSI/ACMA/FGMC FG01-17. Finished installations must comply with the geometric and safety requirements of AS 1657.

3.4.2 Static bending tests for gratings

Static bending tests for grating must be carried out to establish strength and deflection performance in accordance with ANSI/ACMA/FGMC Grating Manual FG01-17.

3.5 Physical and mechanical properties of vent shafts

FPC composite material systems for vent shafts must comply with an appropriate standard such as ACMA/UCSC UP01-18.

3.5.1 Static bending (horizontal loading) test for vent shafts

A static bending test must be carried out to establish strength and deflection performance following the procedures specified in Section 5.2.1 of the ASCE Manual of Practice No 104.

3.6 Physical and mechanical properties of GRP shafts to BS EN 13121-3

FPC composite material systems for the manufacture of GRP shafts must comply with BS EN 13121-3.

3.6.1 Chemical protective barrier

The chemical protective barrier must be selected in accordance with the requirements of BS EN 13121-2. The chemical barrier must be ignored in any strength calculations.

3.6.2 Resin

The resin must be a vinyl ester resin as a minimum.

3.6.3 Resin based lining

Where a resin-based lining is used as the chemical barrier, the selection of the type of barrier to be used for any application and its corresponding thickness must be in accordance with the relevant sections of BS EN 13121-2.

3.7 Physical and mechanical properties of GRP maintenance holes and inspection chambers

FPC composite material systems for the manufacture of GRP maintenance holes and inspection chambers must comply with BS EN 15383. GRP access covers must comply with EPS 500.

3.8 Physical and mechanical properties of sandwich panels

The laminates comprising the surfaces of the sandwich panels, the core materials, the face sheet/core interface and adhesive systems for the manufacture of FPC sandwich panels must conform to the requirements of CEN/TS 19101.

A face sheet must possess adequate strength and stiffness to withstand in-plane tension and compression stresses, as well as to prevent wrinkling failure.

The core must exhibit adequate stiffness under shear and out-of-plane forces to ensure effective composite action with the face sheets, minimise changes in sandwich thickness (and consequently its flexural stiffness), and prevent wrinkling of the face sheets.

The core should be reinforced at supports and under concentrated loads.

4. Fabrication and construction

4.1 General

Fabrication must conform to the relevant Australian standards, this specification and the nominated standards herein.

4.2 Fabrication and construction of pultruded members

Fabrication, construction and quality assurance of pultruded members must conform to the requirements of ASCE/SEI 74-23 or BS EN 13706.

Where the composition or configuration of structural components is such that design by analysis cannot be performed in accordance with the provisions of a standard such as ASCE/SEI 74-23 or CEN/TS 19101, structural performance and compliance with the intent of the standard must be established from test results.

All components must be fixed securely.

GRP grating must be designed and manufactured in accordance with ANSI/ACMA/FGMC FG01-17. Finished installations must comply with the geometric and safety requirements of AS 1657.

4.2.1 Pultruded Member Bolted Connections

Bolted connections joining pultruded structural members must conform to section 5 of this specification, to the relevant Australian Standards and with ASCE/SEI 74-23.

Bolt assemblies including nuts and washers must be Grade 316L stainless steel in accordance with section 5 of CPDMS0023.

To simplify the design process, gusset plates, splice plates, and angles connecting elements are to be of a ductile metal (steel, stainless steel or aluminium) and their design is to be in accordance with the relevant Australian Standard for that material.

Bolts need only be tightened to snug tight. Pretensioned or slip critical connections are not permitted. Excessive torque can cause through thickness crushing of the FPC material and must be avoided.

The use of enlarged or slotted holes is not permitted.

To prevent crushing beneath the bolt head or nut, a washer, of diameter at least twice the bolt diameter is required under both the bolt head and the nut. The minimum washer thickness is 2.4mm.

4.2.2 Fastener details, banding and kick plates

All gratings must be firmly fastened to their supports.

Fasteners must be Grade 316 stainless steel.

Fastner details must conform to ANSI/ACMA/FGMC – Grating Manual - FG01-17 FRP as a minimum. A minimum of 4 fasteners is required per panel. Heads proud of the walking surface must be avoided but, where used, must not pose any trip hazard.

Grating panels must be readily removable.

4.2.3 Slip resistance

Walking surfaces including steps, treads and rungs must be slip resistant. The minimum grip resistance in both the direction of travel and perpendicular to the direction of travel must not be less than Class R11 when tested in accordance with AS/NZS 4586 Appendix D Oil/Wet Inclining Platform Test.

4.3 Fabrication and construction of GRP shafts

Detailing, fabrication, construction and quality assurance of GRP shafts must conform to all parts of BS EN 13121.

4.3.1 Joints in GRP shafts

Joints must conform to the requirements of BS EN 13121-3.

4.3.2 Anchorage assemblies and attachments

Anchorage bolts, nuts and washers and any attachments must be galvanised steel or Grade 316L stainless steel in accordance with the Civil Specification.

4.4 Fabrication and construction of GRP maintenance holes and inspection chambers

Detailing, fabrication, construction and quality assurance of GRP maintenance holes and inspection chambers must conform to BS EN 15383 and CEN/TS 14632.

4.4.1 Joints in GRP maintenance holes and inspection chambers

Joints in GRP maintenance holes and inspection chambers must conform to the requirements of BS EN 15383.

4.5 Fabrication and construction of sandwich panels

Fabrication, construction and quality assurance of sandwich panels must conform to the requirements of CEN/TS 19101.

For a face sheet with a sharp change in direction, concentrated deviation stresses arise at the points of directional change. At these locations, web components may be incorporated into the core to counteract the deviation stresses.

Any pretreatment applied to the core prior to the application of the laminates must be specified.

The specification of the orientation of non-homogeneous or anisotropic materials should be clearly indicated at both the material and structural levels.

To accommodate concentrated loads, it is essential to locally reinforce the core by incorporating solid webs, composite profiles, or a higher-strength core material. This reinforcement is necessary to prevent failure due to local indentation.

4.6 Dimensional tolerances

Manufactured and fabricated pultruded FPC components must conform to ASCE/SEI 74-23 or BS EN 13706.

GRP shafts must conform to the dimensional tolerances in BS EN 13121.

GRP maintenance holes and inspection chambers must conform to the dimensional tolerances in BS EN 15383.

Fabrication tolerances for panels must conform to Table 6.1 of ANSI/ACMA/FGMC – Grating Manual - FG01-17 as a minimum.

5. Inspection and testing

5.1 Pultruded members

Manufactured and fabricated pultruded FPC components must be inspected according to ASTM D3917 for dimensional tolerances and for visual defects according to ASTM D4385 or BS EN 13706-2 Annex B and Annex A respectively.

Workmanship must be in accordance with BS EN 13706-2 Annex C.

5.1.1 Compression members

- Must be considered straight if the variation in straightness is equal to or less than 1/500 of the length in the axial direction between points that are laterally supported or braced
- Excessive deviations from straightness must be cause for rejection.

5.1.2 Bolted members

- Must be pinned or bolted and held together firmly during assembly without distorting or enlarging the holes
- Poor matching of holes must be cause for rejection
- Column bases must be set level and to their correct elevation with full bearing on the foundation.
- Column bases must be planed to obtain a satisfactory contact bearing in accordance with the applicable standard.
- Compression joints that depend on contact bearing as part of the splice strength must have the bearing surfaces of individual fabricated pieces prepared accordingly.

5.1.3 The structure

- The frame must be erected true and plumb in conformance with the requirements of the applicable standard.
- The out-of-plumbness of the centreline of any column must not exceed 1/400 of the distance between column working points nor 8 mm.
- Installation of permanent connections must not be completed until the adjacent portions of the structure that are affected have been properly aligned.
- Temporary bracing must be provided, wherever necessary, to support construction loads and ensure stability. The bracing must be left in place as long as required for safety.

5.2 Pressure and leak testing of GRP shafts

Pressure and leak testing must be carried out in accordance with Annex C of BS EN 13121-3 Inspection and test documentation must be provided in accordance with section 17.3.4 of BS EN 13121-3.

5.3 Pressure and leak testing of GRP maintenance holes and inspection chambers

Pressure and leak testing must be carried out in accordance with the relevant Sydney Water standards and BS EN 15383 where required by Sydney Water.

5.4 Sandwich panels

5.4.1 Sandwich panel inspection

In addition to the permissible imperfections in laminates presented in Table 32 of BS EN 13121-3, potential local imperfections such as non-parallel face sheets, face sheet waviness and joint eccentricities must be inspected.

The effects of global and local imperfections must be considered if their presence leads to an increase in stresses within the face sheets or core.

5.4.2 Sandwich panel testing

All physical and mechanical properties of a sandwich panel are dependent on the constituent materials, the processing and conditioning environment. It is customary to initially categorise the properties as laminates, cores, and interfaces. Interfaces refer to the connections between the core and the skin, as well as any additional adhesive joints between core sections.

5.4.2.1 Face sheets

Face sheets must be made of fibre polymer composite laminates and achieve the minimum laminate properties and conform to CEN/TS 19101. The properties must be established by testing and provided with the design documentation.

5.4.2.2 Cores

The mechanical and physical properties of the core are significantly influenced by the material composition, whether it is foam, honeycomb or corrugated structures. Hence, all properties must be directly obtained through testing.

Core material testing must be carried out in accordance with the relevant Australian standards and CEN/TS 19101.

Table B.3 of CEN/TS 19101 presents indicative material properties of several commonly utilised core materials, intended solely as a reference guide for preliminary design only.

Plywood cores are not permitted.

5.4.2.3 Adhesives

Adhesive testing must be carried out in accordance with the relevant Australian standards and CEN/TS 19101.

The characterisation of the adhesive does not provide sufficient information to determine the stiffness and resistance of a bonded connection. Refer to Section 5.5 for adhesive connection testing requirements.

5.4.2.4 Panel testing

Shear and bending moment capacity testing of a complete sandwich panel must be carried out in accordance with sections A.4 and A.5 of EN 14509, respectively.

5.5 Adhesive connections

Adhesive connections must not be used without prior approval by Sydney Water.

Adhesive connections must be checked in accordance with CEN/TS 19101.

Pure adhesive failure (complete failure in the adherend-adhesive interface) must be avoided by appropriate material selection, surface preparation and the use of primers if necessary.

In the event of a mixed-mode failure, adhesive failure must not exceed 10% of the failure surface.

The structural behaviour and performance of adhesive connections must be validated by testing.

Testing of adhesive connections must be carried out in accordance with ASTM D5573

Shear strength of adhesive connections must be validated by lap-shear and peel tests in accordance with ASTM D5868-01 and ASTM D1781-98 to evaluate the bond quality between adherends and adhesive.

Fatigue testing of adhesive connections must conform to ISO 11003-2 or ASTM D3983

6. Design Requirements

6.1 General

FPC laminates must be designed in accordance with the relevant Australian standards, an appropriate standard for the design of laminates such as CEN/TS 19101 and/or the standards nominated in this specification for specific applications.

6.1.1 Stages of construction and operation

The designer must consider all relevant phases of construction, operation and decommissioning including the following as a minimum:

- Manufacturing
- Fabrication / assembly
- Transport
- Handling
- Storage
- Installation / Lifting
- Testing
- Commissioning
- Operation
- Maintenance
- Repair
- Decommissioning

The consideration of each stage must be documented in the design report.

6.1.2 Limit state design

The designer must consider serviceability and ultimate limit states for each component, member and joint comprising the structure in accordance with an appropriate standard such CEN/TS 19101 or an equivalent standard.

6.1.3 Finite element models

Where finite element models are used, they must conform to the requirements of an appropriate standard such as CEN/TS 19101.

6.2 Durability requirements for FPC structures

The designers must design FPC components for durability in accordance with CEN/TS 19101.

The designer must consider the following environmental conditions acting separately and/or in combination:

- Temperature variations
- Temperature gradients
- Moisture

- Chemicals
- Ultraviolet radiation
- Abrasion and/or impact
- Lightning
- Fire (in accordance with the project requirements)
- Electrical performance

The effect of different environmental conditions must be taken account by the application of reduction factors in accordance with a recognised standards such as CEN/TS 19101 or determined by testing representative of the actual exposure conditions.

Composite structures and components must be protected from impact actions or designed to ensure that impact actions do not lead to collapse, loss of functionality or reduced durability.

The designer must consider the following as part of the durability design:

- Polymer matrix: type of resin, additive and fillers
- Fibres: type of fibre(s), fibre content and layup
- Composite processing method including the curing procedure
- Production quality of composite materials
- Construction details
- Installation and quality control
- Additional protective measures
- Operation and maintenance

6.2.1 Temperature-dependent effects

Thermal actions and temperature effects on material properties must be considered as part of the design.

The values of maximum and minimum material temperature must be determined from the maximum and minimum service temperatures using an appropriate thermal model.

6.2.2 Time-dependent effects

The designer must consider time dependent effects including creep, relaxation and wear. The time-dependent effects must be taken into account by using the relevant creep coefficients and strength reduction factors from a recognised standard for the design of FPC components such as CEN/TS 19101.

6.2.3 Moisture-dependent effects

The designer must consider moisture dependent effects.

Composite structures that are permanently or frequently submerged in water must have a protective surface coating system applied. The durability and effectiveness of the protective surface coating system must be considered.

Exposed edges of adhesive connections and bolt holes of bolted connections must be prevented from continuous contact with moisture by a protective system.

For composite sandwich panels, measures must be taken to prevent core-face sheet debonding and diffusion of moisture into the core material over time. Diffusion of moisture to the inside face of the core

material must be prevented by means of adequate material selection (e.g. permeability of the composite sheet) and construction detailing (e.g. protection / covering of open / free edges, sealing of holes).

6.2.4 Chemical effects

Changes in physical or mechanical properties of composite materials as a result of exposure to chemical environments over time must be determined from testing, representative of the actual exposure conditions.

The permeability of composite materials to a chemical solution may be reduced by having at the surface a resin-rich layer or surface veil (as with pultruded profiles), of appropriate thickness, and by increasing the degree of polymer resin cure by post-curing. For additional protection against chemicals, an appropriately durable and effective surface protective system must be applied.

For composite sandwich panels, measures must be taken to prevent core-face sheet debonding and diffusion of chemicals into the core material over time.

6.2.5 UV effects

Composite structures exposed to direct UV radiation must be protected through the composite material(s) either having a surface veil or appropriate additives and/or by means of an additional surface protection.

6.2.6 Fire resistance

FPC components and structures that provide:

- means of escape,
- access for emergency service; or
- access for emergency operations,

must have an appropriate minimum fire resistance designed in accordance with CEN/TS 19101 Appendix D.

The appropriate level of fire resistance must be selected by suitably qualified and experienced personnel.

FPC components used in a building must have a level of fire resistance that conforms to the relevant state and federal laws and building codes.

Any fire protection measures incorporated must be designed to allow for maintenance throughout the design life of the asset.

FPC components and structures must not be used in areas of significant bushfire risk without appropriate protection from exposure to fire and elevated temperatures.

6.2.7 Electrical performance

Electrical conductivity or resistivity must be evaluated where required. The electrical performance expectations and any requirements for bonding and grounding should be reviewed by a suitably qualified electrical engineer as part of the design process.

6.3 Pultruded FPC members

In addition to the requirements of the relevant Australian Standards, pultruded FPC components must satisfy the requirements of ASCE/SEI 74-23 or BS EN 13706.

6.3.1 Material properties

As a minimum, the pultruded FPC member must achieve the minimum laminate properties in Table 1-1 and Table 1-2 of ASCE/SEI 74-23 or EN 13706 E23. The properties must be established by testing and provided with the design basis.

6.3.2 Design Basis

Pultruded FPC members must be designed in accordance with ASCE/SEI 74-23, in addition to meeting the design requirements specified in CPDMS0023.

6.4 GRP shafts

In addition to the requirements of the relevant Australian Standards, GRP shafts must be designed to meet the requirements of this specification and BS EN 13121-3 as a minimum.

The designer must specify in the design report which of the three permissible design methods in BS EN 13121-3 the designer intends to use.

BS EN 13121-3 may be used for the design of shafts however the designer must consider matters that are not covered by the standard including but not limited to:

- Geotechnical and structural design to resist loading imposed on the structure by the ground, groundwater, surcharge etc
- Seismic design for a structure embedded in the ground
- Durability design of the materials for long term exposure to the surrounding environment including the groundwater
- Hydrostatic pressure and buoyancy with the shaft in an empty state.

6.5 GRP maintenance holes and inspection chambers

In addition to the requirements of the relevant Australian Standards, GRP maintenance holes and inspection chambers must be designed to meet the requirements of BS EN 15383 and access covers must conform to EPS 500.

6.6 Sandwich panels

In addition to the requirements of the relevant Australian Standards, sandwich panels must conform with CEN/TS 19101

For honeycomb materials, strength and stiffness values must be obtained from tests on specimens with thicknesses that match the sandwich panel design.

6.7 Vent shafts

In addition to the requirements of the relevant Australian Standards, vent shafts must conform with CEN/TS 19101

6.8 Connections

6.8.1 Bolted connections

The analysis and design of bolted connections of pultruded members must conform to the relevant Australian Standards and either ASCE/SEI 74-23 or CEN/TS 19101.

6.8.2 Adhesive connections

Adhesive connections must not be used on Sydney Water projects without prior approval from Sydney Water.

Where adhesive connections are permitted by Sydney Water the requirements of this section shall apply.

The structural performance of adhesive connections and compliance with this specification must be established from test results that are evaluated in accordance with CEN/TS 19101 or ASCE/SEI 74-23.

A composite structure with adhesive joints must be fail-safe, meaning that joint failure will not result in the failure of the structure or critical components. In accordance with EN 1990, failure of an adhesive joint is considered an accidental situation.

In the case of fatigue loading, the adhesive connection design must comply with relevant Australian Standards and Clause 10 of CEN/TS 19101.

The adhesive connection design must consider the impact of the loading rate on the adhesive and the connection.

To minimise eccentricities, adhesive joints are to be designed symmetrically about the axis of application of load.

The adhesive layer thickness should be specified and verified with particular attention to the relationship to the connection dimensions.

The joint design and structural analysis must account for the impact of eccentricities in the joint that result from manufacturing and fabrication tolerances.

Adhesive fillets and the tapering of adherends may be implemented where appropriate to mitigate stress peaks. The decreased efficacy of the taper and the inclusion of fillets in lap-shear connections and any decrease in the adhesive/adherend stiffness ratio must be considered.

In instances of on-site adhesive application, the influence of low temperatures on the adhesive curing process and the associated delayed development of glass transition temperature and the mechanical properties must be considered.

The submission of test results of adhesive connections constitutes a hold point (FPC4, Table 7-1)

6.8.3 Joints

Where the effects of the behaviour of joints on the distribution of internal forces and moments within a structure are significant, the joint behaviour must be considered by the designer in accordance with CEN/TS19101.

6.8.4 Detailing

6.8.4.1 General

The detailing of members must comply with the relevant standards nominated in this specification.

The detailing of members and joints should ensure that:

- stress concentrations are avoided or minimised
- effects of environmental conditions are minimised

6.8.4.2 Sandwich panels

The thickness of sandwich face sheets must not be less than 1mm.

Stress concentrations must be reduced at changes in thickness of face sheets and laminates through the use of transitions. A tapering angle of between 2 and 10 degrees must be applied.

Face sheets must not be joined using butt type connections. Scarf, step-lap or single-strap connections may be used to connect face sheets. The detailing of scarf, step-lap or single strap connection must comply with the detailing rules in CEN/TS 19101.

7. Hold points

Table 7-1 Hold Points

Hold point no.	Process held	Required documentation	Relevant clause
FPC 1	Design	Project quality plan	2.1.1
FPC 2	Fabrication	Various	2.2
FPC 3	Fabrication	Shop drawings	2.5
FPC 4	Fabrication	Qualification test results for adhesive connections	6.8.2

Ownership

Ownership

Role	Title
Group	Engineering and Technical Support
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Change history

Version No.	Prepared by	Date	Approved by	Issue date
1	Dara McDonnell	27/02/2026	Norbert Schaper	27/02/2026