FRP STRUCTURAL PULTRUSION TECHNICAL SPECIFICATIONS

COMPOSITE FIBER TECHNOLOGIES

WAGNERS

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1 INTRODUCTION

BALDWIN SWAMP ENVIRONMENT PARK BRIDGE,
BUNDABERG, QLD, AU

Wagners is the market leader in the manufacture of Fiber Reinforced Polymer (FRP) structural components. Wagners have been manufacturing, supplying, and installing fiber composite structures around Australia and the world for over 16 years. Wagners predominantly use the pultrusion method to manufacture various square and circular hollow profiles which are engineered for use in a variety of applications such as road bridges, pedestrian bridges, boardwalks, electrical crossarms and tank columns.

Given the variety of raw materials available and differing manufacturing techniques used in the production of FRP pultrusion across the world, it is important to note that not all pultrusion is the same and will not give the same performance over the design life of a project. The key elements in establishing Wagners as a world leader of pultrusion manufacturing are the materials utilized and the manufacturing technique specific to the Wagners product. In combination, these elements lead to the high mechanical properties and assured product quality evident with the Wagners structural pultrusion. The performance of the Wagners pultrusion profiles are determined by extensive and rigorous testing to enable us to provide information on how our products will perform over a wide range of conditions and advise as to their limitations.

The following information introduces the architect, designer and/or engineer to the fundamental structural pultrusion characteristics and provides performance information to allow selection of the right material for the job to ensure the full design life and structural requirements are met.

2 SPECIFICATION REQUIREMENT INPUTS

2.1 GENERAL

2.1.1 Summary and Scopes of Work

A. The work under the Contract relates to the supply of FRP structural pultrusion components as specified herein.

B. The Contractor is responsible for all labor, materials, equipment, and incidentals governed by this specification to manufacture the FRP components in accordance with any structural drawings provided by the Principal.

2.1.2 Submittals

A. The Contractor shall provide full details of the FRP materials, including all associated manufacturing processes, test certificates, adhesive, and fasteners.

B. Relevant construction and/or structural drawings for all FRP components shall be submitted to the Design Engineer for approval in accordance with the requirements as per this specification. Fabrication of components shall not commence until written approval from the Design Engineer and/or the Principal is received.

C. The Contractor shall provide any certificates or quality management plans in accordance with the requirements as detailed in Section 2.7.

2.2 DESIGN CRITERIA

A. The design of the FRP components shall be certified by a suitably qualified engineer with experience in designing fiber composite structures.

B. The design of the FRP components shall be in accordance with "Structural Design of Polymer Composites, EUROCOMP Design Code and Handbook," edited by John L Clark.

C. The design of the FRP components shall be in accordance with governing building codes, standard, and the requirements of the Principal as applicable.

D. Substitution of any component or modification of the system shall be made only when approved by the Architect, Design Engineer or the Principal.

2 SPECIFICATION REQUIREMENT INPUTS

2.3 MATERIAL PROPERTIES

A. Reinforcement: Continuous ECR type glass fiber in accordance with ASTM D578.

B. Matrix: Vinyl Ester Resin.

C. Fiber Mass Fraction: = 60-80%

D. Fiber Volume Fraction: = 50-60%

E. Water absorption: ≤ 0.2%

F. A synthetic surface veil fabric must encase the glass reinforcement.

2.4 MECHANICAL PROPERTIES

A. The FRP components must have the following mechanical properties and show conformance to these properties in conjunction with the quality assurance requirements as detailed in Section 2.7.

PROPERTY	NOTATION	VALUE	TEST METHOD
Tensile Strength – Longitudinal	f_{Lt}	88.5×10^3 psi	ISO 527-4
Tensile Modulus of Elasticity – Longitudinal	E_{Lt}	5.26×10^6 psi	
Tensile Strength – Transverse	f_{Tt}	7.98×10^3 psi	ISO 527-4
Tensile Modulus of Elasticity – Transverse	E_{Tt}	1.57×10^6 psi	
Compressive Strength – Longitudinal	f_{Lc}	70.3×10^3 psi	ASTM D6641
Compressive Modulus of Elasticity – Longitudinal	E_{Lc}	4.83×10^6 psi	
Compressive Strength – Transverse	f_{Tc}	17.4×10^3 psi	ASTM D6641
Compressive Modulus of Elasticity – Transverse	E_{Tc}	1.68×10^6 psi	
In-Plane Shear Strength – Longitudinal	f_{Lv}	12.2×10^3 ksi	ASTM D7078
In-Plane Shear Modulus of Elasticity – Longitudinal	G_L	0.62×10^6 ksi	
Interlaminar Shear Strength	f_{Iv}	6.83×10^3 ksi	ASTM D2344

NOTE: The values in the table are the characteristic values to be used for design in normal ambient conditions. It does not include adjustment factors to account for temperature, humidity, and chemical environments.

B. The Contractor shall provide a material property document which is to include mechanical testing results, analysis of results and derivation of characteristic values.

2 SPECIFICATION REQUIREMENT INPUTS

COOKTOWN FISHING PLATFORM,
COOKTOWN, QLD, AU

2.5 DURABILITY AND DESIGN LIFE

A. Design life to be a minimum of 100 years.

B. A UV-resistant coating must be applied to all FRP components. The coating material must have undergone 20,000+ hours of QUV-B testing in accordance with ASTM G154. The testing must show no degradation to the structural integrity of the FRP components.

C. Apply a waterproofing compound or compatible resin coating to seal any end cut fibers that are a result of drilling or cutting of the FRP components.

2.6 ACCESSORIES

A. Unless noted otherwise, all bolts, brackets, rivets and screws must be grade A4/316 stainless steel, property class 70 to ISO 3506.

B. All FRP hollow sections must be reinforced with anti-crush inserts to resist crushing loads from bolt tightening and to enhance bolted connection capacities.

2 SPECIFICATION REQUIREMENT INPUTS

2.7 QUALITY ASSURANCE

2.7.1 Certification

A. The Contractor must be certified to ISO 9001 Quality Management System.

2.7.2 Manufacturing Tolerances

A. Manufacturing tolerances are to be in accordance with ASTM D3917.

B. The visual quality of the pultruded FRP components shall be in accordance with ASTM D4385.

2.7.3 Batch Testing

A. The Contractor must have in place a sampling test plan. The test plan shall identify the testing facility, product tested, quantity/frequency of testing and types of tests carried out for each batch.

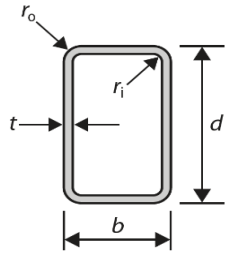
B. Batch testing of the pultrusion is to be performed by the manufacturer or an accredited third-party testing laboratory at regular intervals as stated on their sampling test plan to ensure the products continued adherence with the technical requirements as specified herein.

C. The Contractor must provide a written Certificate of Compliance on all orders guaranteeing the pultrusion has been tested and complies with the technical requirements.

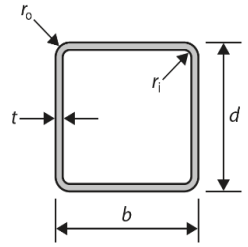
D. The Contractor must be able to provide to the Principal, individual test results and/or a report for each batch as required and as stated in their test plan.

3 SIZING AND PART NUMBERS OF WAGNERS PULTRUSION

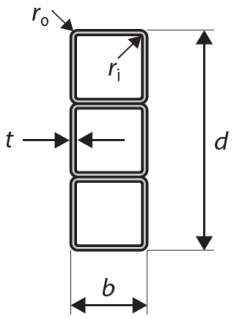
Rectangular Hollow Section



Square Hollow Section



Bonded Rectangular Beams



PRODUCT CODE	PROFILE TYPE	DIMENSIONS								
			Actual Dimension Depth d	Width b	Thick. t	Outside Corner Radius r_o	Inside Corner Radius r_i	Mass per ft	External Surface Area per ft	Gross Section Area A_g
			in.	in.	in.	in.	in.	lb/ft	ft^2/ft	$in.^2$
GV5.26-RH3x13/64	Rectangular Hollow Sections	WCFT	4″	3″	13/64″	3/8″	3/16″	2.16	1.09	2.45
GV5.26-SH4x13/64	Square Hollow Sections	WCFT	4″	4″	13/64″	3/8″	3/16″	2.60	1.26	2.96
GV5.26-SH5x1/4		WCFT	5″	5″	1/4″	3/8″	3/16″	4.05	1.58	4.60
GV5.26-BR8x13/64	Bonded Rectangular Beams	WCFT	8″	4″	13/64″	3/8″	3/16″	5.20	1.99	5.91
GV5.26-BR12x13/64		WCFT	12″	4″	13/64″	3/8″	3/16″	7.80	2.72	8.87
GV5.26-BR16x13/64		WCFT	16″	4″	13/64″	3/8″	3/16″	10.4	3.44	11.81
GV5.26-BR20x13/64		WCFT	20″	4″	13/64″	3/8″	3/16″	13.0	4.17	14.77
GV5.26-BR10x1/4		WCFT	10″	5″	1/4″	3/8″	3/16″	8.13	2.48	9.21
GV5.26-BR15x1/4		WCFT	15″	5″	1/4″	3/8″	3/16″	12.2	3.38	13.81
GV5.26-BR20x1/4		WCFT	20″	5″	1/4″	3/8″	3/16″	16.2	4.27	18.45
GV5.26-BR25x1/4		WCFT	25″	5″	1/4″	3/8″	3/16″	20.2	5.15	22.94

4 SPECIFYING WAGNERS PULTRUSION

STEPS	ITEM TO REQUEST	EXAMPLE	
		PRODUCT REQUIREMENT	PRODUCT CODE
1	Reinforcement Type	Glass Fiber (ECR)	G
2	Resin Matrix Type	Vinyl Ester	V
3	Nominal Modulus of Elasticity	5.26x10⁶ psi	5.2
4	Profile Type	Square Hollow Section	SH
5	Profile Size	4x4 inches	4
6	Wall Thickness	13/64 inch	13/64
		Product Code Output:	**GV5264.9-SH4x13/64**

PINKENBA WHARF, BRISBANE
QLD, AU

5 WAGNERS DRAWING NOTES

COMPOSITE FIBER NOTES:

B1. ALL MATERIAL AND WORKMANSHIP SHALL COMPLY WITH WAGNERS CFT MANUFACTURING PTY LTD (WCFT), WORK INSTRUCTIONS, INSTALLATION GUIDES AND QUALITY ASSURANCE STANDARDS.

B2. UNLESS OTHERWISE NOTED OR APPROVED, COMPOSITE MATERIALS FOR USE IN THIS PROJECT SHALL BE MANUFACTURED FROM ECR GLASS AND VINYL ESTER RESIN CONFORMING WITH ISO 9002 STANDARD.

B3. ALL MEMBERS SHALL BE IN SOUND CONDITION FREE FROM PITTING, DE-LAMINATIONS AND OTHER DEFECTS WHICH ARE LIKELY TO IMPAIR THE STRUCTURAL CAPACITY OF THE MEMBERS.

B4. WHERE MEMBERS ARE TO BE BOLTED A WCFT INSERT OR BUSH IS REQUIRED.

- ALL WCFT INSERTS & BUSHES UNLESS NOTED OTHERWISE ARE TO BE: GLUED
- WCFT INSERTS & BUSHES THAT ARE REQUIRED TO BE GLUED SHALL BE GLUED USING APPROVED POLYURETHANE ADHESIVE SUPPLIED BY WAGNERS AND APPLIED AS PER WAGNERS WORK INSTRUCTIONS.

B5. APPLY A WATERPROOFING COMPOUND OR COMPATIBLE RESIN COATING TO SEAL ANY END CUT FIBERS AS A RESULT OF DRILLING, CUTTING OR DAMAGE TO THE COMPOSITE FIBER PROFILES.

B6. ALL EXPOSED ENDS OF COMPOSITE MEMBERS SHALL HAVE ENDCAPS INSTALLED AS PER WAGNERS WORK INSTRUCTIONS AND INSTALLATION GUIDES.

B7. WHERE ADAPTER ENDCAPS ARE SHOWN, THEY ARE TO BE INSTALLED ON SITE AS PER WAGNERS WORK INSTRUCTIONS AND INSTALLATION GUIDES. ENDCAPS ARE TO BE LOCALLY TRIMMED SO THAT THEY DON'T INTERFERE WITH BRACKETS.

B8. ALL MEMBERS TO BE MARKED WITH THE MEMBER NUMBER, IF ENDCAPS ARE TO BE INSTALLED IN THE FACTORY THEY ARE TO BE STAMPED OTHERWISE IT IS TO BE LEGIBLY WRITTEN WITH A WHITE PEN.

B9. FINISHES & COLOR:

- ALL MEMBERS IN DIRECT CONSTANT SUNLIGHT ARE TO BE COATED WITH THE APPROVED TWO PACK FLUOROPOLYMER COATING APPLIED AS PER WAGNERS WORK INSTRUCTIONS AND INSTALLATION GUIDES.
- ALL OTHER MEMBERS ARE TO BE COATED WITH THE APPROVED TWO PACK ACRYLIC POLYURETHANE COATING APPLIED AS PER WAGNERS WORK INSTRUCTIONS AND INSTALLATION GUIDES.
- COLOR OF ALL COMPOSITE MEMBERS TO BE = _____

B10. AS FRP SECTIONS ARE ORTHOTROPIC THE EVALUATION AND UNDERSTANDING OF MATERIAL PROPERTIES WHEN DESIGNING COMPOSITE STRUCTURES IS PARAMOUNT. ALSO OF IMPORTANCE IS THE UNDERSTANDING OF HOW THESE MATERIAL PROPERTIES ARE USED:

- WHEN CONSIDERING A LIMIT STATE OF COLLAPSE, RUPTURE OR EXCESSIVE DEFORMATION OF A STRUCTURE, SECTION, MEMBER OR CONNECTION IT SHALL BE CONFIRMED THAT: RD ≥ ED (WHERE RD = DESIGN CAPACITY (EQUAL TO ΦR) AND ED = DESIGN ACTION EFFECT (SEE CLAUSE 4.2) THE DESIGN CAPACITY (ΦR) IS A CAPACITY REDUCTION FACTOR (Φ) MULTIPLIED BY R - DEFINED IN AS1170.0 CL 1.5 AS THE "NOMINAL CAPACITY (BASED ON FIFTH PERCENTILE STRENGTH)". TO COMPLY WITH THIS REQUIREMENT AND TO BE ABLE TO USE IN AN ENGINEER VALIDATED DESIGN, CHARACTERISTIC VALUES OF MATERIAL PROPERTIES SHALL BE CALCULATED IN ACCORDANCE WITH ASTM D7290. THIS STANDARD DEFINES THE CHARACTERISTIC VALUE AS "A STATISTICALLY-BASED MATERIAL PROPERTY REPRESENTING THE 80% LOWER CONFIDENCE BOUND ON THE 5TH-PERCENTILE VALUE OF A SPECIFIED POPULATION". REQUIRED MATERIAL PROPERTIES AND APPLICABLE TEST METHODS ARE LISTED IN THE TABLES. FOR EACH PROPERTY IN THESE TABLES A MINIMUM OF TEN TESTS CONDUCTED IN A NATA APPROVED OR AUSTRALIAN UNIVERSITY ARE REQUIRED BEFORE APPLYING THE PROCEDURE IN ASTM D7290 TO DETERMINE THE CHARACTERISTIC VALUE. AND ARE DETERMINED BASED ON THE FOLLOWING CONDITIONS:

5 WAGNERS DRAWING NOTES

- SHORT TERM LOADING
- AMBIENT TEMPERATURE OF 73°F ± 2°F AND RELATIVE HUMIDITY OF 50 ± 10%
- A NEUTRAL CHEMICAL ENVIRONMENT

B11. WFCT COMPOSITE MATERIALS:

COMPONENT MATERIAL	MATERIAL
Reinforcement	Continuous ECR Glass Fiber
Matrix	Vinyl Ester Resin
Veil	Thermoplastic Non-Woven
Additives	Proprietary catalysts, mould release and polymer additives

NOTE: For further information, contact Wagners.

B12. WCFT BONDING ADHESIVE PROPERTIES:

WHERE MEMBERS ARE TO BE BONDED, MEMBERS SHALL BE BONDED USING APPROVED EPOXY ADHESIVE SUPPLIED BY WAGNERS AND APPLIED AS PER WAGNERS WORK INSTRUCTIONS.

PROPERTY	NOTATION	VALUE	TEST METHOD
Tensile Strength	f_t	4.95×10^3 psi	ISO 527-2
Tensile Modulus	E_t	3.49×10^5 psi	ISO 527-2
Lap Shear Strength	f_v	0.73×10^3 psi	ASTM D3161
Heat Deflection Temperature	HDT	185°F	ISO 75

NOTE:

1. **The values in the table are based on a cure schedule of 24 hrs @ ambient + 8 hrs @ 176°F.**
2. **The values in the table are the design values to be used in normal ambient conditions. It does not include adjustment factors to account for temperature, humidity & chemical environments.**

5 WAGNERS DRAWING NOTES

B13. THE MECHANICAL PROPERTIES OF WCFT GRADE GV36 SHS FRP MEMBERS ARE:

PROPERTY	NOTATION	VALUE	TEST METHOD
Tensile Strength – Longitudinal	f_{Lt}	88.5x10³ psi	ISO 527-4
Tensile Modulus of Elasticity – Longitudinal	E_{Lt}	5.26x10⁶ psi	
Poisson's Ratio – Longitudinal	ν_L	0.28	
Tensile Strength – Transverse	f_{Tt}	7.98x10³ psi	ISO 527-4
Tensile Modulus of Elasticity – Transverse	E_{Tt}	1.57x10⁶psi	
Poisson's Ratio – Transverse	ν_T	0.09	
Compressive Strength – Longitudinal	f_{Lc}	70.3x10³ psi	ASTM D6641
Compressive Modulus of Elasticity – Longitudinal	E_{Lc}	4.83x10⁶ psi	
Compressive Strength – Transverse	f_{Tc}	17.4x10³ psi	ASTM D6641
Compressive Modulus of Elasticity – Transverse	E_{Tc}	1.68x10⁶ psi	
In-Plane Shear Strength – Longitudinal	f_{Lv}	12.2x10³ psi	ASTM D7078
In-Plane Shear Modulus of Elasticity – Longitudinal	G_L	0.62x10⁶ psi	
Interlaminar Shear Strength	f_{lv}	6.38x10³ psi	ASTM D2344

NOTE: The values in the table are the characteristic values to be used for design in normal ambient conditions. It does not include adjustment factors to account for temperature, humidity, and chemical environments.

B14. THE PHYSICAL PROPERTIES OF WCFT GRADE GV36 SHS FRP MEMBERS ARE:

PROPERTY	NOTATION	VALUE	TEST METHOD
Density	p	127 lb/ft³	ASTM D792
Barcol Hardness		60	ISO 62
Water Absorption		0.2 %	ASTM D7029
Glass Transition Temperature	T_g	266°F	ISO 1172
Fiber Mass Fraction Fiber Volume Fraction	W_r V_r	77.4 % 57.7 %	ISO11359-2
Coefficient of Thermal Expansion - Longitudinal	α_L	2.7944x10⁻⁶ in/in/°F	ASTM D2583

NOTE: The values in the table are mean values obtained from tests at ambient temperature and relative humidity.

B15. THE DESIGN OF THE FRP COMPONENTS SHALL BE IN ACCORDANCE WITH "STRUCTURAL DESIGN OF POLYMER COMPOSITES, EUROCOMP DESIGN GUIDE AND HANDBOOK", EDITED BY JOHN L CLARK.

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