ORIGINATION FORM

Date: **6/10/14**
Originator: Jordan Thomas / Charles Boyd
Contact Information: **414-4306 / 414-4275**

Specification Title: Fiber Reinforced Polymer (FRP) Composite Structural shapes
Specification Section, Article, or Subarticle Number: **973**

Why does the existing language need to be changed? **Criteria for Thermoset Pultruded and Vacuum Infusion Processed Structural Shapes has been added; names of structurally reinforced composite lumber (SCL) and dimensional fiberglass fiber reinforced composite lumber (FFRCL) have been changed to Reinforced Thermoplastic Structural Shapes (RTSS) and Thermoplastic Structural Shapes (TSS), respectively; test criteria for RTSS and TSS have been revised slightly.**

Summary of the changes: **Entire section has been replaced with a new version**

Are these changes applicable to all Department jobs? **No**
If not, what are the restrictions? **Only applicable for jobs with FRP composite structural members**

Will these changes result in an increase or decrease in project costs? **No**
If yes, what is the estimated change in costs?

With who have you discussed these changes? **FRP industry representatives, Chase Knight, Gevin McDaniel**

What other offices will be impacted by these changes? **Construction, Materials**

Are changes needed to the PPM, Design Standards, SDG, CPAM or other manual? **Structures Manual, Materials Manual**

Are all references to external publications current? Yes (with the possible exception of Materials Manual 12.1 that is referenced out of Spec 105?)
If not, what references need to be updated (please include changes in the redline)?

Is a Design Bulletin, Construction Memo, or Estimates Bulletin needed? **Yes, it is under development**

Contact the State Specifications Office for assistance in completing this form.
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M E M O R A N D U M

DATE: June 25, 2014

TO: Specification Review Distribution List

FROM: Daniel Scheer, P.E., State Specifications Engineer

SUBJECT: Proposed Specification: **9730000 Structural Plastics.**

In accordance with Specification Development Procedures, we are sending you a copy of a proposed specification change.

This change was proposed by Jordan Thomas and Charles Boyd of the State Structures Design Office update the language for industry practice.

Please share this proposal with others within your responsibility. Review comments are due within four weeks and should be sent to Mail Station 75 or online at http://www2.dot.state.fl.us/SpecificationsEstimates/Development/IndustryReview.aspx . Comments received after **July 23, 2014,** may not be considered. Your input is encouraged.

DS/dt
Attachment

STRUCTURAL PLASTICS.
(REV 6-13-14)

SECTION 973 is deleted and the following substituted:

SECTION 973
FIBER REINFORCED POLYMER (FRP) COMPOSITE STRUCTURAL ~~PLASTICS~~*SHAPES*

973-1 Description.

This ~~work~~ *Section* covers ~~structural plastic~~*material and fabrication requirements for fiber reinforced polymer (FRP) composite structural shapes* ~~components including fiberglass structurally reinforced composite lumber (SCL) and dimensional fiberglass fiber reinforced composite lumber (FFRCL)~~.

973-2 Product Acceptance.

~~Use structural plastics listed on the Department's Qualified Products List (QPL). Manufacturers seeking evaluation of products for listing on the QPL must submit an application in accordance with Section 6 and include independently certified test reports, and manufacturer's certification that the material meets the requirements of this Section.~~

~~Structural plastic components used in Contractor-developed custom designs may be used in place of QPL listed products. For Contractor-developed custom designs, meet the product acceptance criteria in Section 471~~*Obtain FRP composites from a producer that is currently on the list of Producers with Accepted Quality Control Programs for Fiber Reinforced Polymer. Producers seeking inclusion on the list shall meet the requirements of 105-3*.

973-3 ***Thermoset Pultruded Structural Shapes.***

Thermoset pultruded structural shapes must meet the requirements in the materials section of the ASCE, Pre-Standard for Load & Resistance Factor Design (LRFD) of Pultruded Fiber Reinforced Polymer (FRP) Structures.

Manufactured components shall be inspected according to ASTM D3917 for dimensional tolerances and ASTM D4385 for visual defects.

Pultruded profiles located on bridge and overhead sign structures shall meet a flame spread index of Class B in accordance with ASTM E84 and meet the requirements of UL94 with a rating of V-1.

973-4 Vacuum Infusion Processed (VIP) Structural Shapes:

973-4.1 Materials:

973-4.1.1 Fibers: *Use commercial grade glass fibers that conform to ASTM D578. Glass fibers may be in any form such as rovings, woven fabrics, braided fabrics, stitched fabrics, continuous fiber mats, continuous strand mats, continuous filament mats (CFM), and chopped strand mats (CSM) of any size or weight.*

Each structural element shall contain a minimum of 40% (by weight) of glass fibers oriented in a minimum of two directions in accordance with the manufacturer's requirements.

Tensile strength of glass fiber strands, yarns and rovings shall not be less than 290 ksi in accordance with ASTM D7290, determined by a tension test in accordance with ASTM D2343.

***973-4.1.2 Resin:** Use a commercial grade thermoset resin for fabricating shapes.*

***973-4.1.3 Additives:** Additives such as fillers, promoters, accelerators, inhibitors, UV agents, and pigments, used in the processing or curing shall be compatible with the fiber and resin.*

***973-4.2 Physical and Mechanical Properties:** The physical properties of VIP FRP products shall conform to the requirements of Table 4-1. The characteristic mechanical properties of VIP FRP composite structural members, determined in accordance with ASTM D7290, shall equal or exceed the minimum requirements in Table 4-2 for shapes and Table 4-3 for plates.*

Table 4-1
Required Physical Properties - VIP FRP

Physical Property	Requirement	Test Method
Barcol Hardness	> 40	ASTM D2583
Glass Transition Temperature	> 180 F	ASTM D4065
Coefficient of Thermal Expansion	$< 7.5 \times 10^{-6}$ in/in/ F (longitudinal)	ASTM D696
Moisture Equilibrium Content	< 2%	ASTM D570, Section 7.4

Table 4-2
Required Mechanical Properties - VIP FRP Shapes

Property	Minimum Requirement	Test Method
Longitudinal Tensile Strength	30,000 psi	ASTM D3039
Transverse Tensile Strength	7,000 psi	
Longitudinal Tensile Modulus	3×10^{6} psi	
Transverse Tensile Modulus	0.8×10^{6} psi	
Longitudinal Compressive Strength	30,000 psi	ASTM D6641
Longitudinal Compressive Modulus	3×10^{6} psi	
Transverse Compressive Modulus	1×10^{6} psi	
In-Plane Shear Strength	8,000 psi	ASTM D5379
In-Plane Shear Modulus	0.4×10^{6} psi	ASTM D5379
Interlaminar shear strength	3,500 psi	ASTM D2344

Table 4-3
Required Mechanical Properties -VP FRP Plates

Property	Minimum Requirement	Test Method
Longitudinal Tensile Strength	20,000 psi	ASTM D3039
Transverse Tensile Strength	7,000 psi	
Longitudinal Tensile Modulus	1.8×10^{6} psi	

Table 4-3 *Required Mechanical Properties -VP FRP Plates*		
Property	*Minimum Requirement*	*Test Method*
Transverse Tensile Modulus	*0.7 x 10^6 psi*	
Longitudinal Compressive Strength	*24,000 psi*	*ASTM D6641*
Transverse Compressive Strength	*15,500 psi*	
Longitudinal Compressive Modulus	*1.8 x 10^6 psi*	
Transverse Compressive Modulus	*1 x 10^6 psi*	
Longitudinal Flexural Strength	*30,000 psi*	*ASTM D790*
Transverse Flexural Strength	*13,000 psi*	
Longitudinal Flexural Modulus	*1.6 x 10^6 psi*	
Transverse Flexural Modulus	*0.9 x 10^6 psi*	
In-Plane Shear Strength	*6,000 psi*	*ASTM D5379*
In-Plane Shear Modulus	*0.4 x 10^6 psi*	
Interlaminar shear strength	*3,500 psi*	*ASTM D2344*

973-4.3 Fire, Smoke and Toxicity: *VIP profiles located on bridge and overhead sign structures shall meet a flame spread index of Class B in accordance with ASTM E84 and meet the requirements of UL94 with a rating of V-1.*

973-4.4 Impact Tolerance: *Where impact resistance is stipulated, impact resistance shall be determined in accordance with ASTM D7136.*

973-5 Thermoplastic Structural Shapes.

973-5.1 General: *For the purpose of this specification, use the following definitions:*

a. Thermoplastic Structural Shapes (TSS) includes a thermoplastic matrix reinforced with chopped fiberglass filaments.

b. Reinforced Thermoplastic Structural Shapes (RTSS) includes a thermoplastic matrix reinforced with chopped fiberglass filaments and continuous FRP reinforcing bars meeting the requirements of this Section. Steel reinforcing bars are not permitted.

973-5.2 **Materials**~~.~~***:***

~~———~~Use polyethylene made from recycled post consumer or post industrial thermoplastics. Mix the ~~plastic~~ *polyethylene* with appropriate colorants, UV inhibitors, hindered amine light stabilizers~~, and~~ antioxidants*, and chopped fiberglass reinforcement* so that the resulting product meets the ~~material property~~ requirements specified in Table~~s~~ *5*-1 *for TSS* and *Table 5*-2 *for RTSS*. *Use a minimum of 15% (by weight) chopped fiberglass reinforcement for both TSS and RTSS. The* ~~Structural plastic~~ *thermoplastic matrix* must not corrode, rot, warp, splinter or crack. ~~The skin must be smooth and black in color unless otherwise specified in the Contract Documents. Skin is the surface material exposed to the atmosphere. Core is the material that surrounds and bonds to the fiberglass reinforcing rods.~~

For RTSS members, ~~T~~*t*he use of separate materials for skin and core is at the discretion of each manufacturer; however, ~~if a single material is used, that~~*both* material*s* must meet the requirements ~~for both skin and core~~*in Table 5-1*. *The material surrounding the rebar within 1 inch from the rebar surface shall not contain voids greater than 3/4 inch diameter and extend no further than 2 inches along the length of the member. The cross section of the product*

shall not contain voids exceeding 1-1/4 inches in diameter and the sum of all voids greater than 3/8 inches in diameter shall not exceed 5% of the cross sectional area.

~~Manufacture structural plastic~~*Extrude final product* as one continuous piece with no joints or splices to the dimensions and tolerances in accordance with Table 5-3. ~~Interior voids shall not exceed 3/4 inches in diameter. Structural plastic members shall be free of twist and curvature.~~

~~Reinforce square fiberglass structurally reinforced composite lumber with a minimum of four fiberglass reinforcing rods placed in the corners of the section.~~

~~Reinforcing rods must be continuous and offer a minimum flexural strength of 70.0 ksi when tested in accordance with ASTM D4476 and a minimum compressive strength of 40.0 ksi when tested in accordance with ASTM D695. Steel reinforcing rods are not permitted.~~

Reject any sections ~~of structural plastic~~ containing cracks or splits. ~~Also, inspect the ends of the reinforcing rods and reject any sections containing reinforcing rods with voids or cracks.~~

~~Add a minimum of 15% (by weight) chopped fiberglass reinforcement to the polyethylene used for fiberglass structurally reinforced composite lumber and a minimum of 15% (by weight) chopped fiberglass reinforcement for smaller dimensional fiberglass fiber reinforced composite lumber. The fiberglass reinforcement may be reduced when other means of controlling cracking are specified with test results which show long term cracking is nonexistent.~~

~~Fiberglass structurally reinforced composite lumber must meet the minimum structural properties listed in Table 4.~~

~~Dimensional fiberglass fiber reinforced composite lumber must meet the minimum physical properties listed in Table 5.~~

~~Table 1~~
~~Plastic Material Properties - SCL~~

~~Density~~	~~ASTM D792~~	~~Skin~~	~~55-63 pcf~~
~~Density~~	~~ASTM D792~~	~~Core~~	~~48-63 pcf~~
~~Water Absorption~~	~~ASTM D570~~	~~Skin~~	~~2 hrs:<1.0% weight increase~~ ~~24 hrs:<3.0% weight increase~~
~~Brittleness~~	~~ASTM D746~~	~~Skin~~	~~Brittleness temperature to be less than - 40°C~~
~~Impact Resistance~~	~~ASTM D256 Method A (Izod)~~	~~Skin~~	~~Greater than 0.55 ft-lbs/in~~
~~Hardness~~	~~ASTM D2240~~	~~Skin~~	~~44-75 (Shore D)~~
~~Ultraviolet~~	~~ASTM D4329 UVA~~	~~Skin~~	~~500 hours<10% change in Shore D Durometer Hardness~~
~~Abrasion~~	~~ASTM D 4060~~	~~Skin~~	~~Weight Loss: <0.02 oz~~ ~~Cycles=10,000~~ ~~Wheel=CS17~~ ~~Load=2.2 lb~~
~~Chemical Resistance~~	~~ASTM D543~~	~~Skin/Core~~ ~~Sea Water~~ ~~Gasoline~~ ~~No. 2 Diesel~~	~~<1.5% weight increase~~ ~~< 9.5% weight increase~~ ~~<6.0% weight increase~~
~~Tensile Properties~~	~~ASTM D638~~	~~Core~~	~~2200 psi at break min.~~
~~Compressive Modulus~~	~~ASTM D695~~	~~Core~~	~~40 ksi min.~~

~~Static Coefficient of Friction~~	~~ASTM D1894~~	~~Skin~~	~~0.25, wet max.~~
~~Nail Withdrawal or Screw Withdrawal~~	~~ASTM D6117~~	~~Skin/Core~~	~~60 lb (nail) min.~~ ~~400 lb (screw) min.~~

Table 5-1
RTSS Matrix

Property	*Test Method*	*Requirement*
Density	*ASTM D792*	*48–63 pcf*
Water Absorption	*ASTMD570*	*2 hrs: <1.0% weight increase* *24 hrs: <3.0% weight increase*
Brittleness	*ASTM D746*	*Brittleness temperature < minus 40°C*
Impact Resistance	*ASTM D256, Method A (Izod)*	*>0.55 ft-lbs/in*
Hardness	*ASTM D2240*	*44-75 (Shore D)*
Ultraviolet	*ASTM D4329 UVA*	*500 hours <10% change in Shore D Durometer Hardness*
Abrasion	*ASTM D 4060*	*Weight Loss: <0.02 oz* *Cycles = 10,000* *Wheel = CS17* *Load = 2.2 lb*
Chemical Resistance	*ASTM D543*	*Sea Water: <1.5% weight increase* *Gasoline: <9.5% weight increase* *No. 2 Diesel: <6.0% weight increase*
Tensile Properties	*ASTM D638*	*2200 psi at break min.*
Compressive Modulus	*ASTM D695*	*40 ksi min.*
Static Coefficient of Friction	*ASTM D1894*	*0.25, wet max.*
Screw Withdrawal	*ASTM D6117*	*400 lb (screw) min.*

Table 5-2
~~Plastic Material Properties - FFRCL~~*TSS Matrix*

Property	*Test Method*	*Requirement*
Density	ASTM- D792	50-65- pcf
Impact Resistance	ASTM- D256 Method A (Izod)	~~Greater than~~> 2.0- ft-lbs/in
Hardness	ASTM- D2240	44-75 (Shore- D)
Ultraviolet	ASTM- D4329 (UVA)	500 hours <10% change in Shore- D Durometer Hardness
Chemical Resistance	ASTM- D756 or ASTM- D543 ~~Sea Water~~ ~~Gasoline~~ ~~No. 2 Diesel~~	*Sea Water:* <1.5% weight increase *Gasoline:* <7.5% weight increase *No. 2 Diesel:* <6.0% weight increase
Tensile Properties	ASTM- D638	3000 psi at break min.

Table 5-2 ~~Plastic Material Properties - FFRCL~~*TSS Matrix*		
Static Coeffecient of Friction	ASTM- D2394	0.25, wet or dry min.
Nail Withdrawal or Screw Withdrawal	ASTM- D6117	250 lb (nail) min. 400 lb (screw) min.
Scant Modulus at 1% Strain	*ASTM D6109*	*150,000 psi min.*
Flexural Strength	*ASTM D6109*	*2,500 psi min.*
Compressive Strength	*ASTM D6108*	*2,200 psi min.*
Compressive Strength Perpendicular to grain	*ASTM D6108*	*700 psi min.*

~~Table 3~~ ~~Dimensions and Tolerances~~		
~~Structural Plastic~~	~~Dimension~~	~~Tolerance~~
~~Length~~	~~Per order (80 ft Maximum)~~	~~0/+6 inch~~
~~Width – SCL~~ ~~Width – FFRCL~~	~~See Contract Plans~~	~~±1/2 inch~~ ~~±1/4 inch~~
~~Height – SCL~~ ~~Width – FFRCL~~	~~See Contract Plans~~	~~±1/2 inch~~ ~~±1/4 inch~~
~~Skin Thickness~~	~~3/16 inch minimum~~	~~n/a~~
~~Distance from outer surface to center rebar elements (SCL)~~	~~2 inches~~	~~±1/2 inch~~
~~Straightness (gap, bend or inside while lying on a flat surface)~~		~~<1-1/2 inches per 10 feet~~

~~Table 4~~ ~~Structural Properties for SCL~~		
~~Member Size~~		~~10 inches x 10 inches min.~~
~~Modulus of Elasticity~~	~~ASTM D6109~~	~~521 ksi min.~~
~~Stiffness, E.I.~~	~~ASTM D6109~~	~~4.05E+08 lb-inch^2 min.~~
~~Yield Stress in Bending~~	~~ASTM D6109~~	~~5.3 ksi min.~~
~~Weight~~		~~30-37 lb/ft~~

~~Table 5~~ ~~Minimum Properties for FFRCL~~		
~~Modulus of Elasticity~~	~~ASTM D6109~~	~~300,000 psi~~
~~Flexural Strength~~	~~ASTM D6109~~	~~2,500 psi~~
~~Compressive Strength~~	~~ASTM D6108~~	~~2,200 psi~~
~~Compressive Strength Perpendicular to grain~~	~~ASTM D6108~~	~~700 psi~~

Table 5-3 *Tolerances*	
Dimension	*Tolerance*
Length	*0/+6 inch*
Width – RTSS *Width – TSS*	*±1/2 inch* *±1/4 inch*
Height – RTSS *Width – TSS*	*±1/2 inch* *±1/4 inch*
Clear cover from outer surface to rebar elements (RTSS)	*≥3/4 inch (wales)* *±1/2 inch (other)*
Straightness (while lying on a flat surface)	*<1-1/2 inches per 10 feet*