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**Load and Resistance Factor
Design (LRFD) for
Pultruded Fiber Reinforced
Polymer (FRP) Structures**

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CONTENTS

PREFACE		xi
ACKNOWLEDGMENTS		xiii
1 GENERAL PROVISIONS		1
1.1	Scope	1
1.1.1	Applicability and Exclusions	1
1.1.2	Maximum Service Temperature	1
1.1.3	Units	1
1.2	Reference Standards, Specifications, and Codes	1
1.3	Materials	2
1.3.1	FRP Constituent Materials	2
1.3.2	Physical and Mechanical Properties of Pultruded FRP Products	2
1.3.3	Fire, Smoke, and Toxicity	3
1.3.4	Durability and Environmental Effects	3
1.3.5	Impact Tolerance	4
1.4	Design Basis	4
1.4.1	Limit States Design	4
1.4.2	General Analysis Requirements	4
1.4.3	Design for Strength	4
1.4.4	Design for Serviceability	4
1.4.5	Seismic Design	4
1.5	Loads and Load Combinations	4
1.5.1	Nominal Loads	4
1.5.2	Load Combinations for Strength Limit States	5
1.5.3	Load Combinations for Serviceability Limit States	5
1.5.4	General Structural Integrity	5
1.6	Structural Design Drawings and Specifications	5
1.7	Fabrication, Construction, and Quality Assurance	5
1.7.1	Shop and Construction Drawings	5
1.7.2	Fabrication and Construction	5
1.7.3	Quality Assurance and Control	5
2 DESIGN REQUIREMENTS		7
2.1	Scope	7
2.2	Properties of Sections	7
2.3	Design Strength	7
2.3.1	Basic Strength Requirement	7
2.3.2	Prequalified Fiber Reinforced Polymer Building Products	7
2.4	Nominal Strength and Stiffness	7
2.4.1	Nominal Strength	7
2.4.2	Reference Strength and Modulus	8
2.4.3	Statistical Basis for Reference Strength and Modulus	8
2.4.4	Adjustments to Reference Strength	8
2.4.5	Notches, Holes, and Other Stress Concentrations	8
2.5	Stability of Frames and Members	9
2.5.1	General Requirements	9
2.5.2	Design Requirements for Frame Stability	9
2.5.3	Required Strength of Frames	9
2.5.4	Design Requirements for Member Stability	9
2.5.5	Bracing of Members and Frames	9
2.6	Design for Serviceability	10
2.6.1	Deformations	10
2.6.2	Vibration	10
2.6.3	Connection Slip	10

	2.6.4	Expansion and Contraction	10
	2.6.5	Deterioration	10
2.7		Design for Ponding	10
2.8		Design for Fatigue	11
2.9		Design of Connections	11
2.10		Gross and Net Areas	11
	2.10.1	Gross Area	11
	2.10.2	Net Area	11
3		DESIGN OF TENSION MEMBERS	13
3.1		Scope	13
3.2		General Provisions	13
3.3		Nominal Axial Tensile Strength	13
3.4		Slenderness Limitation	13
3.5		Built-Up Members	13
4		DESIGN OF COMPRESSION MEMBERS	15
4.1		Scope	15
4.2		General Provisions	15
4.3		Slenderness and Effective Length Considerations	15
	4.3.1	Member Length	15
	4.3.2	Effective Length Factor	15
	4.3.3	Compression Member Effective Length	15
	4.3.4	Compression Member Effective Slenderness Ratio	15
4.4		Factored Critical Stress in Compression for Common Sections	15
	4.4.1	Geometrically Symmetric I-Shaped Sections	15
	4.4.2	T-Shaped Sections	16
	4.4.3	Single Angle Sections with Equal Legs	16
	4.4.4	Square and Rectangular Tube Sections	17
	4.4.5	Circular Tube Sections	17
	4.4.6	Square, Rectangular, and Circular Solid Sections	17
4.5		Compression Strength for Members with Other Cross Sections	17
4.6		Compression Strength for Built-Up Members	17
5		DESIGN OF MEMBERS FOR FLEXURE AND SHEAR	19
5.1		Scope	19
5.2		Design of Members for Flexure	19
	5.2.1	Design Basis	19
	5.2.2	Material Rupture	19
	5.2.3	Local Buckling	19
	5.2.3.1	Singly Symmetric I-Shaped Sections Bent about the Major Axis	19
	5.2.3.2	Doubly Symmetric Channels Bent about the Major Axis	19
	5.2.3.3	Tee Sections Bent about the Major Axis	20
	5.2.3.4	Back-to-Back Angle Sections	20
	5.2.3.5	Square and Rectangular Box Members	20
	5.2.3.6	Doubly Symmetric I-Shaped Members Bent about the Minor Axis	20
	5.2.3.7	Singly Symmetric Channels Bent about the Minor Axis	20
	5.2.4	Lateral-Torsional Buckling	21
5.3		Design of Members for Shear	21
	5.3.1	Design Basis	21
	5.3.2	Strength of Members Due to Material Rupture in Shear	21
	5.3.3	Strength of Members Due to Web Shear Buckling	21
	5.3.4	Design of Web Stiffener	22
	5.4	Design of Members for Concentrated Forces	22
	5.4.1	Design Basis	22
	5.4.2	Factored Strength of Members Due to Tensile Rupture of Web(s)	22
	5.4.3	Local Material Failure at Web-Flange Juncture Under Concentrated Load	22
	5.4.4	Factored Strength of Members Due to Web Compression Buckling	22
	5.4.5	Factored Strength of Members Due to Flange Flexural Failure	22
5.5		Design for Copcs, Notches, Holes, and Openings	23
	5.5.1	Copes, Notches, Holes, and Openings in the Flange or Web	23
	5.5.2	Doubler Plate Requirements	23

6	DESIGN OF MEMBERS SUBJECTED TO COMBINED FORCES AND TORSION	25
6.1	Scope	25
6.2	Design Requirements.	25
6.3	Doubly and Singly Symmetric Members Subjected to Flexure and Axial Force	25
6.4	Doubly Symmetric Members Subjected to Torsion and Combined Torsion, Flexure, and/or Axial Force	25
6.4.1	Circular and Rectangular Tubes Subjected to Torsion	25
6.4.2	Rectangular Hollow Tubes Subject to Combined Torsion, Flexure, and Axial Force	26
7	DESIGN OF PLATES AND BUILT-UP MEMBERS	27
7.1	Scope	27
7.2	General Provisions	27
7.3	Design of Plates Subjected to Flexure.	27
7.4	Design of Plates Subjected to Through-the-Thickness Shear	27
7.4.1	Nominal Shear Strength of Plates	27
7.4.2	Pull-Through Strength of Plates	28
7.5	Design of Plates Subjected to In-Plane Tensile Loading	28
7.5.1	Nominal Tensile Strength of Plates	28
7.5.2	Nominal Strength of Plates Subjected to Longitudinal Tension	28
7.5.3	Nominal Strength of Plates Subjected to Transverse Tension	28
7.6	Design of Plates Subjected to In-Plane Compressive Loading	28
7.6.1	Nominal Compressive Strength of Plates	28
7.6.2	Nominal Material Rupture Strength of Plates Subjected to Compression	28
7.6.3	Nominal Buckling Strength of Plates Subjected to Longitudinal Compression	28
7.6.4	Nominal Buckling Strength of Plates Subjected to Combined Longitudinal and Transverse Compression	29
7.7	Design of Plates Subjected to In-Plane Shear Loading	29
7.7.1	Nominal In-Plane Shear Strength of Plates	29
7.7.2	Nominal Material Rupture Strength of Plates Subjected to In-Plane Shear	29
7.7.3	Nominal Buckling Strength of Plates Subjected to In-Plane Shear.	29
7.8	Design of Built-Up Members	29
7.9	Design of Plates for Serviceability.	29
8	DESIGN OF BOLTED CONNECTIONS	31
8.1	Scope	31
8.1.1	Axially Loaded Connections.	31
8.1.2	Placement of Bolts	32
8.1.3	Framing Connections	32
8.2	General Provisions	32
8.2.1	Scope	32
8.2.2	Bolts	32
8.2.3	Size and Use of Bolt Holes	32
8.2.4	Nuts and Washers	32
8.2.5	Connection Geometry Requirements	32
8.3	Connection Design	32
8.3.1	Design Basis	32
8.3.2	Single Row Bolted Connections.	33
8.3.2.1	Tension and Shear Strength of Bolts, R_{bt}	33
8.3.2.2	Pull-Through Strength, R_{tt}	34
8.3.2.3	Pin-Bearing Strength, R_{br}	34
8.3.2.4	Net Tension Strength, R_{nt}	34
8.3.2.5	Shear-Out Strength, R_{sh}	35
8.3.2.6	Cleavage Strength, R_{cl}	35
8.3.3	Bolted Connections with Two or Three Rows of Bolts	35
8.3.3.1	Tension Strength at First Bolt Row, $R_{nt,f}$	35
8.3.3.2	Shear-Out Strength Between Rows of Bolts, R_{sh}	36
8.3.3.3	Block Shear Strength, R_{bs}	36
8.3.4	Simple Frame Connections	36
8.3.4.1	Shear Strength of Clip Angle, $R_{sh,sp}$	36
8.3.4.2	Members in Tension and Flexure with Splice Connections	36
8.3.4.3	Compression Members with Bearing Connections	37
8.4	Column Bases and Bearing on Concrete	37

9	SEISMIC DESIGN REQUIREMENTS	39
9.1	Seismic Loads	39
9.1.1	Seismic Design Category A	39
9.1.2	Design Parameters for Seismic Force-Resisting Systems in Seismic Design Categories B through F	39
9.1.3	Limitations on Seismic Force-Resisting Systems in Seismic Design Categories D through F	39
9.1.4	Design for Elements Not Part of the Seismic Force-Resisting System.	39
9.2	Seismic Force-Resisting Systems	39
9.2.1	Generic Pultruded FRP Structures	39
9.2.2	Multi-Tier Concentrically Braced Frame	39
9.2.3	Enhanced Connection Strength Braced Frame	40
9.2.4	Ordinary Braced Cooling Towers	40
	APPENDIX A SYMBOLS AND NOTATIONS	41
	APPENDIX B GLOSSARY	49
C1	GENERAL PROVISIONS	53
C1.1	Scope	53
C1.1.1	Applicability and Exclusions	53
C1.1.2	Maximum Service Temperature	53
C1.1.3	Units	53
C1.2	Referenced Specifications, Codes, and Standards	53
C1.3	Materials	53
C1.3.1	FRP Constituent Materials	53
C1.3.2	Physical and Mechanical Properties of Pultruded FRP Products	54
C1.3.3	Fire, Smoke, and Toxicity	54
C1.3.4	Durability and Environmental Effects	54
C1.4	Design Basis	54
C1.4.1	Limit States Design	54
C1.4.2	General Analysis Requirements	54
C1.4.3	Design for Strength	54
C1.4.4	Design for Serviceability	55
C1.4.5	Seismic Design	55
C1.5	Loads and Load Combinations	55
C1.5.1	Nominal Loads	56
C1.5.2	Load Combinations for Strength Limit States	56
C1.5.3	Load Combinations for Serviceability Limit States	56
C1.5.4	General Structural Integrity	56
C1.6	Structural Design Drawings and Specifications	56
C1.7	Fabrication, Construction, and Quality Assurance	56
C2	DESIGN REQUIREMENTS	57
C2.3	Design Strength	57
C2.3.1	Basic Strength Requirement	57
C2.3.2	Prequalified FRP Building Products	61
C2.4	Nominal Strength and Stiffness	61
C2.4.1	Nominal Strength	61
C2.4.2	Reference Strength and Modulus	61
C2.4.3	Statistical Basis for Reference Strength and Modulus	61
C2.4.4	Adjustments to Reference Strength	61
C2.4.5	Notches, Holes, and Other Stress Concentrations	62
C2.5	Stability of Frames and Members	62
C2.5.1	General Requirements	62
C2.5.2	Design Requirements for Frame Stability	62
C2.5.3	Required Strength of Frames	62
C2.5.5	Bracing of Members and Frames	63
C2.6	Design for Serviceability	63
C2.6.1	Deformations	63
C2.6.2	Vibration	63
C2.7	Design for Ponding	64

C2.8	Design for Fatigue	64
C2.9	Design of Connections	64
C3	DESIGN OF TENSION MEMBERS	65
C3.1	Scope	65
C3.2	General Provisions	65
C3.3	Nominal Axial Tensile Strength	65
C3.4	Slenderness Limitation	66
C3.5	Built-Up Members	66
C4	DESIGN OF COMPRESSION MEMBERS	67
C4.1	Scope	67
C4.2	General Provisions	67
C4.3	Slenderness and Effective Length Considerations	67
C4.3.1	Member Length	67
C4.3.2	Effective Length Factor	67
C4.3.4	Compression Member Effective Slenderness Ratio	67
C4.4	Factored Critical Stress in Compression for Common Sections	67
C4.4.1	Geometrically Symmetric I-Shaped Sections	68
C4.4.2	T-Shaped Sections	68
C4.4.3	Single Angle Sections with Equal Legs	68
C4.4.5	Circular Tube Sections	69
C4.4.6	Square, Rectangular, and Circular Solid Sections	69
C4.5	Compression Strength for Members with Other Cross Sections	70
C4.6	Compression Strength for Built-Up Members	70
C5	DESIGN OF MEMBERS FOR FLEXURE AND SHEAR	71
C5.1	Scope	71
C5.2	Design of Members for Flexure	71
C5.2.2	Factored Nominal Strength of Members Due to Material Rupture	71
C5.2.3	Factored Nominal Strength of Members Due to Local Buckling	71
C5.2.4	Factored Strength Due to Lateral-Torsional Buckling	71
C5.3	Design of Members for Shear	72
C5.3.3	Strength of Members Due to Web Shear Buckling	72
C5.3.4	Design of Web Stiffeners	73
C5.4	Design of Members for Concentrated Forces	73
C5.4.1	Design Basis	73
C5.4.2	Factored Strength of Members Due to Tensile Rupture of Web(s)	73
C5.4.3	Factored Nominal Strength of Members Due to Local Material Failure at Web-Flange Junction Under Concentrated Load	73
C5.4.4	Factored Strength of Members Due to Web Compression Buckling	73
C5.4.5	Factored Strength of Members Due to Flange Flexural Failure	73
C5.5	Design for Copes, Notches, Holes, and Openings	73
C5.5.1	Copes, Notches, Holes, and Openings in the Flange or Web	73
C6	DESIGN OF MEMBERS SUBJECTED TO COMBINED FORCES AND TORSION	75
C6.1	Scope	75
C6.3	Doubly and Singly Symmetric Members Subjected to Flexure and Axial Force	75
C6.4	Doubly Symmetric Members Subjected to Torsion and Combined Torsion, Flexure, and/or Axial Force	75
C6.4.1	Circular and Rectangular Tubes Subjected to Torsion	75
C6.4.2	Rectangular Hollow Tubes Subjected to Combined Torsion, Flexure, and Axial Force	76
C7	DESIGN OF PLATES AND BUILT-UP MEMBERS	77
C7.1	Scope	77
C7.2	General Provisions	77
C7.3	Design of Plates Subjected to Flexure	78
C7.4	Design of Plates Subjected to Through-the-Thickness Shear	78
C7.4.1	Nominal Shear Strength of Plates	78
C7.4.2	Pull-Through Strength of Plates	78

C7.5	Design of Plates Subjected to In-Plane Tensile Loading	79
C7.5.1	Nominal Tensile Strength of Plates	79
C7.6	Design of Plates Subjected to In-Plane Compressive Loading	79
C7.6.1	Nominal Compressive Strength of Plates	79
C7.6.3	Nominal Buckling Strength of Plates Subjected to Longitudinal Compression	80
C7.6.4	Nominal Buckling Strength of Plates Subjected to Combined Longitudinal and Transverse Compression	80
C7.7	Design of Plates Subjected to In-Plane Shear Loading	80
C7.7.1	Nominal In-Plane Shear Strength of Plates	80
C7.7.2	Nominal Material Rupture Strength of Plates Subjected to In-Plane Shear	80
C7.7.3	Nominal Buckling Strength of Plates Subjected to In-Plane Shear.	81
C7.8	Design of Built-Up Members	81
C7.9	Design of Plates for Serviceability.	82
C8	DESIGN OF BOLTED CONNECTIONS	83
C8.1	Scope	83
C8.1.1	Axially Loaded Connections.	84
C8.1.2	Placement of Bolts	84
C8.1.3	Framing Connections	84
C8.2	General Provisions	85
C8.2.1	Scope	85
C8.2.2	Bolts	85
C8.2.3	Size and Use of Bolt Holes	85
C8.2.4	Nuts and Washers	85
C8.2.5	Connection Geometry Requirements	86
C8.3	Connection Design	88
C8.3.1	Design Basis	88
C8.3.2	Single Row Bolted Connections.	88
C8.3.2.1	Tension and Shear Strength of Bolts, R_{bt}	90
C8.3.2.2	Pull-Through Strength, R_{tt}	90
C8.3.2.3	Pin-Bearing Strength, R_{br}	90
C8.3.2.4	Net Tension Strength, R_{nt}	91
C8.3.2.5	Shear-Out Strength, R_{sh}	93
C8.3.2.6	Cleavage Strength, R_{cl}	93
C8.3.3	Bolted Connections with Two or Three Rows of bolts.	93
C8.3.3.1	Tension Strength at First Bolt Row, $R_{nt,f}$	93
C8.3.3.2	Shear-out Strength between Rows of Bolts, R_{sh}	94
C8.3.3.3	Block Shear Strength, R_{bs}	94
C8.3.4	Simple Frame Connections	95
C8.3.4.1	Shear Strength of Clip Angle, $R_{sh,sp}$	96
C8.3.4.3	Compression Members with Bearing Connections	97
C8.4	Column Bases and Bearing on Concrete	97
Appendix	CA8.3.3 Bolted Connections with Two or Three Rows of Bolts—Full Formulae.	97
	CA8.3.3.1 Load Distribution per Bolt Row.	97
	CA8.3.3.2 Net Tension Strength at First Bolt Row, $R_{nt,f}$	97
C9	SEISMIC DESIGN REQUIREMENTS	99
C9.1	Seismic Loads	99
C9.1.1	Seismic Design Category A	99
C9.1.2	Design Parameters for Seismic Force-Resisting Systems in Seismic Design Categories B through F	99
C9.1.3	Limitations on Seismic Force-Resisting Systems in Seismic Design Categories D through F.	99
C9.1.4	Design for Elements Not Part of the Seismic Force-Resisting System.	99
C9.2	Seismic Force-Resisting Systems	100
C9.2.1	Generic Pultruded FRP Structures.	100
C9.2.2	Multi-Tier Concentrically Braced Frame	100
C9.2.3	Enhanced Connection Strength Connection Braced Frame	100
C9.2.4	Ordinary Braced Cooling Towers	100
	REFERENCES	101
	INDEX	107

PREFACE

This standard is intended for use in the design of new buildings and other structures constructed of pultruded fiber-reinforced polymer (FRP) composite structural shapes, connections, and prefabricated building products. This standard does not cover tendons and cables. The standard applies to pultruded FRP structural shapes that have symmetric and balanced glass reinforcement and fiber architecture combined with a polymeric matrix. This standard was prepared by the Fiber Composites and Polymers Standards (FCAPS) committee of the Codes and Standards Activities Division of the Structural Engineering Institute of ASCE.

This standard is limited in its applicability to pultruded FRP composite shapes that utilize glass fiber reinforcement. The provisions were developed to apply to buildings and other structures; thus, the scope of the provisions resembles the scope of ASCE 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. Fiber-reinforced polymer structural systems, members, and components may be highly sensitive to their service environments. The registered design professional is advised to ascertain that the provisions and material constants herein apply to the structural component or system in their service environment under consideration.

The design strength and stiffness values provided in this standard apply to new structural products that are being placed into service for the first time. The standard provisions may not apply to structural products that may have been put into service prior to approval of the standard by ASCE.

This standard is intended for use by licensed engineers, structural engineers, architects, other professionals licensed in design of particular structures, and design professionals.

The LRFD pre-standard was developed by a select committee of authors for ASCE and sponsored by American Composites Manufacturers Association (ACMA) and member companies of the Pultrusion Industry Council (PIC). ASCE was tasked to assemble authors to write the required chapters and commentary for the standard. A project team (PT) of authors was selected based on knowledge and experience in this technology. Dr. Mehdi Zarghamee, Simpson Gumpertz & Heger Inc., was selected to serve as the project coordinator during this project. In addition to the PT, ASCE selected a volunteer Project Advisory Committee (PAC), who reviewed and commented on the pre-standard at various stages. The ACMA and the Pultrusion Industry Council (PIC) organized an LRFD Technical Committee of volunteer industry engineers, and technical and manufacturing experts.

The project team (PT) of authors for the LRFD pre-standard are as follows:

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- Abdul-Hamid Zureick, Ph.D., Georgia Institute of Technology – Chapter 4: Compression Members and Bearing
- Hota GangaRao, Ph.D., P.E., West Virginia University – Chapter 3: Tension Members and Chapter 6: Members Under Combined Loads
- Larry Bank, Ph.D., P.E., F.ASCE, University of Wisconsin at Madison – Chapter 5: Members in Bending and Shear and Chapter 8: Joints and Connections
- Jack Lesko, Ph.D., Virginia Polytechnic Institute and State University – Chapter 7: Plates

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CHAPTER 1 GENERAL PROVISIONS

This chapter establishes the scope of the standard and its design basis; summarizes referenced specifications and standards; and provides general requirements for materials, contract documents, fabrication, and quality assurance.

1.1 SCOPE

1.1.1 Applicability and Exclusions This standard is intended for use in the design of new buildings and other structures constructed of pultruded fiber-reinforced polymer (FRP) composite structural shapes, connections, and prefabricated building products. This standard does not cover tendons and cables. The standard applies to pultruded fiber-reinforced polymer (FRP) structural shapes that have symmetric and balanced glass reinforcement and fiber architecture combined with a polymeric matrix. The design of pultruded FRP structural shapes containing fibers other than glass shall be established in accordance with Section 2.3.2.

1.1.2 Maximum Service Temperature The maximum service temperature for pultruded FRP structural members, components, and systems designed according to this standard shall not exceed $T_g - 40$ °F ($T_g - 22$ °C), in which T_g is the glass transition temperature of the composite system determined in accordance with ASTM E1640.

1.1.3 Units Where the provisions of this standard require units, they are provided as US customary units, with SI units provided either parenthetically or as footnotes to tables. Many of the equations presented do not require explicit statement of units; in these equations the designer shall use units for all quantities that are consistent.

1.2 REFERENCE STANDARDS, SPECIFICATIONS, AND CODES

The following standards, specifications, and codes are referenced in this standard.

ACI 318-19 Building code requirements for structural concrete
ANSI/AISC 360-16 *Specification for Structural Steel Buildings*
ASCE 7-16 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*
ASTM A307-14 *Standard Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength*
ASTM A436-84(20) *Standard Specification for Austenitic Gray Iron Castings*
ASTM A563-15 *Standard Specification for Carbon and Alloy Steel Nuts*
ASTM C581-15 *Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service*

ASTM C666-15 *Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing*
ASTM D570-18 *Standard Test Method for Water Absorption of Plastics*
ASTM D578-18 *Standard Specification for Glass Fiber Strands*
ASTM D638-14 *Standard Test Method for Tensile Properties of Plastics*
ASTM D696-19 *Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 °C and 30 °C with a Vitreous Silica Dilatometer*
ASTM D790-17 *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*
ASTM D883-20 *Standard Terminology Relating to Plastics*
ASTM D907-15 *Standard Terminology of Adhesives*
ASTM D953-19 *Standard Test Method for Pin-Bearing Strengths of Plastics 2019*
ASTM D1144-16 *Standard Practice for Determining Strength Development of Adhesive Bonds*
ASTM D2343-17 *Standard Test Method for Tensile Properties of Glass Fiber Strands, Yarns, and Rovings Used in Reinforced Plastics*
ASTM D2344-16 *Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates*
ASTM D2583-13 *Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor*
ASTM D3878-19 *Standard Terminology of High-Modulus Reinforcing Fibers and Their Composites*
ASTM D3917-15 *Standard Specification for Dimensional Tolerance of Thermosetting Glass-Reinforced Plastic Pultruded Shapes*
ASTM D4385-19 *Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products*
ASTM D5379-19 *Standard Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method*
ASTM D5766-18 *Standard Test Method for Open-Hole Tensile Strength of Polymer Matrix Composite Laminates*
ASTM D6641-16 *Standard Test Method for Determining the Compressive Properties of Polymer Matrix Composite Laminates Using a Combined Loading Compression (CLC) Test Fixture*
ASTM D7136-15 *Standard Test Method for Measuring the Damage Resistance of a Fiber-reinforced Polymer Matrix Composite to a Drop-Weight Impact Event*
ASTM D7290-17 *Standard Practice for Evaluating Material Property Characteristic Values for Polymeric Composites for Civil Engineering Applications*