FRP Rebar – Shoreline & Coastal Application Examples

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Composites
AN INFINITE WORLD OF POSSIBILITIES

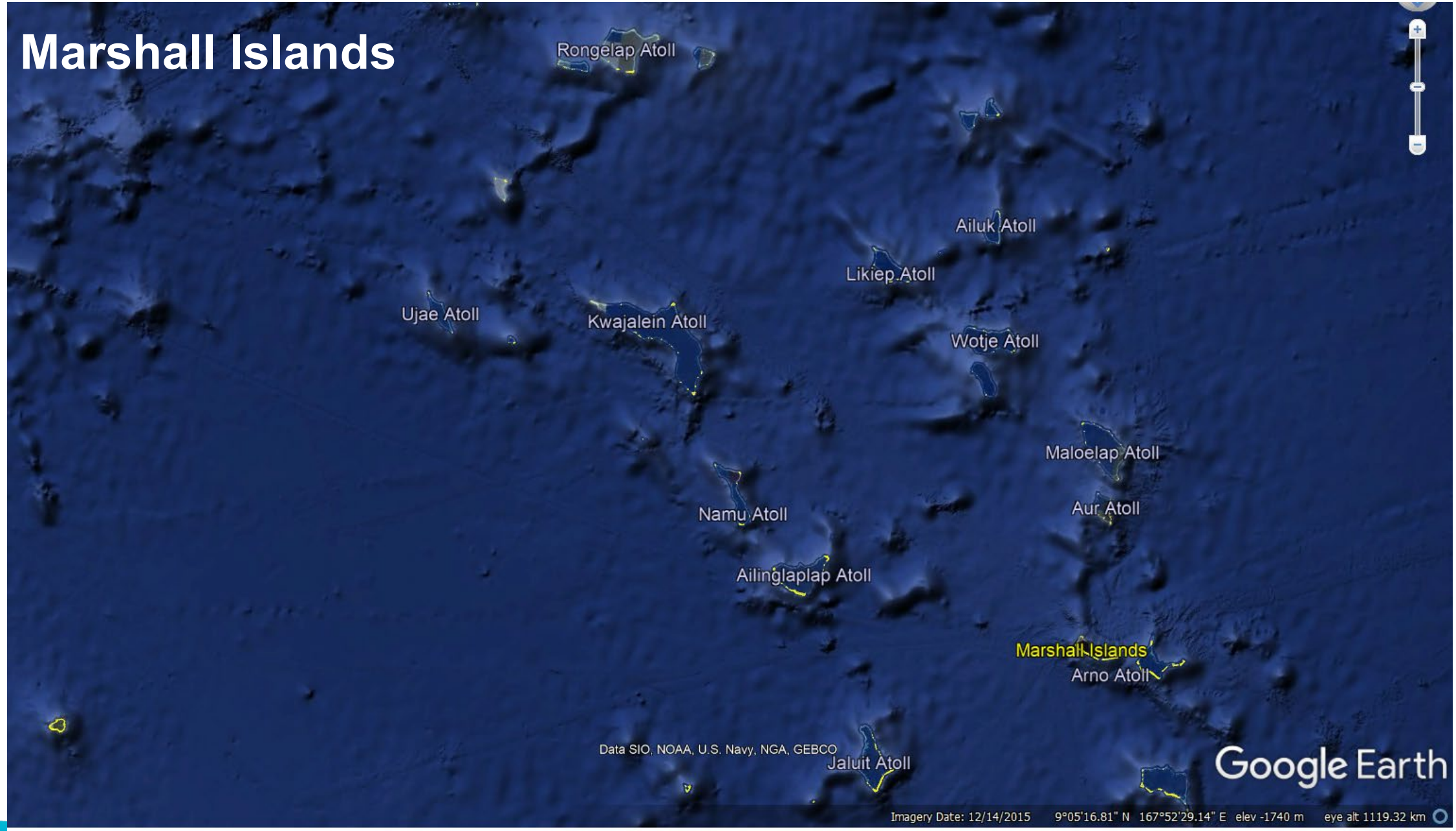
FRP Rebar - Shoreline & Coastal Applications - Outline

- Buildings on low lying Pacific Islands
- Canal Construction – Middle East
- Primary Reasons for Use of GFRP Rebar
- Additional Benefits Users Found
- Important Considerations
- Codes & Guides
- Industry Standards
- Testing

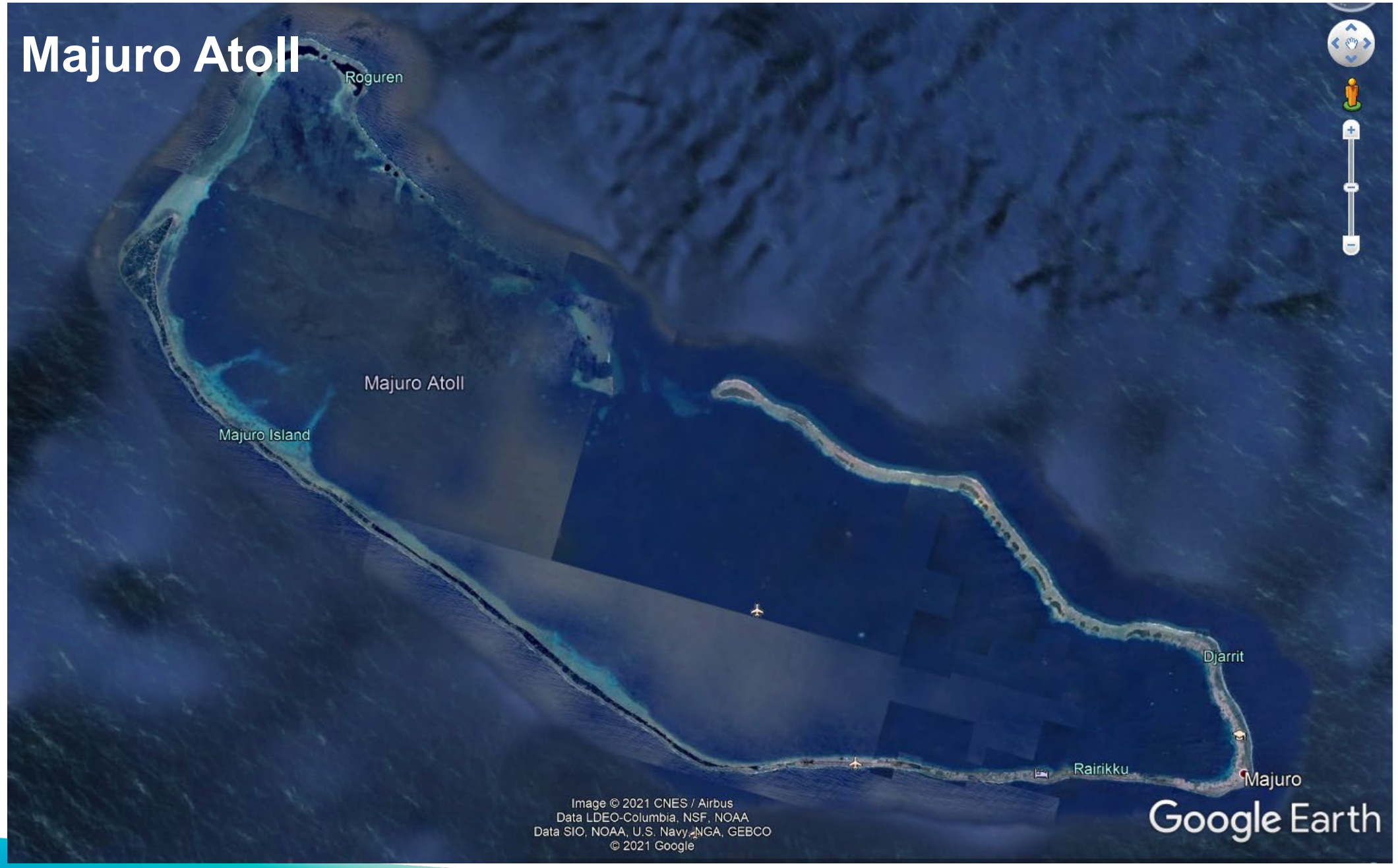
Shoreline Construction

Shoreline Construction

Marshall Islands



Majuro Atoll



Majuro


Coast to Coast = 300 Yards
Majuro
Image © 2021 CNES / Airbus
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Building

- Downside of a Tropical Paradise
- Spalling on steel reinforced concrete structures

Corrosion

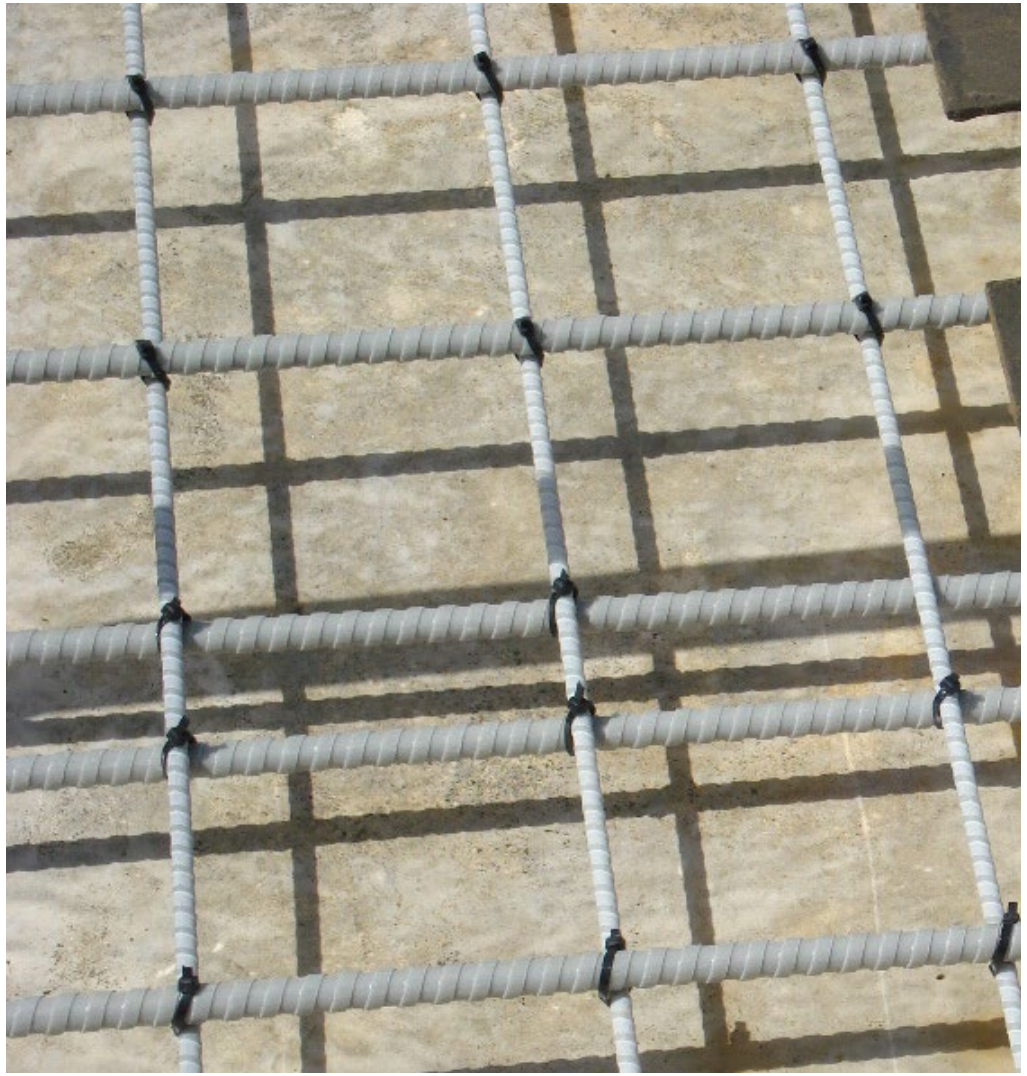
- The Most Common Reason to use GFRP rebar
- **To avoid this dreaded chemical equation:**

$$4Fe + 3O_2 \rightarrow 2Fe_2O_3$$

Aggregate Availability

Quality Aggregate – Essential for Good Concrete

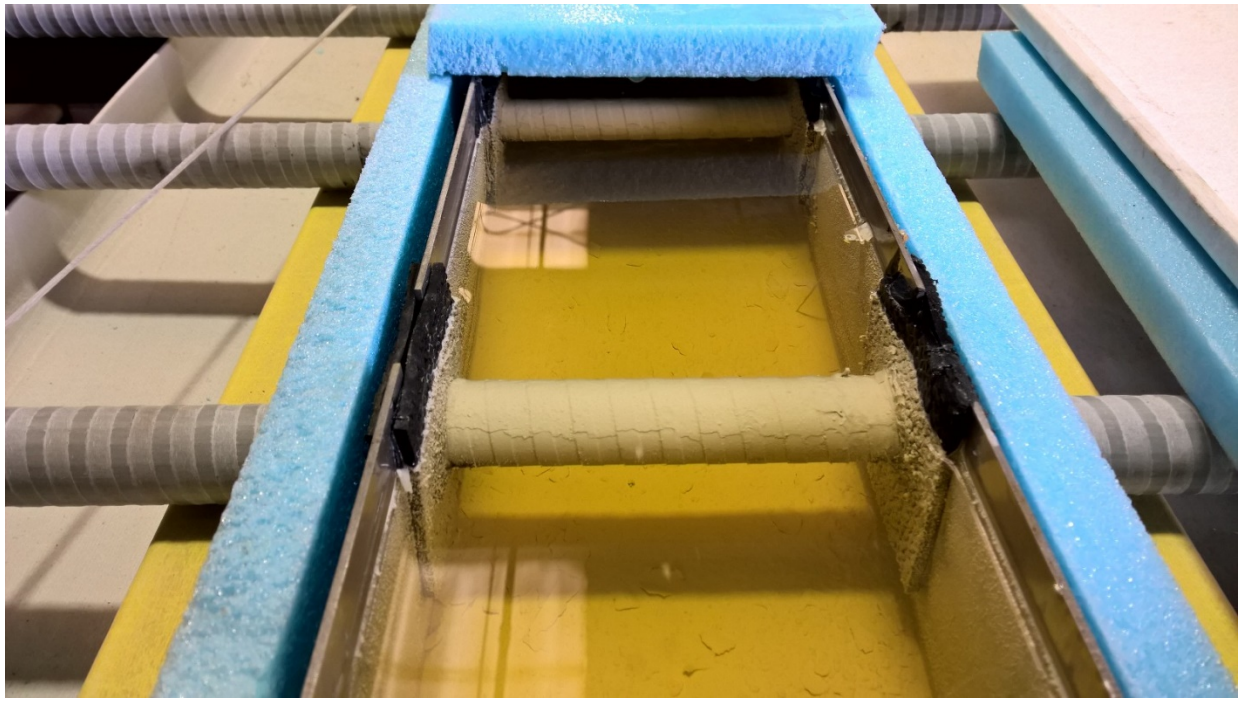
GFRP Rebar



GFRP Rebar Durability

ACI 440.3R – Accelerated Durability Test

96% Tensile Strength Retained after equivalent of 100 Years



Saltwater

Schools on the Marshall Islands

The Future, Marshall Islands


Sea Wall, Dibbah, United Arab Emirates
Dibba Al Hisn

Dibba, MSE Panels

Dibba Canal

Reinforcement Options

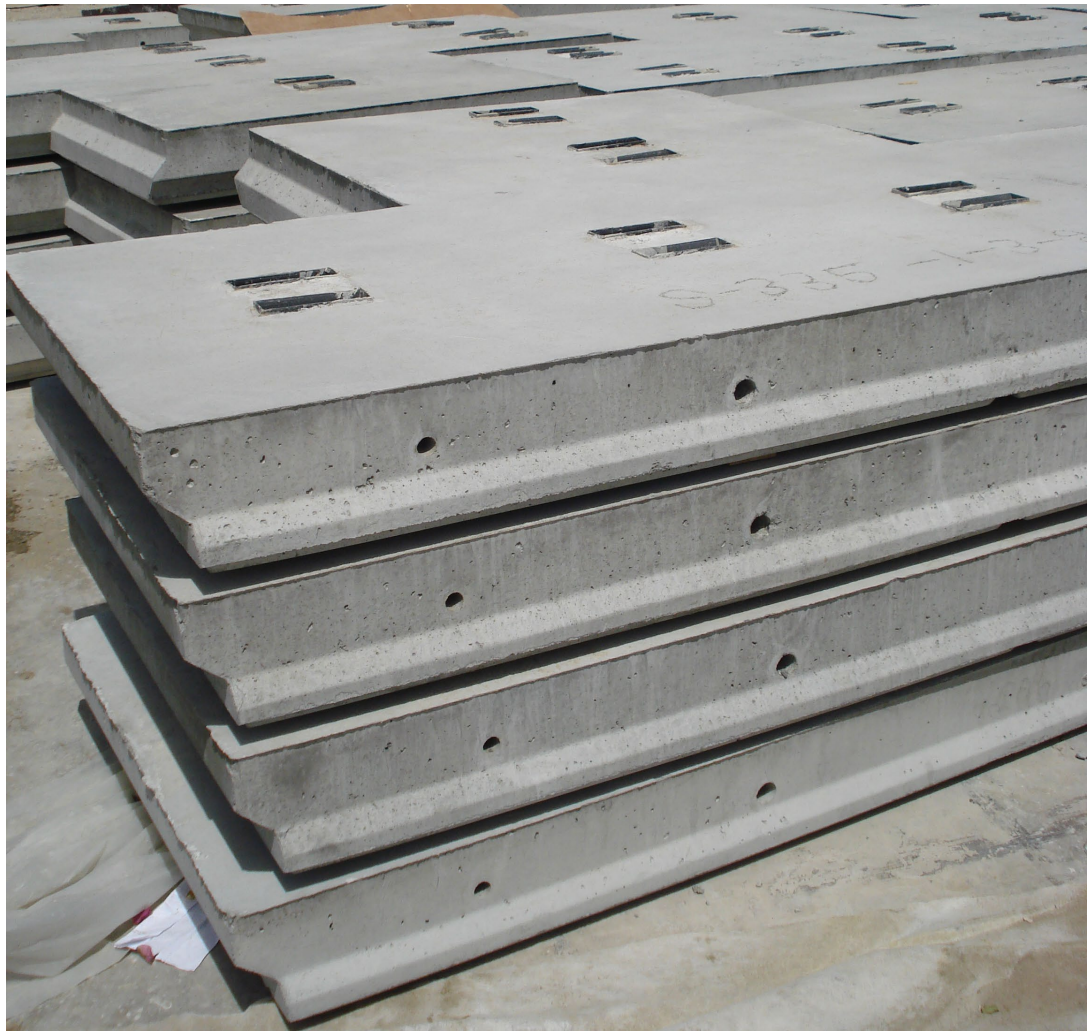
Precast Mould

Precast Panels

Completed Canal

Freight Costs

Panel Thickness



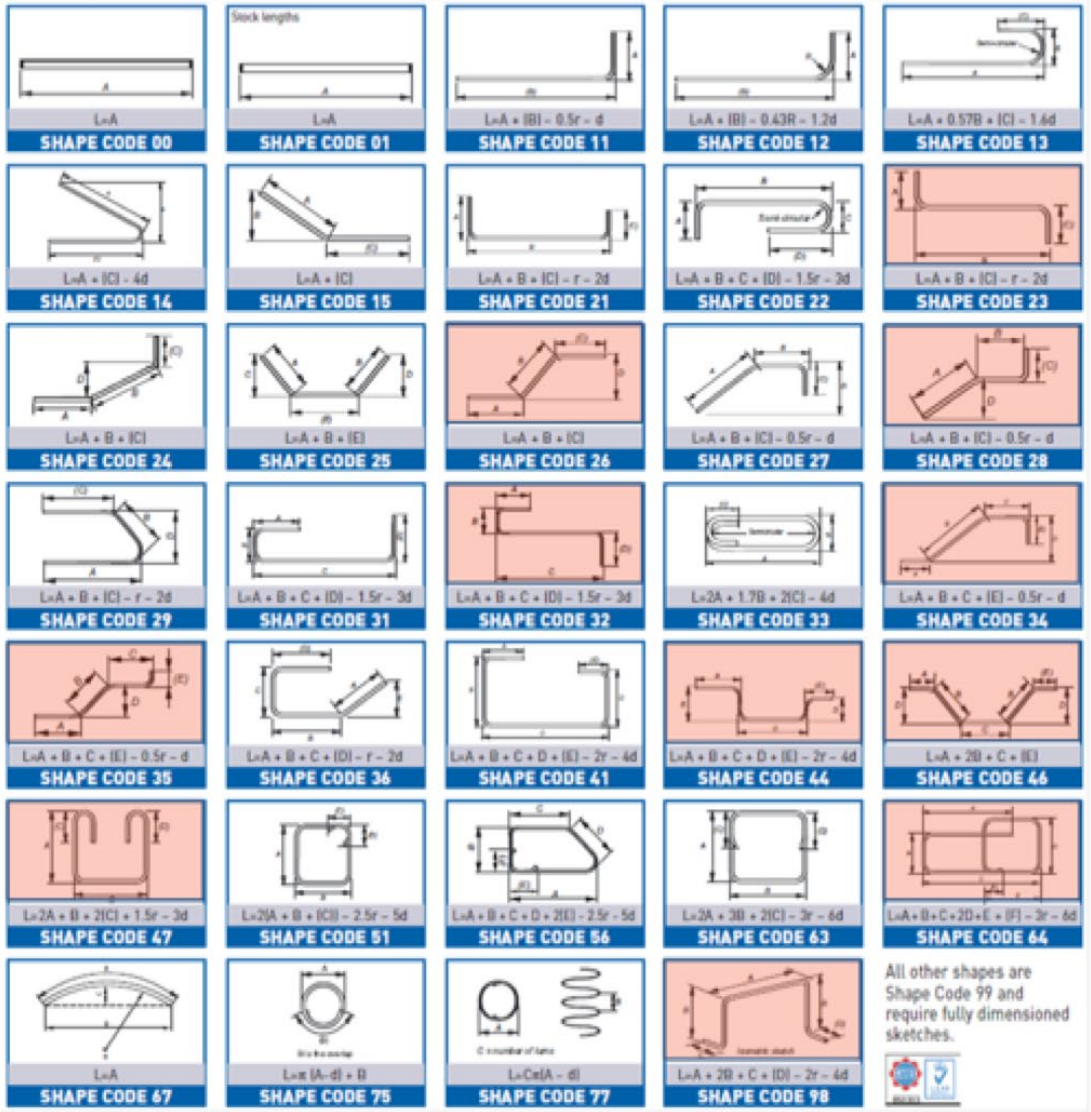
Important Considerations

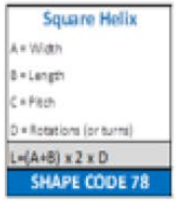
Rebar Bends

- Made to Order
- Different Supply Chain to Steel
- Plan Ahead

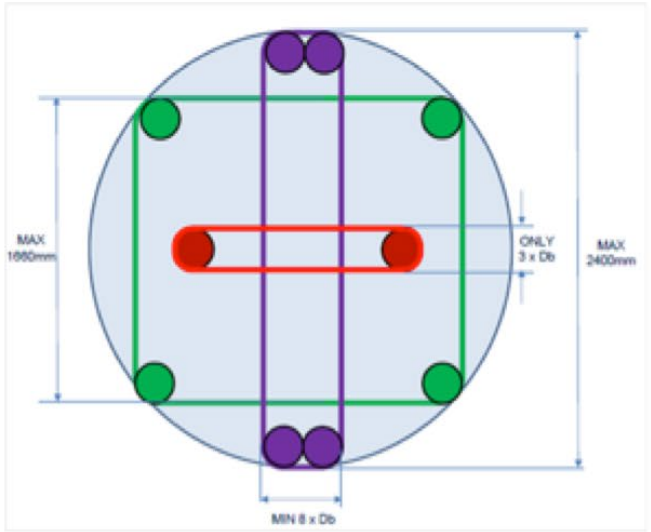
Shapes - Disadvantages

BS8666 Shape Number:





USA Bar Size Conversion		
#	in.	mm
2	0.250	6.4
3	0.375	9.5
4	0.500	12.7
5	0.625	15.9
6	0.750	19.1
7	0.875	22.2
8	1.000	25.4
9	1.125	28.6
10	1.250	31.8



The maximum possible dimensions depend on the shape of the Bend.

Example: For a square, the maximum A & B Dimensions are 1660mm

For a rectangular shape, you may be able to get the A dimension close to 2400mm if the B dimensions is minimum.

To calculate whether a square AxB =1000x2000mm can by manufactured:

D = Sqrt(A^2 + B^2) < 2,400mm

D = Sqrt(1000^2 + 2000^2) = 2,236mm < 2,400mm = OK

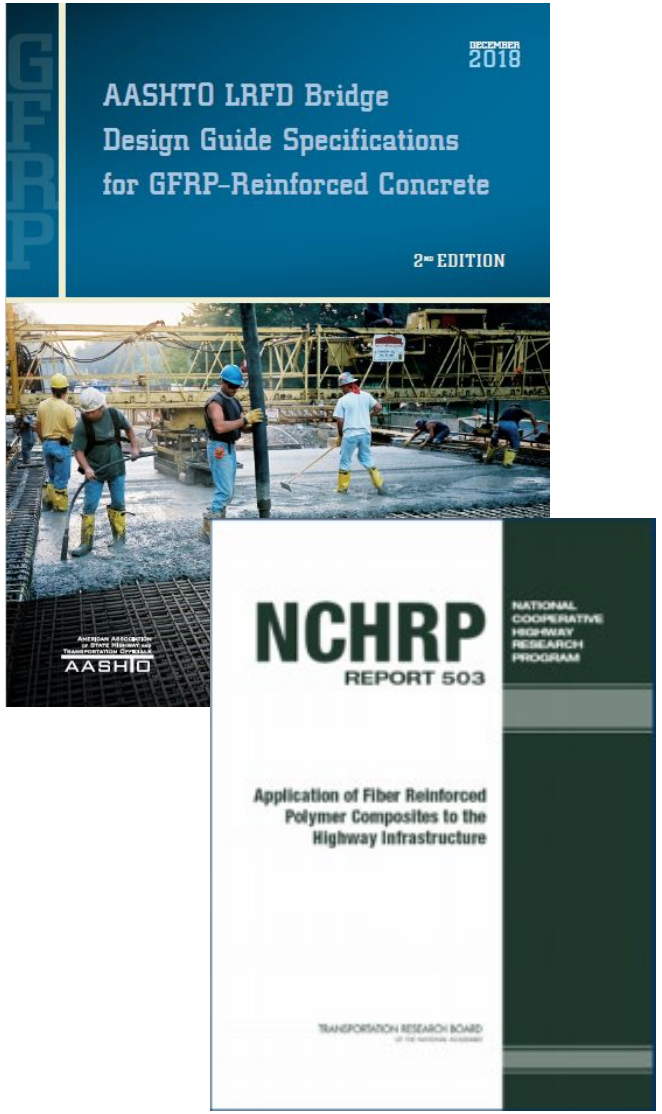
The minimum dimensions depend on the bar diameter, which is what sets the bend radius, and consequently the diameter of the corner former. The minimum B dimension would be when the corner formers touch each other.

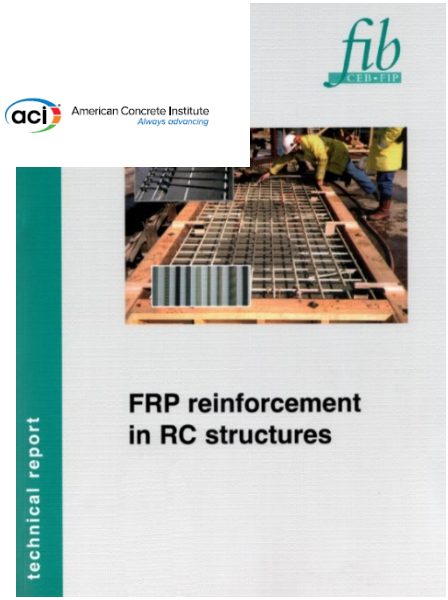
Shapes - Advantages

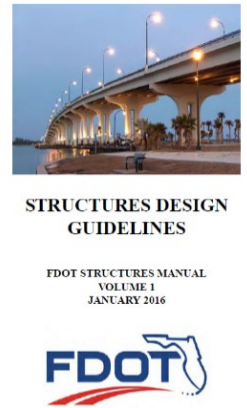
- Flexibility
- Lighter than Steel
- Giant Slinky’s

Shapes - Flexibility

Codes & Guides







Industry Standards

This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: D7957/D7957M – 17

Standard Specification for Solid Round Glass Fiber Reinforced Polymer Bars for Concrete Reinforcement[1]

This standard is issued under the fixed designation D7957/D7957M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers glass fiber reinforced polymer (GFRP) bars, provided in cut lengths and bent shapes and having an external surface enhancement for concrete reinforcement. Bars covered by this specification shall meet the requirements for geometric, material, mechanical, and physical properties described herein.

1.2 Bars produced according to this standard are qualified using the test methods and must meet the requirements given by Table 1. Quality control and certification of production lots of bars are completed using the test methods and must meet the requirements given in Table 2.

1.3 The text of this specification references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables) shall not be considered as requirements of the specification.

1.4 The following FRP materials are not covered by this specification:

1.4.1 Bars made of more than one load-bearing fiber type (that is, hybrid FRP).

1.4.2 Bars having no external surface enhancement (that is, plain or smooth bars, or dowels).

1.4.3 Bars with geometries other than solid, round cross sections.

1.4.4 Pre-manufactured grids and gratings made with FRP materials.

1.5 This specification is applicable for either SI (as Specification D7957M) or inch-pound units (as Specification D7957).

1.6 The values stated in either inch-pound units or SI units are to be regarded as standard. Within the text, the inch-pound units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.7 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health and environmental practices and determine the applicability of regulatory limitations prior to use.

1.8 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

C904 Terminology Relating to Chemical-Resistant Nonmetallic Materials

D570 Test Method for Water Absorption of Plastics

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D2584 Test Method for Ignition Loss of Cured Reinforced Resins

D3171 Test Methods for Constituent Content of Composite Materials

D3878 Terminology for Composite Materials

D7205/D7205M Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars

D7617/D7617M Test Method for Transverse Shear Strength of Fiber-reinforced Polymer Matrix Composite Bars

D7705/D7705M Test Method for Alkali Resistance of Fiber Reinforced Polymer (FRP) Matrix Composite Bars used in Concrete Construction

D7913/D7913M Test Method for Bond Strength of Fiber-Reinforced Polymer Matrix Composite Bars to Concrete by Pullout Testing

D7914/D7914M Test Method for Strength of Fiber Reinforced Polymer (FRP) Bent Bars in Bend Locations

[1] This specification is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.10 on Composites for Civil Structures.

Current edition approved Aug. 1, 2017. Published August 2017. Originally approved in 2017. DOI: 10.1520/D7957_D7957M-17

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

CSA GROUP

CSA S807:19
National Standard of Canada

Specification for fibre-reinforced polymers

Standards Council of Canada
Conseil canadien des normes

Testing

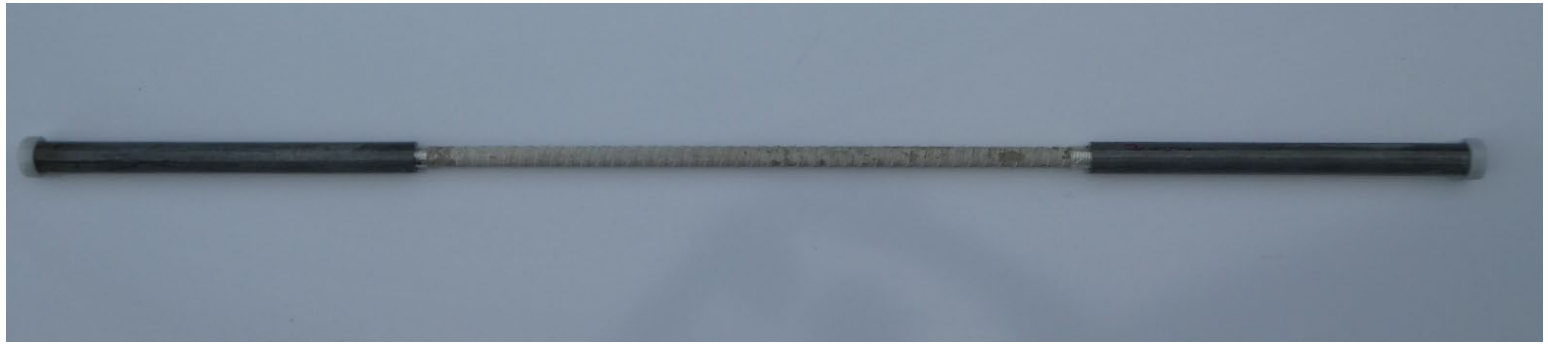
Testing GFRP is a specialist activity

Many test labs don’t have appropriate experience

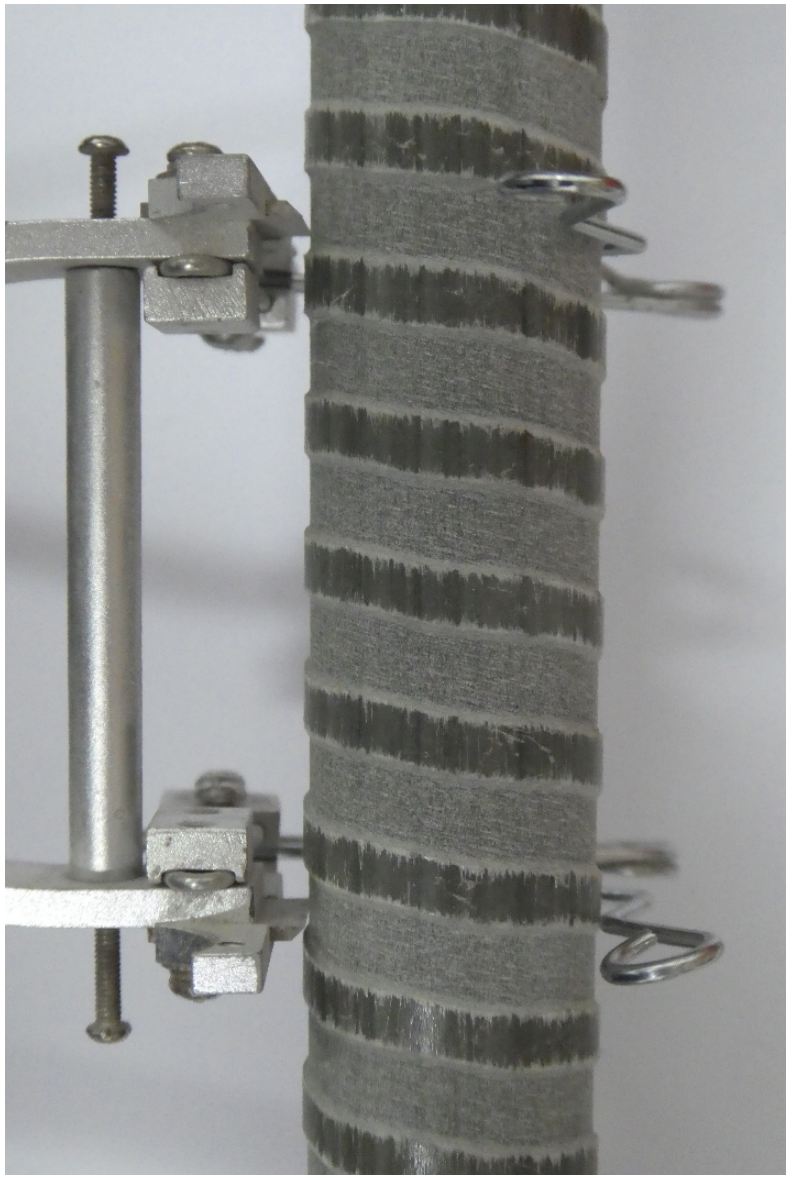
Get Recommendations of suitable labs

Tensile Test Method

- ASTM D7205/7205M – Standard Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars

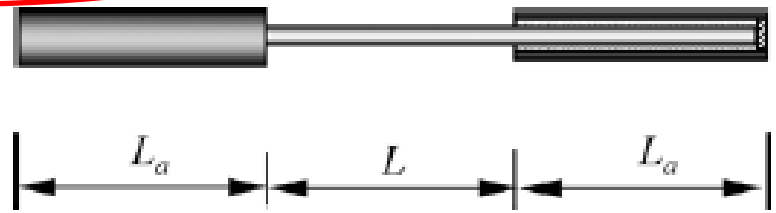


Typical Sample



Tensile Test Specimens

8.2.1 *Overall Specimen Length and Gage Length*—The total length of the specimen shall be the free length plus two times the anchor length, L_a. The free length between the anchors, L, shall be not less than 380 mm [15 in.] nor less than 40 times the effective bar diameter.



FRP bar type	Diameter of the FRP bar, d	Outside diameter of the steel tube	Minimal length of the steel tube, L_a
GFRP	6.4 mm [0.25 in.]	35 mm [1.38 in.]	300 mm [12 in.]
GFRP	9.5 mm [0.38 in.]	35 mm [1.38 in.]	300 mm [12 in.]
GFRP	13 mm [0.50 in.]	42 mm [1.63 in.]	380 mm [15 in.]
GFRP	16 mm [0.63 in.]	42 mm [1.63 in.]	380 mm [15 in.]
GFRP	19 mm [0.75 in.]	48 mm [1.88 in.]	460 mm [18 in.]
GFRP	22 mm [0.88 in.]	48 mm [1.88 in.]	460 mm [18 in.]
GFRP	25 mm [1.00 in.]	48 mm [1.88 in.]	460 mm [18 in.]
GFRP	29 mm [1.13 in.]	48 mm [1.88 in.]	460 mm [18 in.]
GFRP	32 mm [1.25 in.]	75 mm [2.95 in.]	800 mm [32 in.]

Specimen Length of 19mm (3/4”) sample

= 40x19mm + 2x460mm = 1680mm (66”)

Conclusion

- GFRP is a Genuine Alternative to Steel as a reinforcement for environments where steel is not suitable

✓ Cost Effective

✓ Proven History

✓ Codes & Guides

✓ Ideal for Challenging Environments

Don’t Forget – GFRP Rebar is Not the same as Steel

- Engage with Manufacturer Early
  - Learn about Lead Times
  - Learn about the Shape Limitations
  - Ensure accurate BOQ’s
- Find a lab with Experience
  - Get recommendations
  - Consider Universities

Thank You

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