To Whom It May Concern,

I am writing to confirm that Rebar X Glass Fiber Reinforced Polymer (GFRP) rebar complies with the building codes listed within and is suitable as a substitute for conventional steel rebar in slabs-on-grade, foundation footings and cast in place walls.

Substitution in Footings, Stem Walls, and Slabs-on-Grade

- Rebar X Glass Fiber Reinforced Polymer (GFRP) rebar, sizes #3 and #4 may replace steel rebar sizes #4 and #5, respectively, in typical residential and commercial foundation elements:
  - Inverted-T footings
  - Slabs-on-grade with continuous exterior footings
  - Stem walls with top and bottom longitudinal reinforcement
  - Driveways and parking lots

Independent Test Results

Tested by Metallurgical Engineering Services, Inc. (MES) in Richardson, TX (Lab No. 49631, March 19, 2025) on #4 GFRP composite rebar (nom. dia. 0.5 in, 36 in length):

- Tensile Strength (ASTM D7205-21):
  - Avg. Peak Load: 28,497 lbf
  - Avg. Strength: 142,500 psi
  - Ultimate Elongation: 2.28%
  - Elastic Modulus: 6.65 Msi
- Transverse Shear Strength (ASTM D7617-11):
  - Avg. Load: 5,690 lbf
  - Avg. Strength: 14,200 psi
- Bond Strength to Concrete (ASTM D7913-14):
  - Avg. Load: 5,070 lbf
  - Avg. Strength: 1,291 psi (2.5 in bonded length, 0.5 in diameter)
- Thermal Expansion (ASTM E831-24): 5.72 μm/m°C
- Glass Content (ASTM D2584-18): 78.3% average by mass

Basis for Code Compliance

- ACI 318: Many footings and walls qualify as “plain concrete.” Rebar X Glass Fiber Reinforced Polymer (GFRP) meets minimum reinforcement re-quirements.
- Tensile Strength Comparison:
  - #3 Rebar X (14.2 kips) > #4 Grade 40 steel (8 kips)
  - #4 Rebar X (28.5 kips) > #5 Grade 40 (12.4 kips)
- Shrinkage and Temperature Reinforcement: Compliant per ACI 440.1R. Lower modulus reduces curing cracks.
- Corrosion Resistance: Ideal for humid, coastal zones (e.g., Florida). Far exceeds steel rebar in this category.

Tensile Strength Comparison Justification

To validate the substitution claim, the tensile capacity of each bar is calculated as:

$$\text{Tensile Capacity} = A \times f_t \tag{1}$$

where:

- A is the nominal cross-sectional area,
- f_t is the tensile strength (GFRP) or yield strength (steel).

Grade 40 Steel Rebar:

- #4 bar (Area = 0.20 in²): $0.20 \times 40,000 = 8,000$ lb = 8.0 kips
- #5 bar (Area = 0.31 in²): $0.31 \times 40,000 = 12,400$ lb = 12.4 kips

Rebar X Glass Fiber Reinforced Polymer (GFRP) (based on ASTM D7205-21 lab results):

- #3 PirateBar (est. Area = 0.10 in²): $0.10 \times 142,500 = 14,250$ lb = 14.25 kips
- #4 PirateBar (Area = 0.20 in²): $0.20 \times 142,500 = 28,500$ lb = 28.5 kips

Comparison:

- #3 Rebar X (14.25 kips) > #4 Grade 40 Steel (8.0 kips)
- #4 Rebar X (28.5 kips) > #5 Grade 40 Steel (12.4 kips)

This supports the stated substitution guidance based on tensile capacity.

Drag Equation: Shrinkage & Temp. Reinforcement Comparison Using ACI 440.1R Let:

$$\rho_f = \frac{\mu L w_c}{E_f \varepsilon_{fu}}, \tag{2}$$

with:

- μ: subgrade friction coefficient
- L: slab length or spacing
- w_c: concrete weight
- E_f: elastic modulus (6.65 Msi)
- ε_{fu}: 2.28% ultimate strain

The required reinforcement ratio for shrinkage and temperature in slabs-on-grade is given by the above drag equation.

Assume:

- Subgrade friction: $\mu = 1.5$
- Slab length: $L = 20$ ft $= 240$ in
- Concrete weight: $w_c = 145$ pcf $= 0.145$ kip/ft^3
- GFRP modulus: $E_f = 6.65 \times 10^6$ psi
- Ultimate strain: $\varepsilon_{fu} = 0.0228$

$$\rho_f = \frac{1.5 \times 20 \times 0.145}{6.65 \times 10^6 \times 0.0228} = \frac{4.35}{151,620} = 2.87 \times 10^{-5}$$

Bar Area Provided vs. Required:

- #3 GFRP: Area = 0.11 in^2
- #4 GFRP: Area = 0.20 in^2

Assume bars @ 12″ spacing:

$$\rho_{\#3\ \text{GFRP}} = \frac{0.11}{12} = 9.17 \times 10^{-3} \quad \text{(OK)}$$

$$\rho_{\#4\ \text{GFRP}} = \frac{0.20}{12} = 1.67 \times 10^{-2} \quad \text{(OK)}$$

Comparison with Grade 40 Steel:

- #4 Steel: $E_s = 29 \times 10^6$ psi, yield strain: $\varepsilon_y = 40,000/29,000,000 = 0.00138$
- #5 Steel: Area = 0.31 in^2, spacing = 12″

$$\rho_{\#4\ \text{Steel}} = \frac{0.20}{12} = 1.67 \times 10^{-2}$$

$$\rho_{\#5\ \text{Steel}} = \frac{0.31}{12} = 2.58 \times 10^{-2}$$

Both #3 and #4 Rebar X GFRP exceed the required ρ_f by over 300×. Similarly, steel bars at typical spacing far exceed shrinkage requirements, but GFRP offers higher strength-to-weight ratio and corrosion resistance.

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