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This engineering statement documents the code-compliant basis for the use of Pirate Rebar GFRP reinforcement in insulated concrete form (ICF) wall construction. ICF wall assemblies are evaluated as cast-in-place reinforced concrete walls, with structural performance governed by the concrete core and internal reinforcement rather than the insulating formwork. GFRP reinforcement is recognized through ASTM material standards and ACI 440.11 design provisions under the International Building Code alternative materials framework, in the same manner that steel reinforcement is accepted through ASTM A615 and ACI 318. Review of published research and available independent testing indicates that GFRP reinforcement performs effectively in flexure-dominated wall systems, including ICF construction. Based on first-order mechanics and conservative assumptions consistent with ACI 440, Pirate Rebar's larger-diameter, higher-strength GFRP reinforcement would be expected to provide equal or greater flexural resistance than smaller-diameter reference GFRP bars when used at comparable spacing and detailing, subject to project-specific engineering by the licensed Engineer of Record.

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### To Whom It May Concern,

This paper is a code-based evaluation of the use of Pirate Rebar's Glass Fiber Reinforced Polymer (GFRP) reinforcement within Insulated Concrete Form (ICF) wall systems. Building codes classify ICF construction as a form of *cast-in-place reinforced concrete wall*, where the foam serves only as permanent formwork and insulation, and all structural capacity comes from the concrete core and its reinforcement.

Accordingly, all reinforcement functions in ICF systems —vertical bars, horizontal bars, corner bars, and splices—may be designed in accordance with recognized concrete design standards. When engineered under ACI 440.11 and manufactured to ASTM D7957, Pirate Rebar GFRP is a fully permissible and structurally appropriate alternative to steel reinforcement for all reinforcement roles within an ICF wall assembly.

### Applicable Codes and Standards

The use of GFRP reinforcement in ICF wall systems is governed by nationally accepted building codes and design standards, including:

- **International Building Code (IBC)** – Provisions for structural concrete
- **International Residential Code (IRC)** – Engineered design provisions for concrete systems
- **ACI 440.11** – *Code Requirements for Structural Concrete Reinforced with Fiber-Reinforced Polymer Bars*
- **ASTM D7957** – *Standard Specification for GFRP Reinforcing Bars*
- **ACI 318** – Requirements for concrete design not specifically addressed by ACI 440.11

### Code Recognition Pathway for GFRP Reinforcement

#### Material Compliance

Pirate Rebar GFRP products meet the following requirements:

- Conformance with ASTM D7957, covering material properties and durability
- Tensile strength, modulus, and linear-elastic behavior required for ACI 440.11 design
- Compatibility with concrete used in ICF construction

#### Code Acceptance Logic

Building codes recognize reinforcement materials based on **ASTM material standards and ACI design standards**, rather than the presence or absence of ICC-ES evaluation reports.

- **Steel rebar** is recognized through **ASTM A615** and **ACI 318**
- Steel reinforcement **does not require** and is **not evaluated** under any ICC-ES acceptance criteria

GFRP reinforcement follows the **parallel and equivalent acceptance pathway**:

- **ASTM D7957** provides the mandatory material specifications
- **ACI 440.11** provides the governing structural design requirements
- **IBC §104.11 (Alternative Materials and Methods)** explicitly permits code-compliant materials designed using recognized standards

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Accordingly, GFRP reinforcement is recognized by the IBC as an acceptable reinforcement material for reinforced concrete structures, including ICF walls, when designed in accordance with the referenced ASTM and ACI standards.

### Structural Evaluation

ICF wall assemblies are evaluated using standard reinforced concrete design principles, with the use of GFRP reinforcement governed by ACI 440.11.

### General Behavior

- **Concrete Core Behavior:**  
The concrete core serves as the primary load-bearing element, resisting axial, flexural, and shear forces consistent with conventional reinforced concrete wall design.
- **GFRP Reinforcement Behavior:**  
GFRP bars function as linear-elastic, non-corroding tension reinforcement and are designed per ACI 440.11 for development length, lap splicing, crack control, serviceability, and ultimate strength requirements.
- **Reinforcement Roles and Locations:**  
Vertical, horizontal, and corner reinforcement may be provided using GFRP bars in ICF wall assemblies, including below-grade and above-grade applications, when spacing, embedment, detailing, and structural demand are designed in accordance with ACI 440.11.
- **Formwork Consideration:**  
The ICF form serves solely as permanent formwork and insulation and does not contribute to structural capacity.

### Flexural Performance Basis for ICF Walls

Pirate Rebar's review of published research and available independent testing indicates that GFRP reinforcement has been demonstrated to perform effectively in flexure-dominated concrete wall systems, including ICF construction.

Published testing of GFRP-reinforced ICF wall panels using 7/16-in. GFRP bars in approximately 8-in.-thick concrete sections demonstrated ultimate flexural capacities comparable to steel-reinforced panels, despite the use of smaller reinforcement area and lower elastic modulus. This result indicates that GFRP reinforcement can efficiently develop flexural resistance in ICF wall systems.

Most residential ICF walls, however, utilize concrete core thicknesses of 4 to 6 inches, resulting in more lightly reinforced, tension-controlled sections. In such configurations, flexural capacity is governed primarily by reinforcement area and ultimate tensile strength rather than elastic modulus or compression block depth. Accordingly, the use of larger-diameter, higher-strength GFRP reinforcement would be expected to provide equal or greater flexural resistance than both smaller-diameter GFRP bars and conventional steel reinforcement when used at

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comparable spacing and detailing, subject to project-specific engineering in accordance with ACI 440.

For tension-rupture-controlled flexural behavior, a first-order scaling relationship applies. In such cases, nominal flexural capacity may be approximated as the product of the tensile force in the reinforcement and the internal lever arm.

The tensile force in the GFRP reinforcement may be expressed as:

$$T_f \propto A_f f_{fu}$$

where  $T_f$  is the tensile force in the reinforcement,  $A_f$  is the reinforcement area, and  $f_{fu}$  is the ultimate tensile strength of the GFRP. Together, these parameters describe the force capacity of the reinforcement at rupture.

Accordingly, nominal flexural capacity may be approximated as:

$$M_n \approx T_f z$$

where  $M_n$  is the nominal flexural moment capacity and  $z$  is the internal lever arm. For similar wall geometry and reinforcement layout,  $z$  may be considered comparable.

Under these assumptions, the relative flexural capacity may be estimated as:

$$\frac{M_{n,Pirate}}{M_{n,ref}} \approx \frac{A_{Pirate} f_{fu,Pirate}}{A_{ref} f_{fu,ref}}$$

Using comparable test conditions and replacing and replacing a 7/16" GFRP bar (reported  $f_{fu} \approx 134$  ksi) with Pirate Rebar's 1/2" GFRP ( $f_{fu} = 149.5$  ksi,  $E_f = 8,079$  ksi,  $\epsilon_{fu} \approx 2\%$ ) the estimated capacity ratio is:

$$\left( \frac{0.50}{0.4375} \right)^2 \left( \frac{149.5}{134} \right) \approx 1.46$$

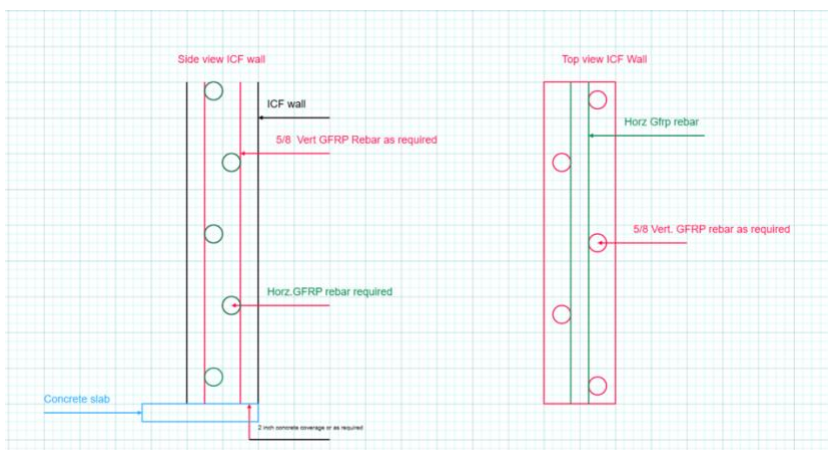
i.e., **on the order of ~40–45% higher flexural resistance** in comparable tension-rupture-controlled configurations, subject to project-specific engineering, detailing, and governing limit states (bond, shear, compression) per ACI 440.

For illustrative purposes only, please see the diagram below depicting an acceptable format for the GFRP placement:

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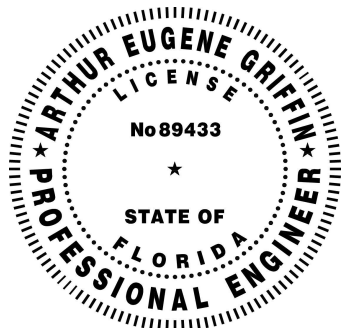
### Professional Application & Engineering Responsibility

When designed in accordance with ACI 440.11 and applicable provisions of ACI 318, ICF wall systems reinforced with Pirate Rebar GFRP products may be engineered to meet nationally recognized requirements for strength, serviceability, and detailing applicable to reinforced concrete wall construction.

This document is intended to provide the technical basis supporting the use of GFRP reinforcement in ICF construction. Final design, detailing, and certification for any specific project must be provided by the licensed Engineer of Record based on project-specific loading, geometry, and applicable local code amendments.

Sincerely,  
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\*Engineer's seal covers design only. Engineer assumes no liability for product defects, fabrication, installation, or construction means and methods.



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