*Assessment of GFRP Properties: A Literature Review*

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EXECUTIVE SUMMARY:

*There has been significant development in the design and use of GFRP reinforcing bars. This report provides an overview of the literature on the properties, characteristics, and performance of GFRP bars. This literature review indicates that when compared with steel reinforcement, GFRP reinforcing bars exhibit lower modulus of elasticity values, lower ductility, and lower bar-concrete bond. The literature also indicates that structures reinforced with GFRP can exhibit larger deflections and larger crack widths. GFRP bars are also lighter than steel bars and are non-conductive and non-magnetic, which provide some potential benefits for specific situations. However, one characteristic that has not achieved consensus in the engineering community is the durability of GFRP when embedded in concrete. In the large majority of cases concrete has a high relative humidity within its pore system and this moisture consists of a high pH solution. When GFRP reinforcing bars are embedded in concrete, the composite surrounding the glass fibers is supposed to protect the glass fibers from potential deterioration. However, the high pH pore solution can penetrate this composite material. As the high pH pore solution penetrates the composite it eventually reaches the glass fiber and these fibers are susceptible to etching and leaching. This etching and leaching of the glass fibers in the GFRP can result in loss of bond between the glass fibers and composite material or can result in weakening of the glass fibers. Both debonding and loss of glass fiber strength result in loss of strength in GFRP reinforcing bars. Loss of strength in GFRP reinforcing bars has been reported throughout the literature. Unlike steel reinforcement, which when corroded exhibits signs of degradation (e.g., rust stains or concrete delamination), when GFRP degrades there are no visual signs of this degradation.*

*Some recent research indicates that GFRP reinforcing bars embedded in field structures do not exhibit degradation or loss of strength. However, these research studies contained no direct measurements of the residual tensile strength of GFRP reinforcing bars. Although indirect measures of GFRP degradation are improving, direct measurements of GFRP reinforcement degradation provide a clear and unambiguous measure of performance. Because the literature indicates that GFRP reinforcing bars do lose strength with time and because degrading GFRP bars provide no visible warning of this degradation, the engineering community must move forward in using this reinforcement with caution.*

KEY FINDINGS:

1. Compared to steel reinforcement, GFRP reinforcement exhibits low modulus of elasticity values, low ductility, and lower bar-to-concrete bond, which can result in structures with larger deflections and larger crack widths.

2. When designing concrete members of the same size, more reinforcement is required for GFRP than for steel.

3. GFRP bars degrade in conditions of moisture in concrete. The consequence of degradation is a significant loss in strength over time.

4. Strength reduction factors are not sufficiently conservative to account for degradation.

5. GFRP reinforced structures exhibit no visible indication of degradation or warning of failure, posing a risk in assessing structural integrity.

6. Reliable, repeatable and accurate methods for assessing the performance of GFRP reinforcement have not been developed. There is minimal consensus on the long-term performance of GFRP reinforced concrete.

7. Accepted durability testing parameters are modified to reduce the severity of the test conditions.

8. In comparative corrosive studies between GFRP and steel reinforcing bars, black carbon steel is used rather than corrosion-resistant steel reinforcement.