Structural Integrity of Reinforced Concrete

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This study investigates the potential of fiberglass rebar as a structural alternative to steel in reinforced concrete applications. Mechanical testing, including compressive and three-point bend tests, revealed that fiberglass rebar offers significant flexural performance, maintaining structural integrity even after visible cracking. Unlike steel, fiberglass specimens demonstrated high deflection capacity and sustained load-bearing ability post-cracking. These findings support the use of fiberglass rebar in scenarios where flexural strength and crack resistance are critical, highlighting its promise for targeted structural applications.

Abstract

This study evaluates the structural integrity of reinforced concrete by comparing the mechanical properties of steel and fiberglass rebar. The primary objective is to assess the differences in material performance, performing compressive and flexural tests to quantify the ductility, load-bearing capacity, and durability of each rebar type under stress. The expected outcome is to determine the viability of fiberglass rebar as an effective alternative to traditional steel, particularly in terms of its mechanical performance and long-term reliability.

Methodology

Sample Specifications

- Samples created using Ready –To-Mix QuikRete
- 3:1 QuikRete to water ratio
- #4 rebar
- Vibrate samples every 1" layer
- Samples dried for three plus weeks

Dimensions [Piers]	Steel 1	Steel 2	Fiber 1	Fiber 2
Diameter [in]	3.75	3.75	3.75	3.75
Height [in]	7.8125	7.65625	7.59375	7.8125

Dimensions [Beams]	Steel 1	Steel 2	Fiber 1	Fiber 2
Width [in]	2.007	2.008	2.008	2.002
Thickness [in]	2.067	2.063	2.065	2.070
Span length [in]	5.118	5.118	5.118	5.118

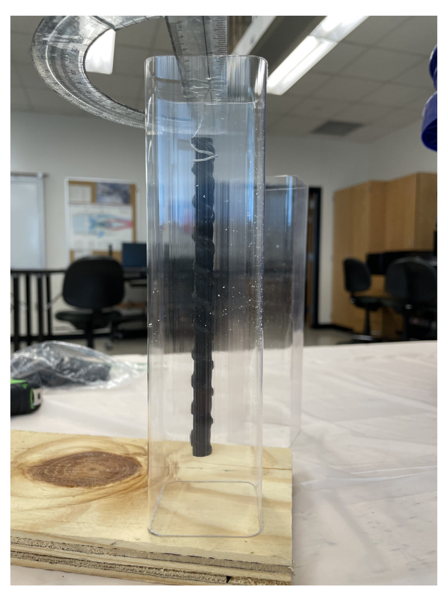


Figure 1 (Setup)

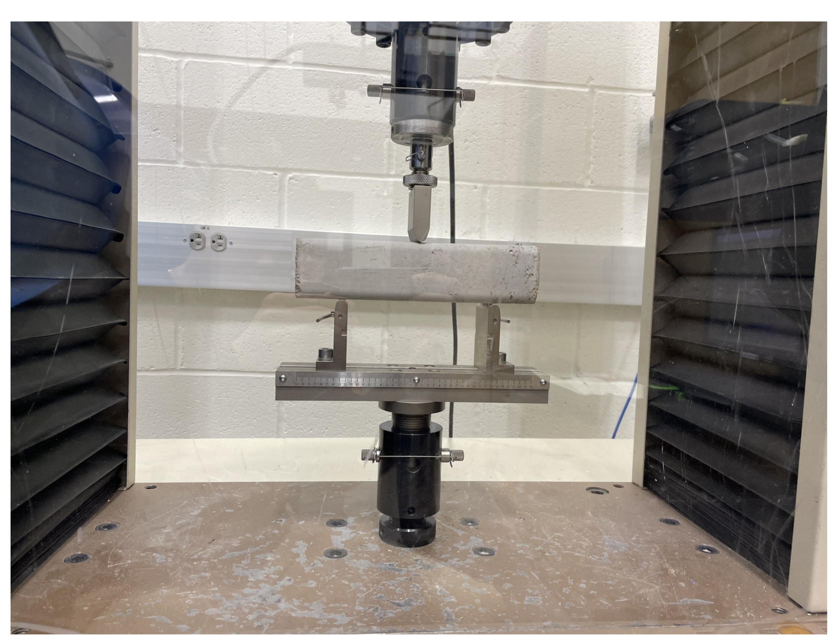


Figure 2(Three-Point Bend Test)

Fiber glass and steel rebar were tested in both compressive and flexural applications. A single 6" rod was set vertically into concrete piers for the compressive test and horizontally in beams for the flexural test. 2 piers and 2 beams contained #4 steel rebar the other 2 piers and beams contained fiberglass rebar.

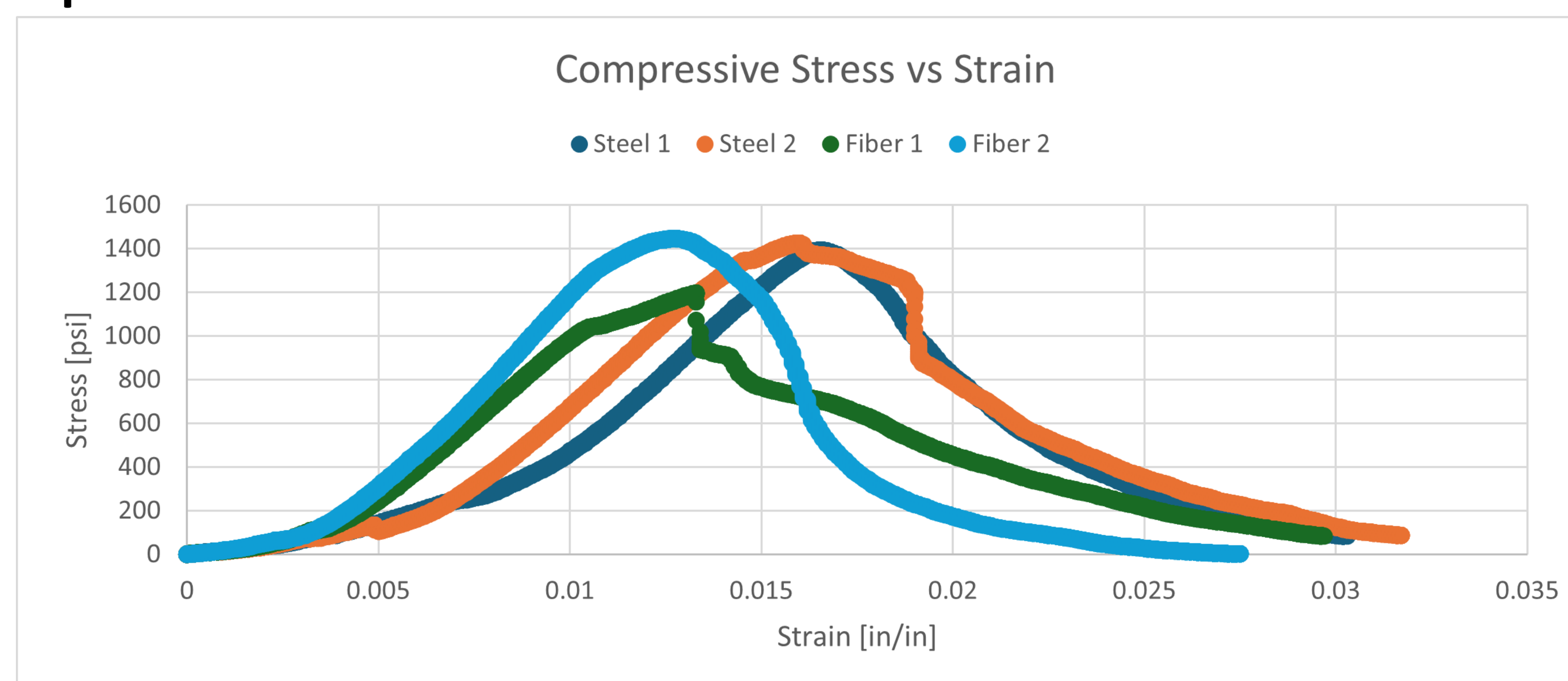
Compressive Test

Piers are tested with a vertical load demonstrating the compressive strength of the material. Deflection rate of 0.05 in/min

Three-Point Bend Test

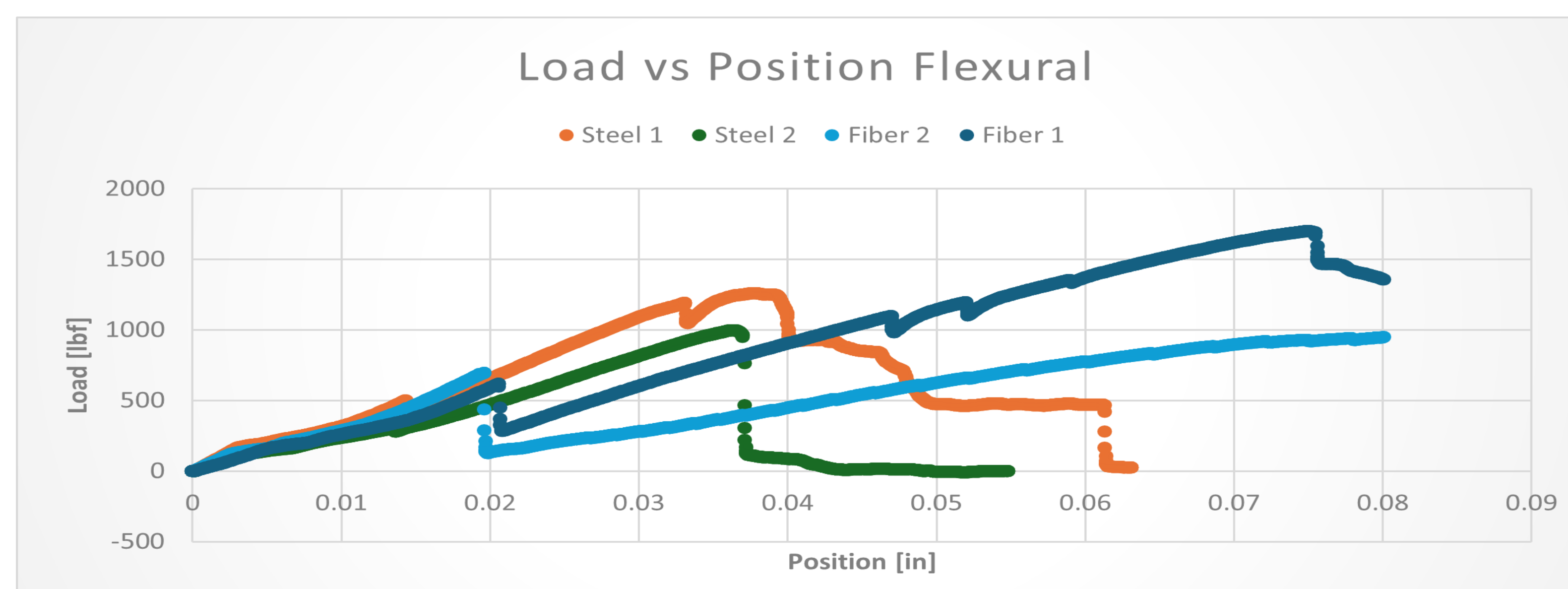
Beams are tested with a horizontal load as shown in the image above (Figure 1) and determines the flexural strength of a material. Deflection rate of 0.015 in/min

Experimental Results



	Steel 1	Steel 2	Fiber Glass 1	Fiber Glass 2
Compressive Strength [psi]	1392.704	1425.027	1196.23	1446.033
Strain at break [in/in]	0.0166	0.016	0.0133	0.0127
Max load [lbf]	15382	15739	13212	15971
Type of failure	Shear	Shear	Compressive	Compressive

In the compressive test the type of rebar did not have a large impact on compressive strength and maximum load. The biggest distinction between the two is the strain at break with the steel samples experiencing 0.0033 higher strain values on average.



	Steel 1	Steel 2	Fiber Glass 1	Fiber Glass 2
Max Load [lbf]	1259.2	995.2	1699.9	947
Max Deflection at Break [in]	0.0378	0.0364	0.075	0.0801

The flexural test demonstrates the difference between steel and fiber glass rebar. Each dip in load demonstrates a crack in the sample. Fiber glass experienced more cracks and higher deflections than the steel samples.

There is not a large distinction between the two when you compare maximum loads. Average load at break for the steel samples was 1,127.2 lbf while the average for fiber glass was 1323.45 lbf. More samples are needed to determine a conclusive difference.

Modes of Failure

Figure 3 (Fiber glass 2 compressive failure)

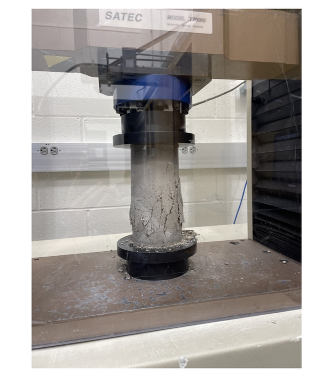


Figure 4 (Fiber glass 2 compressive failure)

Figure 5 (Steel 1 shear failure)

Figure 6 (Fiber glass flexural failure)

Figure 7 (Steel flexural failure)

In the compressive test the rebar affected the mode of failure on the piers. Steel specimens experienced a shearing failure (Figure 5) while fiber glass experienced a compressive failure (Figure 3 & 4).

The flexural test also experienced different modes of failure. Steel samples again sheared (Figure 7) since the steel would not bend with the concrete. This caused the concrete to fail at very small deflections. The fiberglass rebar would bend with the concrete allowing for the higher deflections.

Conclusion

Our data indicates that fiber glass is a viable alternative to steel rebar in some cases, especially in a flexural application. The results to our three-point bend test demonstrate the fiber glass's ability to undergo large deflections and continue to maintain its strength. After multiple cracks the specimens did not fully fracture. In the end the concrete was completely cracked along the cross sectional area of the specimen with the rebar holding the two ends together. Cracks will be visible long before failure and pre-cracked specimens will hold a larger load than the steel counter parts, making it a promising option for certain construction applications.

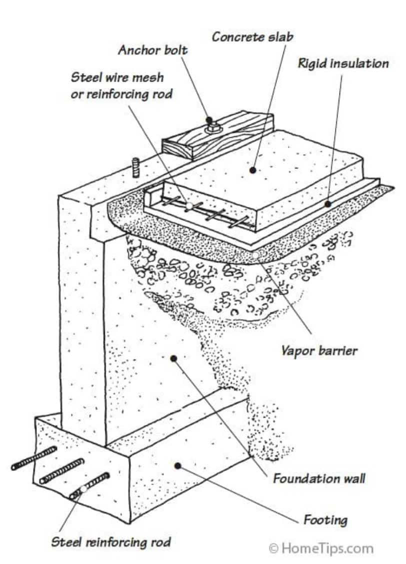


Figure 8 (Foundation)

The above image (Figure 8) demonstrates the foundation of many residential homes. The footing and the foundation wall are in compression where the data did not demonstrate enough evidence for the use of fiber glass rebar. The slab on the other hand experiences flexural forces and this is where fiber glass would be extremely beneficial. A slab reinforced with fiberglass rebar could experience higher deflections before failure making it a viable solution.

References

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