

Freeze-Thaw-Durability of GFRP and BFRP Rebars



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THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE



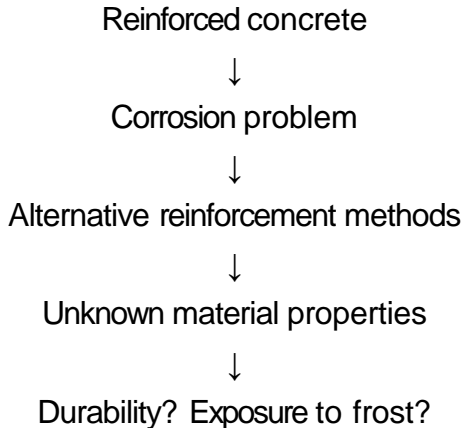
Presentation outline



Introduction

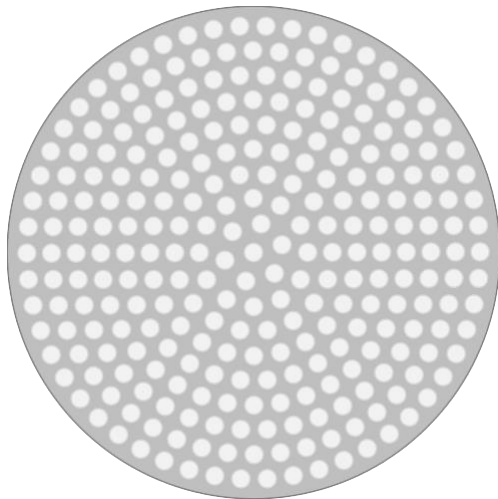
Introduction

Problem Statement



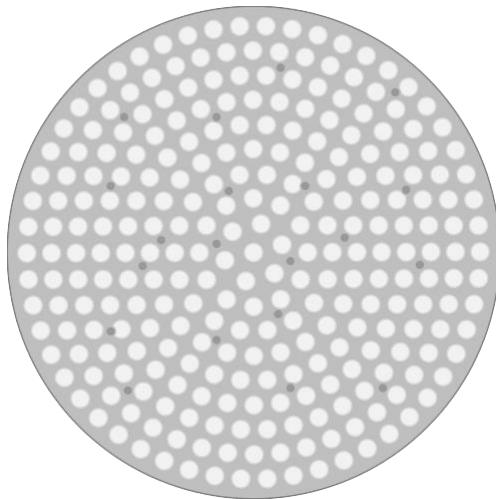
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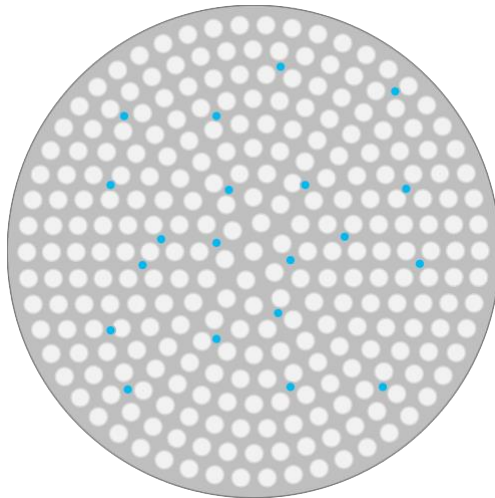
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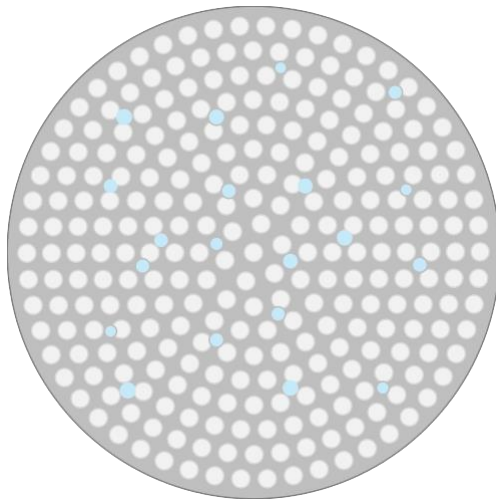
Introduction

Problem Statement



Introduction

Problem Statement



Introduction

Research Significance

- ▶ Fiber-reinforced polymer rebar rods
- ▶ Exposure to freeze-thaw cycles
- Durability
- Strength retention (after aging via freeze-thaw cycles)



Methodology

Methodology

Materials



Methodology

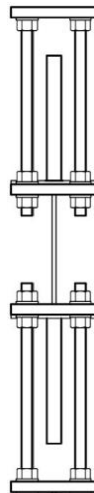
Testmatrix

Material	Diameter		Number of freeze-thaw cycles	Number of strength tests		
	mm	in.		Tensile	Transverse shear	Apparent horizontal shear
GFRP	8	2/8	0	5	7	7
			80			
			160			
	16	5/8	0	5	7	7
			80			
			160			
BFRP	8	2/8	0	5	7	7
			80			
			160			
	16	5/8	0	5	7	7
			80			
			160			

Methodology

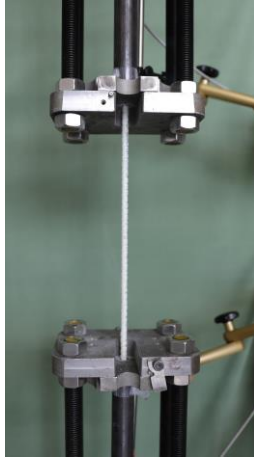
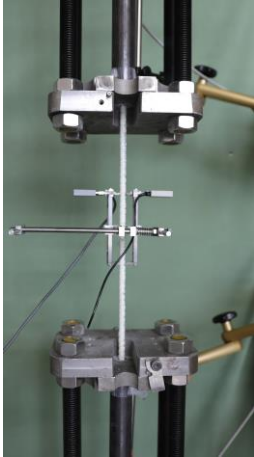
Measurement of tensile strength and elastic modulus

- ▶ Anchor installation with steel pipes
- ▶ Installation in test fixture
- ▶ Strain measurement via extensometer



Methodology

Measurement of tensile strength and elastic modulus



Methodology



a) BFRP 8mm (#2)



b) GFRP 8mm (#2)



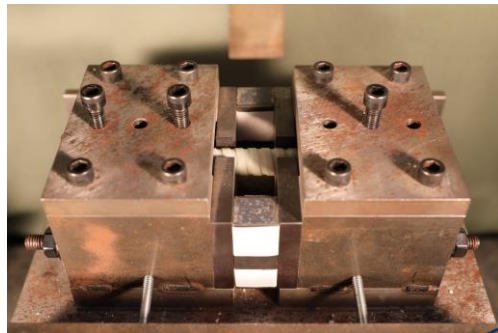
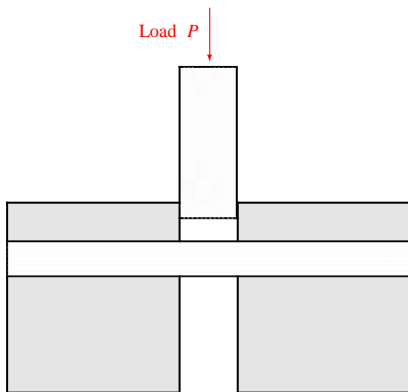
c) BFRP 16mm (#5)



d) GFRP 16mm (#5)

Methodology

Measurement of transverse shear strength



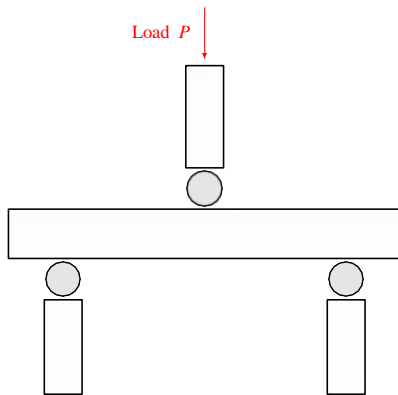
Methodology

Measurement of transverse shear strength



Methodology

Measurement of horizontal shear strength



Methodology

Measurement of horizontal shear strength

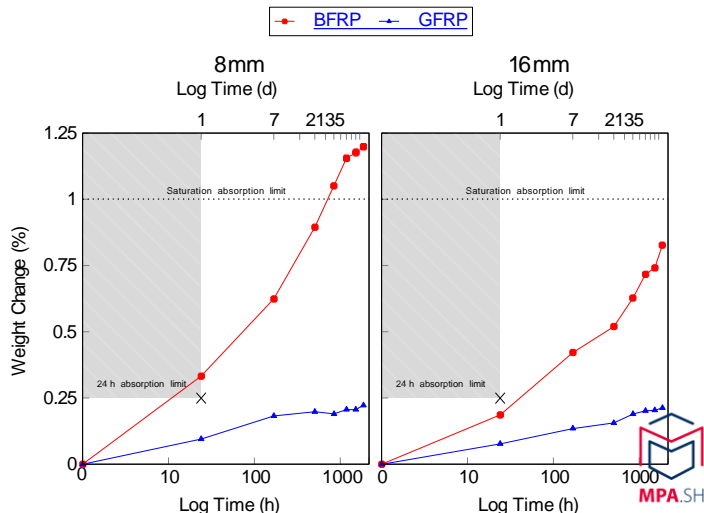


Results

Results

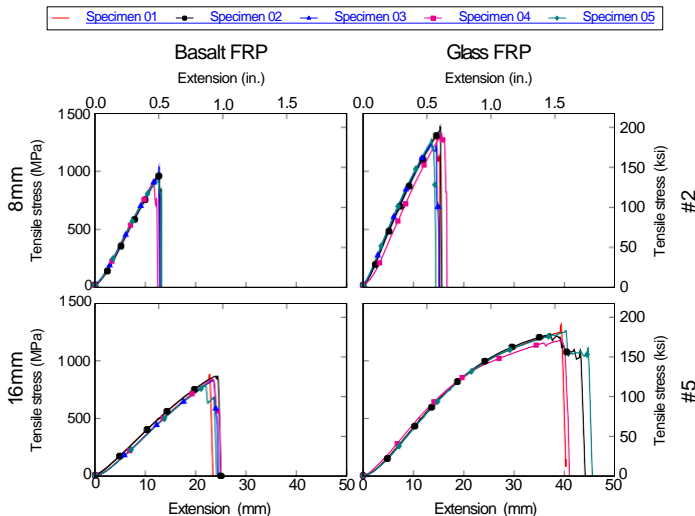
Preliminary analyses

- ▶ Saturation measurement
- ▶ Fiber content
 - ▶ 78.0% for basalt
 - ▶ 87.0% for glass



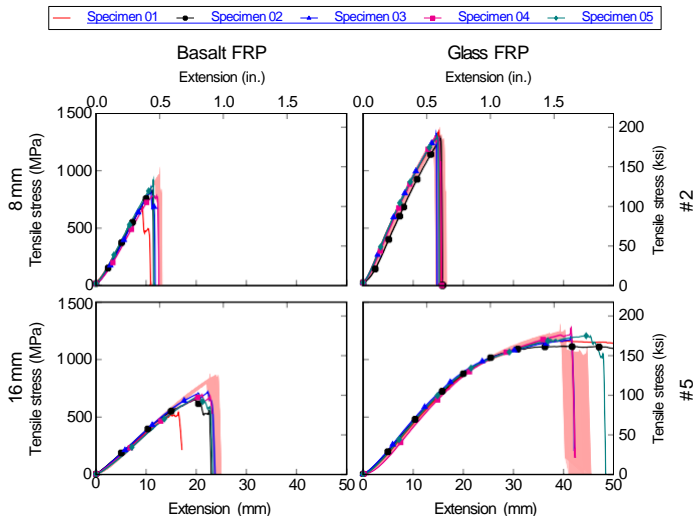
Results

Tensile behavior and tensile strength -- Virgin properties



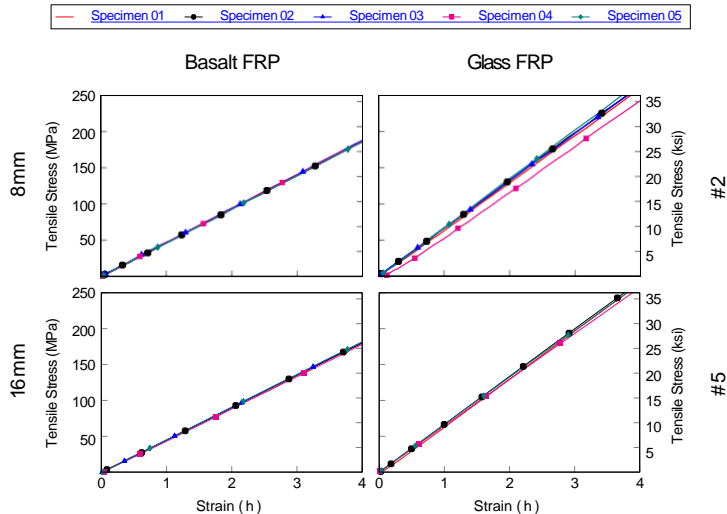
Results

Tensile behavior and tensile strength -- Aged properties (80 cycles)



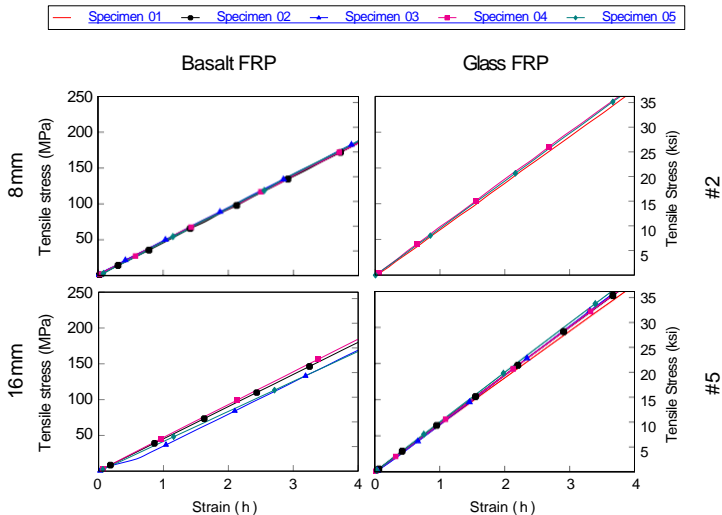
Results

Modulus of elasticity -- Virgin properties



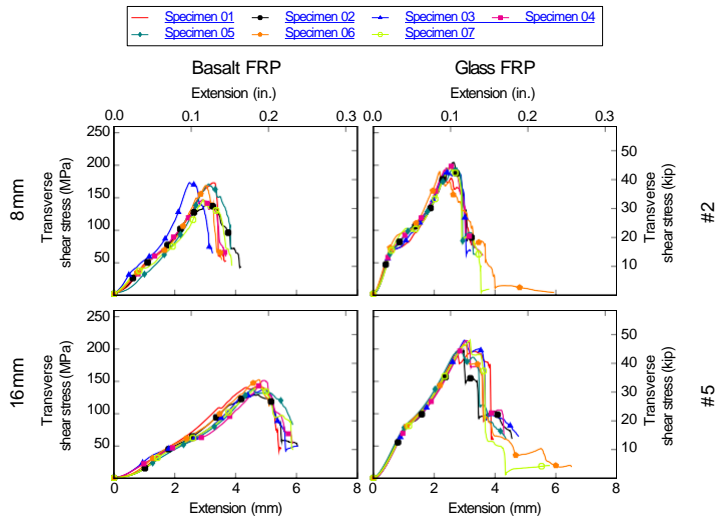
Results

Modulus of elasticity -- Aged properties (80 cycles)



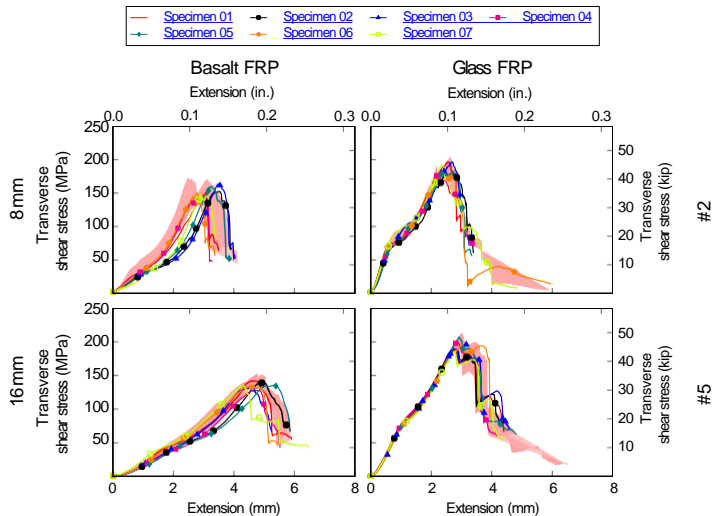
Results

Transverse shear behavior and strength -- Virgin properties



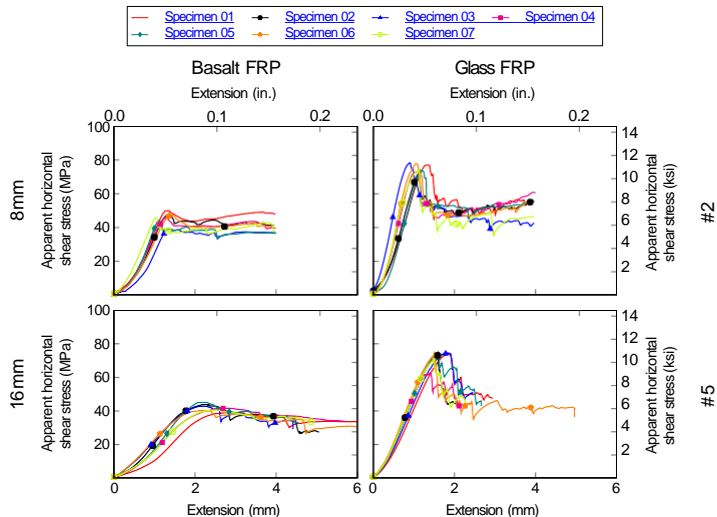
Results

Transverse shear behavior and strength -- Aged properties (80 cycles)



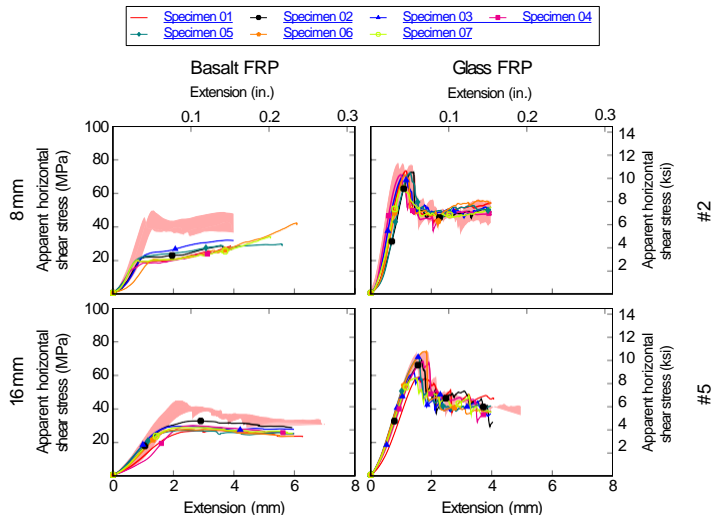
Results

Horizontal shear behavior and strength -- Virgin properties



Results

Horizontal shear behavior and strength -- Aged properties (80 cycles)

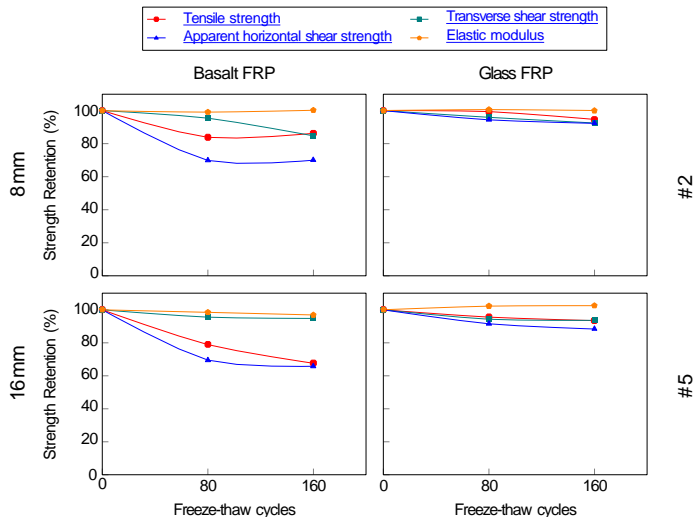


Analysis & Discussion



Analysis & Discussion

Durability evaluation -- All ages and properties



Analysis & Discussion

- ▶ Reduction in strength retention suggests formation of production-related pores
- ▶ Material with higher absorption values suffered greater loss in strength
- ▶ Decrease in tensile strength due to
 - ▶ Production related quality
 - ▶ Resin quality (or pores in resin)
- ▶ Modulus of elasticity **appeared** not to be affected
 - ▶ Measurement method? Strain domain?

Summary

Summary

- ▶ 228 Fiber-reinforced polymer rebar specimens were tested
 - ▶ Made from glass and basalt FRPs
 - ▶ 8 mm and 16 mm diameters

- ▶ Comparison of virgin vs. aged material properties
 - ▶ Aged with 80 and 160 freeze-thaw cycles

- ▶ Tensile and shear strength tests were conducted
 - ▶ Comparison: Virgin vs. aged properties

Conclusion

Conclusion

- ▶ Aging due to freeze-thaw may lead to strength reduction
 - ▶ In this study: Basalt FRP rods were more significantly affected than glass FRP rods

- ▶ Resin matrix appears to be susceptible to freeze-thaw than fibers
 - ▶ Production quality of appears to be of great importance

- ▶ Modulus of elasticity is not affected (within the evaluated deformation domain)

Questions ?

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