



VTRC

Virginia Transportation
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Virginia Department of Transportation

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Use of prepackaged ECC, VHPC, and UHPC in Bridge Structures

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Virginia Concrete Conference, 2020



Outline

- Introduction: High Performance Fiber Reinforced Concretes (HPFRC)
 - ECC, VHPC, UHPC
- Tests
- Prepackaged Materials
- Field Applications
- Conclusions



ECC, VHPC, UHPC

- ECC: engineered cementitious composite
- VHPC: very high-performance concrete
- UHPC: ultra high-performance concrete

Concrete	Compressive Strength (psi)	Ductility
ECC	4,000 at 7d	Y
VHPC	> 11,500	Y
UHPC	> 17,000	Y



Goal is Longevity! Build to Last!



CONCRETE IS DURABLE!

Pantheon: Roman concrete, 2,000 years old!



Year 1 002 020



Build it right! Keep it dry!



Infiltration into Concrete

- Water and solutions penetrate through poor quality concrete, joints, and cracks.
- Cause damage to reinforcement and concrete



Corrosion

- Corrosion is a major distress in reinforced concrete structures exposed to the environment.



Leaking Joints



Cracks

There are two kinds of concrete:

- One cracked
- One about to crack



Charlie Robson

Former VDOT State Materials Engineer



Crack Control with Fibers

- Synthetic fibers in low amounts, 1.5 lb/yd³ (0.1% by volume) are used to minimize plastic shrinkage.
- Larger amounts of fibers up to 2% needed for crack control in hardened concrete.



Fibers

- ECC



PVA fiber

- VHPC / UHPC



Steel fiber hooked end



OL fiber



Crack Control – FRC

- FRC: fiber-reinforced concrete
 - Improve tensile and flexural strengths
 - Increase ductility
- Keep crack width less than 0.1 mm.
Crack widths ≥ 0.2 mm can be and should be sealed.

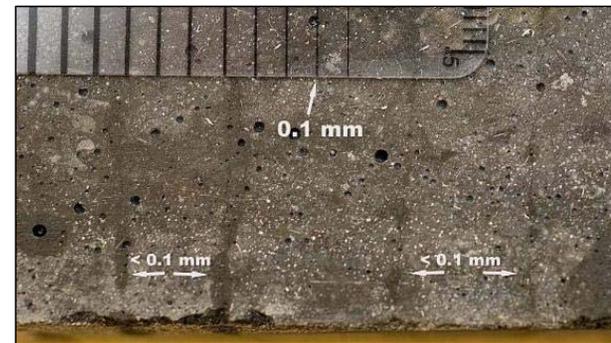


Tight Cracks (<0.1 mm)



ECC

UHPC



Tight Cracks



FRC

- Connections, short lap splices



Tests

- Compressive strength
 - Cube
 - Cylinder
- Flexural strength
- Splitting tensile strength
- Pull-out test



Tests



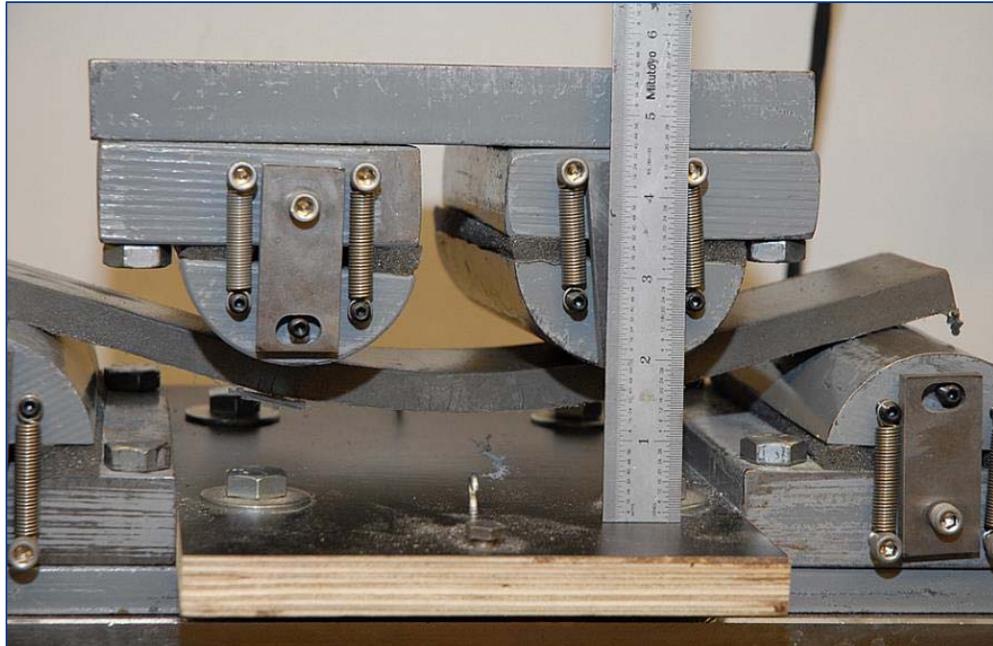
Cube Compressive
Strength



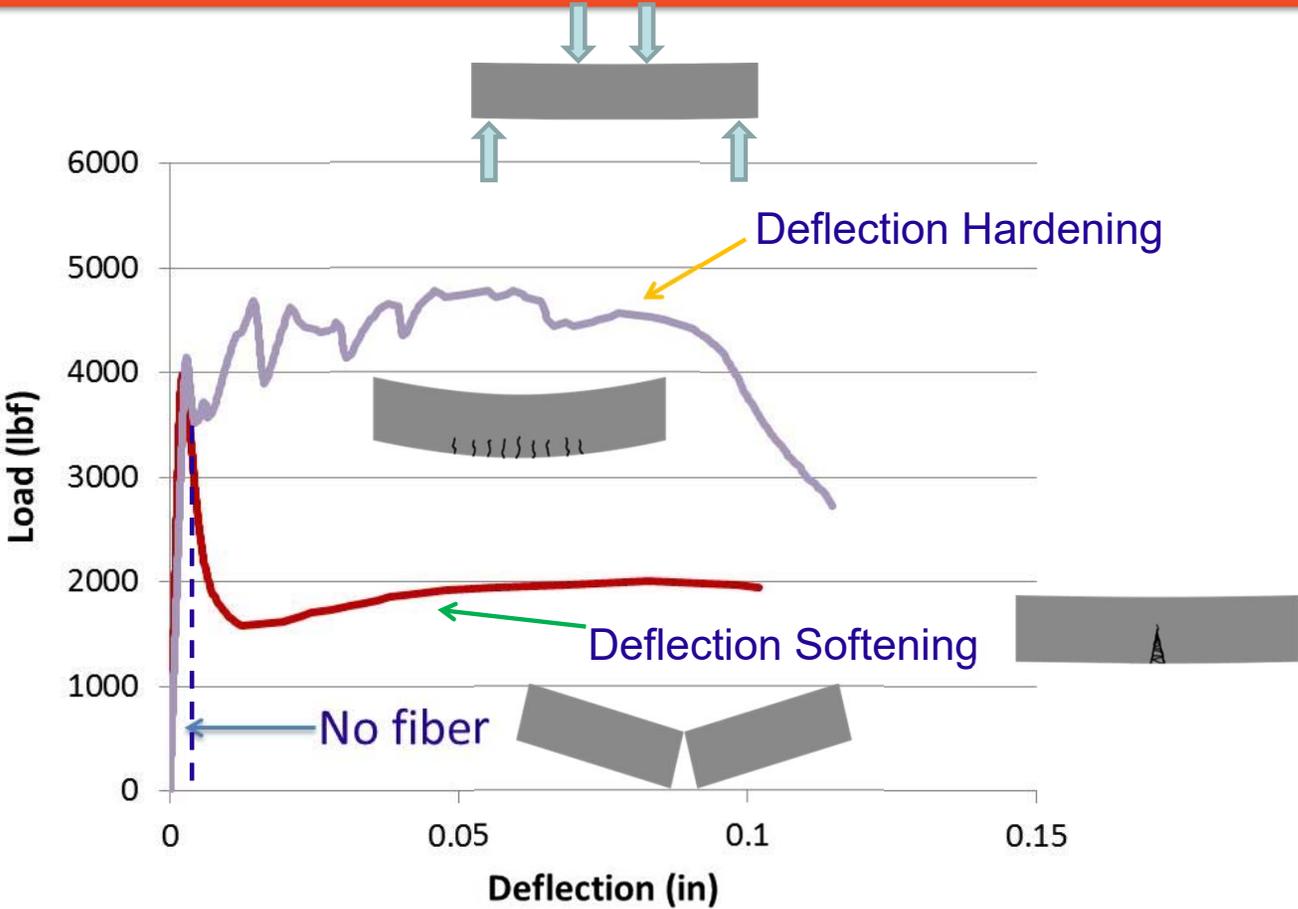
Cylinder Compressive
Strength



Flexural Test



Flexural Test



Tests



Splitting Tensile
Strength



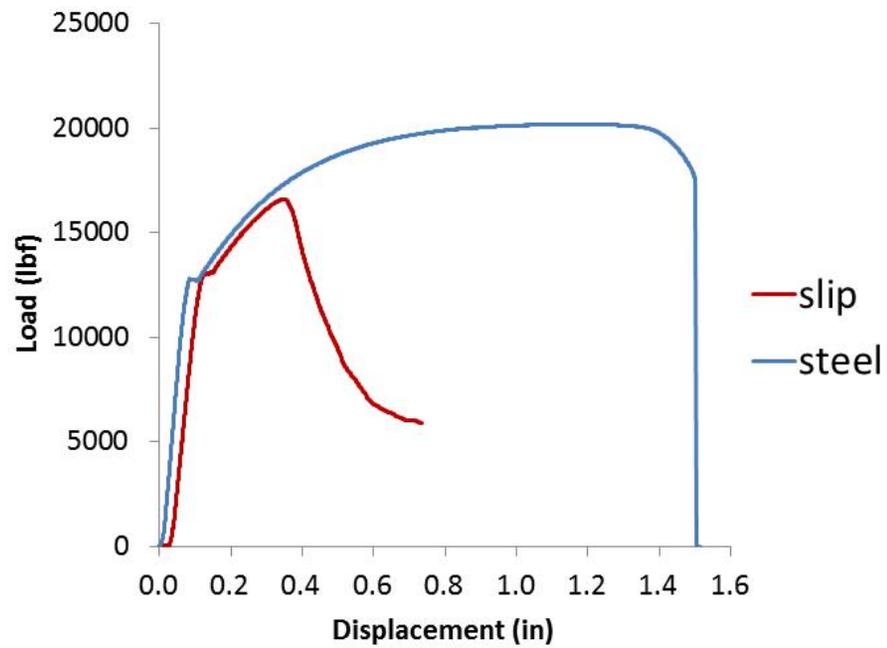
Pull-out



Pull-out Specimen



Typical pullout test graph



Prepackaged Materials

- Ingredients blended and stored in a bag or super sack
- Generally only water is added on site
- Fibers can be in the bags or added separately
- Expect quality and convenience



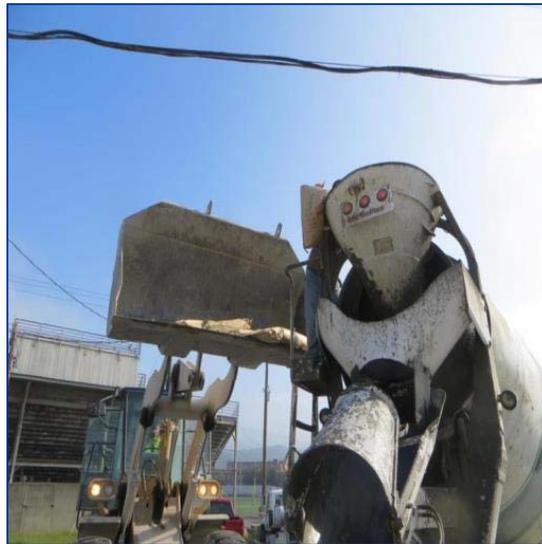
List of Prepackaged Material

- ECC: Three materials in VDOT SPEL (special products evaluation list).
- VHPC: Two materials in VDOT SPEL.
- UHPC: Three materials ready for inclusion in SPEL.
- Continuing evaluation of ECC, VHPC, and UHPC materials.



Mixing FRC

- FRC: Mortar mixers, RMC trucks



Fibers added manually

- HPFRC: efficient mixers



HPFRC - Mixing Small Amounts

- Dual paddle drill mixer
- Mortar mixer



HPFRC - Mixing Larger Amounts



Planetary mixer
(UHPC)

Drum and mortar mixers
(VHPC)



HPFRC Applications in VDOT

- ECC is also known as bendable concrete used in shear keys, closure pours, and culvert repairs.
- VHPC is used in block-outs.
- UHPC is used in beams. It can meet VHPC requirements at early ages.

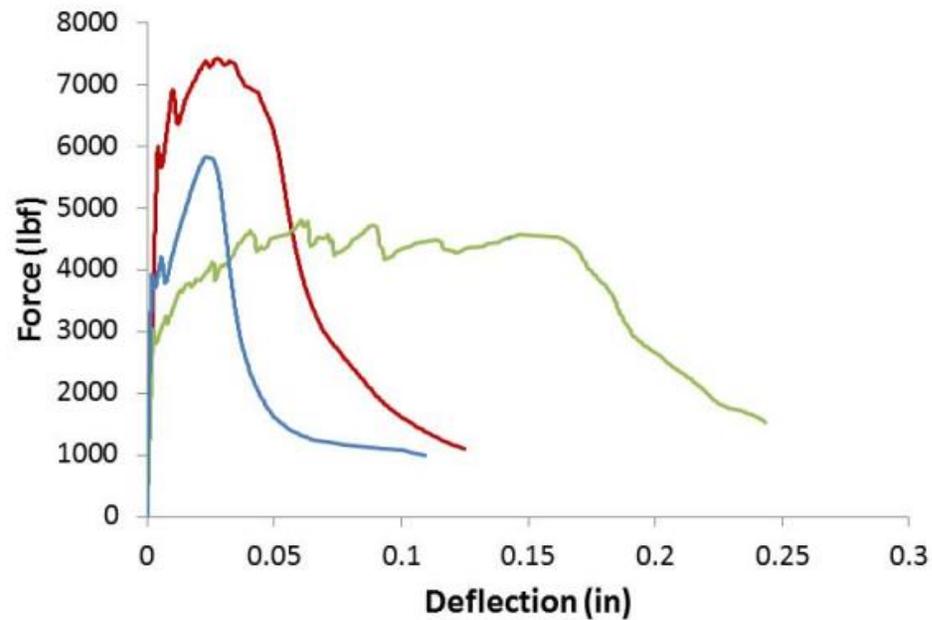


ECC, Kents Store - 2019



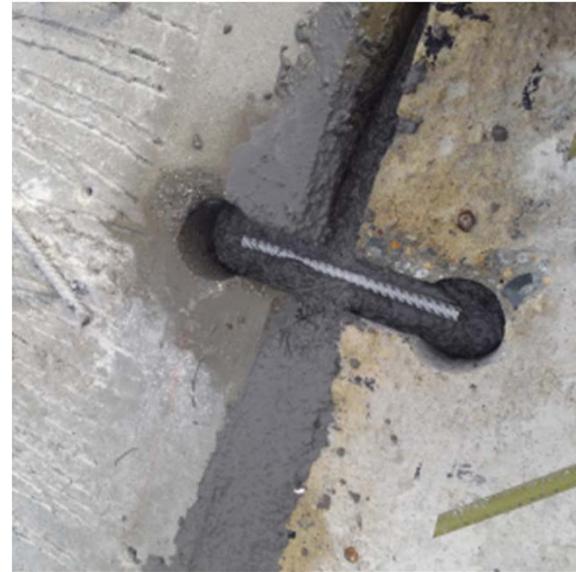
ECC Test Results

7-day flexural strength



VHPC Applications

Block-outs in new construction or repair projects



VHPC, I-64 - 2019



VHPC, Ewing - 2019



VHPC, Sperryville - 2019

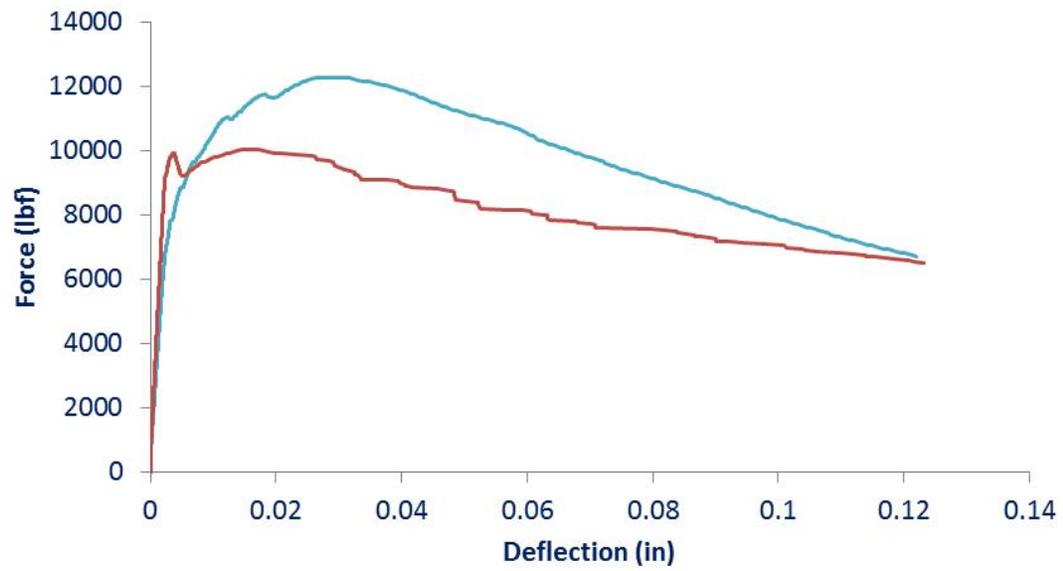


VHPC, I-66 - 2020



VHPC Test Results

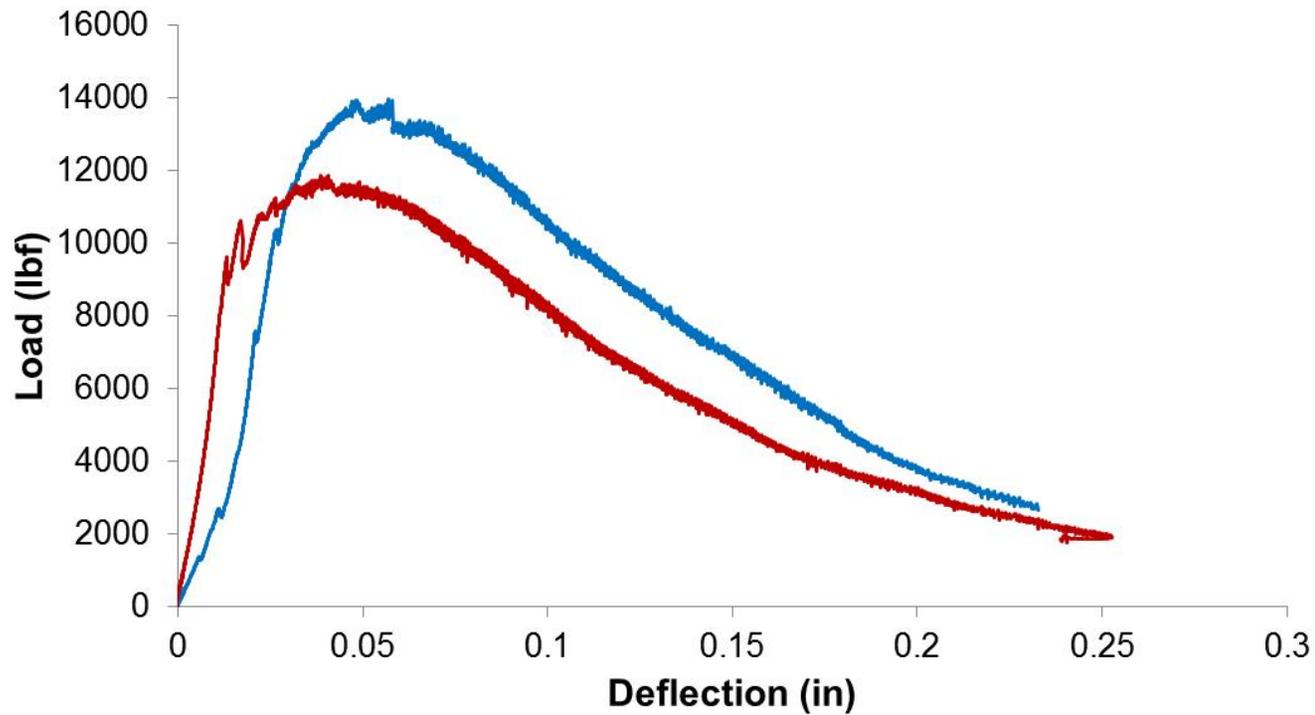
7-day flexural strength with hooked-end steel fiber



UHPC - Route 624 - 2007



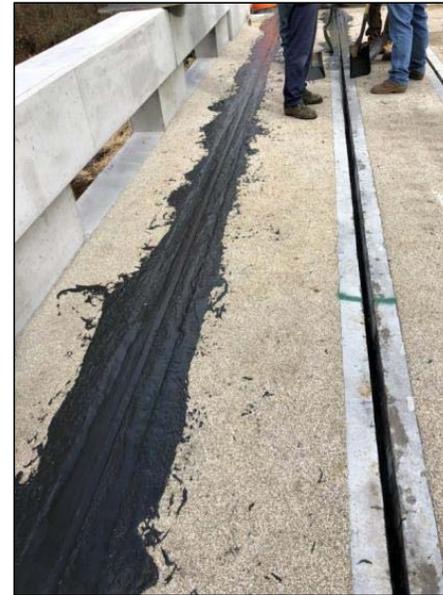
Flexural Strength



4-in-thick beams at 2 months



New UHPC - 2019

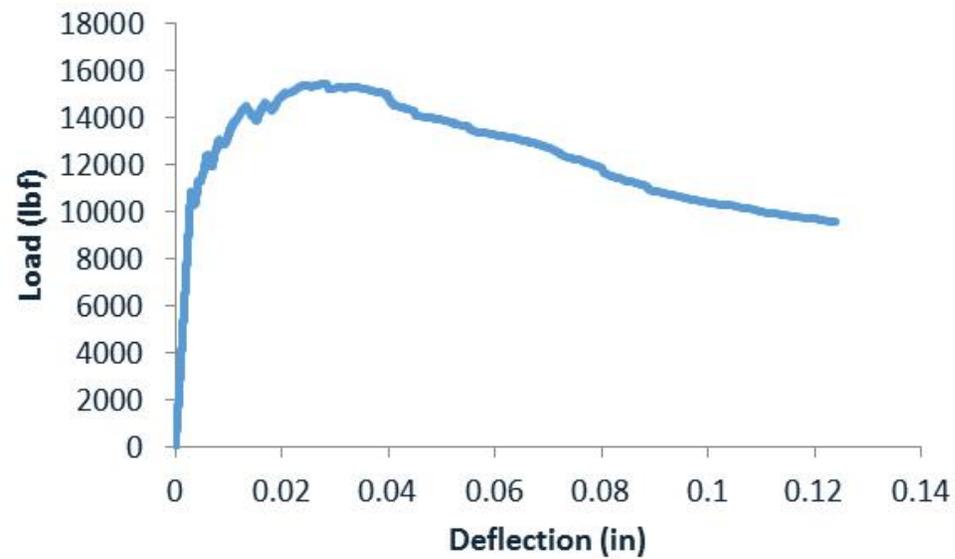


Prepackaged material
Planetary mixer
28-d compressive strength \geq 17,000 psi



Flexural Strength – New UHPC

28d flexural strength



Conclusions

- Fibers in concrete can reduce the width and length of cracks and shorten the lap splices.
- The type and amount of fibers are important in crack control.
- Concretes with high amounts of PVA or steel fibers can achieve crack widths of less than 0.1 mm.
- Prepackaged materials are available to control cracks and provide short lap splices.



Acknowledgements

- FHWA
- VDOT Materials
- VDOT Structure and Bridge
- VDOT Districts
- VTRC
- Industry





Thank You.

