

Precast Ultra-High-Performance Fiber-Reinforced Concrete (UHP-FRC) for Fast and Sustainable Pavement Repair



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Concrete Pavement Deterioration and Repair

- Conventional concrete for pavement: vulnerable to cracking due to low-strength, porous microstructure (high permeability).
- Repair of deteriorated transportation pavement can be costly and time-consuming.
- Need a fast and durable repair method.



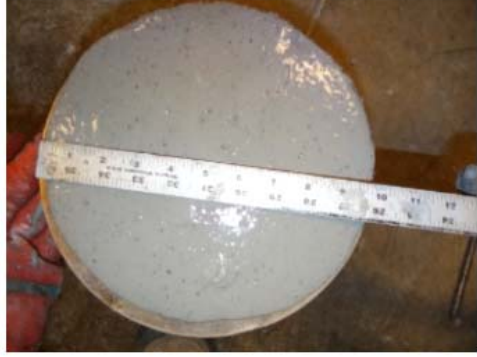
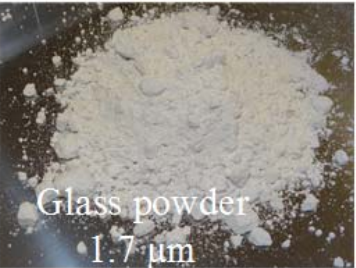
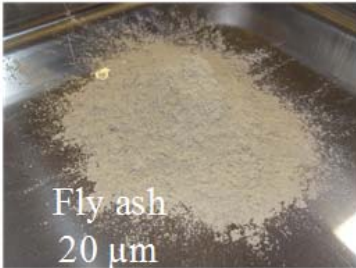
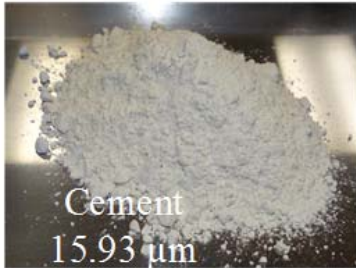
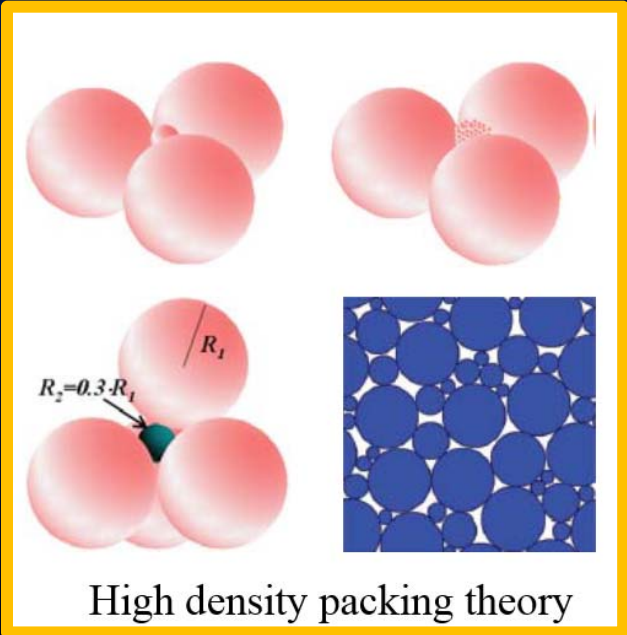
Concrete Pavement Deterioration and Repair

- At the airfield, it is extremely critical and necessary to use rapid construction methods, which can help reduce the periods over which negative impacts occur.
- The cost of delayed or canceled flights can become expensive. This is particularly critical for paving projects requiring the closure of a runway, taxiway, or aircraft parking area. In the case of periods of reduced flight schedules and canceled flights, as well as the reduction in passenger volume, all are accounted for as lost revenues to the airport.

Research Summary:

- Ultra-high-performance fiber-reinforced concrete (UHP-FRC) introduces significant enhancement in the sustainability of concrete structures due to its dense microstructure and crack-resistant capability.
- This research investigated a new method for concrete repair by combining precast UHP-FRC panels with a small quantity of cast-in-place UHP-FRC for pavement repair without any dowel bars. Experimental results proved the feasibility of using this new method for fast pavement repair.
- Implementation: Dallas-Fort Worth international airport₄

Ultra-High-Performance Fiber-Reinforced Concrete (UHP-FRC)

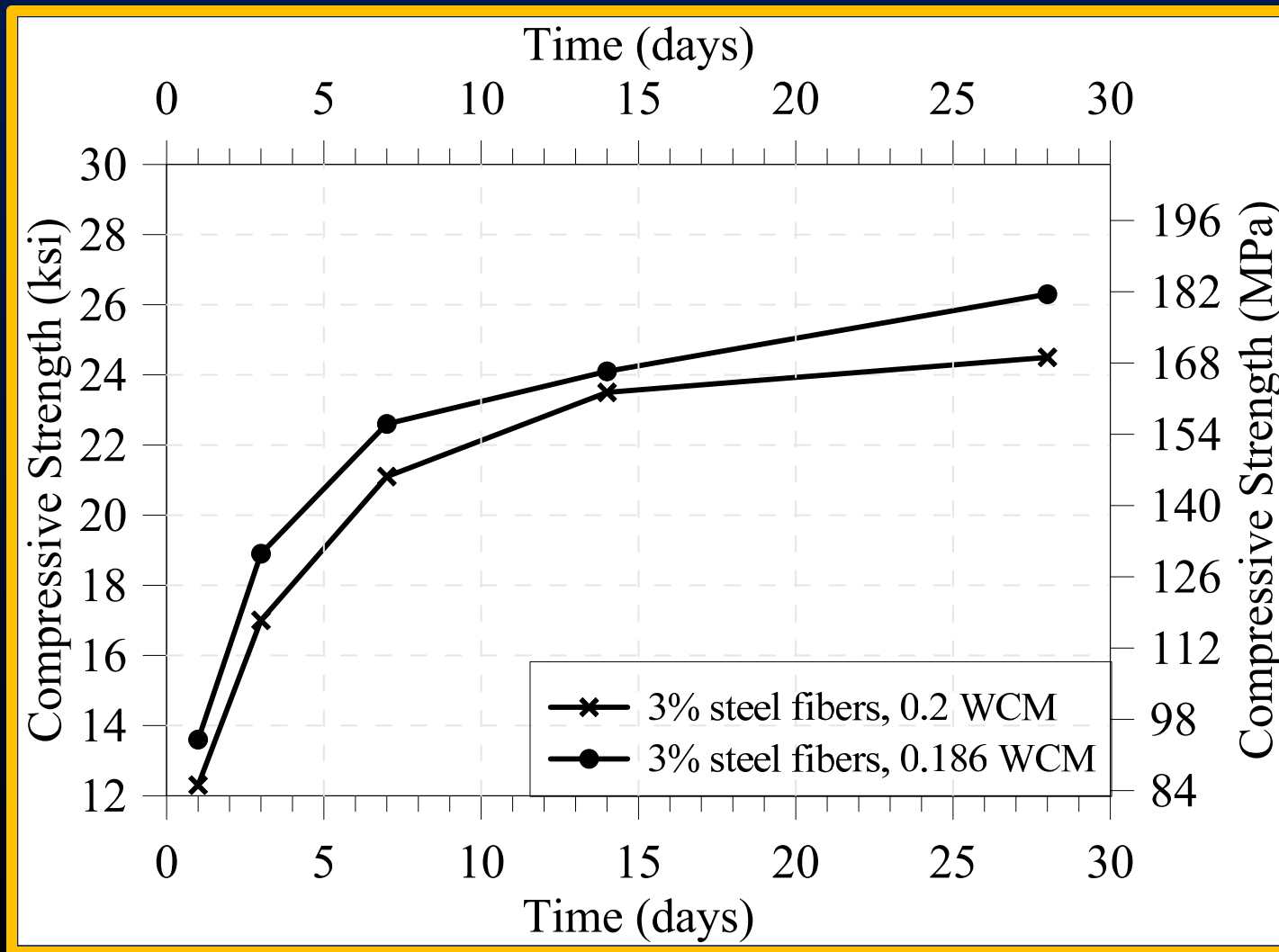


Comparison of typical conventional concrete and UHP-FRC (all data from UT Arlington research except Rapid Chloride Penetration Test)

Properties of Concrete	Conventional Concrete	UHP-FRC
Ultimate Compressive Strength	< 8,000 psi (55 MPa)	18,000 to 30,000 psi (124 to 207 MPa)
Early (24-hour) compressive strength	< 3000 psi (21 MPa)	10,000 – 12,000 psi (69 to 83 MPa)
Flexural Strength	< 670 psi (4.6 MPa)	2,500 to 6,000 psi (17 to 41 MPa)
Shear strength	< 180 psi (1.2 MPa)	> 600 psi (4.1 MPa)
Direct Tension	< 350 psi (2.5 MPa)	up to 1,450 psi (10 MPa)
Rapid Chloride Penetration Test*	2000-4000 Coulombs passed	Negligible (< 100 Coulombs passed)
Ductility	Negligible	High ductility
Ultimate Compressive Strain, ϵ_{cu}	0.003	0.015 to 0.03
Confining	Negligible	High confining capability

- **Low permeability**
- **Higher corrosion resistance for rebars**
- **High cracking resistance**

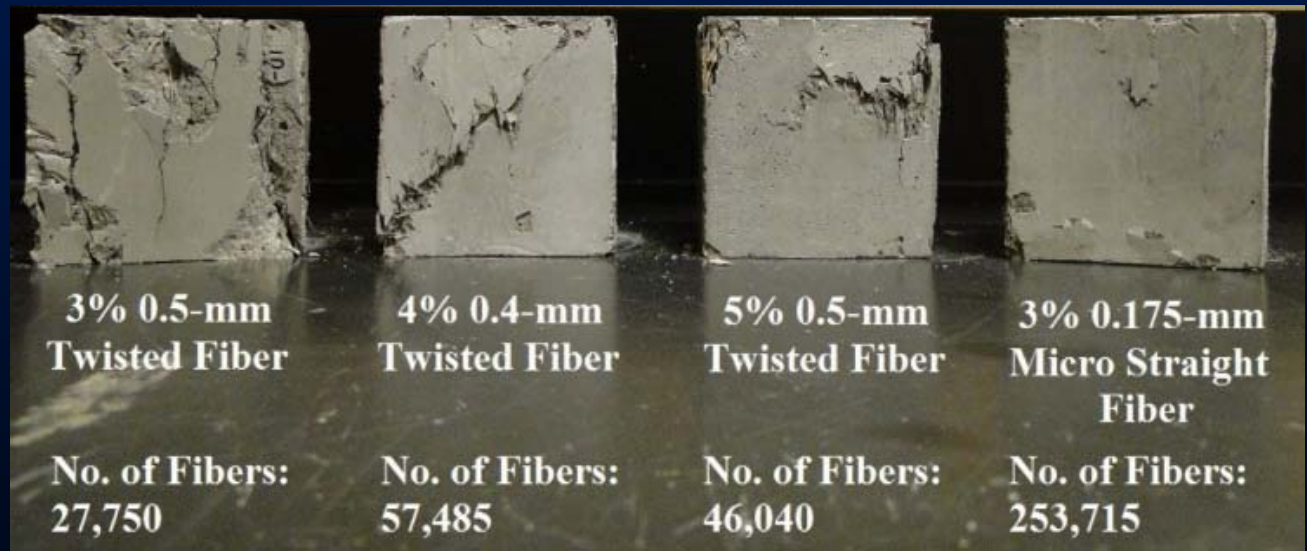
Ultra-High-Performance Fiber-Reinforced Concrete (UHP-FRC): **high early-strength**



Ultra-High-Performance Fiber-Reinforced Concrete (UHP-FRC): High Compressive Strength & Ductility



Plain concrete

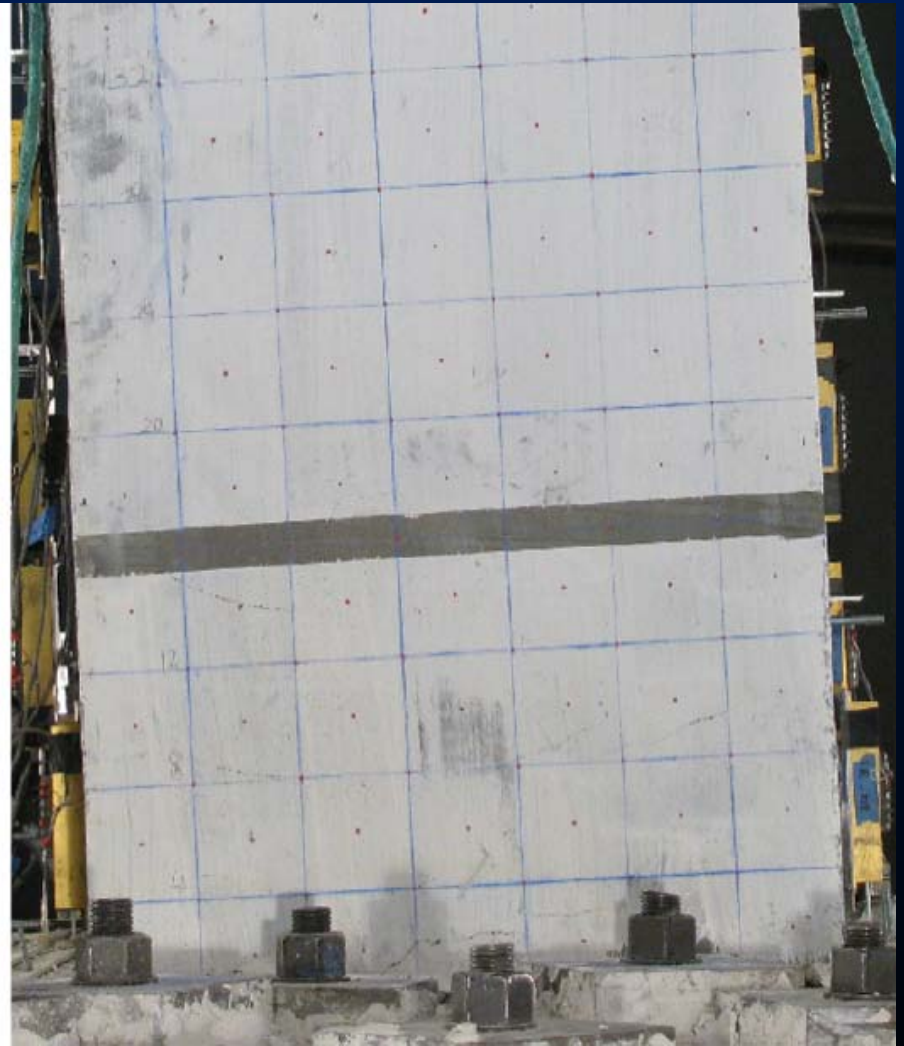


UHP-FRC

Ultra-High-Performance Fiber-Reinforced Concrete (UHP-FRC): **Highly Crack Resistant**



RC Column

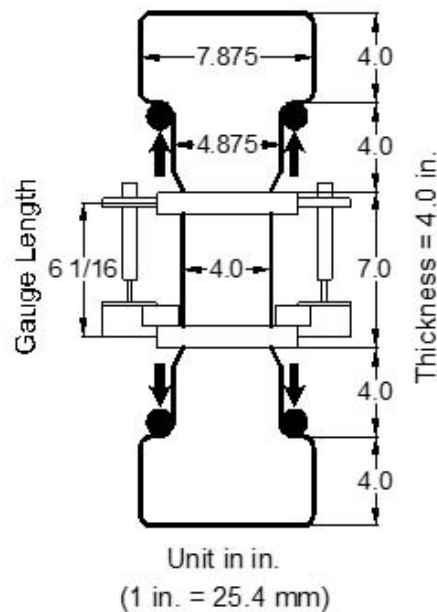


UHP-FRC Column

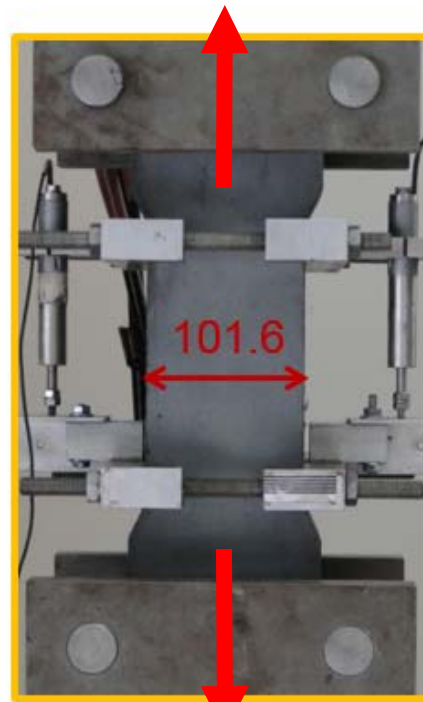
Ultra-High-Performance Fiber-Reinforced Concrete (UHP-FRC): Tensile Testing



Casting (Mesh Reinforcement)

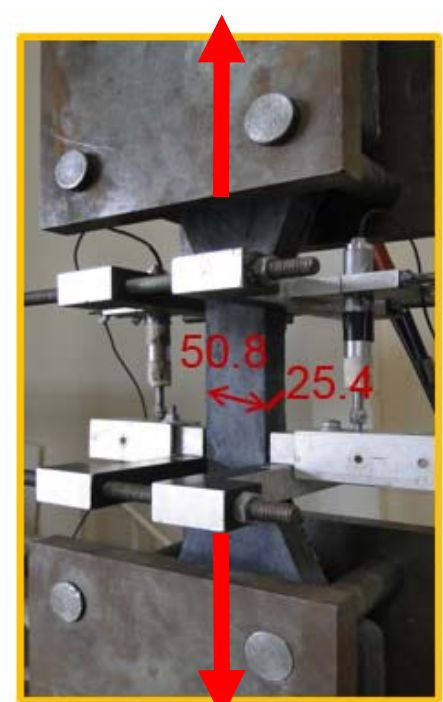


Test Setup



101.6mm×101.6mm

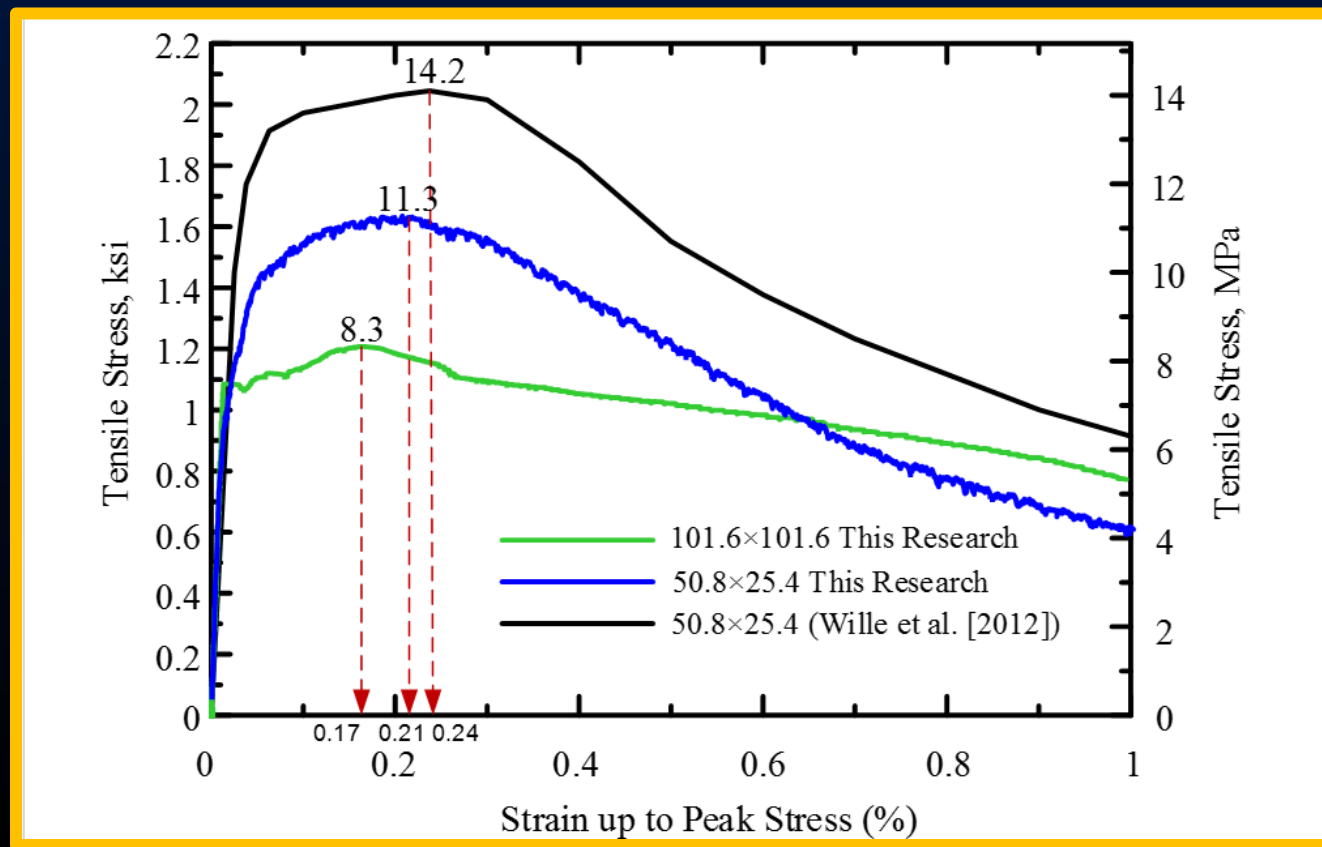
Tensile Testing



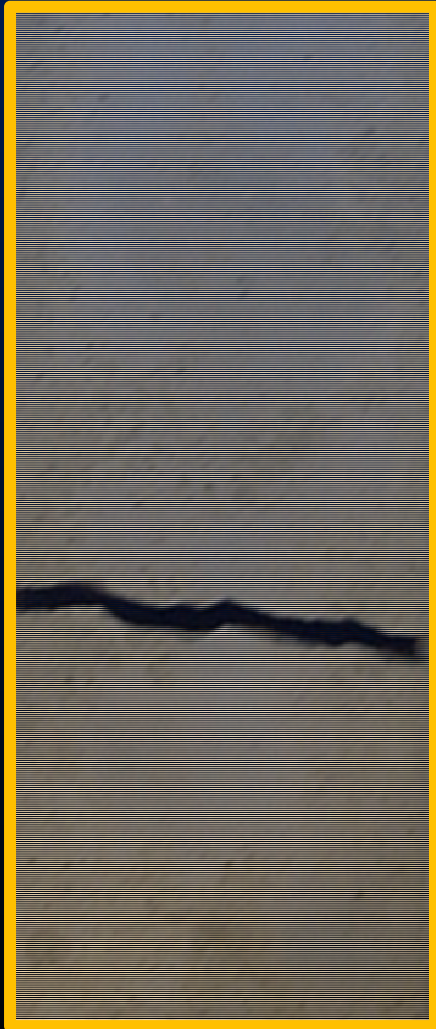
50.8mm×25.4mm

Ultra-High-Performance Fiber-Reinforced Concrete (UHP-FRC): High Tensile Strength & Ductility

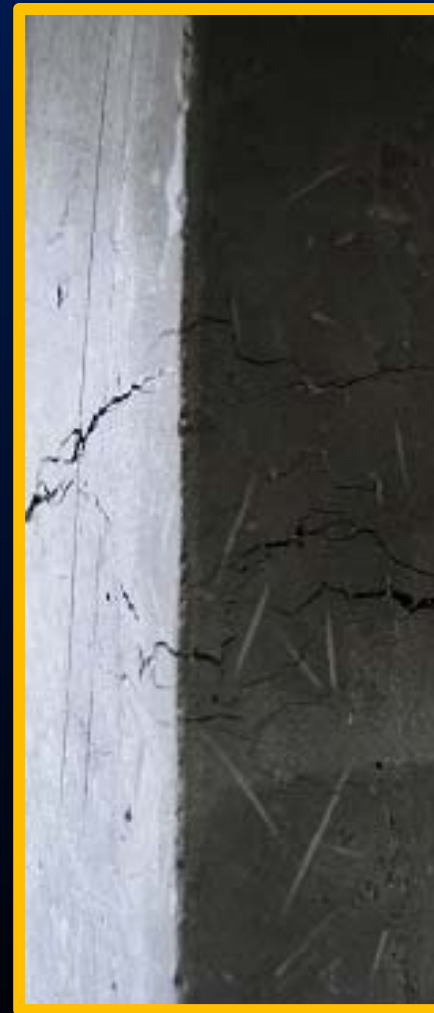
- ✓ Strain at Peak Tensile Strength = **0.2%** (40 times that of plain concrete)



Ultra-High-Performance Fiber-Reinforced Concrete (UHP-FRC): **High Tensile Ductility**



Plain Concrete



UHP-FRC

Task 1

UHP-FRC Mixes with Optimized Performance and Economy

Material development for suitable pavement UHP-FRC mixtures with synthetic fibers. According to Aghdasi et al. (2016)

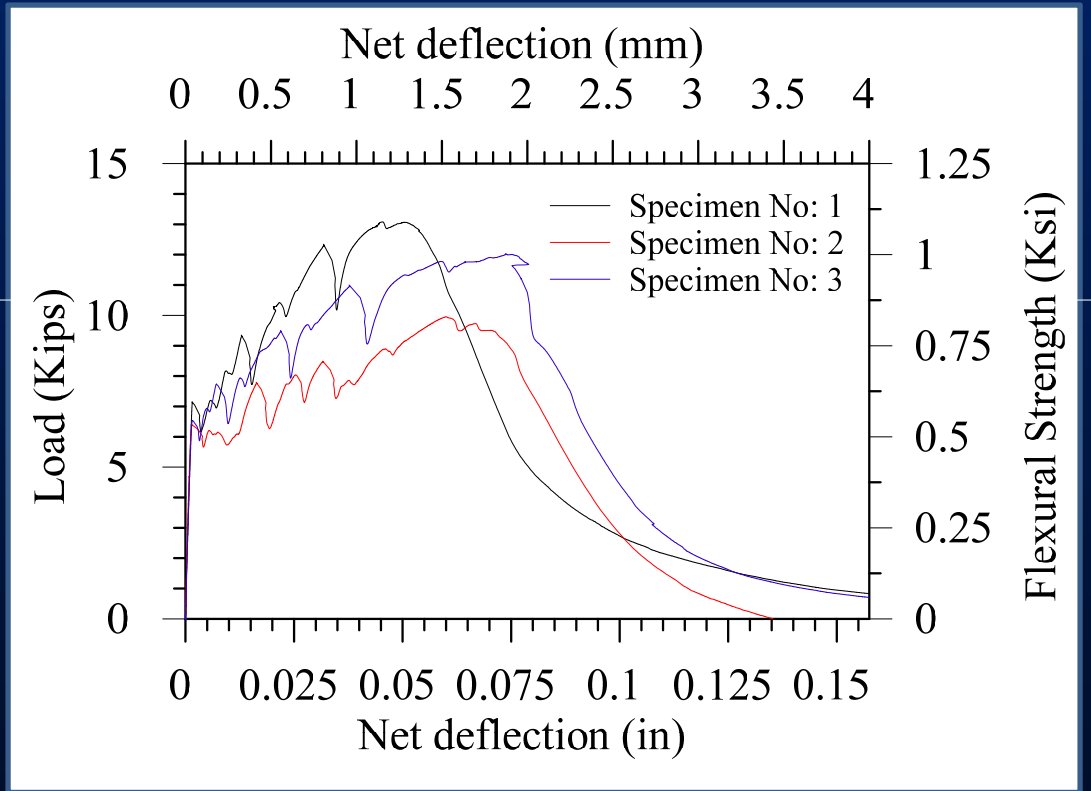
Aghdasi, P., Heid A. E., and Chao, S.-H. (2016), "Developing Ultra-High-Performance Fiber-Reinforced Concrete For Large-Scale Structural Applications," *ACI Materials Journal*, V. 113, No. 5, September-October 2016, pp. 559-570.

Ultra High Molecular Weight Polyethylene Fiber



	Length (mm)	Diameter (mm)	Tensile Strength (ksi)
UHMW Polyethylene Fiber	13	0.0015	375

Load vs net deflection: ASTM C1609 third point bending test at 7-day



Task 2

Developing Fast Pavement Repair Procedure Using Precast UHP-FRC panels

Conventional Method of Concrete Pavement Repair



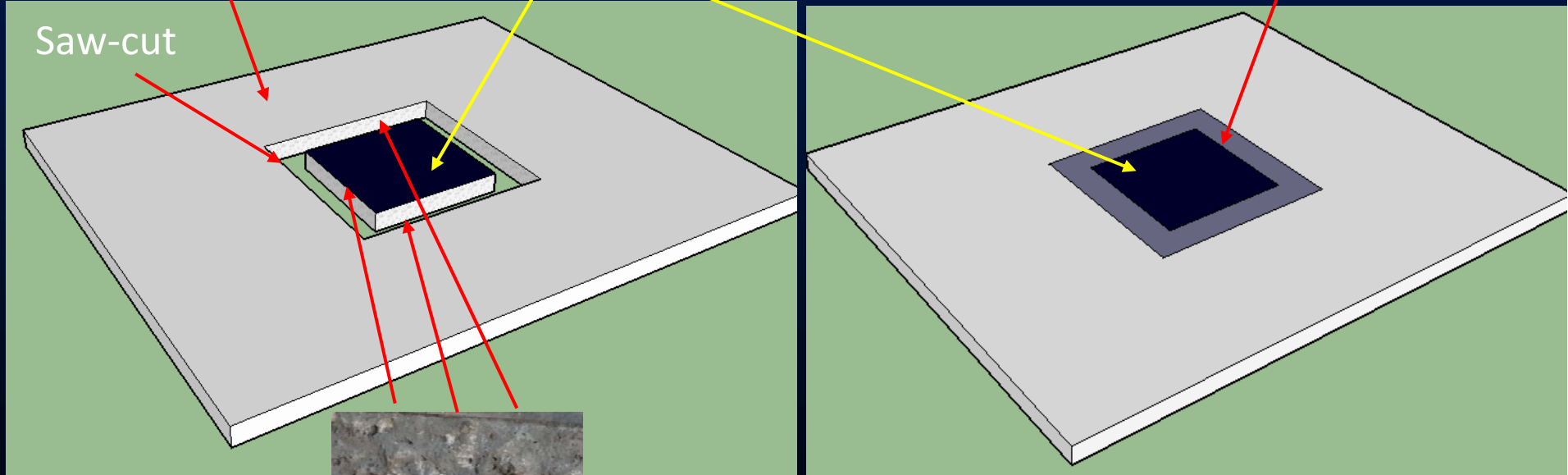
Proposed Methods:

Existing Pavement

Precast patch (UHP-FRC or RC)

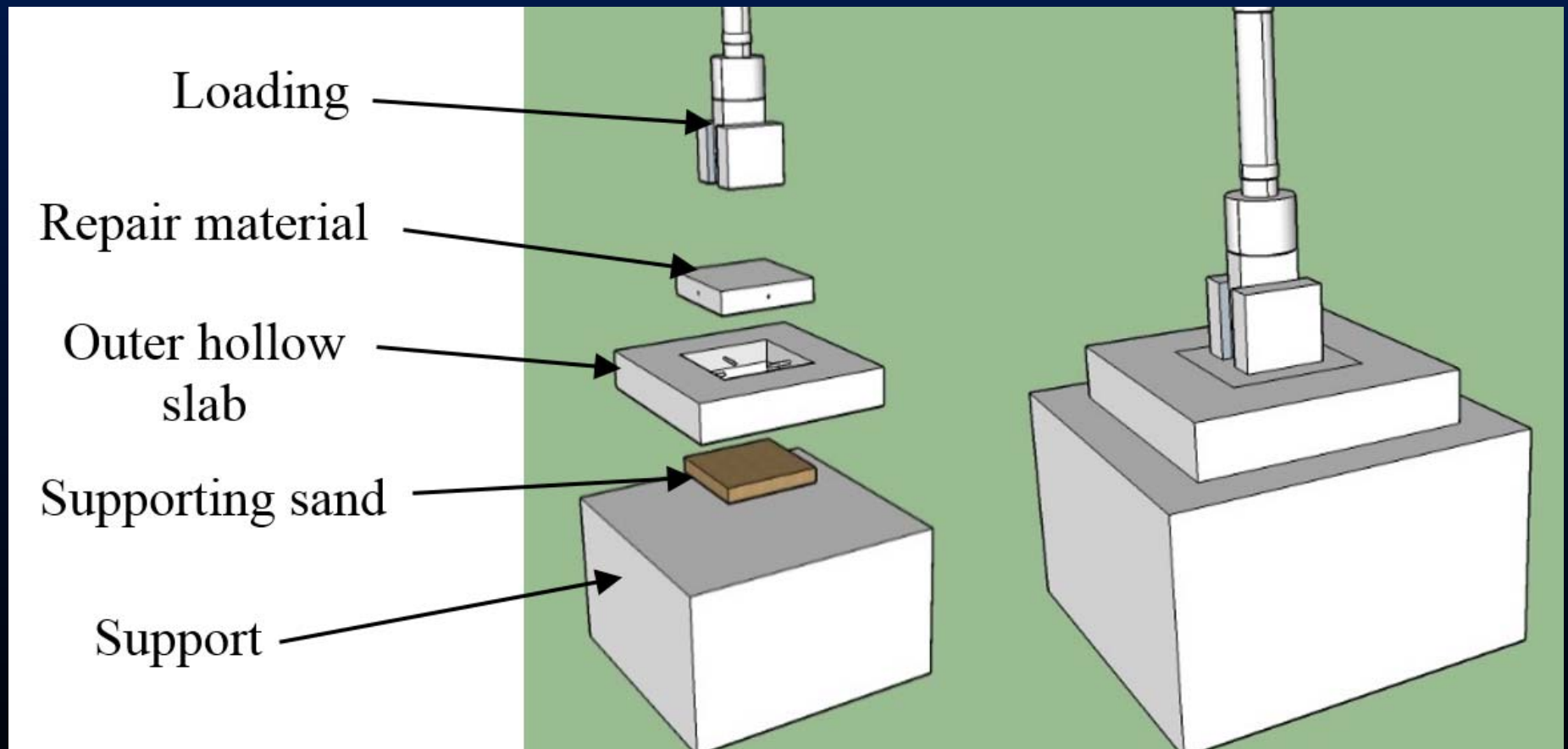
Cast-in-place UHP-FRC

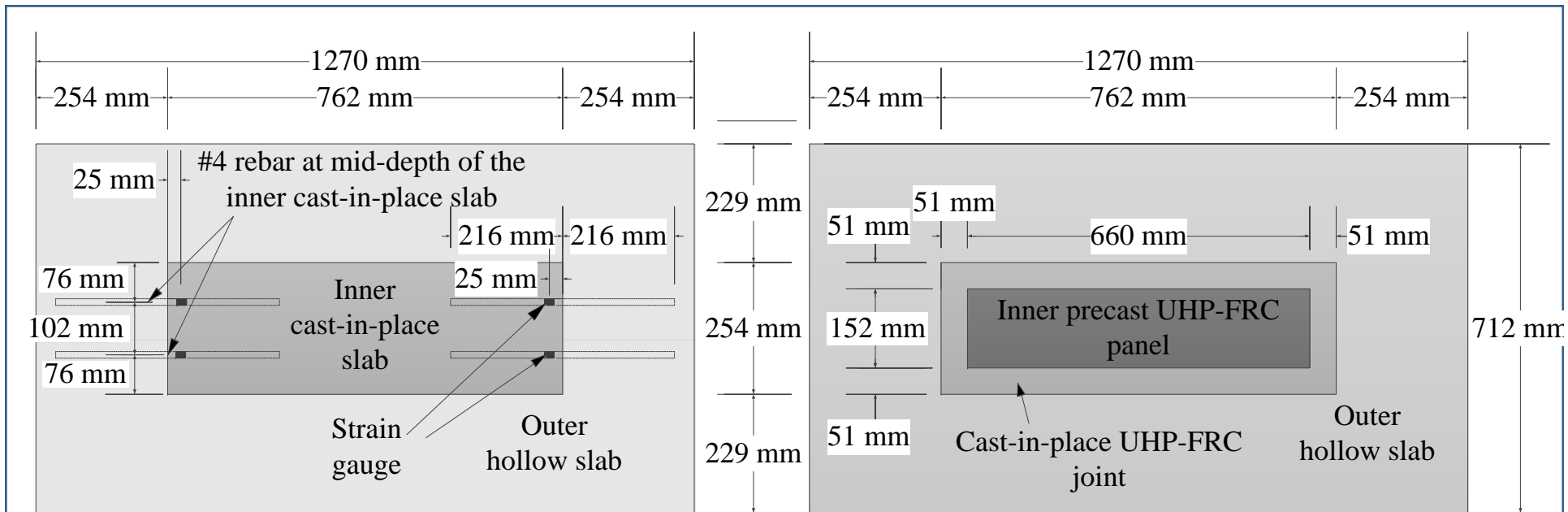
Saw-cut



Roughened Surface to prevent faulting (no dowel bars)

Punch test setup

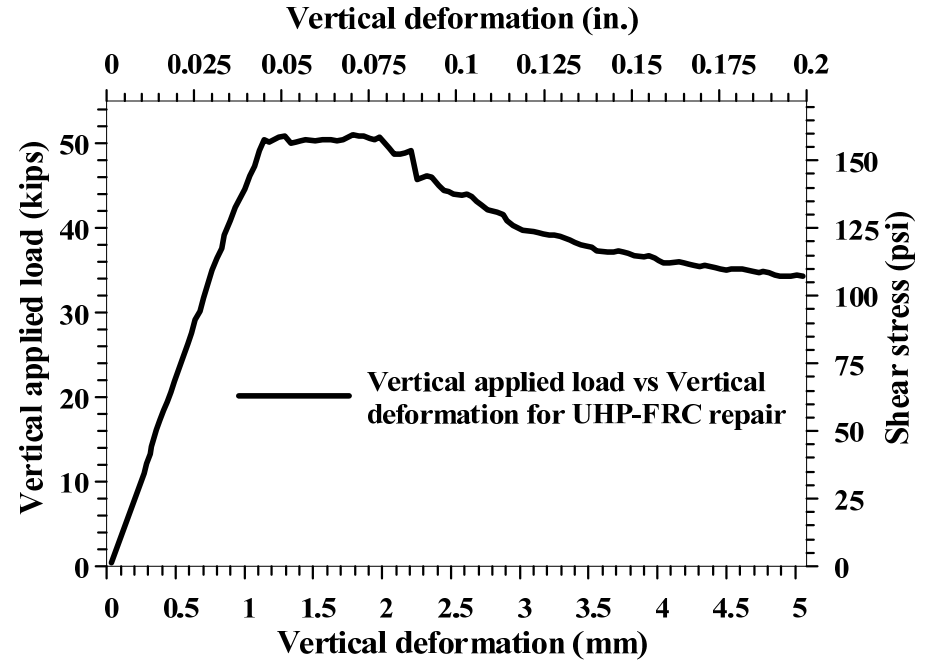
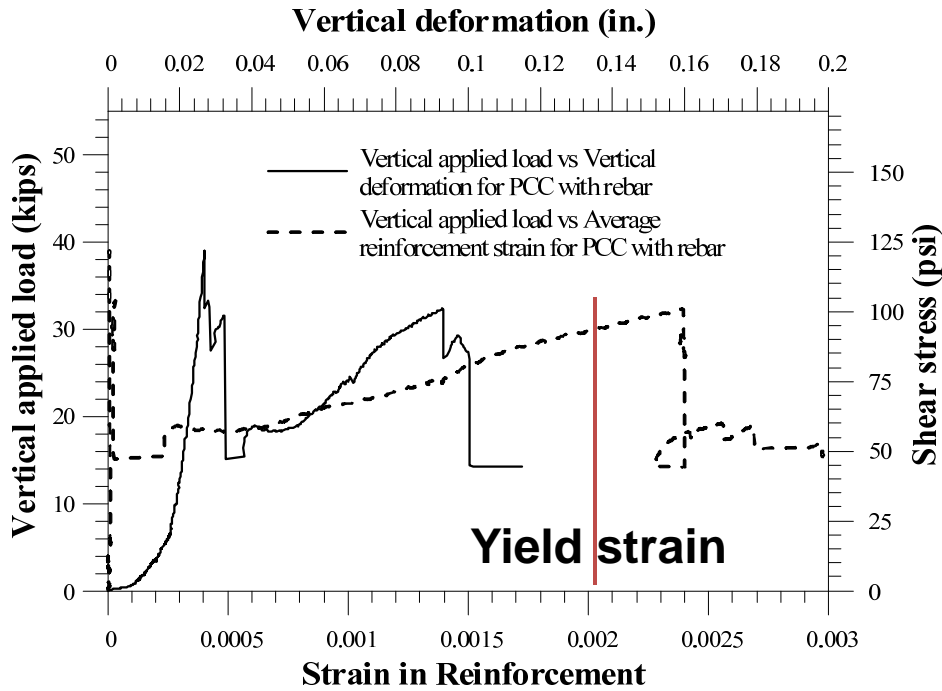




Roughened existing plain concrete (CSP 5)

Roughened UHP-FRC (CSP 5)





Plain concrete with dowel bars

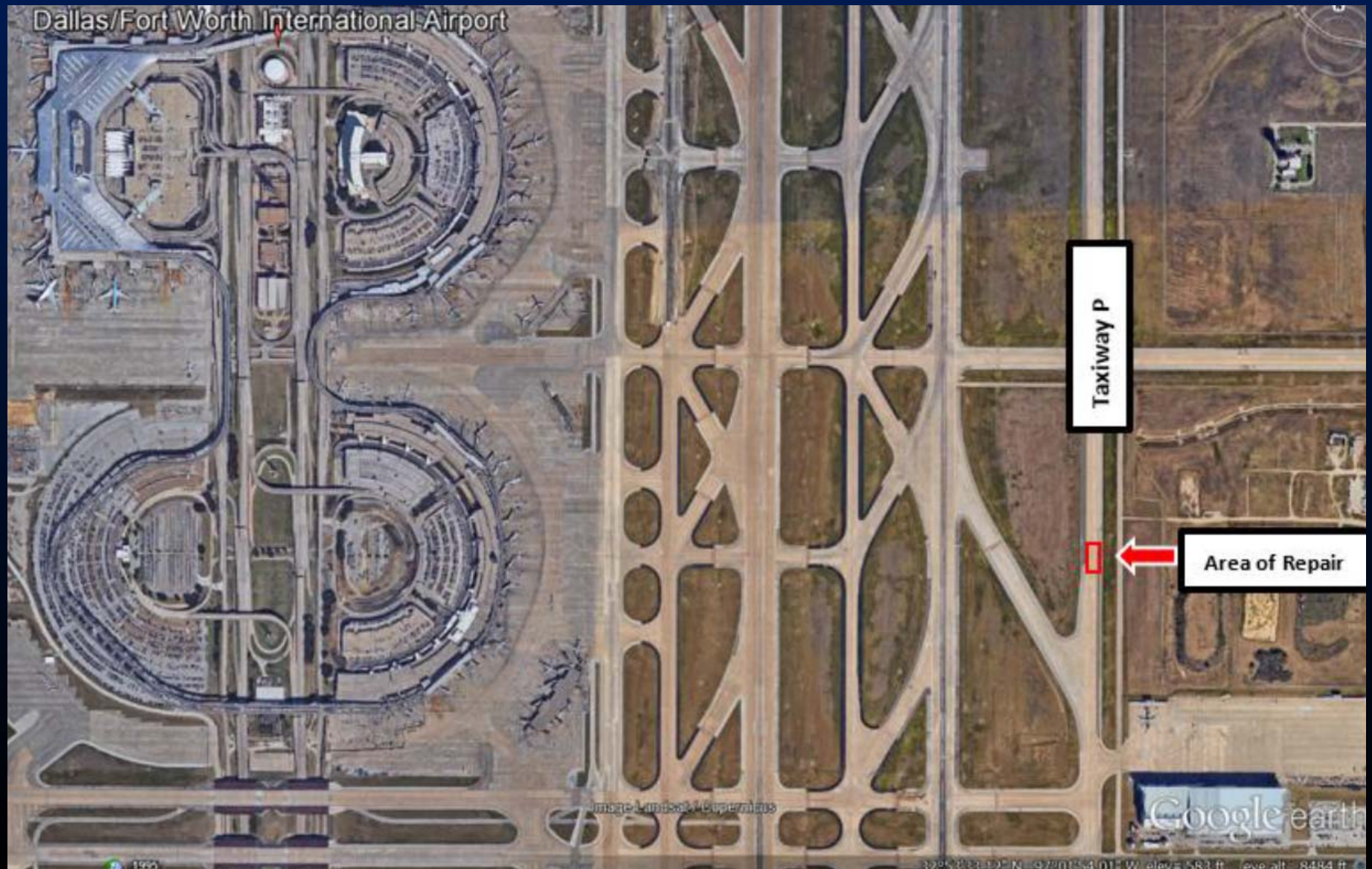
UHP-FRC without dowel bars

Punch specimen	Peak applied vertical load kN (kips)	Vertical deformation at peak: mm (in)	Shear stress kPa (psi)	Remarks
PC with dowel bars and interface surface smooth	173 (39)	0.76 (0.03)	848 (123)	
UHP-FRC without dowel bars and interface roughness CSP5	227 (51)	1.02 (0.04)	1103 (160)	30% more

Task 3

Implementation at Dallas-Fort Worth International Airport

Taxiway P (1162' S of EJ Center Line) (DFW International Airport)





Installation: 6 hours, including demolition. Precast panels reached 5,000 psi in 16 hours.







Load testing (58,000 lbs), totally 100 passes. Pavement perform well. Will have aircraft later to apply heavier loads.

