Transportation Consortium of South-Central States (Tran-SET)

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

**Highlight | Feb. 2018**

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*Developing and investigating UHP-FRC for fast, sustainable, and conventional concrete repair through a series of laboratory tests*

The major problem of concrete is the considerable deterioration and consequent repair work needed due to its brittleness and limited durability. The consequence of concrete deterioration and short service life requires frequent repair and eventual replacement. Ultrahigh-performance fiber-reinforced concrete (UHP-FRC) introduces significant enhancement in the sustainability of concrete structures due to its dense microstructure and damage-tolerant characteristics. These characteristics can significantly reduce the amount of repair-rehabilitation-maintenance work and give transportation infrastructure longer service life, all of which will eventually lower the environmental liability of concrete use. This research will address the strong need to develop fast and sustainable repair UHP-FRC materials for pavement repair that can be easily cast on-site without special treatments (such as heat, pressure, and vacuum); thereby avoiding any major changes to current concrete production practice and to accelerate the use of UHP-FRC materials. This research also investigates a new type of UHP-FRC pavement without joints and dowel bars.

## Problem Statement

Climate change, overloaded and increasing traffic, and other environmental loads can cause fast transportation infrastructure deterioration. Recent statistics indicate that annual pavement maintenance and rehabilitation budget is estimated to increase by around 30% (considering both the influences of climate change and transport demand changes). Deficiencies in conventional concrete and its subsequent impact on the environment calls for a much durable material that will last longer under environmental stress, thereby contributing to the conservation of natural resources and the protection of the ecosystem. Many solutions have been proposed for enhancing the sustainability of concrete, and the use of ultrahigh performance fiber-reinforced concrete (UHP-FRC) is a promising one. UHP-FRC has recently attracted the attention of researchers and practitioners not only because of its high compressive strength but also because of its excellent environmental resistance. Its high-early strength and durability allow for fast reopen the traffic and less future repair.

## Summary

This study addresses the strong need to develop fast and sustainable repair UHP-FRC materials for concrete pavement repair that can be easily cast onsite without special treatments such as heat, pressure, and vacuum.

Pavement repair in partial depth patches and full depth patches (using UHP-FRC) will be carried out in this study, and the performance will be monitored. Due to the relative slip between the old pavement concrete and the UHP-FRC repair fill, the interface crack width tends to increase. However, as the UHP-FRC repair fill is confined on all the four sides by the existing concrete pavement, this confinement provides the sufficient compressive force; thus compressing the interface and resulting shear forces being transmitted by friction (see Figure 1).

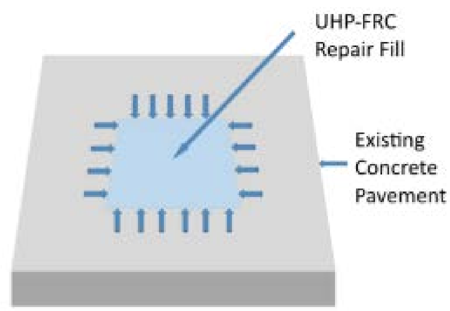


**Figure 1. Depiction of forces involved in the bond interface between the existing concrete and the UHP-FRC repair fill.**

The interface shear strength between existing concrete and repairing UHP-FRC, especially at early age, will also be studied. The ultimate interface shear strength and early interface shear strength will be investigated by using a Slant Shear Test (SST). SST represents a stress state of combined compression and shear, which is close to the actual stress state of the interface between existing concrete and UHP-FRC. A specimen 150 mm x 150 mm cross section with a total height of

560 mm is used for the test. A bond interface angle of 30 degrees with the vertical, longitudinal axis of the specimen, was selected (see Figure 2).

**Figure 2. Slant shear specimens under preparation.**

## Findings

Table 1 summarizes the preliminary results comparing the interface shear strength from roughened surface (without interface shear reinforcement) and smooth surface (with No. 4 interface shear reinforcement). The smooth surface is similar to those saw-cut surface for pavement repair. Only plain concrete was used in this phase. It is seen that, generally, the roughened surface provides greater strength than the smooth surface with dowel bar either after 24-hour or 7-day of casting.

**Table 1. Preliminary results comparing the interface shear strength from roughened and smooth surface.**

| Specimen Top Half | Days | Surface Preparation | Shear Stress (psi) | Peak Longitudinal Load (kips) | Avg. Shear Stress (psi) |
|---|---|---|---|---|---|
| PC | 1 | Roughened | 616 | 50 | 616 |
| | 7 | Roughened | 780 | 63 | 780 |
| PC with #4 rebar | 1 | Smooth | 550 | 36 | 443 |
| | 7 | Smooth | 738 | 59 | 738 |

Figure 3 indicates that the interface shear reinforcement (dowel bar) did not carry much of the load until certain slip had occurred. This is seen from the very small strain (0.0005 << yielding strain of 0.002). This shows that the majority of the load was actually carried by the concrete interface rather than the dowel bar. The strain in the rebar increased significantly after the interface of concrete started to degrade. This study shows that it is possible to use a roughened surface without post-installed dowel bars to reduce labor and repair time. Ongoing research of this project will provide more information on the strength and performance of UHP-FRC repaired pavement.

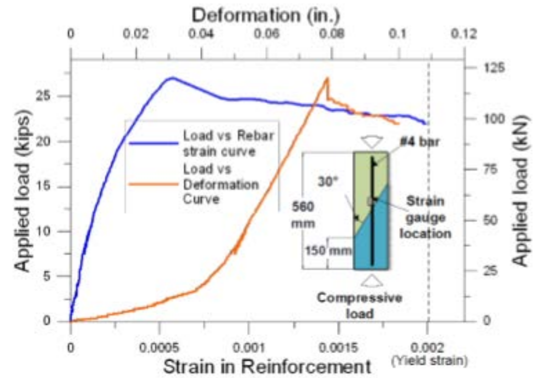


**Figure 3. Applied load versus deformation and applied load versus strain.**

## Impacts

This study serves as the critical first step in implementing UHP-FRC for rapid pavement repair. Results from this research are extpected to form the basis for future studies (such as proof-of-concept field testing in collaboration with local municipalities). This technology will eventually enable municipalities and local governments to repair/rehabilitate their infrastructure in an accelerated fashion by bringing it back into service within twenty-four hours, and without the additional need for conventional reinforcement. This technology will also eventually help municipalities and DOTs to design thinner layers of concrete pavement due to its high tensile strength, which will reduce the cost of material and labor potentially by 40% regarding the pavement rehabilitation process. Further, the potential economic impact in construction could improve with this technology, since the strength and ductility of this concrete will reduce the cost of reinforcement placement and reinforcement materials.

## Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

## Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Mr. Christopher Melson (Tran-SET Program Manager) directly at transet@lsu.edu.

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