MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 24-537 (project 586) | August 2024

Mitigation of Differential Settlement at Highway Bridge Approaches: Lightweight Cellular Concrete Technology



the **ISSUE**

Drivers have probably experienced the familiar "bump" when entering or leaving a bridge. This happens when the roadway leading to a bridge settles more than the bridge itself. The difference in elevation can become large enough to create an uncomfortable—and potentially unsafe—transition for vehicles. It can also contribute to damage to pavement and bridge components and increase long-term maintenance costs. Previous studies estimated that roughly one-quarter of U.S. bridges may experience some form of settlement at their approaches. The problem is particularly challenging where bridge approaches are built on soft or compressible soils.

the **RESEARCH**

This research examined lightweight cellular concrete (LCC) as a way to reduce settlement at bridge approaches. LCC is a cement-based material containing many small air bubbles, which makes it much lighter than conventional soil or aggregate fill while still providing useful strength and stiffness. If the material placed behind a bridge is much lighter, it puts less weight on the underlying soil, reducing compression of weak soils and, therefore, less settlement. The researchers evaluated LCC as a bridge-approach fill and considered its engineering properties, construction characteristics, design requirements, and potential advantages and limitations.

Simple linear and multiple linear regression models (SLR & MLR) were developed using the data produced from five treatment sets. These regression models include the initial yield stress, peak yield stress, and Young's modulus for unconfined and confined-drained axial compression. In addition, an MRL model for the resilient modulus (RM) under varying stress conditions was developed. Lastly, UCS and triaxial compression tests were paired with RM testing to establish a "surrogate" estimate of the RM for engineering practice.

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Project Title

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the **FINDINGS**

Researchers found that an initial curing period of approximately 70 days is required for the LCC to reach a reasonable steady state condition. They found that the RM results were somewhat affected by sample confinement but not significantly affected by increasing saturation. They developed an RM regression model for estimating the RM as a function of the confining stress, deviatoric stress, and dry unit weight. Favorable RM results suggest that LCC can be used as a base or subbase material over the range of saturation and stress conditions explored in this study.

The research also recognizes that LCC is not automatically the right solution for every bridge approach. Proper attention must be given to mix design, drainage, frost conditions, pavement support, construction procedures, and the specific characteristics of the underlying soil.

the **IMPACT**

Lightweight cellular concrete provides a promising way to reduce the "bump at the end of the bridge." Its combination of low weight, adequate strength, flowable placement, and reduced need for compaction can make it particularly useful where bridge approaches are constructed over weak or compressible soils.

The principal benefit of LCC is that it addresses the cause of bridge-approach settlement rather than simply repairing the bump after it develops. By reducing the weight of the approach fill, engineers can reduce the stress placed on weak soils. The research will give transportation agencies tools to evaluate LCC for constructing smoother, more durable bridge approaches. To refine results, the researchers envision implementation through demonstration projects in which LCC approaches could be constructed and monitored in the field.

For more information on this project, download the Main report at https://www.ugpti.org/resources/reports/details.php?id=1286

For more information or additional copies, visit the Web site at www.mountain-plains.org, call (701) 231-7767 or write to Mountain-Plains Consortium, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.

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