PUTTING RESEARCH TO WORK

BRIEF

Preventing Settlement—and Bumps—at Bridge Approaches

Studies conducted by DOTs around the country suggest that about 25 percent of the 600,000 bridges in the United States are affected by bridge approach settlement, or the "bump at the end of the bridge." The difference in elevation between the approach pavement and the bridge deck results from a complex interaction between the bridge structure, backfill soils and foundation soils; poor drainage is one contributing factor. The settlements can result in unsafe driving conditions, rider discomfort, structural deterioration of bridges and long-term maintenance costs.

What's the Problem?

At the national level, about $100 million is spent every year repairing these settlements. When the costs of injuries, damages and litigation are considered as well, the total annual cost is estimated to exceed $200 million. WisDOT and other highway agencies are eager to find more effective ways to eliminate or mitigate bridge approach settlement.

Extensive research over the past 20 years has identified many causes of bridge approach settlement, as well as ways to repair or prevent it. Prevention techniques include more stringent specifications for backfill material, compaction and drainage. Common repair techniques are asphalt patching or overlays, slab jacking and replacing the concrete pavement approach slab.

Research Objectives and Methodology

This study sought to evaluate the performance and effectiveness of two settlement prevention technologies. After conducting a comprehensive review of literature and current mitigation practices used across the country, investigators identified two innovative technologies for testing in the field:

- Backfilling with geosynthetic-reinforced fill.
- Backfilling with flowable fill (controlled low-strength material).

Four bridges under construction in Wisconsin were selected for field testing:

- WIS 173 over Hemlock Creek in Wood County.
- WIS 173 over Cranberry Ditch in Wood County.
- Western Avenue over Cedar Creek in Washington County.
- West Beloit Road over Root River in Milwaukee County.

Two of these bridges (Hemlock Creek and Cranberry Ditch) were built in 2002 on relatively incompressible granular soil foundations. The other two (Western Avenue and West Beloit Road) were built in 2004 on cohesive soil foundations. Both technologies were tested on both types of soil foundations.

After the bridges were completed, survey markers were installed at the surface of the asphalt approaches, and inclinometers with telescopic casings were placed in the backfill. The survey markers were used to measure the surface settlement of the approach pavement over time by surveying the elevations along the approach. The inclinometers were installed to measure the lateral and vertical deflection of the backfill and foundation soils over time.

Investigators conducted regular site visits over a two-year period for the Western Avenue and West Beloit Road bridges and over a five-year period for the Hemlock Creek and Cranberry Ditch bridges to survey elevations and take inclinometer readings. The data were analyzed to determine the performance of the test bridge approaches and the two types of fill.

Investigator

"Both types of mitigation worked well in reducing settlement of abutments and embankments."

– Sam Helwany
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Co-investigators:
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Roadway crews placed geosynthetic-reinforced fill behind the east abutment of the Western Avenue bridge over Cedar Creek in Washington County, which was built on cohesive soil.

Geotechnics TOC Chair

"This research is a good first step toward understanding bridge approach settlement in Wisconsin, especially the importance of the character of the foundation soils."

–Robert Arndorfer
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Results

Based on the findings from the literature search, site visits and field test measurements of the four bridges, researchers reached the following conclusions:

- Movements of approach fills that have granular foundation soils and less than 5 to 7 feet of fill were insignificant over five years compared with the movements of the approach fills with cohesive foundation soils over two years.
- Embankment side slopes that settled and sloughed resulted in erosion and/or movement of backfill material.
- The flowable fill and geosynthetic-reinforced fill on granular soil foundations did not outperform the structure backfill.
- The flowable fill and geosynthetic-reinforced fill on cohesive soil foundations did outperform the structure backfill.
- Flowable fill was more expensive than geosynthetic-reinforced fill for small-quantity jobs and almost twice as expensive as structure backfill.

Further Research

Cohesive soils are greater contributors to bridge approach settlement than granular soils because cohesive soils are frost-susceptible, absorb water, settle over time and may become weaker when wet. Investigators measured significantly less movement of the approach fills for bridge abutments seated on granular foundation soils. In these situations, structure backfill was as effective as flowable fill and geosynthetic-reinforced fill.

Researchers recommend additional fieldwork to test settlement where softer cohesive foundation soils are present or where greater than 7 feet of fill will be required. They also recommend that hydraulic fill be field-tested and compared to flowable fill and geosynthetic-reinforced fill as a possible method for alleviating bridge approach settlement in Wisconsin.

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