# Project Summary

Texas Department of Transportation

# 0-6022: Recommendations for Design, Construction, and Maintenance of Bridge Approach Slabs

## Background

Bridge approach settlement is a common problem for Transportation Departments nationwide. Uneven transition causes inconvenience to passengers and increases the cost of maintenance and repair of distressed approach slabs. The Texas Department of Transportation spends millions of dollars annually to mitigate this problem across the state. However, potential causes for this problem are numerous and purely site specific. Hence this problem may not have a unique solution.

## What the Researchers Did

In this research, settlement mitigation methods for new and existing bridges were studied. For new bridge construction, two methods In this research, settlement mitigation methods for new and existing bridges were studied. For new bridge construction, two methods were selected and studied. The first method was an improvement of foundation technique using Deep Soil Mixing (DSM) columns to stabilize soft foundation soil. The second was an improvement of embankment fill material using a lightweight fill (LWF) material, Expanded Clay Shale (ECS), as a backfill in embankment construction.

The research was performed at two new bridge sites – The DSM site on IH30 and the ECS site on SH360 located in the DFW metroplex. In order to study the effectiveness of the two mitigation methods, three tasks were carried out including laboratory studies, instrumentation and field monitoring, and numerical analysis. Additionally methods using urethane injection and flowable fills were studied for their effectiveness in repairing distressed slabs of existing bridges.

The work undertaken for this 4-year research included the following tasks:

- Researchers conducted a comprehensive literature review on bridge approach problems. Definition of the bump and the causes of the bump and viable techniques used to mitigate the settlement at the bridge approach were reviewed and presented.
- Surveys were conducted with TxDOT districts which revealed various causes of bump problems in Texas and methods attempted to control these settlements.
- From literature reviews and surveys, two techniques, Deep Soil Mixing (DSM) and Light Weight Fills (LWF) were identified for their effectiveness in controlling settlements under approach slabs.
- Laboratory investigations were conducted on soil specimens collected from the new bridge sites over I-30 and SH-360 (DSM & LWFs). Tests were performed in compliance with the Texas Department of Transportation (TxDOT) and the American Society of Testing Materials (ASTM) standard procedures.
- Instrumentation including inclinometer and extensometers was installed on both bridge sites to evaluate the settlement responses under the DSM and ECS methods. Instrumentation data was collected from the field and analyzed by comparing settlement data between both test and control sections.


### Research Performed by:

The University of Texas at Arlington (UTA)
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- Finite element modeling of field sections was attempted using laboratory test results, and these results were compared with the monitored data from the field to validate the numerical model predictions. After validation, design models and charts were developed for DSM and LWF methods to select any of them for bridge construction practice.
- Sites where repair methods using urethane injection was used were monitored for three years.

## What They Found

Based on the research performed, the following major findings are established:

- From the laboratory tests, foundation soils from both IH30 and SH360 exhibited high compressibility properties. Also, DSM treated samples tested in the laboratory indicated that the foundation soil gained more strength and the ECS exhibited high internal friction properties.
- Field results from the bridge sites showed that both the DSM and ECS techniques could be used to mitigate settlement occurring in embankment and foundation subgrade. In the DSM study, the settlement was reduced from 85 mm to 49 mm (measured on the control and test sections, respectively). At the ECS site, researchers found that constructing ECS fill embankments could bring down the settlement from 85.3 mm occurring in the control section to 36.5 mm in the test section.
- The monitored soil movement data were also used as a data validation in the numerical analysis to ensure that the numerical model would provide good simulation of soil displacements. After, validating the FEM models, several DSM design charts with different slope and height of the embankments, as well as area-ratios between DSM and foundation soil were developed. Results indicated that embankment height has profound influence on the amount of the settlements, while the embankment slope does not have a major influence on the settlements. Area-ratios ranging from 0.3 to 0.7 reduced settlements.
- ECS design charts were also developed using similar FEM analyses. Results indicated substantial reductions in approach slab settlements. In the case of ECS methods, erosion and slope stability issues should be considered.
- Both the DSM and ECS methods are more expensive when compared to TxDOT's current approach slab construction design practices on bridge embankments. However, over a longer design life period, these initial costs will be more than compensated due to lesser maintenance costs and less number of closures arising from constant repairs.
- In the repair techniques considered for existing bridges, Urethane injection appears to be providing satisfactory performance. However, it is necessary to perform void mapping underneath the slabs prior to field injection. GPR techniques adapted in the field investigations have provided valuable information on void mapping.

## What This Means

- For new bridges, the DSM and ECS methods are recommended for mitigating settlements underneath the approach slabs. Both methods are proven effective in settlement mitigation and hence design guidelines were developed and provided in the final research report.
- For repairing distressed slabs, use of Urethane is recommended. Two other methods including flowable fills and geofoam blocks showed some potential, but they still need to be evaluated in full scale field investigations.
- Further monitoring would provide long term data that could be valuable in full evaluations of the proposed design models.


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