TEXAS TRANSPORTATION INSTITUTE
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Project Summary Report 4147-S

Project 0-4147: Investigation of Settlement at Bridge Approach Slab Expansion Joint

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PROJECT SUMMARY REPORT

Investigation of Settlement at Bridge Approach Slab Expansion Joint: Bump at the End of Bridge

A number of recently constructed bridge approach slabs using an articulation at mid span and the wide-flange terminal anchorage system have experienced settlement at their expansion joints (see Figures 1 and 2). This problem is more commonly referred to as the bump at the end of the bridge. It is estimated that the Texas Department of Transportation (TxDOT) spends $7 million each year for maintenance associated with the bump at the end of the bridge. This project investigated reasons for the bumps and recommended ways to improve the current situation. As part of the results, a new wide-flange terminal anchorage/bridge approach slab system that is less sensitive to weak embankments was designed and tested.

Figure 1. An Example of Bridge Approach Slab (US 290 at FM 362).

The bump at the end of the bridge may look like a simple problem at first glance: the embankment settles more than the bridge because soil compresses more than abutments on deep foundations. But the bump at the end of the bridge is a very complex problem due to many factors including compaction, drainage, embankment height, traffic level, temperature cycles, and downdrag on the abutment.

What We Did…

The first year of this project undertook:

- a comprehensive review of the literature,
- a series of visual inspections, and
- a series of field and laboratory tests for two selected sites.

Based on first-year results, second-year work focused mainly on minimizing bumps and developing a new approach slab design.

To find out possible causes of the bridge approach slab problem, the research team reviewed many publications related to bridge approach bumps. A survey of TxDOT

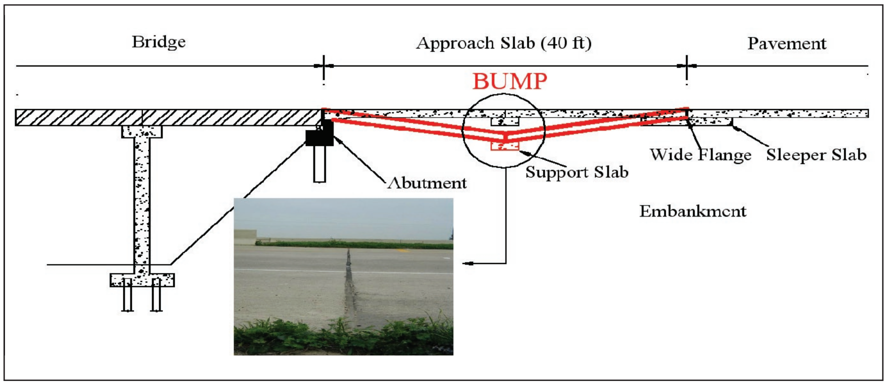

Figure 2. Settlement at Approach Slab (US 290 at FM 362).

districts provided information regarding problems encountered and solutions used to minimize bumps in Texas. The researchers distributed 25 questionnaires and received 16 completed surveys.

A visual survey of some bridges in the Houston District was conducted. This survey consisted of inspecting 18 bridge sites to study the bump problem and identify bridge candidates for a more advanced study. Based on results of these previous tasks and after proper consultation with the project director, researchers selected two bridge sites for detailed investigation: SH 249 at Grant Road and US 290 at FM 362. An extensive series of laboratory and field tests was performed at each site.

During the second year of the project, the finite-element computer program ABAQUS evaluated behavior of the current approach slab design and of a possibly more effective design. The BEST device (Bridge to Embankments Simulator of Transition) was built to simulate the bump at the end of the bridge problem. Multiple BEST tests simulated a range of parameters. Finally, a new approach slab design was proposed based on accumulated data.

What We Found...

Though the researchers identified many causes, interaction between cause and effect remains very complex. According to the National Cooperative Highway Research Program (NCHRP) synthesis 234, the main causes of the differential settlement at bridge approach slabs are:

- settlement of the natural soil under the embankment,
- compression of the embankment fill material due to inadequate fill compaction, and
- a poor drainage behind the bridge abutment and related erosion of the embankment fill.

The surveys received from the TxDOT districts indicated that the problem is widespread (about 25 percent of all bridges have a bump problem) and that it is costly ($7 million in maintenance and repair per year in Texas).

The investigation at the two test bridge sites with significant bumps indicated:

- soil near the abutment was weaker (Figure 3) and wetter than soil away from the abutment,
- soil near the abutment had a relatively high PI (Plastic Index) for an embankment fill, and
- there were no voids under the pavement.

Some of the most important conclusions from the numerical analyses are:

- the presence of a vertically rigid abutment wall creates a major difference in settlement between the abutment wall and the embankment,
- transition zone is about 40 ft with 80 percent of the maximum settlement occurring in the first 20 ft for a uniform load case, and
- the optimum width of the support slabs under the approach slab is 5 ft.

The new proposed approach slab design (Figure 4) is 20 ft to 40 ft long and has one span from the abutment to the sleeper slab. It is designed to carry the full traffic load without support on the soil except at both ends. The BEST test, which represents a 1/20th scale model of the typical transition, indicated that the proposed one-span approach slab gives a smaller bump than the current two-span approach slab (Figure 5).

The Researchers Recommend...

Based on results of this project, the researchers recommend the following:

- Use controlled-quality backfill within 100 ft of the abutment (PI less than 15, less than 20 percent passing #200 sieve, coefficient of uniformity larger than 3). Gradually pass from that backfill to the embankment fill. Compact all fills to 95 percent of modified proctor controlled by inspection. Within the zone 100 ft from the abutment, control the compaction result with an increased frequency of measurement.
- If such backfill cannot be achieved, the embankment fill within that 100 ft zone should be cement stabilized with a smooth transition to the unstabilized backfill.

Use a 20 ft to 40 ft long single-span approach slab designed to carry the full traffic in free span. The articulation in the current approach slab should be eliminated but the wide flange should be kept on the embankment side as a temperature elongation joint.

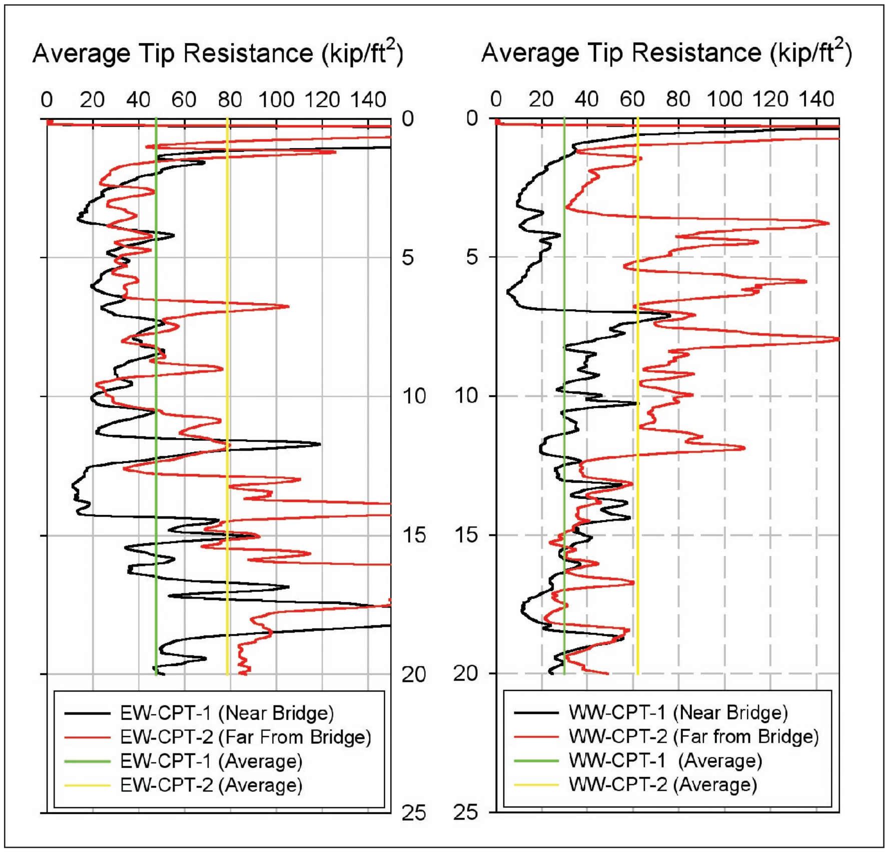

Figure 3. Cone Penetration Testing Result (US 290 at FM 362).

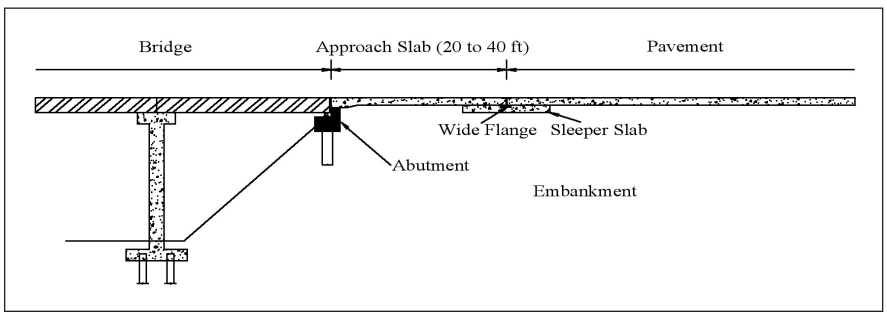

Figure 4. Proposed New Approach Slab Design.

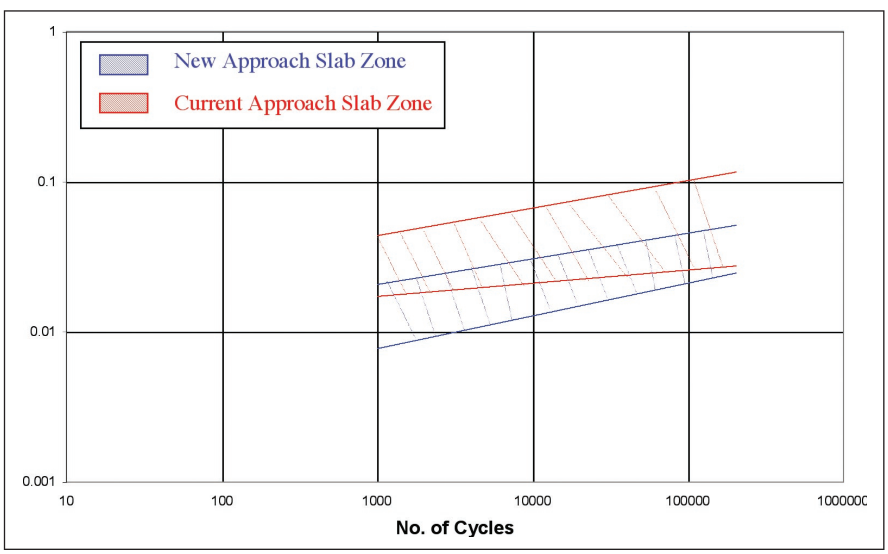

Figure 5. New Approach Slab versus Current Approach Slab: BEST Results.

For More Details . . .

The research is documented in the following reports:

Report 4147-1, *Investigation of Settlement at Bridge Approach Slab Expansion Joint: Survey and Site Investigations*

Report 4147-2, *Investigation of Settlement at Bridge Approach Slab Expansion Joint: Numerical Simulations and Model Tests*

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TxDOT Implementation Status
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The recommendations of this study are being implemented in the majority of the new projects in the Houston District. At this point no formal implementation project is being planned.

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