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FIELD IMPLEMENTATION AND MONITORING OF BRIDGE APPROACH SLABS

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WHY WE ARE DOING THIS…

Bridge approach slab is a concrete transitional roadway between the bridge deck and the asphalt pavement. It is designed to reduce the vehicle dynamic effects on the bridge. However, growing numbers of rough riding and cracked approach slabs with heavy maintenance requirements is sufficient to convince highway agencies that a serious problem exists. The complaints usually describe a 'bump' that motorists feel when they approach or leave bridges. This bump results in reduction of steering response, distraction to the driver, amplified truck impact and dynamic response in bridge decks, and expense to maintenance operations. As a result, the approach slabs can lose their contact supports due to various reasons, including the settlement of soil and the bulging of embankments. Together with the increasing truck load spectra, the approach slab will eventually crack despite the proper compaction made prior to the construction of the approach slabs. Therefore, alternative approach slab designs need to be investigated to solve the rough riding and cracks in approach slabs.

Two new design alternatives, embedded beam (EB) and constant thickness (CT), are developed and optimized during the Phase I of this study using advanced finite element program, ABAQUS.[1,2,3] The two design alternatives were recommended for implementation on the newly constructed Doremus Avenue Bridge to determine and monitor their effectiveness under field conditions. The transition slab (see Appendix A), commonly used in New Jersey Department of Transportation (NJDOT) designs of the approach slabs, are eliminated from the two design alternatives so that they only have a constant thickness of 18 in. Additionally, top layer reinforcements are added to the design alternatives to restrain the concrete from cracking due to thermal stresses. Several approach slab lengths, 35 ft, 45 ft, and 55 ft are investigated to determine the optimum approach slab length. Based on static load tests and long-term monitoring of the EB and CT design alternatives, both design alternatives outperformed existing design used by NJDOT. The EB design alternative has the best performance and did not exhibit any cracks on the Doremus Avenue Bridge under normal truck traffic conditions or soil settlement. The 45 ft length was the optimum design length without increasing the cost of the approach slabs. Therefore, the embedded beam design is recommended and currently adopted by the NJDOT to be the future design standard for bridge approach slabs.

OBJECTIVES

The objective of this research study is to recommend new design alternatives based on field-testing and evaluation of their performance under actual traffic conditions. The study includes:

- Implementation of newly developed design alternatives of approach slabs (Phase I) on the Doremus Avenue Bridge, NJ; the first bridge in NJ designed according to AASHTO LRFD.
- Instrumentation of newly constructed approach slabs with different types of sensors and evaluation of their performance based on of field data.
- Recommend new design detail based on static testing and long-term monitoring of the slab performance under field conditions.

HERE IS WHAT WE DID…

The analysis is carried out in two steps: (1) the consolidation of the soil due to the dead load of the slab where drainage is allowed to occur in the soil and (2) the application of the truckload. In both (2-D and 3-D) FE models, the approach slabs are subjected to multiples of the HS-20 bridge design truck loading. The HS-20 truck has three axles: (1) 8 kips front axle weight, (2) 32 kips middle axle weight, and (3) 32 kips rear axle weight. The longitudinal and transverse spacing of the truck is 14 ft and 6 ft, respectively. The HS-20 truck is modeled as six point loads corresponding to the loads and spacing described above.

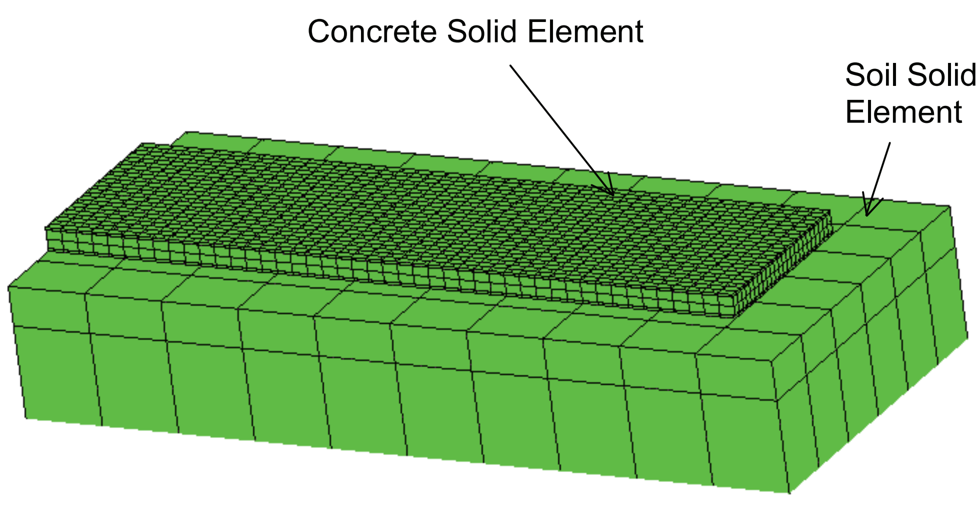

Figure 1. 3-D FE model of the approach slab.

Figure 2 shows the approach slabs located at the south abutment of the Doremus Avenue Bridge and the weigh-in-motion (WIM) system installed in each traffic lane. Figure 52 also shows a crack that has occurred and developed during concreting of the SA-LN-1 approach slab due to cold joints and delay in delivering concrete on time. The behavior of each slab was recorded using the various sensors installed to monitor their long-term behavior. Figure 3 indicates the strain response when the concrete cracks. The cracks were observed as early as 14 days while the strain reading indicates that the same crack was initiated at 140 days. This can be explained by the fact that the VWSG was installed in the bottom rebar mat and the crack was propagating deeper over time.

Figure 4 shows the recommended Embedded beam Design alternative for approach slabs

Figure 2. Crack Location and orientation in new Approach Slab at the Doremus Avenue

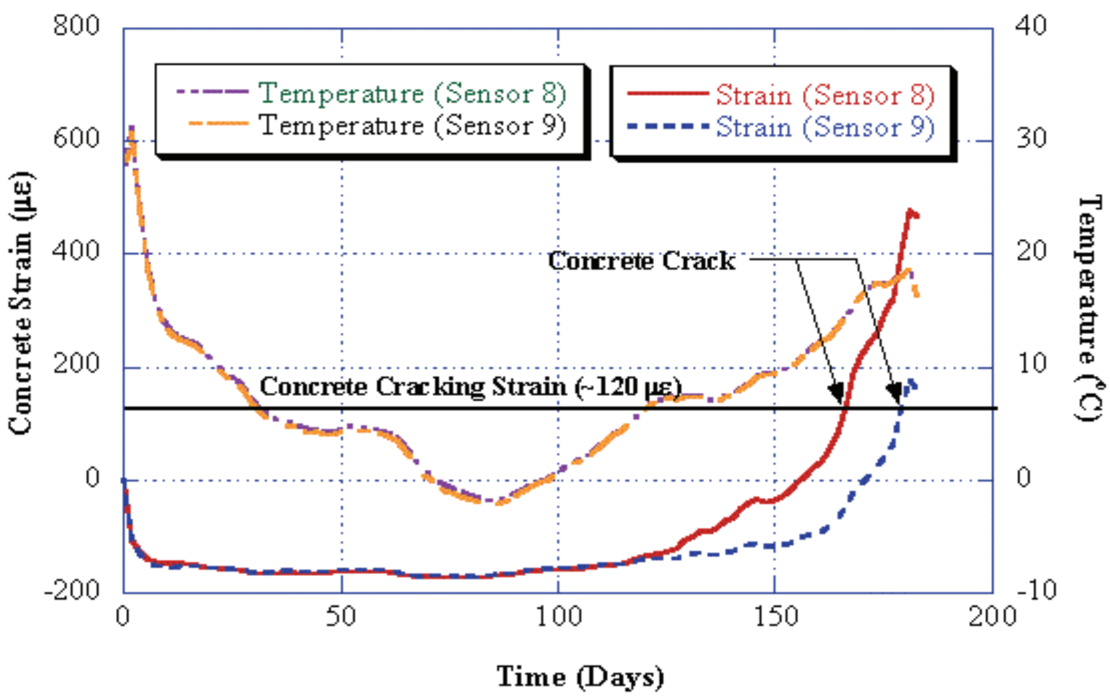

Figure 3. Strain and temperature profile at crack location.

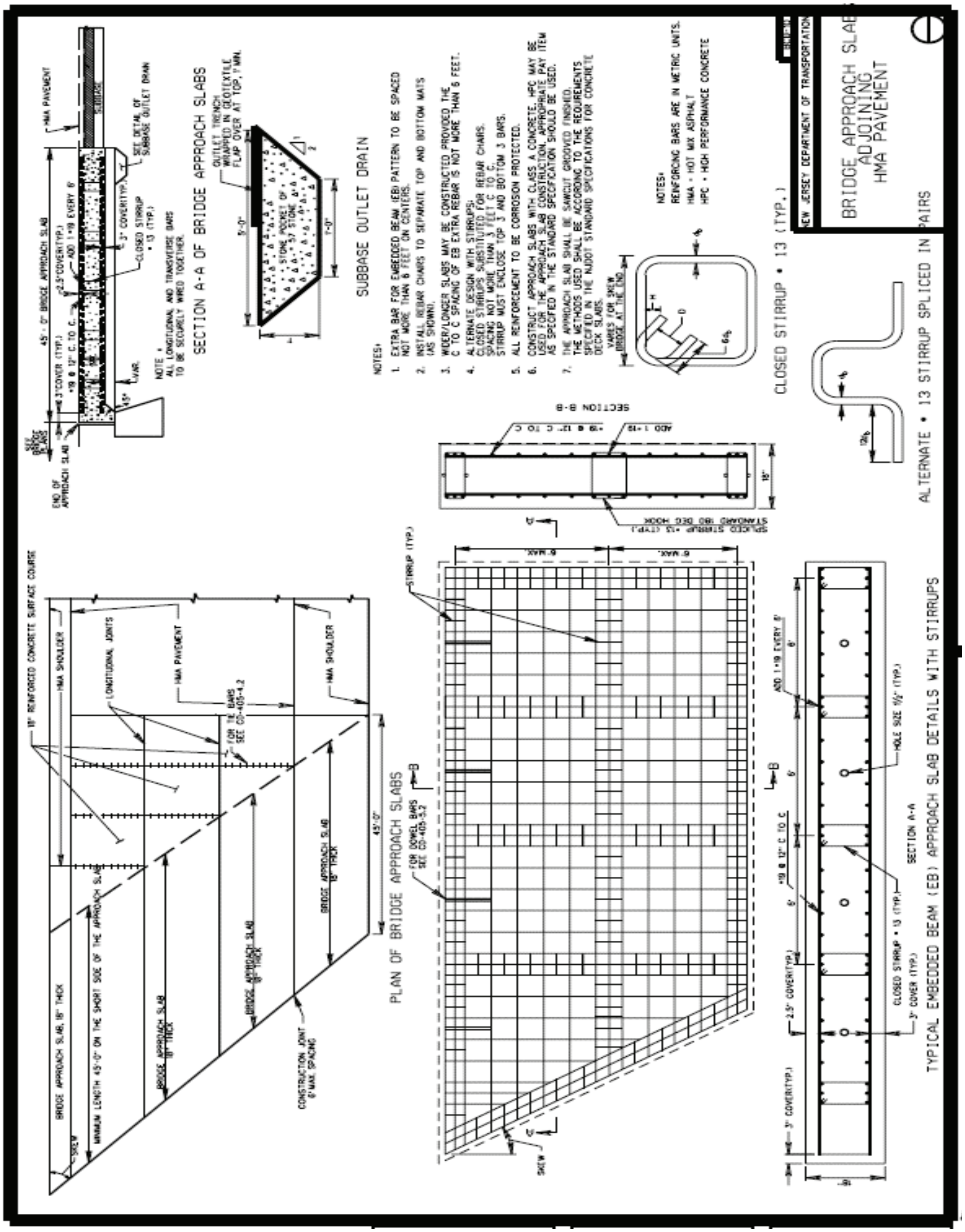

Figure 4. Detail of the NJDOT EB Approach Slabs

FINDINGS……

The following conclusions can be made:

1. Embedded beam (EB) design alternative provides the best performance based on

results from the FE analysis, static load testing, and long-term monitoring performance. None of the EB approach slabs that were properly constructed exhibited any cracks under normal truck traffic conditions or soil settlement.

2. The existing 3D finite element model gives accurate prediction of the strains in the approach slabs in comparison with actual measurements from the vibrating wire strain gages.
3. Long-term monitoring of the construction of the approach slab provides significant information of the construction process, design assessment, and failure detection. The sensors were successfully used in detecting construction problems at two occasions: (1) premature loading and (2) development of cold joints.
4. Over the period of the long term monitoring (e.g., 2 years), there is no significant amount of settlement in the soil underneath approach slab.
5. A 35ft and 45ft slab has the capacity to take 4.5 HS20, while a 55ft slab has a load carrying capacity of 4.3 HS20. The 45 ft length was the optimum design length without increasing the cost of the approach slabs.

RECOMMENDATIONS

The following recommendations can be made:

1. Adopt the EB design alternative as the detail for the NJDOT new design of approach slabs. Eliminate transition slabs, i.e. adopt approach slabs with 18" constant thickness.
2. Ensure proper compaction of the backfill material below the approach slab since it is extremely important in minimizing settlement.
3. Extend the length of the wing wall beyond the current practice of 25-30 feet to minimize embankment bulging.
4. Continue to monitor the performance of the approach slabs for a longer period of time (i.e., beyond the current duration of the project) to allow for the observation of any soil settlement or embankment bulging and their effects.

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A final report is available online at
http://www.state.nj.us/transportation/research/research.html

If you would like a copy of the full report, please FAX the NJDOT, Division of Research and Technology, Technology Transfer Group at (609) 530-3722 or send an e-mail to Research.Division@dot.state.nj.us and ask for:

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