Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Design and Detailing of Cast-in-Place and Precast Concrete Approach

Research Objectives

The objective of this study was twofold: 1) investigated the causes of cracking of standard CIP concrete approach slabs and proposed a refined design, detailing, and construction procedure; and 2) proposed design alternatives using precast/prestressed concrete approach slabs based on the experience gained from the recent implementation. Special attention was given to the longitudinal joints between the approach slabs, transverse joints with the paving section and end of floor. The new design alternatives could benefit from the recent development in the use of advanced materials, such as ultra-high performance concrete and glass fiber reinforced polymer (GFRP) reinforcement to enhance durability and speed of construction.

Research Benefits

Improved the durability of approach slabs reducing user costs associated with their repair and replacement actions due to road closures and detours. Also, developed precast/prestressed concrete alternatives and using advanced materials will result in higher quality, more efficient use of materials, and accelerated construction.

Principal Investigator

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Background

The approach slab is a structural concrete slab designed to span from the back wall of the abutment (i.e. end of the bridge floor) to the grade beam or sleeper slab where the paving section begins. The purpose of the approach slab is to carry the dead and live loads over the backfill behind the abutments to avoid possible settlement of the backfill. Despite the simplicity of approach slab design as one-way reinforced concrete slab, it has been reported that most approach slabs experience cracking at early ages, which results in premature deterioration and shorter service life. The causes of this cracking are not clearly understood. On the other hand, NDOT recently considered the use of precast concrete approach slabs to achieve higher quality and faster construction than cast-in-place (CIP) concrete approach slabs. The first implementation of precast concrete approach slabs was completed in the summer of 2018 in the construction of Belden-Laurel Bridge. Several lessons were learned from this project, which could be considered to improve the design, fabrication, and construction of precast concrete approach slabs. Therefore, it was important and timely to re-visit the current design, detailing, and construction practice of standard CIP and precast concrete approach slabs in order to improve their durability and speed of construction.

Conclusion

Approach slab is a structural concrete slab that spans from the backwall of the abutment (i.e. end of the bridge floor) to the beginning of the paving section. The purpose of the approach slab is to carry the traffic loads over the backfill behind the abutments to avoid differential settlement that causes bumps at the bridge ends. Cast-in-place concrete approach slab is the current practice in US with various spans, reinforcement, thicknesses, joints, and concrete covers. NDOT has observed premature cracking in a significant number of approach slabs, which could result in a shorter service life and costly repairs/replacements as well as traffic closures and detours. The objective of this project was to investigate the extent and causes of approach slab cracking and propose necessary design, detailing and construction changes that could mitigate this deterioration. The literature on current approach slab practices by other state DOTs was reviewed and an analytical investigation was conducted using finite element analysis to evaluate the performance of different approach slabs under live load, volume changes due to shrinkage and temperature, and soil friction. Several parameters were considered in this investigation, skew angle, bridge width, joint location, and connection type. Analysis results indicate that volume changes cause high tensile stresses along abutment line, which result in the observed cracking. Several design changes were proposed, and precast concrete approach slab alternatives are considered as promising solutions that could result in longer service life and accelerated construction.

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Interested in finding out more?
Final report is available at:
NDOT Research Website

NDOT Recommendations Based Off Research Project

Bridge Division will add the provided design to the Bridge Operation Policy Decision and Procedures (BOPP) under the accelerate bridge construction. The Department will be looking for a feasible site to follow the new design.

- *As provided by Fouad Jaber, Lead TAC Member*

Research Readiness Level (RRL) Assessment

RRL 4

Level : : (Implementation with Follow up)
Research/Technology refined and adopted by the Department. Benefits of the implementation will be evaluated for a time frame of 1 year after construction.

Technology Transfer

Publications

- Morcous G., and Tawadrous R. (2020) "Circular Shear Pocket Connection for Full-Depth Precast Concrete Deck Construction", ASCE Journal of Bridge Engineering, 26(5).
- Abo Elkhier, M., and Morcous, G. (2020) "Design and Detailing of Bridge Approach Slabs: Cast-in-Place and Precast Concrete Options", Sustainable Issues in Infrastructure Engineering, Springer, December.

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