JOINT TRANSPORTATION RESEARCH PROGRAM

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Long-Term Behavior of Integral Abutment Bridges

Introduction

Integral abutment bridges, a type of jointless bridge, are the construction option of choice when designing highway bridges in many parts of the country. Rather than providing an expansion joint to separate the substructure from the superstructure to account to volumetric strains, an integral abutment bridge is constructed so the superstructure and substructure are continuous. The abutment is supported by a single row of piles which must account for the longitudinal movement previously accommodated by the joints.

The primary advantage of an integral abutment bridge is that it is jointless (expansion joints are eliminated) and thus reduces both upfront and overall life-cycle costs. In addition to other benefits provided by integral construction, the reduction in overall cost has led to INDOT requiring all new structures within certain geometric limitation be integral. These geometric limitations, traditionally based on engineering judgment, have been modified over time based as investigations have revealed more about the behavior of integral abutment bridges.

While there has been a considerable amount of research and investigation conducted on the behavior of integral abutment bridges, information is limited on both long-term behavior and the effects of highly skewed structures. Because there is a great desire for the application of these structures to be expanded, this research serves to expand the understanding of the behavior of integral abutment structures. Additionally, updated geometric limitations are recommended along with design recommendations and recommended analysis procedures for properly modeling integral abutment behavior.

Findings

The research program was conducted in four phases. First, a field monitoring program was implemented to observe and understand the in-service behavior of three integral abutment bridges. The results of the field investigation were used to develop and calibrate analytical models

U.S.-231 over AEP Railroad Spur.

that adequately capture the long-term behavior. Second, a single-span, quarter-scale integral abutment bridge was constructed and tested to provide insight on the behavior of highly skewed structures. Third, from the acquired knowledge from both the field and laboratory investigations, a parametric analysis was conducted to characterize the effects of a broad range of parameters on the behavior of integral abutment bridges. Finally, geometric guidelines were developed based on analysis of the parametric study. Based on the results of the program the following conclusions were made in regards to the long-term behavior and effects of skew for integral abutment bridges:

Long Term Behavior:

- Temperature differentials cause the cyclic behavior of the abutment movement.
- Lateral earth pressure reduces to approximately zero during phases of contraction indicating that a gap forms behind the abutment. Therefore, lateral earth pressure is not the cause of ratcheting.
- Concrete shrinkage of the deck causes net inward movement of the bridge (contraction) and is the cause

of ratcheting.

- The maximum lateral pile demand occurs due to contraction. The demand is a combination of temperature change and concrete shrinkage. Therefore, the largest possible demand, for a particular structure, will occur on the coldest day of the year for a bridge made integral on the hottest day of the year.
- The ratcheting of the abutment reduces in magnitude each year and will not continue for the entire life of the structure. A steady-state cyclic displacement occurs after a period of approximately seven years.

Skew:

- Skew of an integral abutment bridge causes rotation of the abutment and transverse movement of the structure.
- The largest longitudinal and transverse displacements occur at the acute corner. Therefore, this corner provides the greatest lateral demand on the piles.
- The transverse displacement occurs toward the acute side of the abutment.
- H-Piles should be oriented with the webs placed perpendicular to the centerline of the structure to minimize flexural forces.
- Skew has a minimal effect for values less than 30°. For structures with skews greater than 30°, the effect becomes significant.

Implementation Recommendations

Based on the findings of this study, equations were developed to calculate the demand lateral displacement for piles of integral abutment bridges. The equations contain components of longitudinal and transverse displacement as a function of length and skew. Using these equations and allowable deformation capacities of common pile sections, a design curve was developed for maximum structural length and skew. It is recommended that this incorporation of this curve be into the INDOT design manual be considered.

References

Frosch, R. J., & Lovell, M. D., *Long-term Behavior of Integral Abutment Bridges*. Publication FHWA/IN/JTRP-2011/16. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 2011. DOI: 10.5703/1288284314640

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