LOUISIANA TRANSPORTATION RESEARCH CENTER

LTRC

RESEARCH PROJECT CAPSULE

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TECHNOLOGY TRANSFER PROGRAM

Developing the Load Distribution Formula for Louisiana Culverts

JUST THE FACTS:

Start Date:
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18 months

End Date:
August 31, 2021

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Sponsored jointly by the Louisiana Department of Transportation and Development and Louisiana State University

POINTS OF INTEREST:

Problem Addressed / Objective of Research / Methodology Used / Implementation Potential

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PROBLEM

Figure 1
One of the cast-in-place box culverts analyzed in LTRC 16-3ST project

According to the National Bridge Inventory (NBI), culverts make up almost 140,000 out of the total national bridge inventory of over 614,000 (Federal Highway Administration, 2016), which translates into about 23% of the bridge inventory. In Louisiana, the bridge inventory includes approximately 2,600 culverts. Cast-in-place (CIP) reinforced concrete (RC) box culverts constitute a sizeable portion of the overall culvert inventory. Culverts have to be load-rated like other bridges to ensure their structural integrity.

However, following current load rating procedures for these culverts often yields unacceptable load rating factors even though their performance is acceptable with no signs of distress, such as cracking or excessive deformations. Unacceptable rating factors can lead to load posting, which restricts the use of the transportation network. Alternatively, upgrading these culverts may avoid load posting; however, the associated work may be cost prohibitive. Buried cast-in-place reinforced concrete culverts are known be a robust structural system that can withstand highway traffic because they behave as a highly statically indeterminate system. There are main differences between the design of culverts and other types of bridges.

First, single axle loads, and sometimes single wheel loads, are the controlling live load conditions for the design of culverts, as opposed to the gross vehicle weight (GVW) that controls the design of typical bridge spans. Second, the depth of the soil fill above any culvert is determined based on the hydraulics and roadway geometric conditions at the bridge site, which is known to vary greatly and accordingly has a great impact on the live load effects on the buried culvert. In 2010, National Cooperative Highway Research Program (NCHRP) Project 15-29 produced Report 647 "Recommended Design Specifications for Live Load Distribution to Buried Structures" (Petersen et al. 2010). Simplified design equations (SDEs) for the structural response of buried structures based on three-dimensional (3D) analysis of 830 buried culverts were developed. The report also provides guidelines for conducting 2D and 3D modeling analyses for culverts that are not covered by the

SDEs. In this work, the effect of pavement on live load distribution was ignored, which can have a significant effect on reducing actual pressures that reach the box. While this may be a conservative assumption for design purposes, it penalizes existing culverts with pavement over their top soil fill.

Current AASHTO live load distribution equations are conservative; specifically for low-fill height culverts, and give conservative internal forces for critical cross sections. This conservatism affects rating process since it distributes live load to a narrower area, which in turn, increases pressure intensity and internal forces, and conducts low rating factors.

OBJECTIVES

The objective of this study is to develop live load distribution formulas that can be used to represent the dimensions of the affected area over buried CIP reinforced concrete box culverts through an extensive parametric study that covers attributes of existing culverts in Louisiana's bridge inventory. The proposed formulas will take into account Louisiana standard details for negative moment reinforcement at exterior corners. The developed formulas will be validated using data from LTRC project 16-3ST "Live Load Rating of Cast-in-Place Concrete Box Culverts."

METHODOLOGY

To complete the objectives of this study, four main deliverables have been outlined. First a parametric study will be performed looking at several parameters including but not limited to: earth-fill height, earth-fill type, pavement type, geometric configuration, top slab thickness, and concrete compressive strength. After the parametric study has been completed, 2D and 3D finite element analyses will be completed using a more realistic live load distribution. Next live load distribution formulas will be developed using a multilinear regression model considering critical sections for flexure. The developed formulas will be validated using field data obtained through the completion of LTRC Project 16-3ST. A workshop will be conducted at the end of the study to demonstrate the application of the developed formulas for cast-in-place reinforced concrete box culverts' ratings.

IMPLEMENTATION POTENTIAL

The findings of this study will help DOTD to make informed decisions about load rating and load posting of cast-in-place reinforced concrete box culverts. The newly developed formulas will take into account DOTD standard details that may not be within the scope of NCHRP Project 15-54 "Proposed Modifications to AASHTO Culvert Load Rating Specifications" and update conservative formulas from AASHTO-LRFD.