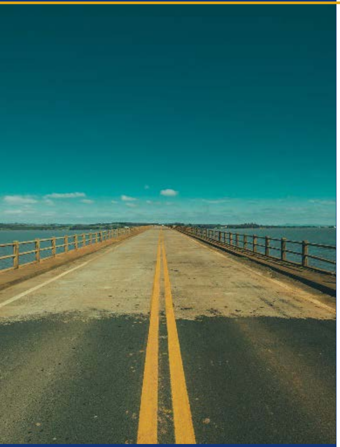
Transportation Consortium of South-Central States (Tran-SET)

A Comprehensive Framework for Life-Cycle Cost Assessment of Reinforced Concrete Bridge Decks

Reducing life-cycle cost of transportation infrastructure through quantification of direct/indirect bridge maintenance costs and optimizing type of bridge material



Highlight | Jan. 2019

Project No. 18STOKS02

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POP: March 2018 – November 2019

Various environmental and mechanical stressors cause deterioration of concrete bridge decks. Normal wear and tear, freeze and thaw cycles, and chloride penetration due to deicing salts can cause aggressive deterioration that usually require frequent interventions during the life-cycle of the bridge. These interventions include deck maintenance, repairs, or deck replacement. The quantification of the life-cycle cost of bridge decks considering maintenance and repair activities represents a significant challenge facing local and state transportation agencies. The life-cycle maintenance activities not only increase the direct life-cycle cost of the bridge, but they also lead to significant indirect user costs due to increased traffic delays, work zone crashes, and operating cost. Accordingly, the proper quantification of indirect costs associated with life-cycle bridge management activities including maintenance, repair, and rehabilitation activities is of paramount importance. This study attempts to fill the knowledge gap in quantifying the indirect costs associated with bridge deck maintenance and their impact on overall bridge life-cycle cost.

Background

Reinforced concrete bridges constructed using regular black reinforcement require regular maintenance and replacements to remedy the deteriorative effects associated with corrosion. Reinforcement manufacturers developed several products that can offer better corrosion resistance than regular steel. Examples include epoxy coated rebars, galvanized reinforcement, and corrosion resistant steel. The use of corrosion resistance reinforcement will increase the initial cost of the structure but may reduce the maintenance needs along the life-cycle of the bridge which can lead to a reduction in the life-cycle cost. Accordingly, identifying the steel material with the lowest life-cycle cost requires comprehensive life-cycle analysis which not only considers the initial construction cost, but also the direct and indirect cost of maintenance actions performed along the service life of the bridge. This study focuses on introducing an approach that: (a) characterizes the life-cycle maintenance needs and repair intervals associated with bridge decks constructed using various reinforcement alternatives, (b) develops a systematic methodology for quantifying the impact of bridge maintenance on indirect life-cost including the effect of increased travel time, work zone crashes, operating cost, greenhouse gas emissions, and social losses, and (c) compares different steel reinforcement materials (e.g., regular, epoxy coated, galvanized, stainless steel, and MMFX) based on their long-term performance and maintenance. The life-cycle cost analysis will integrate a sustainability assessment including evaluating the carbon footprint of bridge decks constructed using different reinforcement alternatives.

Project Summary

The above research objectives will be achieved through conducting a survey to collect information on corrosion related maintenance/replacement procedures in the South-Central region. Data collection will cover different approaches used to extend the service life of bridge decks. The survey will focus on quantifying the need for corrosion-related bridge deck interventions based on geographic location of the bridge, the intervals of corrosion-related maintenance, strategies adopted by different departments of transportation to reduce corrosion deterioration of bridge decks, and the cost associated with these activities. The collected data will also include information on the reinforcement type and traffic control procedure during maintenance/repair activities.

Data from the survey will be used to develop a systematic approach for quantifying the life-cycle cost of bridges with decks constructed using different reinforcement alternatives. In addition to direct cost of maintenance and repair activities during the service life, the approach will quantify the social, economic and environmental impacts of maintenance actions on the LCC arising from traffic disruptions. These impacts include the increased travel time, operating cost, time loss, work zone crashes and fatalities, in addition to other socioeconomic impacts such as lost business and lack of adequate access.

Status Update

A study implementing life-cycle cost analysis (LCCA) is currently being conducted on RC bridge decks constructed with conventional and corrosion resistant reinforcement.

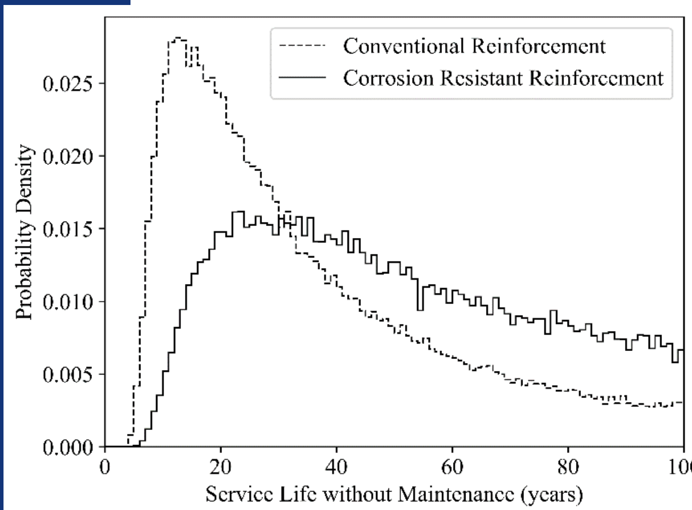

Figure 1. Service life of a bridge deck with conventional and corrosion resistant reinforcement

The life-cycle cost is computed as (a) direct costs including initial construction and subsequent maintenance activities, and (b) indirect costs, including traffic delay and environmental impact. Probabilistic analysis is adopted to account for uncertainties associated with these aforementioned costs.

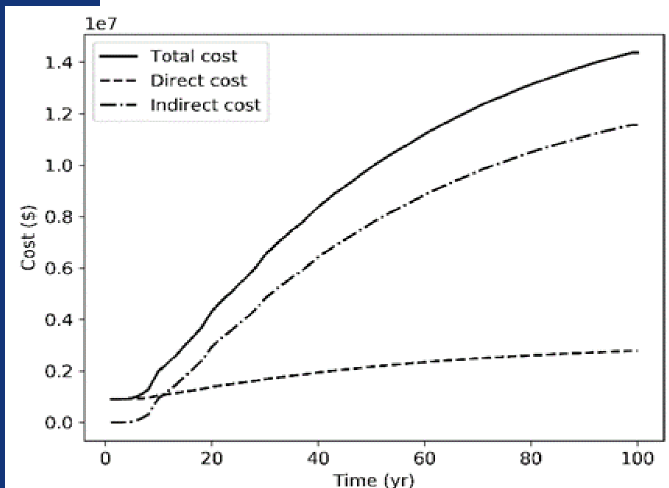

Figure 2. Life-cycle cost of the bridge deck employing conventional reinforcement.

An illustrative example is studied to compare the life-cycle cost of bridge decks employing conventional and corrosion resistant reinforcement. The decks constructed using conventional reinforcement have a higher probability of a shorter service life compared to those utilizing corrosion resistant reinforcement. Accordingly, the use of corrosion resistant reinforcement can reduce the frequency of maintenance activities and its associated indirect cost.

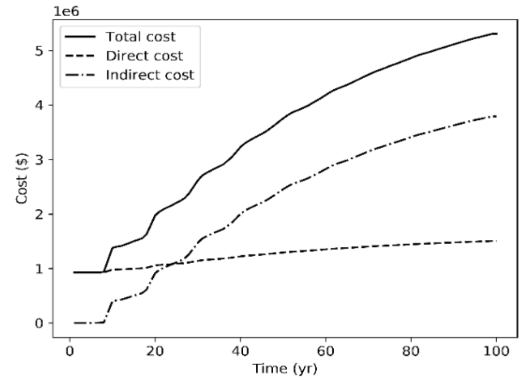

Figure 3. Life-cycle cost of the bridge deck employing corrosion resistant reinforcement.

Impacts

The proposed approach can be implemented by bridge officials to make informed decisions on intervention activities and material selection based on detailed life-cycle cost analysis that consider agency costs, as well as user costs. Implementing the proposed research will lead to improved sustainability, durability and longevity of transportation infrastructure. This study addresses two of the key research focus areas of Tran-SET: “improving durability and extending the life of the infrastructure” and “preserving the existing transportation system”.

Tran-SET

Tran-SET is Region 6’s University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 “to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes”.

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Mr. Christopher Melson (Tran-SET Program Manager) directly at transet@lsu.edu.

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