JOINT TRANSPORTATION RESEARCH PROGRAM

Principal Investigator: Mark Bowman, Purdue University, bowmanmd@purdue.edu 765.494.2220
Program Office: jtrp@purdue.edu, 765.494.6508, www.purdue.edu/jtrp
Sponsor: Indiana Department of Transportation, 765.463.1521

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Life-Cycle Cost Analysis for Short- and Medium-Span Bridges

Introduction

Life-cycle cost analysis (LCCA) is a method used to assess the total cost of a project. LCCA is particularly useful when a single project has different alternatives that fulfill the original requirements. Alternatives could differ in initial investment or cost, operational costs, maintenance costs, or other long-term costs. This kind of analysis, when applied to bridge infrastructure projects, is called bridge life-cycle cost analysis (BLCCA). According to NCHRP Report 483 (Hawk, 2002): "Several recent legislative and regulatory requirements recognized the potential benefits of life-cycle cost analysis and call for consideration of such analyses for infrastructure investments, including investments in highway bridge programs." This contemporary tendency has been the main driving force for the research and use of BLCCA throughout the country. The current study focuses on efforts to identify the best approach to incorporate BLCCA in new bridge construction in Indiana.

The cost involved in building a bridge depends upon different factors. The following features can play a role in the initial cost:

- number of substructure elements needed;
- right-of-way and earthwork required to develop the height of the approach due to the depth of the bridge structure type;
- typical deck span and thickness for the superstructure;
- span length and material properties;
- distance for shipping from the precast plant or fabrication shop to the bridge site; and
- familiarity of the contractors with the type of bridge construction.

However, long-term costs must be considered when estimating the overall cost of the project and determining its LCC.

Long-term costs include but are not limited to the following:

- repair or rehabilitation of the bridge deck;
- repair of collision-damaged concrete or steel girders;
- repainting a steel bridge;
- removal of the deck for a pre-stressed bulb-tee without damaging the girder;

- routine maintenance;
- the cost of inspection for fracture-critical steel bridges;
- inspection to identify and repair duct voids in grouted post-tensioned concrete bridges;
- and miscellaneous minor repairs such as spot painting or concrete patching.

Without watchful consideration of the long-term costs and full life-cycle costing, initial investment decisions that look attractive could result in a waste of economic resources. The design decision at the beginning of the project can create less than optimal requirements in future years. According to the American Society of Civil Engineers and ENO Center of Transportation (2014): "An examination of the full life-cycle costs can help an agency in determining the appropriate investment in an asset given current and future constraints."

Findings

For this project an initial cost and LCCA comparison was made for simply supported and continuous bridge structures. Different LCC profiles were proposed for different superstructure types. Additionally, cost-effective life-cycle profiles were suggested for the different alternatives.

Three different bridge span ranges were proposed to categorize the cost-effectiveness of multiple superstructure design solutions:

- span range 1 for bridges with maximum spans between 30 ft and 60 ft;
- span range 2 for spans within 60 ft and 90 ft; and
- span range 3 for structures longer than 90 ft and shorter than 130 ft.

Additionally, cost allocation for different agency costs including initial and long-term costs were presented. User costs were avoided since those depend on assumptions of traffic and specific site conditions that are considered an oversimplification for the aim of this report.

In order to compare different alternatives with different service lives, the present worth of the LCC method was suggested. This method computes the net present value of a single LCC that is repeated over time indefinitely based on its service life. Using this method, a LCCA comparison was made for simply supported and continuous bridges. Results showed that for span range 1, slab bridges are the most cost effective solution for spans up to 35 ft. In contrast, a galvanized steel alternative is the optimal solution for spans up to 60 ft (for the case of simply supported beams, cost-effectiveness of the galvanized option goes up to 65 ft). For spans longer than 60 ft, the prestressed bulb tee option is the most cost-effective solution, for both simply supported and continuous beams. However, for simply supported beams, galvanized steel plate girders are also cost-effective for spans between 90 ft and 105 ft.

Implementation

The LCC profiles developed in this study can be applied to the planning and design of new state and locally owned bridges. As a result, INDOT now has proposed profiles for different superstructure types that correspond to the most effective working action distribution for new bridges. Charts included in this report present the most cost-effective bridge structure solutions for simply supported and continuous bridges of different span ranges. These charts are a suggested tool for designers to use during the early stages of planning for new structures. Their use could result in the most cost-effective structure selection for new bridges and ultimately result in cost savings for bridge owners.

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