Late Life Low Cost Deck Overlays

Tech Transfer Summary

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This research project evaluated alternative options for late-life bridge deck overlay systems that would be more cost effective and reduce closure time compared to standard overlay practices employed by the Iowa Department of Transportation.

Objective

The primary objective of this study was to identify late-life bridge deck overlay systems that will provide a sufficient service life extension but be more cost-effective and require less closure time than conventional overlays currently used by the Iowa DOT. The most promising late-life deck overlay systems were identified by comparing benefit-cost ratios based on recent cost database and service life information.

Background & Problem Statement

When a bridge deck is considered for replacement, it is not uncommon that the deck needs significant repairs to maintain the riding surface until funding is available for the replacement and a construction contract can be executed. Traditionally, Iowa DOT has used low-slump portland cement concrete overlays on bridge decks, which can provide a significant service life extension. Low-slump overlays, however, have significant costs and traffic impacts during construction. For bridges with a limited remaining service life, other deck overlay options that have lower costs and traffic impacts while maintaining the riding surface may be desirable.

Cost and traffic impact reductions can be obtained by changing two components of an overlay system: materials and/or construction. Materials that require shorter curing times than conventional portland cement concrete such as polymer concrete, rapid set concrete, or asphaltic concrete can reduce traffic impacts. A reduced construction procedure that lowers or removes certain construction requirements can reduce both costs and traffic impacts. In this study, different combinations of overlay materials and construction procedures were evaluated in the context of late-life applications and compared to aid in the decision-making process for placement of late-life overlays.

Research Description

A comprehensive literature review of bridge deck overlay practices was completed for eleven Midwest states. Practices in three additional states (California, New York, and Virginia) were also reviewed to cover overlay types not commonly used in the Midwest. Overlay types included portland cement concrete (PCC) overlays, low-slump dense concrete (LSDC) overlays, high performance concrete (HPC and SFC) overlays, ultra-high performance concrete (UHPC) overlays, latex-modified concrete (LMC) overlays, very early strength LMC (LMCVE) overlays, thin broom-seed polymer concrete overlays (TPO), premixed polymer concrete overlays (PPCO), hot-mixed asphalt (HMA) overlays (without waterproofing membranes), HMA with waterproofing membranes (WPM), and polymer-modified asphalt (PMA) overlays.

Based on the review of the current practices in Iowa, a cost-benefit analysis was conducted using six overlay systems that offer lower cost and/or shortened traffic closure time compared to the Iowa DOT Class O concrete overlay, which was selected as the baseline case. These six overlays are: LMCVE, PPCOs, TPOs, HMA WPM, HMA, and PMA. Two different construction procedures were considered in the analysis: standard procedure and reduced procedure. The standard procedure is based on current Iowa specifications while the reduced procedure includes the same steps as in the standard procedure except that Class A Deck Repairs including sounding, removing, and patching concrete within the repair areas are not performed. The reduced procedure is based on a practice used by Minnesota and Michigan DOTs for bridge decks with a limited remaining service life in which a concrete or asphalt overlay is placed on a deck surface that has been scarified to improve bonding, but removal of the deteriorated concrete is not required. The omission of Class A Deck Repairs can significantly reduce construction cost and time but will also decrease service life of the overlay.

To complete the analysis, it was assumed that the deck has an existing Iowa DOT Class O concrete overlay, which is typical for a deck in late life. Except when the new overlay is thin polymer concrete, the existing overlay (assumed to be 1 3/4-inch thick, Iowa standard concrete overlay) and an additional 1/4-inch concrete shall be removed and replaced with a new overlay 2 inches in thickness, resulting in no change in the driving surface elevation. Unit costs for the different overlay types and construction procedures were estimated from bidding tables of select states. A summary of the cost-benefit analysis results is provided in the tables below for each construction procedure. Other assumptions and limitations of the analysis are provided in the report.

Comparison of Different Overlay Systems - Standard Construction Procedure

Overlay Type	Criteria			Differences from Baseline		
	Cost ($/SY)	Construction time (days)	Service life (years)	Cost	Construction time (days)	Service life
Class O (Baseline)	122	6	16 - 32	0%	0.0	↔
LMCVE	185	3	14 - 29	52%	-3.0	↔
PPCO	207	3	20 - 30	70%	-3.0	↔
TPO	83	3	7 - 15	-32%	-3.0	↓↓
HMA with WPM	108	3	12 - 19	-11%	-3.0	↓
HMA w/o a WPM	72	3	3 - 7	-41%	-3.0	↓↓↓
PMA	157	3	10 - 15	29%	-3.0	↓

Comparison of Different Overlay Systems - Reduced Construction Procedure

Overlay Type	Criteria			Differences from Baseline		
	Cost ($/SY)	Construction time (days)	Service life (years)	Cost	Construction time (days)	Service life
Class O	82	5	10 - 15	-32%	-1.0	↓↓
LMCVE	146	2	7 - 15	20%	-4.0	↓↓
PPCO	168	2	5 - 10	38%	-4.0	↓↓
HMA with WPM	69	2	6 - 8	-44%	-4.0	↓↓↓
HMA w/o a WPM	33	2	2 - 4	-73%	-4.0	↓↓↓
PMA	117	2	5 - 8	-3%	-4.0	↓↓↓

Key Findings

The cost-benefit analysis results are summarized in the table below where the required service life has been divided into three categories: short (4 years or less), medium (5 to 10 years), and long (10 to 15 years); for each category appropriate overlay options are marked, and their cost and traffic impact are shown. This table can be used as a decision-making tool for selecting overlay options appropriate for each service life category.

The conclusions drawn from this study are as follows:

1. There is a literature gap regarding the installation and performance of overlays applied late in the life of bridge decks.
2. HMA overlays with WPM, HMA overlays without WPM, and thin polymer overlays (Standard Procedure) are cost-competitive compared to Class O PPC overlays.
3. LMCVE, PPCO, thin polymer overlays, HMA overlays with WPM, HMA overlays without WPM, and PMA overlays can be advantageous for bridges where short traffic closures are required because they have a significantly smaller traffic impact than the Class O PPC overlays used by the Iowa DOT.
4. Amending the standard construction procedure for late-life overlays to omit partial-depth (Class A) repairs produces overlay options that have reduced costs and construction time, but may still be capable of providing the required service life extension until the deck is replaced.

Selection of Overlays for Different Service Life Categories

Required Service Life			Cost ($/SY)	Traffic closure (days)	Overlay Materials	Procedure
Short (SL < 5)	Medium (5≤ SL <10)	Long (10≤ SL< 15)				
✓	✓	✓	122	6	Class O	Standard
✓	✓	✓	185	3	LMCVE	Standard
✓	✓	✓	207	3	PPCO	Standard
✓	✓	×	83	3	TPO	Standard
✓	✓	✓	108	3	HMA with WPM	Standard
✓	×	×	72	3	HMA w/o a WPM	Standard
✓	✓	✓	157	3	PMA	Standard
✓	✓	✓	82	5	Class O	Reduced
✓	✓	×	146	2	LMCVE	Reduced
✓	✓	×	168	2	PPCO	Reduced
✓	✓	×	69	2	HMA with WPM	Reduced
✓	×	×	33	2	HMA w/o a WPM	Reduced
✓	✓	×	117	2	PMA	Reduced

Recommendations and Implementation Benefits

Recommendations from this research study are as follows:

1. Based on the experiences of the Michigan and Minnesota DOTs, a reduced construction procedure that limits or fully excludes Class A repairs may be implemented exclusively for late-life overlay installations to reduce costs and construction time. A field study is recommended to confirm the feasible service life of overlays constructed using this new procedure.
2. We recommend that a cost-benefit analysis similar to that presented in this study but with more refinement be performed for several bridges with varying deck conditions and service life requirements to confirm the costs and economic benefits predicted in this study.
3. HMA overlays with waterproofing membranes are less expensive than PCC overlays, and can be installed quickly. Although these overlays are typically not used in Iowa due to concerns over long-term performance, they may be considered for late life decks with a short or medium remaining service life.
4. Reinforced asphalt overlays (other than HMA overlays with waterproofing membranes) are expected to provide longer service life than HMA overlays, and may also be investigated as potential late-life overlays in a trial field study.

The contents of this report may be used to update or revise Iowa DOT construction procedures and specifications for bridge deck overlays on late-life bridges with limited service life extension requirements. The cost-benefit analysis results and associated tables can be used as a decision-making tool for selecting a late-life overlay based on cost, construction time, and required service life. The specifications and details compiled in the report can be used by Iowa DOT for developing final special provisions for the recommended overlay system(s), as well as for reference during future trial applications.