

Pavement

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**Project Title:**

Development of a Statistical Model to Predict Materials' Unit Prices for Future Maintenance and Rehabilitation in Highway Life Cycle Cost Analysis

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## Development of a Statistical Model to Predict Materials' Unit Prices for Future Maintenance and Rehabilitation in Highway Life Cycle Cost Analysis

Enhance the current LCCA procedure to predict more realistic unit prices and project costs for the future M&R activities and thus select the most cost-effective alternative in LCCA.

### WHAT WAS THE NEED?

Federal Highway Administration promotes the use of Life-Cycle Cost Analysis (LCCA) to study the pavement investment alternative on the state highway projects. LCCA is an analytical technique that uses engineering economic principles to evaluate long-term investment options. The analysis enables total cost comparison of competing pavement alternatives with equivalent benefits. LCCA can be used to study either new construction projects or to examine preservation strategies for existing transportation assets.

California Department of Transportation (Caltrans) uses LCCA as a comprehensive analysis of a facility's value, which requires the software tool RealCost. This tool is sponsored by the Pavement Program in the Division of Maintenance. The RealCost tool provides guidance and data for performing LCCA for pavement.

Using LCCA will help assure that pavement alternatives are analyzed objectively and consistently statewide, regardless of who engineers, builds, or funds the project. The cost calculation module of the existing Caltrans' RealCost LCCA software requires a unit price per material to calculate the agency costs of future maintenance and rehabilitation (M&R) projects. Caltrans' LCCA procedure manual guides engineering staff to the statewide flat unit prices as a default or the user must find relevant unit prices from the Caltrans historical contract cost database.



Caltrans provides a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability.

The LCCA technique has been used by the California Department of Transportation on highway projects since 2007, with a focus on the cost-effectiveness comparison of different design alternatives presented in pavement materials and pavement cross-section design. In LCCA, long-term prediction must account for uncertainties in the fluctuation of pricing of materials. Economic recessions and the global pandemic are examples that have significant influences in changing future material unit prices and project costs. Each project decision must consider all the unique project factors for the State's highway system that are being evaluated by the LCCA process, to get the most value from Caltrans project. Caltrans Project Delivery Program's engineers need to use design, material, and construction solutions that add value to the State's facilities and improve the delivery of the projects and support the State's business needs.

## WHAT WAS OUR GOAL?

The objectives of this research are to investigate the sensitivity of materials' unit prices due to external components (project size, climate region, and other socio-economy variables) in the life cycle cost; and develop a statistical model to predict material and construction-related cost inputs for future M&R projects to support accurate LCCA for California highway projects.

These goals must be balanced with meeting project budget and schedule, so the roadway can be operational as quickly as possible and reduce both opportunity costs and real project costs. Some state facilities need to continue to move traffic as an active facility throughout construction, possibly using strategic project phasing.

The only way to truly achieve a best-value project while fully meeting all of Caltrans' needs is to identify and prioritize these goals and evaluate solutions.

## WHAT DID WE DO?

and various California socio-economic parameters over time. The primary pavement materials' unit prices in the past 20 years (1999–2018) were collected from the Caltrans Construction Contract Cost database, and trends were explored by geographical region (California districts), climate regions, and project size to identify any differences related to such factors.

In the statistical model development process, the researchers categorized the unit prices of each pavement material into four project sizes (small, medium, large, and extra-large projects), and calculated average unit prices in each category. The research also investigated socio-economic parameters related to highway construction to identify factors that affect and can help predict future unit prices of pavement materials.

The future values of the critical socio-economic parameters were predicted for a 50-year LCCA period using time series models. Using the pavement materials' unit prices from a Caltrans database as well as the socioeconomic data collected, multiple regression models were developed to estimate the annual unit prices of each pavement material for the next 50 years.

## WHAT WAS THE OUTCOME?

The purpose of this study was to enhance the accuracy and practicality of the highway LCCA results, with the aim of enabling practitioners to select cost-effective material and construction alternatives.

The program currently uses the primary pavement material items' unit prices from the past 20 years (1999–2018), collected from the Caltrans Construction Contract Cost database.

The results showed no significant price differences by geographical or climate region, but differences were observed according to project size.

In view of the observed trends and critical variables, the research team employed multiple regression models (MRM) to predict the unit price of pavement materials for use in LCCA for future M&R projects in California. Implementing the MRM to the current LCCA M&R tables requires clear discussion and consent between the Pavement Program and University of California Pavement Research Center prior to its implementation.

This discussion needs to take place since there were instances where predicted unit prices were 15 to 20 times higher in 60 years, when using the regression model. So, the research team used average unit prices in the latest year for calculating future M&R activities costs. However, in other cases or data sets during the research, the multiple regression models predicted realistic unit prices of pavement materials for LCCA for future M&R activities when the trend of the future predicted unit price values were compared to the trend of the past unit price values.

The data-driven scientific approach as described in this research reduces risk caused by such uncertainties and enables practically reasonable predictions for the future. The key contribution of this research was the development of statistical models to predict the future unit prices as an alternative to the standard practice of using uniform unit prices for the future M&R activities.

Based on these findings and recommendations, this research may be implemented by Caltrans in five years. The expectation of the Pavement Program is that the unit price data will become large enough to update the regression models to the materials that had unrealistic future high values because these materials will have been used more often in projects.

## WHAT IS THE BENEFIT?

The public and Caltrans will benefit from this research because the study results will enhance the accuracy and practicality of the highway LCCA results in selecting cost-effective material and construction alternatives. This cost-effective model for material recommendations and construction alternatives will provide cost savings. Caltrans is a leader in this area of project cost estimating and for this reason other State and Local Department of Transportations may benefit from the recommendations of this research. The models developed in this research can be implemented to enhance the current LCCA procedure to predict more realistic unit prices and project costs for the future M&R activities and thus select the most cost-effective alternative in LCCA.

## LEARN MORE

The current Caltrans LCCA method can be accessed at this link:  
<https://dot.ca.gov/programs/maintenance/pavement/concrete-pavement-and-pavement-foundations/life-cycle-cost-analysis>

Caltrans Policy Memorandum for Design Staff to use LCCA in Project Delivery Documents can be accessed at this link:  
<https://dot.ca.gov/-/media/dot-media/programs/maintenance/documents/dd-107-a11y.pdf>

To view the evaluations:  
<https://transweb.sjsu.edu/research/1806-Predict-Material-Prices-Pavement-LCCA>



**IMAGES**

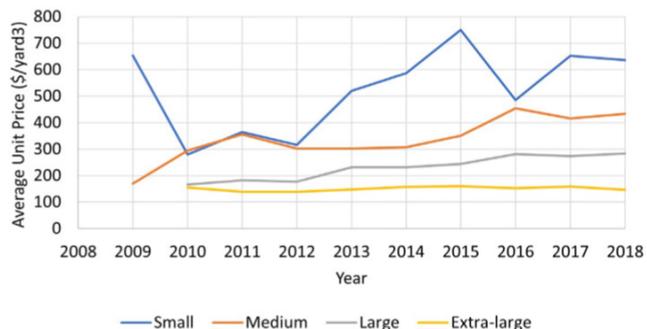


Image 1: Average Unit Prices of joint Plain Concrete Pavement by Project Size (2008-2018)

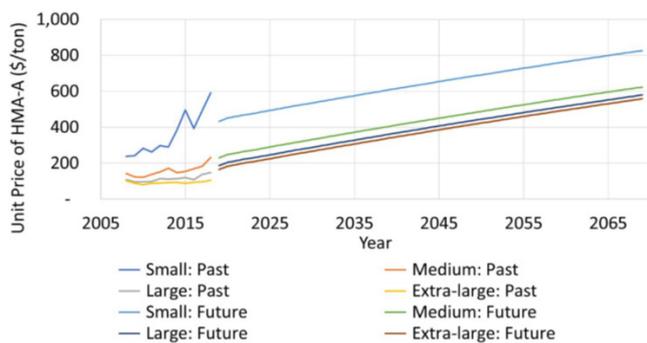


Image 2: The Unit Price of HMA-A for the Past Collected and the Future Predicted by Project Size

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