CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

Project Summary Report 1739-S
Project 0-1739: A Life Cycle Cost Analysis of Rigid Pavements
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PROJECT SUMMARY REPORT

A LIFE CYCLE COST ANALYSIS OF RIGID PAVEMENTS

WHAT WE DID...

The Texas Department of Transportation (TxDOT) commissioned a research project in 1996, summarized here, to promote life cycle cost analysis of rigid pavements throughout the TxDOT districts by developing a uniform methodology for performing life cycle cost analysis that will eventually include all pavement types.

The major objective of this project was to develop a comprehensive, modular life cycle cost methodology that could evaluate existing and future projects. This methodology was to include a framework for life cycle cost analysis that was comprehensive and able to encompass all possible aspects of pavement design, agency costs, user costs, and other costs that are created as a consequence of a highway project.

Life cycle cost analysis allows state agencies to evaluate different alternatives for proposed highway projects, based on the estimated or calculated life cycle cost for each alternative. The American Association of State Highway Officials (AASHO) first introduced the concept of life cycle cost analysis (or cost-benefit analysis) to the broader highway construction arena in 1960. Also during the 1960s, two projects were undertaken that advanced the application of life cycle cost principles to pavement design and pavement-type selection: The National Cooperative Highway Research Program (NCHRP) conducted a study under project NCHRP 1-10 to promote the concept of life cycle cost analysis. Later, the Texas Department of Transportation (TxDOT) funded a project to develop the Rigid Pavement System (RPS), which performs a life cycle cost analysis of rigid pavements and ranks alternate designs by total life cycle cost.

The 1986 and the 1993 editions of the American Association of State Highway and Transportation Officials' Pavement Design Guide encouraged the concept of life cycle costing and gave detailed discussions about the various costs that should be considered in life cycle cost analysis. Other countries, such as Canada, Australia, and Egypt, have also developed life cycle cost analysis methodologies.

This project represents an advancement in life cycle cost analysis, providing as it does a new framework for life cycle cost analysis. In the four decades since AASHO began advocating calculation of the full costs associated with highway pavement projects, various life cycle cost methods have been developed. The life cycle cost framework developed in this project encompasses as many aspects of pavement and highway design as possible. Many existing life cycle cost analysis procedures treat either one type of pavement only, or different pavement types in different manners. One of the main outcomes of this research is a product that allows planners to calculate life cycle costs of highway pavement projects, and to then compare those life cycle costs between various alternate designs. More specifically, this project (1) identified parameters related to pavement performance, deterioration rates, agency costs, and user costs; and (2) developed a software package to implement the comprehensive life cycle cost methodology. This software package includes a fully functional, Windows-based, easy-to-use computer software program that calculates life cycle cost for rigid (portland cement concrete) pavements.

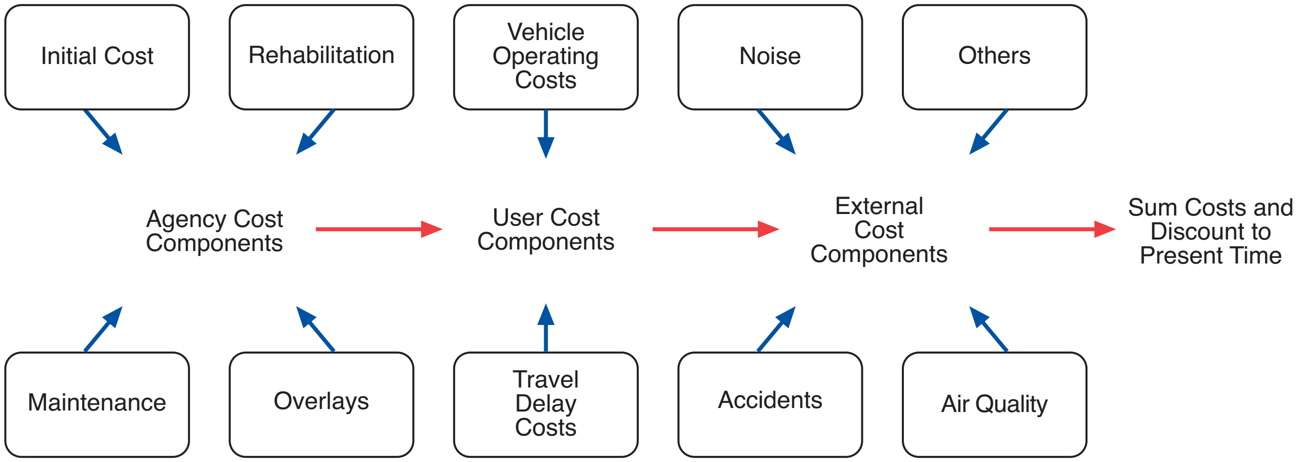

Figure 1. Cost Components of the Framework

WHAT WE FOUND...

In developing the framework for a new life cycle cost methodology, all possible aspects of pavement performance, rehabilitation, social and economic impacts, and public safety were studied, considered, and included (where appropriate). Many of these components are neither fully understood nor easily calculated, yet an attempt to quantify and valuate each aspect was made in developing the framework.

The first step in the framework is to determine the initial cost of the pavement alternative. This initial cost is based on such design inputs as pavement thickness, number of layers, aggregate type, and concrete properties.

The next step in the framework is to evaluate how well the pavement design alternative will perform over its intended lifetime. This evaluation is performed by predicting the distresses that will occur in the pavement at the end of each year in the lifetime of the pavement. If the distresses are severe enough to require attention, rehabilitation and maintenance activities will be specified and the associated costs will be calculated. In addition, the associated user costs (based on construction activities or work zones) and other external costs are calculated.

Figure 1 shows all the cost components that go into the life cycle cost analysis framework. For each year that a pavement alternative is evaluated, the maintenance and rehabilitation routine in the computer program determines whether repair work is required and, if so, what the appropriate repair costs would be; associated user costs and external costs are calculated as well.

Figure 2 is a flow chart that graphically shows the framework of the program. It depicts each step in the program, as well as the components of each of the modules in the program.

The life cycle cost framework developed in this project predicts both agency and user costs over the expected life of a pavement design alternative, but, as in all cases, the final decision regarding the selection of a preferred alternative is the responsibility of the engineer.

The computer program developed in this project is the "Rigid Pavement Life Cycle Cost Analysis Program," or RPLCCA. It is a Windows-based program - meaning that it has a graphical user interface and that it is also fairly self-explanatory and easy to use.

The user is required to enter project-level inputs, which apply to all the pavement design alternatives in the project, and alternative-specific inputs, which are individual to each specific alternative. In both cases, the inputs are grouped in specific screens with other related input variables.

Once all the inputs have been specified, the user can perform the analysis. There are two options in running the life cycle cost analysis: The user can rely on the performance equations built into the program to predict when rehabilitation and maintenance activities need to be completed, or the user can decide (specify) when and over how much of the project to perform maintenance and rehabilitation activities. In the first case, the program is specifying maintenance activities and overlays automatically; in the second case, the program is being used only as a tool to calculate the total life cycle cost.

THE RESEARCHERS RECOMMEND...

This project presented a framework, and a computer software program based on that framework, for performing life cycle cost analyses. Included in this framework are models that predict pavement performance, user costs and accident rates at work zones, and possible rehabilitation designs. Many of these models are outdated and should be replaced by more reliable models, as well as be calibrated to specific local conditions. This is especially applicable to the pavement performance models. Research should be undertaken to replace these models and to improve the predictive quality of the framework. The models currently included in the computer software can be replaced without much difficulty.

In addition to replacing the existing models that are out of date and poor predictors of pavement performance, new models should be developed that can predict the effects of increased air pollution, business impacts, noise, overlays, and other components that may be identified in future research.

A major improvement that should be undertaken is the ability to automatically calibrate the performance models using local condition survey data. This could be accomplished by allowing the engineer to enter distress information along with historical, environmental, and as-built construction data. This information, plus variability in such construction aspects as concrete strength, slab thickness, and surface roughness, should be used. Once a methodology is developed, this functionality can be integrated into the RPLCCA software.

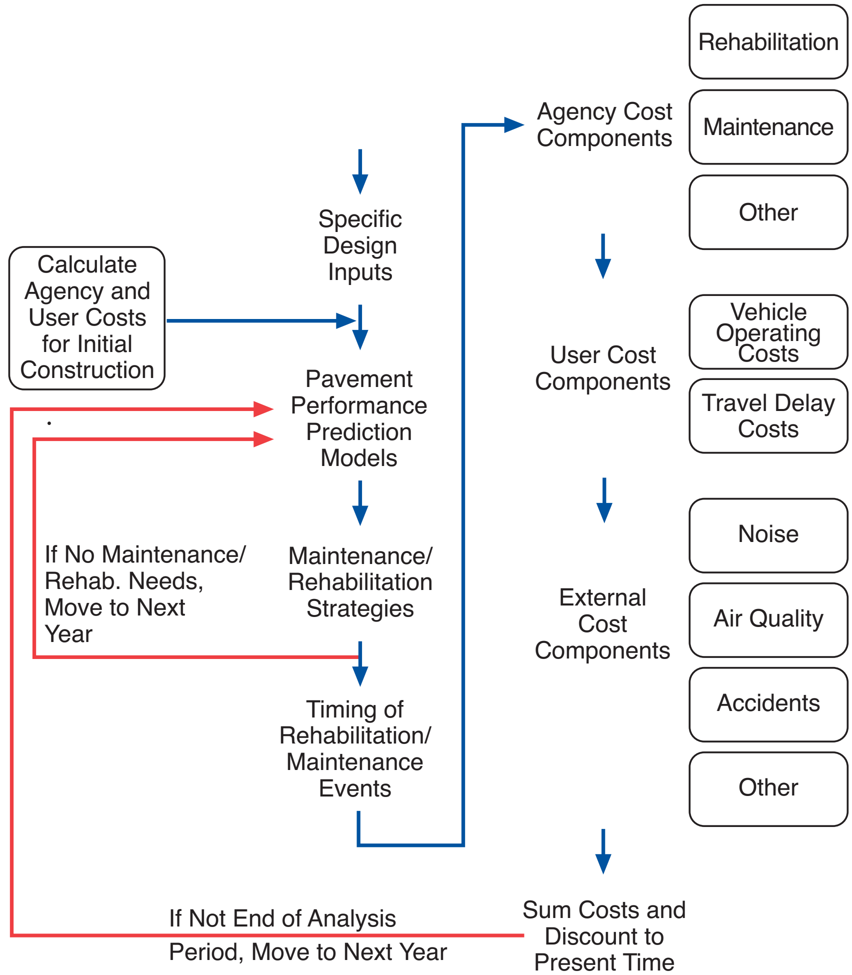

Figure 2. Comprehensive Life Cycle Cost Analysis Framework

IMPLEMENTATION RECOMMENDATIONS

The project director and researchers recommend that an implementation program for the software and users' manual be conducted within the next 12 months. This program should be comprised of three elements:

1. Training of TxDOT district engineers on the use of the software.
2. Improvements made to the software based on a wide variety of projects that reflect the diversity of district needs.
3. Distribution of a fully improved version of the software to all interested TxDOT district engineers and other parties.

The training program, essential to the implementation of this software, must be aimed at thoroughly introducing the software to all TxDOT districts.

For More Details ...

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TxDOT Project Director: Mohan Yeggoni — Resigned

The research is documented in the following reports:

Report 1739-1, *Life-Cycle Cost Analysis of Portland Cement Concrete Pavements*. Published November 2001

Report 1739-2, *A Sensitivity Analysis of the Rigid Pavement Life Cycle Cost Analysis Program*. Published September 2001

Report 1739-3, *State of the Art Computer Program for LCCA of Rigid Pavements*. Software December 2000

To obtain copies of the report, contact: CTR Library, Center for Transportation Research, phone: 512/232-3138, email: ctrlib@uts.cc.utexas.edu.

TXDOT IMPLEMENTATION STATUS
JULY 2001

Implementation of the Rigid Pavement Life Cycle Cost Analysis Program (RPLCCA) will be done through the funding of IPR 5-1869. This IPR will cover the cost to develop a Web-based training site for this software and other software developed by the research program. TxDOT engineers will be able to get trained and download the software from this site. The Web site will also have the capability to contact engineers at the Pavement Section for additional technical support.

For more information, please contact Dr. German Claros, P.E., Research and Technology Implementation Office (512) 467-3881 or email at gclaros@dot.state.tx.us.

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