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Development of Cost Effective Treatment Performance and Treatment Selection Models

INTRODUCTION

Louisiana Department of Transportation and Development (DOTD) has spent substantial financial resources on various rehabilitation and maintenance treatments to minimize the pavement distresses and improve the pavement life. Unfortunately, a full-scale performance assessment and cost-effectiveness analysis of various pavement treatments has not been conducted. A recent study completed by LTRC regarding the pavement management system (PMS) and performance modeling emphasized the importance of developing treatment performance and selection models. In this regard, LTRC initiated a three-phase research study that addresses such needs by developing rigorous treatment performance and selection models that are specific to the mission and management strategies of DOTD. The three phases are: Phase I—Review and Project Selection; Phase II—Performance Modeling and Costs and Benefits of Treatments; and Phase III—Model Integration and Training.

This final report focuses on the results of Phase I and Phase II of the study. Phase I relates to the review of district pavement treatment practices and project selection for the development of pavement treatment performance models. Phase II deals with the performance modeling and costs and benefits of treatments. The data obtained from Phase I was used to develop cost-effective pavement treatment performance and treatment selection models during Phase II of the study. Trigger values for optimum timing of pavement treatments and an approach to use the performance models cost effectively were established. All these findings are integrated in the software and training for DOTD staff, which was completed during Phase III of this study.

OBJECTIVE

The overall objective of this study was to develop pavement treatment performance models in support of cost-effective selection of pavement treatment type, project boundaries, and time of treatment. The development of the proposed models was based on historical pavement distress data available in DOTD's mainframe and PMS database.

METHODOLOGY

Two main databases were utilized for the generation of the various pavement models: (a) pavement distress data and (b) historical data. The pavement distress data were obtained through DOTD's PMS ongoing data collection program of all distress information throughout the state of Louisiana. The historical data of when projects were completed were extracted from the tracking of projects system (TOPS), project letting schedule (LETS), and design and as built files in the mainframe database. These databases were obtained from the PMS section. The two databases were merged into one main database. Once the main database was generated, all roadways where different treatment projects were implemented were identified. For each pavement project, various tables were generated to include a minimum of the information such as data source; project/section identification number (control section, log-mile, project number, etc.); route name and number (I-10, LA-1, US-90, etc.); highway functional classification (interstate, arterial, collector, local, etc.); pavement performance data (distress data, i.e. cracking, IRI, and rutting) before and after treatment; type and cost of the treatment action; type and thickness of the overlay; year/age of construction of treatments; traffic data (ADTT, ESAL, etc.); and all possible maintenance actions (crack repair, grinding and milling, etc.). The tabulated information was then used to select the various pavement sections relative to the available time series treatment performance data. The accepted projects were then divided into four pavement types including flexible pavement (ASP), composite pavement (COM), jointed concrete

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pavement (JCP), and continually reinforced concrete pavements (CRC). The pavement types were further divided based on the type of treatments including overlay, chip seal, microsurfacing, and replacement. Climatic data for each project were also generated. Statistical analysis was used to develop regression models for pavement performance models. Treatment transition matrices were used to produce treatment trigger and reset values. Based on extensive literature review and study, treatment cost benefit analyses were developed as a guideline for future treatment selection and application. Finally, based on the results and analyses of data, various conclusions and recommendation were drawn.

CONCLUSIONS

District Surveys and Data Mining

- The pavement design practices are consistent amongst the various districts. In general, the pavement conditions and the controlling distress/condition before and after treatment vary from one district to another. Furthermore, the pavement treatment trigger values used by the districts vary from one district to the next.
- The PMS databank is missing some critical data elements. These include layer thicknesses, traffic, detailed costs, material properties, and so forth. During the study, substantial time was spent by the DOTD staff and members of the research team in collecting such data.
- Life-Cycle Cost Analysis (LCCA) is not used by any district in their decision-making process. Currently, LCCA and the estimated treatment benefits are used by many states to arrive at cost-effective decisions.

Treatment Performance Models and Treatment Cost Benefits Analysis

- Pavement treatment performance prediction models were developed for IRI, rut depth, fatigue, longitudinal, and transverse cracking that simulate the measured data very well. The newly developed temperature and precipitation indices showed strong statistical significance for predicting pavement distresses. The indices along with other variables were incorporated into the pavement performance prediction models.
- A methodology for the selection of the treatment was developed. The treatment cost benefit analysis (TCBA) is based on (a) the benefits of each treatment estimated by the area under the performance curve; and (b) costs including agency and user costs along with the salvage value. The TCBA is applicable to various combinations of multiple treatments.

Calibration of Treatment Triggers, Resets, and Deduct Values

- Treatment transition matrices (T2M) were developed based on the before and after treatment data. The matrices included three estimates of the treatment benefits: treatment life, service life extension, and the remaining service life. The T2M analyses were found to be a valuable tool for evaluating the effectiveness of pavement treatments, time of treatment, and the trigger values. Detailed time dependent pavement performance data are available in the DOTD database. However, the cost data are available in a summary format only. Such data address the total cost of the entire pavement project and its associated work plan and not the treatment cost alone.
- Based on the results of the before and after treatment pavement performance and treatment benefits analyses listed in the T2M, the DOTD treatment trigger and reset values were calibrated for each road class and distress, treatment, and pavement types.
- Calibration of deduct points for cracking were based on two approaches. One was based on cracks with low, medium, and high severity levels; the second utilized the concept of the summations of cracks with all severity levels, as is in-line with MEPDG. Two sets of deduct-point models based on the previous two approaches were developed, which produced results that were consistent and coherent with the existing state-of-the-practice of DOTD.

RECOMMENDATIONS

- All costs and other pavement treatment project related data should be integrated into the PMS database for easy access. This would assist the Department engineers and staff to access the data easily and to enhance intra-communication channels.
- Since the pavement distress and condition vary considerably from one 0.1-mile long pavement segment to the next along a given project, the actual costs would also vary. It is highly recommended that DOTD require the contractor to include the treatment costs of each 0.1-mile long pavement segment in the invoice. The data should be kept in the database and used in future studies to re-calibrate the treatment trigger values based on maximizing the benefits.
- It is strongly recommended that the image data digitization process be improved by training the data digitizer and by establishing stricter quality control/quality assurance processes.
- It is strongly recommended that the proposed deduct point systems and the newly calibrated trigger values be adopted and implemented as soon as possible. These values can be used for the selection of treatment type and time and project boundaries. The newly calibrated trigger values should be published using two terminologies: the actual value of the distress and the associated deduct points. This should assist the DOTD staff to relate deduct points to distress values.
- It is strongly recommended that the newly developed pavement prediction models, the new deduct point systems, and the calibrated trigger values be periodically visited, verified, and re-calibrated as more pavement performance and cost data become available.