Research Summary

South Carolina Department of Transportation | Office of Materials and Research

Project Information

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Research Administration

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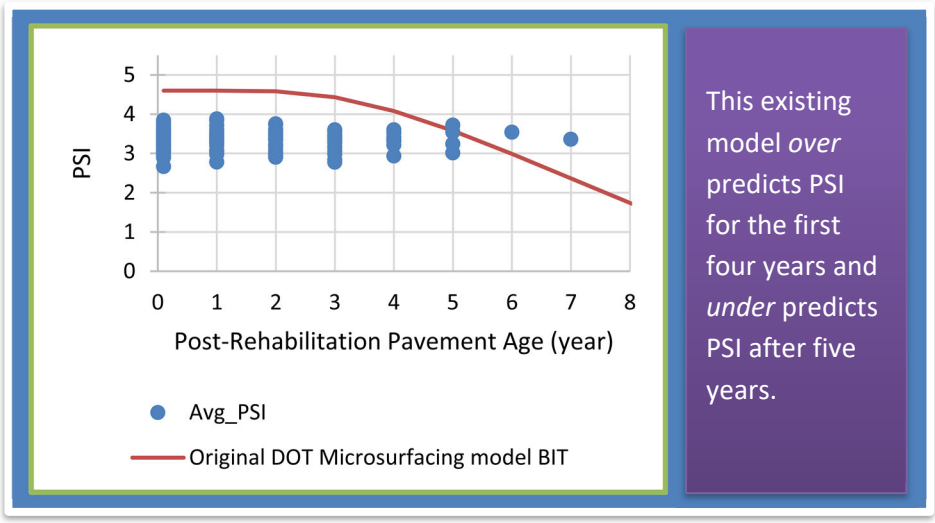
This final report is available online at:

http://www.scdot.scltap.org/projects/completed/

Pavement Performance Curves: Modeling Pavement Deterioration for SCDOT

Problem

The South Carolina Department of Transportation (SCDOT) pavement management system relies on pavement performance models to estimate future pavement conditions. Their prediction accuracy is critical to the SCDOT in optimizing the scheduling of maintenance activities and budgeting for these activities to achieve a predetermined level of performance. The pavement performance models being used by the SCDOT were formulated in 1989 by Stantec with assistance from SCDOT personnel, and they were based on engineering experience of pavement performance in South Carolina. Since their initial development, the parameters of the adopted sigmoidal, or S-shaped, function have not been updated. The original model parameters may no longer reflect current pavement degradation trends due to changes in materials, construction practices, and traffic loads, as well as changes in the technology being used to collect pavement roughness and distress data. Figure 1 shows the difference between the projected PSI over time from an existing performance model compared to calculated PSI from IRI data collected between 2000 to 2020.



Objectives

The objectives of this research project were to: 1) validate and, if necessary, update the SCDOT existing PSI and PDI prediction models for new construction, existing pavements, and treatment types most frequently utilized by the SCDOT to preserve or rehabilitate pavements on the interstates and primary routes, and 2) supplement the Highway Pavement Maintenance Application (HMPA) with a search of paper records to determine when and what preservation or rehabilitation treatments were applied to the pavements.

Research

This project focused on evaluating those models that are associated with the top five maintenance activities performed on the interstates and the top five activities performed on primary routes in the last ten years in South Carolina.

There are seven different combinations of treatment and pavement types for interstates as shown in Table 1 and there is a separate model for PSI and PDI; thus, a total of 14 interstate models were evaluated using pavement roughness and distress data collected from 2000 to 2020 on 117 road sections that span 953 lane-miles. For primary routes, consisting of only asphalt pavements, a total of ten models (five for PSI and five for PDI) were evaluated using pavement roughness and distress data collected from 294 road sections that span 1,116 lane-miles.

To evaluate the PSI and PDI models and parameters, their predicted values were compared against measured data for the applicable treatment type and pavement type. The difference was quantified using the metric Mean Absolute Percentage Error (MAPE). To develop new parameter values for each model, MATLAB's built-in curve fitting function and constrained optimization function were used. The robustness of these parameters which were developed as part of this project was validated by comparing the mean squared error (MSE) of the model when applied to training data and test data.

Results

Among the seven proposed interstate PSI models (Table 1), the relative improvement over existing models ranges between 36.74% and 75.80%, and among the seven proposed interstate PDI models (Table 1), the relative improvement ranges between 7.76% and 80.72%. Among the five proposed primary route PSI models (Table 2), the relative improvement over existing models ranges between 72.79% and 85.25%, and among the five primary route PDI models (Table 2), the relative improvement ranges between 51.69% and 75.11%. The MSE results showed that the proposed models were not overfitted to training data.

Table 1. Performance of proposed interstate models compared to existing models

Treatment / Pavement Type	Mean Absolute Percentage Error (%)				Relative Improvement	
	Current PSI model	Proposed PSI model	Current PDI model	Proposed PDI model	PSI (%)	PDI (%)
GR CON	10.20	5.23	17.46	12.33	48.71	29.35
GR CRC	11.19	7.08	9.53	7.16	36.74	24.85
OC CON	26.64	14.44	34.80	28.91	45.78	16.91
MR 2-4"+200 PSY BIT	12.71	3.74	10.35	4.85	70.56	53.12
MR 2-4"+200 PSY BOC	10.28	3.09	8.08	7.41	69.94	8.32
MR 1-2"+400 PSY BIT	12.78	3.09	87.68	16.90	75.80	80.72
MR 1-2"+400 PSY BOC	8.89	2.57	12.68	11.69	71.06	7.76

Table 2. Performance of proposed interstate models compared to existing models

Treatment / Pavement Type		Mean Absolute Percentage Error (%)				Relative Improvement	
		Current PSI	Proposed PSI	Current PDI	Proposed PDI	PSI (%)	PDI (%)
MR 1-2" BIT		32.70	7.22	14.33	6.60	77.92	53.97
MR 1-2" + 200 PSY BIT		28.06	7.63	37.18	14.60	72.79	60.73
Crack Seal	Crack Seal BIT	32.13	7.84	60.50	22.77	75.61	62.37
	US/SC default	40.70	7.84	91.49	22.77	80.75	75.11
OL 100-200 PSY BIT		29.39	4.34	11.51	5.56	85.25	51.69
Micro-surfacing BIT		36.29	6.34	38.92	16.76	82.54	56.95

Recommendations

From the findings in this project, it is recommended that the SCDOT consider updating the parameters of the 14 interstate models and 10 primary route models. Overall, the recommended PSI and PDI model parameters show a slower degradation rate compared to the current values for the first 10 years after receiving treatment. Therefore, adopting the recommended parameter values will enable the SCDOT to better identify those pavement candidates that are truly in need of repair and avoid making repairs to those that still have sufficient remaining service life.

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