Management System for Bituminous Surface Treatments in Northern Canada

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Low-cost bituminous surface treatments (BSTs) have been used since the early 1970s on northern Canadian highways to provide an improved level of service to the motoring public. This paper details the development of a management system for these surfaces. The elements of BST distress are discussed and a weighting system is developed to allow the calculation of an overall distress parameter. Criteria for the selection of rehabilitation projects in the short term are discussed. Performance models are developed using Markov and regression analysis techniques for use in life-cycle cost studies needed for the ranking of projects and establishment of multiyear operating budgets. Examples based on the BST management system showing the effects of budget cuts or different maintenance strategies are included.

The majority of Canada's northern roads are low-volume highways covering long distances between isolated communities. They present complicated problems for highway managers for the following reasons. They are costly to maintain because of isolated maintenance centers; most trips are long-distance trips requiring a higher level of service; and heavy truck traffic associated with resource development constitutes a disproportionate percentage of the total traffic.

Bituminous surface treatments (BSTs), also known as chip seals, provide an interesting alternative for northern highways. Their dust-free surfaces provide an improvement over gravel surfaces but without the costly capital outlays required for hot-mix pavements.

This paper deals with the management system developed for a network encompassing more than 2200 km of BST in northern British Columbia and the Yukon in the northwestern part of Canada. The area is characterized by an arctic climate, permafrost, and mountainous terrain.

BST management systems are similar to pavement management systems but require changes in rehabilitation philosophy. Pavement management systems for hot-mix pavements emphasize the need for timely interventions to protect the investment in the pavement while it still has a considerable salvage value. In contrast, a BST does not have any structural value, and when it reaches an unacceptable ride score, its useful life is finished.

BITUMINOUS SURFACE TREATMENTS

BSTs consist of a single application of well-graded aggregate applied directly to an asphalt film sprayed on the subgrade or base course. For the roads under consideration in this paper, the asphalt binder used for the most part is an HF-250S (a high-float emulsion) with a typical application rate of 3.25 L/m^2 and an aggregate application rate of 45 kg/m^2.

The three types of surfacing for road structures used in northern Canada are as follows:

- **Class 1**: BST applied directly to unimproved subgrades. These roads are short-lived structures in which a BST is the most economical from of dust control. Truck volumes are generally low.
- **Class 2**: BST applied on top to 75 to 150 mm of crushed gravel. These roads are light-duty pavements serving moderate traffic volumes with few trucks and provide an improved level of service over Class 1 BSTs.
- **Class 3**: Staged construction in which full depths of base and subbase are initially placed with a BST surface. Service volumes range between 300 and 700 vehicles per day. When traffic volumes warrant and budgets permit, the BST is replaced with asphalt concrete.

BST MANAGEMENT SYSTEMS

The key to the BST management system is the collection and analysis of BST distresses. BST sections (less than 10 km long) are visually rated by a panel. A descriptive table of individual distress ratings is used as well as training sessions to ensure consistency of the ratings. Each type of distress in Table 1 is evaluated on a scale of 1 to 10 based on the extent and severity of distress. The rating panel also recommends a rehabilitation strategy that may or may not be followed depending on funding and priorities.

At the project level, sections needing rehabilitation are identified for the following year's program. At the network level, a generalized model of BST performance permits the ranking and optimization of strategies needed for long-term budgeting and planning.

Project-Level Analysis

Before the implementation of the BST management system, projects were selected on criteria ranging from "this BST looks thin" to "this section is x years old," resulting in a program that often reflected the personalities involved rather than need.

With the adoption of the BST management system, the program became technically sound and more uniform and cost-effective. An effort is now made to ensure

TABLE 1 Weighting Values Used to Calculate BCI Based on Extent and Severity of Individual Distresses

DISTRESS	WEIGHTING VALUE USED TO CALCULATE BCI
Ravelling	1.0
Bleeding	1.0
Rutting	1.0
Subgrade Failure	1.5
Shoulder Disintegration	0.5
Potholes	1.3
Patching	1.0
Cracking	0.5
Distortions	1.2
Corrugations	0.4
Streaking	0.3
Joints	0.3

that the maintenance supervisors still have input because as front-line mangers they provide an important evaluation of section performance and rehabilitation techniques.

Ride score is the predominant distress that prompts rehabilitation projects, but severe bleeding, rutting, raveling, potholes, and subgrade failures can also prompt projects.

The sections listed for rehabilitation are then developed into a program. Consideration included in program development are the following:

- Construction economics dictates that a mediocre section located between two poor sections be resealed at the same time as the poor sections, given that forces must be mobilized from considerable distances.
- An evaluation of the distress and its environment is required. If a section showing considerable bleeding distress is in otherwise good condition, a decision to post Slippery When Wet signs might be adequate in a given locale but unacceptable in another that has warmer summers and more traffic.
- If a section needs to be reconstructed for geometric or drainage reasons within 2 or 3 years, an evaluation is made of whether the existing BST surface can be maintained at a minimum level of service.

Network Analysis

The key to ranking rehabilitation sections and developing long-term strategies is reliable performance modeling. A review of the data indicated that at the network level a composite index (BCI) gave a better indication of overall performance than ride score:

$$\text{BCI} = 5\ (\Sigma_{i=1}^{n}\ w_i(s_i)/10 + \text{ride score})$$

where w_i is a weighting value representing the relative weight of each distress (Table 1) and s_i is the severity and extent of distress expressed on a scale from 0 to 10.

Figure 1 shows the average BCI as a function of age for the BST classes. A regression model is used for the Class 3 data and Markov models (*1*) are used for Classes 1 and 2. Markov models account for the "survival-of-the fittest" limitations in the data, particularly for those BSTs with a short life span. For example, the BCI value of 57 obtained by taking the average BCI for 4-year-old Class 1 BSTs (Figure 1) neglects those 4-year-old BSTs that have failed and have already been rehabilitated. If these sections are considered, the data would shift downward closer to the Markov prediction curve.

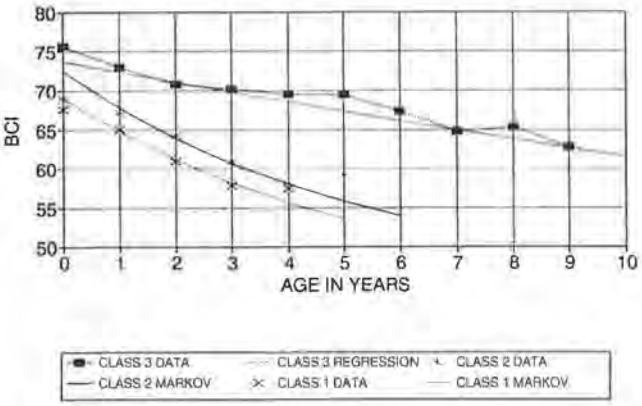

FIGURE 1 Performance curves for BST classes.

A statistical analysis of the calculated BCIs and the rating panel recommendations along with life-cycle cost analyses indicated that the terminal BCI was on the order of 65 for Class 3 BSTs and 60 for Classes 1 and 2. Using this information and Figure 1, it can be concluded that the average life of a Class 3 BST is 7 years, 3.5 years for Class 2, and 2.5 years for Class 1.

MANAGE (Figure 2) is a computer program designed by Public Works and Government Services Canada to calculate life-cycle costs of BSTs. The user inputs budget levels and the program calculates user costs, maintenance and rehabilitation costs, and cost-benefit ratios.

Shown here are two "what-if" examples using MANAGE: an evaluation of maintenance strategies and the effect of decreasing annual maintenance budgets.

For Class 3 BSTs, only a limited number of options exist:

- Reversion of the surface to gravel.
- Overlaying with another BST without correcting the ride score, or
- Ripping up the BST (increasing the cost by 75 percent), reworking the base course, and reapplying a new BST, thereby restoring the ride score to its initial state.

As performance models were developed, it was noted that unlike pavement, a BST overlay, because of its minimal thickness, did not restore ride score. Other deficiencies were corrected, but without a change in the ride score, the efficiency of protecting the initial investment was questionable.

Cost-benefit ratios were calculated using MANAGE by considering the base case as a reversion of the BST to gravel. An examination of Figure 3 indicates that for all budget levels the option of ripping up and reapplying a BST had higher cost-benefit ratios than the reapplication option alone, despite the higher initial costs associated with the ripping-up option.

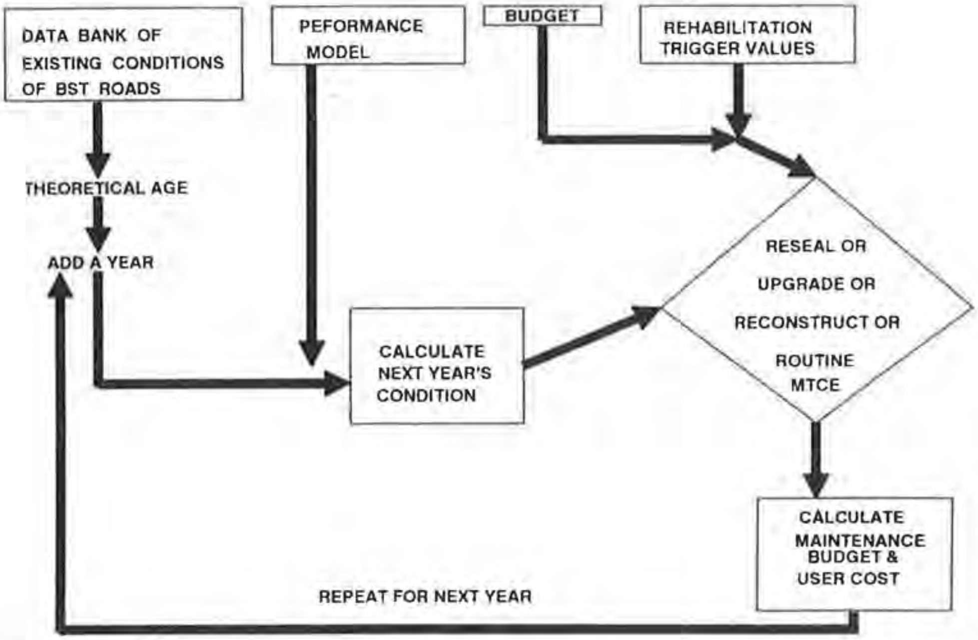

FIGURE 2 Schematic diagram of MANAGE.

For personnel used to working with conventional pavements, ripping up structurally sound BST required a major change in outlook. The BST management system was used to substantiate such a decision at all management levels.

Figure 3 also provides insight into long-term rehabilitation budgets for Class 3 BSTs. The more money spent on rehabilitation (to the maximum limit established by rehabilitating BSTs only when the BCI fell below 65), the higher the cost-benefit ratios.

Figure 4 presents the data in a different format. BCIs were calculated for 33, 50, 66, 75, 90, and 100 percent of a budget based on rehabilitating BSTs when the BCI falls below 65. Figure 4 indicates the number of sections below an acceptable standard in any given year. At 90 percent of the most efficient budget, there is little difference in the number of deficient sections, but below the 90 percent level the number of deficient sections increased dramatically with decreasing budgets.

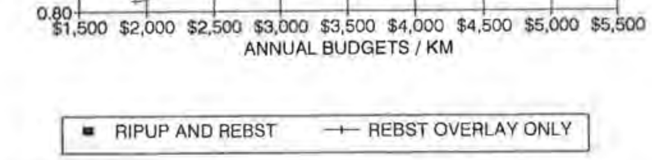

FIGURE 3 Benefit/cost ratios for overlay and rip-up/reapply BST options.

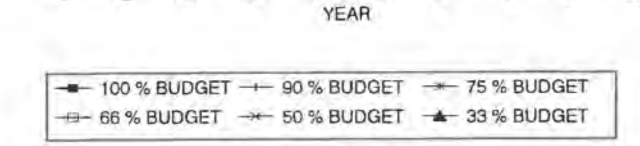

FIGURE 4 Percentage of sections showing unacceptable performance.

SUMMARY AND CONCLUSIONS

A BST management system has been developed for BST roads in northern Canada. At the project level, the system identifies sections needing rehabilitation based on unacceptable levels of rutting, bleeding, distortions, raveling, potholes, and ride score.

For multiyear plans, the system allowed the development of performance curves with an estimate of service lives, which in turn permitted an evaluation of rehabilitation strategies.

REFERENCE

1. Cook, W. D., and A. Kazakor. Pavement Performance Prediction and Risk Modeling in Rehabilitation Budget Planning: A Markovian Approach. *Proc, Second International Conference on Managing Pavements*, Toronto, Ontario, Canada, 1987.
