Choosing Cost-Effective Maintenance

G.J. CHONG, W.A. PHANG, AND F.W. JEWER

A project is described that was conducted under the Pavement Maintenance Strategies Task Force of the Ontario Ministry of Transportation and Communications. Its objectives were (a) to develop guidelines for corrective pavement maintenance to be used by maintenance patrol staff that suggest a method for evaluating pavement distress and the appropriate cost-effective and practical maintenance treatment alternative and (b) to conduct a pilot test of the developed guide to verify the procedures to be carried out in full later. The guidelines were developed from existing standards for pavement maintenance quality and related management systems data combined with the judgment of individuals experienced in the fields of pavement design and evaluation, construction, and maintenance. Emphasis was on the collection of subjective performance data on various maintenance treatments through personal interviews with experienced maintenance personnel. This material was incorporated into a working copy of the pavement maintenance guidelines. The pilot test was based on the working copy and a combination of an audiovisual presentation and individual instruction of selected maintenance patrol staff. This was followed by a return visit to patrols for interviews to obtain comments on the usefulness, ease of use, and validity of action levels described in the guidelines. The pilot test was conducted in 14 patrols in the five regions of the province. The results obtained confirmed that the working copy of the pavement maintenance guidelines could, with some minor changes, be adopted for full use in the province.

As the television commercial unfolds, the richly dressed elderly lady with the chauffeur and the Mercedes-Benz in the background stresses the point that her enviable life-style was achieved through shrewd investment in material goods that are of lasting value. Furthermore, she maintains her affluent life-style by protecting her investments against undue depreciation through a program of cost-effective maintenance. She has chosen Speedy Muffler King to do the corrective maintenance necessary on her car's muffler because of their lifetime guarantee. Her message is simple: Protect your investment by timely maintenance at the cheapest cost or suffer the consequence of reduced resources. This message, a perfectly sound management practice at any time, is particularly fitting in this time of high inflation and fiscal restraint. The extensive highway system in Ontario, like the lady's fine car, has been a very sound investment because benefits accrued to the public have been worth many times the money spent. The system represents billions of dollars of public funds and is a valuable asset that must be protected against unwarranted deterioration that can affect the useful service life as well as the quality of service offered the public. In addition, emphasis now is not only to protect but to prolong the pavement service life, because continuing budgetary constraints will surely result in the curtailment and postponement of capital expenditures for the highway system.

In order to achieve the twin objectives of protecting and prolonging the service life of the pavement in the system, a maintenance program that promotes timely maintenance and fosters cost-effectiveness is needed. In Ontario, a systematic approach to the total maintenance program has recently been developed that tries to incorporate these needs. The two principal features of the approach are these:

1. Pavement quality standards for the maintenance management system are being revised to introduce more-uniform methods of deficiency identification and to foster corrective actions that are estimated to be most cost-effective, i.e., corrective maintenance; and
2. Complementing these deficiency-corrective actions are the courses of action that anticipate the occurrence of deficiencies or are intended to retard progression of defects, i.e., preventive maintenance.

The corrective-maintenance measures are carried out to protect the integrity and safety requirements of the pavement system, and the development and implementation of this corrective-maintenance management process is the subject of this paper. The preventive-maintenance feature of the systematic approach deals with those actions that stave off the inevitable consequences of age and traffic. Development in this area is described elsewhere (1).

OBJECTIVES

The basic objectives of this study were as follows:

1. The development of a corrective-maintenance guide to be used in identifying the most suitable type of maintenance treatment for any given pavement condition and the most appropriate timing of the application,
2. The development of a process for evaluating the cost-effectiveness of various maintenance treatments, and
3. Pilot testing to confirm the systematic management process of corrective maintenance represented by this guide as the proper and effective methodology for full implementation.

APPROACH

The chief aim of the guide is to help patrol staff, patrol supervisors, and district maintenance staff to identify the most cost-effective maintenance treatment for any given pavement distress problem. Therefore, this guide must include four basic elements:

1. A simple and functional system of identifying and describing the distress problem,
2. A list of appropriate alternative solutions to correct the problem,
3. A standardized methodology for cost-effectiveness comparison to generate the most desirable solution, and
4. A standard for quantity and quality of work output for each possible solution.

There previously existed approved ministry methods to identify and describe various kinds of pavement distress that were used in assessing pavement condition ratings (2,3) as well as maintenance quality and performance standards (4). These methods and standards served as the basis for formulating this guide.

The general approach used for the project can be described as follows:

1. Use the existing methods and standards to formulate a functional but comprehensive format that contains the four basic elements outlined above and obtain estimates of life of treatments by interviewing experienced maintenance staff,
2. Verify the functional practicality of this format through personal interviews of experienced personnel,
3. Formulate a working guide for pilot testing and verification, and
4. Assess the pilot-test results to establish

the final product, the publication Pavement Maintenance Guidelines: Distresses, Maintenance Alternatives and Performance Standards (5).

FORMULATING THE GUIDE

The aim is to provide a practical guide for our district maintenance field staff to use in their day-to-day operations. Use of this guide does not require our field staff to produce an inventory of pavement distress. It is not a full-blown pavement management system, but it is an important part of our overall pavement maintenance strategies.

Although it is not practical to reproduce the guide here, a typical example will enable the reader to comprehend the structure of the guide--treatment of alligator cracking.

Figure 1. Alligator cracking (extract from pavement maintenance guide).

Description:	Cracks form a network of multi-sided (polygon) blocks resembling the skin of an alligator. The block size can range from 5 to 10 cm to about 50 cm. The alligatored area may or may not be accompanied by distortion in the form of depression, and may occur anywhere on the pavement surface.	
Possible causes:	1. Insufficient pavement strength. 2. Poor base drainage and stiff or brittle asphalt mix at cold temperature.	
Severity:	**Class.**	**Guidelines** (Base on appearance and surface distortion)
	Slight	Alligator pattern established with corners of polygon blocks fracturing
	Moderate	Alligator pattern established with spalling of polygon blocks
	Severe	Polygon blocks begin to lift; may or may not involve potholes.
Density:	*Local:*	Less than 30% of pavement surface affected; distress spotted over localized areas only.
	General:	More than 30% of pavement surface affected; distress spotted evenly over entire length of pavement section.

Pavement Condition Survey Scheme

The first requirement of the guide is a system of identification and description of various kinds of pavement distress. This system must be simple and direct because it is not the function of the district maintenance field staff to trace the performance history of the highway pavements or to evaluate the pavement performance periodically to satisfy a data bank. For field staff, it is only important that they provide detailed descriptions of the extent of occurrence (density) and severity of any specific distress so that an appropriate maintenance treatment can be chosen.

Therefore, the simple scheme is based on work descriptions and action-oriented classification scales because (a) word descriptions are on a value scale in common everyday use, (b) the surveyor assesses and describes conditions in familiar terms, (c) the surveyor is only concerned about what action to take in view of the density and severity of the distress, and (d) the word descriptions help directly in identifying appropriate alternative maintenance treatments.

The terms "local" and "general" are used to describe the density of any pavement distress as follows: "local" means that less than 30 percent of the pavement surface area is affected by distress and that distress is spotted over localized areas only; "general" means that more than 30 percent of the pavement area is affected by distress and that the distress is spotted evenly over the entire length of the pavement section.

Eight types of distress for flexible pavements and 10 types of distress for rigid pavements are included in the guide. The extract from the guide shown in Figure 1 illustrates a typical format used

Table 1. Example of maintenance treatment alternatives: treatments for alligator cracking.

Evaluation			Maintenance Function Classification[a]		
Severity	Density	Recommended Maintenance Treatment Alternative	Routine Patrol	Nonpatrol	Expected Effective Life (years)
Slight	Local	No action			
	General	No action but monitor closely for future development			
Moderate	Local	Spray patch	1004		1
		Cold-mix patch	1001		1
		Hot-mix patch	1001 1002	1002	4
		Hot-mix patch for multilanes		1002	4
	General	Same as above but notify district office of situation and maintain close monitoring			
Severe	Local	Cold-mix patch	1001		0.5
		Hot-mix patch	1001 1002	1002	3
		Excavate; granular and hot-mix patch	1002	1002	7
		Improve drainage (additional)	-[b]	-[b]	
	General	Hot-mix patch for highways with AADT < 2000 and notify district office	1002		2
		Mulch for AADT < 2000		1014	3
		Granular lift and surface treatment for highways with AADT < 2000		1017	4
		Hot-mix patch over selected areas and notify district office for further action for highways with AADT > 2000	1002	1002	3

Note: AADT = average annual daily traffic.

[a]Numbers listed correspond to maintenance performance standards. [b]Contract work only.

Figure 2. Example of maintenance performance standard.

M-1002

MACHINE PATCHING
PLACING AND SPREADING

DESCRIPTION			
The machine placing and spreading of premixed asphaltic materials (hot or cold mix) to repair major surface defects such as depressions, bumps and other pavement defects. Includes preparation of patching area and compaction.			
ROAD TYPE HOT MIX MULTI-LANE	HOT MIX 2-3 LANE	MULCH 2-LANE	ALTERNATIVE METHOD FOR ALL ROAD TYPES
CREW SIZE 1-Grader Opr. 1-Roller Opr. 2-Shovellers/Rakers 1 to 5-Drivers (Asphalt Supply) 1 to 2-Drivers (Traffic Cont.)	1-Grader Opr. 1-Roller Opr. 2-Shovellers/Rakers 1 to 5-Drivers (Asphalt Supply) 1 to 3-Flagmen (Traffic Cont.)	1-Grader Opr. 1-Roller Opr. 2-Shovellers/Rakers 1 to 5-Drivers (Asphalt Supply) 1 to 3-Flagmen (Traffic Cont.)	2-Screed Oprs. 1-Roller Opr. 2-Shovellers/Rakers 1 to 5-Drivers (Asphalt Supply) 1 to 2-Drivers or 1 to 3-Flagmen (Traffic Cont.)
EQUIPMENT 1-Crew Carrier 1-Grader 1-Roller 1 to 5-Dump Trucks 1 or 2-Sign Trucks or Sign Trailers	1-Crew Carrier 1-Grader 1-Roller 1 to 5-Dump Trucks	1-Crew Carrier 1-Grader 1-Roller 1 to 5-Dump Trucks	1-Crew Carrier 1-Tailgate Spreader 1-Roller 1 to 5 Dump Trucks 1 to 2 Sign Trucks/ Sign Trailers
MATERIALS Hot or Cold Mix	Hot or Cold Mix	Cold Mix	Hot Mix
ACCOMPLISHMENT Tonnes	Tonnes	Tonnes	Tonnes
MANHOURS PER ACCOMPLISHMENT 0.7 - 2	0.7 - 2	0.7 - 2	
ACCOMPLISHMENT PER DAY 105 - 35	105 - 35	105 - 35	

to describe a pavement distress, in this case alligator cracking.

Maintenance Treatment Alternatives

Maintenance treatment alternatives run from simple spray patching to full-width machine-laid hot-mix patching and even to full-width single-course hot-mix resurfacing. However, in spite of the many maintenance treatments available, there is a more-limited selection suitable for correcting any particular distress condition. This is because the appropriateness of the treatment depends on the distress, the stage to which it has progressed, the timing of the treatment, the class of road and type of traffic, the traffic volume, the availability of materials, equipment, and funds, and so forth. Nevertheless, it is useful to have a uniform approach to the evaluation and description of pavement distress that is coordinated with corresponding sets of suitable maintenance alternatives from which effective solutions may be chosen.

Table 1 illustrates how appropriate maintenance treatments are identified based on the evaluation of severity and density of the distress (columns 1 and 2, Table 1). If, for example, moderate local alligator cracking is the condition, the alternatives suggested are spray patching, cold-mix patching, hot-mix patching, or hot-mix patching for multilanes.

Maintenance Treatment Performance Standard

Maintenance treatment alternatives can vary from work that can be done by patrol and equipment crews to work that needs specialized equipment and skilled personnel and to full-scale contract work. In general, routine corrective and small-scale preventive-maintenance work is usually handled by patrol-sized crews. Capability is generally dependent on the size of the job and on equipment and personnel available.

For these routine corrective and small-scale preventive-maintenance activities, performance standards are available to help the district maintenance staff plan, budget, and schedule their work by giving them necessary information to estimate costs, to estimate production quantities and material needs, to schedule workers and equipment for the job, and to provide the procedural steps that make up the maintenance method to ensure work quality.

For each of the alternative maintenance treatments listed in Table 1, there are maintenance performance standard numbers classified either as routine patrol or as nonpatrol. When the number listed is classed as "routine patrol", this means that the work is within the capability of average maintenance patrol forces. A listing under "nonpatrol" conveys the message that additional resources are needed and

Table 2. Example of labor cost chart for calculating unit cost of surface repairs.

Men in Crew	Hours Worked on Operation							
	1	2	3	4	5	6	7	8
1	8.05	16.10	24.15	32.20	40.25	48.30	56.35	64.40
2	16.10	32.20	48.30	64.40	80.50	96.60	112.70	128.80
3	24.15	48.30	72.45	96.60	120.75	144.90	169.05	193.20
4	32.20	64.40	96.60	128.80	161.00	193.20	225.40	257.60
5	40.25	80.50	120.75	161.00	201.25	241.50	281.75	322.00
6	48.30	96.60	144.20	193.20	241.50	289.80	338.10	386.40
7	56.35	112.70	169.05	225.40	281.75	338.10	304.45	450.80
8	64.40	128.80	193.20	257.60	322.00	386.40	450.80	515.20
9	72.45	144.90	217.35	289.80	362.25	434.70	507.15	579.60
10	80.50	161.00	241.50	322.00	402.50	483.00	563.50	644.00

Note: Crew cost based on $8.05/h standard provincial labor rate for 1979-1980.

Figure 3. Extract from pavement maintenance guide that shows method for machine patching.

Recommended Method

1. Set up safety devices and signs in accordance with "Traffic Control Manual for Highway Work Operations."
2. Remove any loose or broken sections of existing pavement extending into the good pavement about 30 cm. Clean up the patch area, removing all loose material and water.
3. Compact the subgrade, if necessary.
4. Apply a tack coat at each end of the patch and along the centreline joint when one lane is to be patched.
5. Place and spread the mix with a grader or a tailgate spreader.
6. Smooth and feather out the edges of the patch.
7. Be sure that enough mix material has been placed to obtain the proper grade and cross-fall.
8. Compact the patch area, rolling progressively from the high side toward the low side, overlapping a few centimetres on each pass.

Note: Joints at the ends of the patch should be spray patched at a later date.

Procedures for Placing and Spreading Hot or Cold Mix Asphalt (Machine Patching)

must be provided either by combining patrol forces or by contracting out the work.

Cost-Effectiveness

The mission of the maintenance staff is to select the most cost-effective maintenance treatment appropriate to the particular situation, to ascertain its practicality, and to carry out the maintenance.

Cost comparison of maintenance alternatives is best made by using their equivalent annual cost, which is based on the cost of doing the job and the expected life of the work accomplished. The performance standards provide the estimated cost of each maintenance alternative chosen, which is the basic unit cost. That is,

(Personnel + equipment + materials)/(accomplishment per day) = unit cost.

To obtain the equivalent annual cost, which is the indicator used to evaluate cost-effectiveness, the unit cost is matched against the life expectancy of the maintenance treatment. That is,

Unit cost/(expected life of alternative in years) = equivalent annual cost.

Expected life is defined as the time in years (or months or even weeks) before the distress treated reappears and progresses to the condition that existed prior to the treatment. The expected life given for each maintenance alternative under a particular situation represents the median value of estimates obtained through interviews with experienced maintenance staff.

Table 3. Preidentified equipment listing and rental rates.

Description	MTC Equipment Code	Current (1979) Rental Rates ($/h)
Half-ton pickup	0003	3.00
Three-quarter-ton pickup	0006	3.10
Three-quarter-ton five-man cab	0006	3.10
Three-ton dump	0023	3.90
Four-ton dump	0023	4.05
Five-ton dump	0031	7.10
	0041	8.40
	0051	
	0052	9.05
Grader (100 hp)	0105	9.95
Portable roller	0558	8.70
	0562	5.45
	0564	14.70
Loader (1.25 yd^3)	0430	8.20
Asphalt tailgate spreader	0719	7.65
Maintenance kettle	0420	7.35
Rubber/asphalt kettle	0422	13.10
Concrete saw (router)	0630	9.80
Asphalt distributer	0892	17.45[a]
Pulvi-mixer	0461	22.90
	0462	18.55
Aggregate spreader	0721	28.35
Wobble-wheel roller	0559	13.65
Steel-wheel roller	0563	10.90
	0566	16.35
	0567	16.35
Broom-towed type	0186	15.90
Air compressor	0232	7.65
	0239	7.65
Jackhammer	0360	2.40
Sign-truck unit	0655	3.80
Sign trailer	0861	7.35

[a] Add to truck rate.

Figure 4. Cost calculation for machine patching: hot mix.

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO
MAINTENANCE PRODUCTION UNIT COST AND ANNUAL COST

OPERATION
NUMBER 1002
ACTIVITY Hot Mix Patching

Alligator Cracking; Moderate, Local

CREW SIZE

POSITION	CLASS	No. MEN	RATE	HOURS / DAY	COST	% OF TOTAL
TOTAL		9	8.05	72	$579.60	

EQUIPMENT COMPLEMENT

TYPE	No. PCS.	RATE	HOURS / DAY	COST	% OF TOTAL
Crew carrier 3/4 T - 5M	1	$3.10	6	$ 18.60	
Dump truck 5 T	3	9.05	18	162.90	
Grader – 100 H.P.	1	9.95	6	59.70	
Roller	1	14.70	6	88.20	
TOTAL				$329.40	

MATERIAL

TYPE	QUANT. / DAY	UNIT	COST / UNIT	COST	% OF TOTAL
	70	t	$2004	$1402.80	
TOTAL				$1402.80	

GRAND TOTAL COST PER DAY $2311.80

ACCOMPLISHMENT : PER DAY (APPROX.)	70 t	
PRODUCTION RATE : MAN-HOURS PER ACCOMPLISHMENT UNIT	1.029	ACCOMPLISHMENT MAN - HOURS
UNIT COST : DOLLARS PER ACCOMPLISHMENT UNIT	$ 33.03	TOTAL COST ACCOMPLISHMENT
ANNUAL COST : DOLLARS PER YEAR	$198.18	UNIT COST EXPECTED LIFE

REMARKS

Section of Highway to be prepared 30 km.
Std. Planning Value Applied;
.8t/E2L km.
30 km x .8 t = 24 t Reqd.
24 t x $33.03 = $792.72

Expected life of repair four years

The last column in Table 1 gives four years as the life for hot-mix patching (performance standards 1001 and 1002) for correction of moderate local alligator cracking and one year for either cold-mix patching or spray patching. The details of the comparison of cost-effectiveness for these alternatives in this situation are given below.

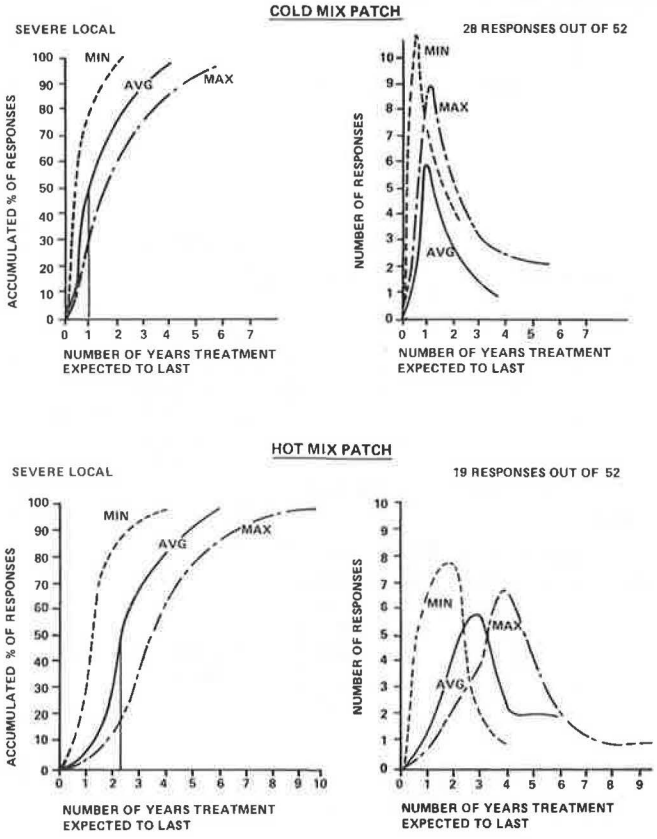
In determining the most cost-effective maintenance treatment available, the cost of every recommended alternative must be compared: personnel, equipment, and materials are the major components that determine the cost of each alternative. The following must be calculated:

1. The required crew size, equipment, and materials are stated in the maintenance performance standards (Figure 2). This standard (M-1002) suggests a crew of 6-12 workers. Equipment consists of one crew carrier, one grader or tailgate spreader, one roller, one to five dump trucks, and one or two sign trucks or trailers. The materials are cold or hot mix. The recommended method, illustrated by a photograph, is given in Figure 3.
2. Examples of a labor cost chart and equipment rental rates for calculating the unit cost of surface repairs (in dollars per hour) are provided in Tables 2 and 3. In hot-mix patching, a crew size of, say, nine workers will cost $579.60/day (Table 2). The cost of equipment rental is computed by summing the cost of equipment per day. The cost of a piece of equipment is dependent on rental rates and the number of hours it is used per day. As an example, one crew carrier used for 6 h/day at rental rates of $3.10/h will cost $18 60/day. The cost of materials varies according to tender or locality. The cost of these items is recorded on a form similar to that in Figure 4.
3. The total cost of maintenance per day is the total of the crew cost, equipment cost, and material cost per day.
4. The accomplishment per day is the result of processed materials per day.
5. The unit cost in dollars per accomplishment unit is calculated as follows:

Total cost/accomplishment = unit cost.

6. The annual cost in dollars per year is calculated from

Figure 5. Expected effective life of maintenance for distortion of severe local condition.



Unit cost/expected life = annual cost.

Similar cost calculations are also recorded for the alternative treatments of cold-mix patching and spray patching.

Following the completion of these calculations for each alternative, a cost comparison may be made and the most cost-effective alternative is made evident. The comparison in this case is in favor of machine patching by using hot mix. However, the urgency of maintenance; the availability of materials, equipment, and funds; and a variety of other factors should be considered before a decision is made as to maintenance treatment.

VERIFICATION OF FORMAT

A draft format of the pavement distress manifestations and maintenance treatment alternatives was prepared as described earlier. In this draft it was suggested that certain maintenance treatments and alternatives are suitable for various conditions of pavement distress (Table 1). The very significant item that was missing from the draft was the expected effective life of a maintenance treatment.

Methodology

This draft and a questionnaire were presented to a selected group of staff members within the ministry and responses were later solicited during individual interviews. The candidates interviewed were chosen for their present and past experiences in pavement maintenance. In all, more than 50 candidates were selected; each had had maintenance-related experience of more than 20 years, i.e., an aggregate of more than 1000 person years of experience. Information obtained was assembled and analyzed to establish the processes in the pavement maintenance guide, to verify the suitability of alternative treatments, and to provide the estimates of expected effective life for each treatment and condition.

Questionnaire Results

Responses to the questionnaires indicated that, in general, the format presented is efficient, understandable, and simple for use as a management tool in the hands of the field maintenance staff. Overall, only minor changes, additions, and deletions were required.

The missing expected effective life of the various maintenance treatments was provided by the experienced personnel. The expected life given for each maintenance treatment under a particular situation represents the median value of estimates provided by the subjects interviewed. An example of the analysis is given in Figure 5.

It should be clearly understood, however, that the expected life based on past experience is provided at this time only as a guide. An organized monitoring program will be undertaken to verify many of these estimates. However, when it is realized that for rigid pavements there were 32 treatment situations for which estimates of expected lifetimes were needed and that 102 estimates were needed for flexible pavements (a total of 134 estimated lifetimes), this verification task appears formidable.

The results were assembled and a working copy of the pavement maintenance guide was established for pilot testing.

WORKING COPY

The working copy consisted essentially of three sections. The first told the patrol worker how to use the guide to identify the extent and severity of any given type of distress, how to use the guide to identify suitable alternative maintenance treatments for the specific condition, how to calculate which of the alternatives is the most cost-effective (provided it is an activity within the worker's scope), and finally how to report the condition if the remedial measures are outside of the worker's capability.

The second section consisted of types of distress and maintenance alternatives for both flexible and rigid pavements. The types of distress for flexible pavements, which are adequately illustrated by means of photographs, are (a) raveling and streaking; (b) flushing; (c) slippery surface; (d) potholes; (e) rippling and shoving; (f) wheel-track rutting; (g) distortion (sagging, dishing, depression, settlement, bump and frost-related bump, and excessive crown); and (h) cracking (longitudinal and transverse, map, progressive edge and edge breaking, and alligator). The maintenance alternatives for these distresses are manual patching by using cold mix or hot mix, machine patching by using cold mix or hot mix, crack filling with or without routing, spray patching by using liquid asphalt, mulching pavement by using grader mixing or spreader mixing, treating the surface, cold planing, heater planing, burning and sealing, and hot-mix patching by using recycled asphaltic materials.

The types of distress for rigid pavements and their corresponding maintenance alternatives are also adequately illustrated in the guide. Types of distress for shoulder and surface drainage are also described and illustrated by photographs, but no treatments are given. This chapter is simply a reminder of the importance of shoulder and surface

drainage as related to pavement performance service life.

The third and final section of the guidelines contains the performance standards. Each standard provides information on required crew size, equipment, materials, the unit of accomplishment, the person hours per unit of accomplishment, and the accomplishment per day. Further, the standard provides a step-by-step fully illustrated description of the method used to carry out the treatment.

PILOT TESTING

The working copy of the pavement maintenance guidelines, which incorporated all the recommended changes, was printed for distribution in the pilot study. The main objectives of the pilot study were to determine the practicality of the processes, the suitability of the treatments, and the success of the cost-effectiveness approach and to gauge the overall impression of the maintenance patrols to the greater recognition given to maintenance through these processes.

Approach

A small number (14) of maintenance patrols was selected in different geographical areas of the province (five regions) to provide equal representation. Instruction was provided through an audiovisual presentation to the patrol workers and patrol supervisory staff that described the proposed guide and its use. This was followed by a question-and-answer session. Use of this guide as a management tool was examined by the selected maintenance staffs. Last, the effectiveness of this guide was verified through questionnaires and individually conducted personal interviews.

Results of Pilot Testing

The results indicated that, in general, the guide in its existing working-copy format required only minor changes. Highlights of the questionnaire results are as follows:

1. The guide is easy to use and understand.
2. The guide provides uniformity in evaluation processes and management methodology.
3. The guide offers a simple and functional system of identifying and describing the distress problems.
4. The guide offers the appropriate maintenance alternatives for the types of distress identified.
5. The guide offers an easy-to-use methodology for comparing and choosing the most cost-effective maintenance alternative for the distress problem.
6. At the patrol and patrol-supervisory levels, there is a developing awareness of their responsibility for choosing practical and cost-effective treatments and a sure knowledge of their role in the task of pavement maintenance.

APPLICATION OF FINDINGS

The findings from the pilot testing project were assembled to effect the required changes in the working copy. The result is Pavement Maintenance Guidelines: Distresses, Maintenance Alternatives and Performance Standards (5). Full use of this guide by the field maintenance staff is being carried out by the ministry's maintenance branch.

FUTURE RESEARCH

Studies to provide performance data on maintenance alternatives are needed to verify the life estimates used in the guide that were obtained through personal interviews of experienced maintenance staff. Monitoring programs are also needed for work methodologies, materials, and equipment to improve maintenance techniques and thus lengthen the effective life of the treatment. New maintenance techniques and equipment and new materials that become available should be examined periodically in the future to extend the usefulness of the guidelines.

REFERENCES

1. W.A. Phang and W. Blum. Preventive Pavement Maintenance Concepts. Ontario Ministry of Transportation and Communications, Downsview, 1980.
2. G.J. Chong, W.A. Phang, and G.A. Wrong. Manual for Condition Rating of Flexible Pavements: Distress Manifestations. Ontario Ministry of Transportation and Communications, Downsview, Aug. 1975.
3. G.J. Chong, W.A. Phang, and G.A. Wrong. Manual for Condition Rating of Rigid Pavements: Distress Manifestations. Ontario Ministry of Transportation and Communications, Downsview, Aug. 1977.
4. Maintenance Manual Quality Standard, Volumes 1 and 3. Ontario Ministry of Transportation and Communications, Downsview, n.d.
5. G.J. Chong, F. Jewer, and K. Macey. Pavement Maintenance Guidelines: Distresses, Maintenance Alternatives and Performance Standards. Ontario Ministry of Transportation and Communications, Downsview, Rept. SP-001, 1980.

Publication of this paper sponsored by Committee on Maintenance and Operations Management.