



Symposium on Transportation Technology



Maintenance of the Highway Infrastructure

Management of Highway Maintenance

Maintenance of the Highway Infrastructure

Management of Highway Maintenance

J.H. Blaine

MINISTRY OF TRANSPORTATION

LIBRARY AND
INFORMATION CENTRE

Presented at the Symposium on Transportation Technology
Riyadh, Saudi Arabia
April 13-15, 1985

Hosted by the Ministry of Communications
Kingdom of Saudi Arabia
in co-operation with
the Ministry of Transportation and Communications
Province of Ontario, Canada

Published by:
Ontario Ministry of Transportation and Communications
Hon. George McCague, Minister
H.F. Gilbert, Deputy Minister

Published without prejudice
as to the application of the findings.
Crown copyright reserved; however, this
document may be reproduced for non-commercial
purposes with attribution to the Ministry.

For additional copies, contact:
Transportation Industry Office
Ministry of Transportation and Communications
1201 Wilson Avenue
Downsview, Ontario
Canada M3M 1J8
(416) 248-3807

March 1985

ABSTRACT

The Ministry of Transportation and Communications (MTC) provides and maintains a provincial highway system which satisfies the mobility, economic, social, and institutional needs of the people of Ontario. This is done with due regard for energy conservation and environmental impact.

During the 1960s, large-scale expansion of the provincial highway system was necessary to meet the needs of an expanding economy and population growth. Urbanization required new and expanded road systems to satisfy increasing traffic volumes. Rural highways were required to address the agricultural, industrial, and natural resource needs concomitant with an expanding economy.

As the highway system increased, and funding restrictions became necessary, there emerged an increasing emphasis on ensuring a maximum life cycle of the infrastructure. Proper and timely maintenance became a major factor in achieving maximum benefit from the capital costs.

The Provincial Highways Program within MTC is responsible, through a comprehensive policy development and planning process, for administration, design, construction, and maintenance of the provincial highways. The current major thrust of the program is in the area of preservation, and the first priority of available funds is placed on the maintenance and protection of the infrastructure. The program strategic plan requires that highway maintenance maintain current levels of service, with some redistribution within its functions and continued efficiency improvements.

The Ministry's Maintenance Management System is used in the development and allocation of resource needs for maintaining the highway system, as well as monitoring expenditure of those resources to meet the responsibility of the Provincial Highways Program.

TABLE OF CONTENTS

	PAGE
1/ INTRODUCTION	1
2/ IDENTIFIED NEED	2
3/ PURPOSE OF MMS	3
4/ DEVELOPMENT OF MMS	3
5/ PLANNING PROCESS	6
6/ ORGANIZING AND DIRECTING	8
7/ CONTROLLING	9
8/ TRAINING	9
9/ SYSTEM UPDATE	10
10/ CONCLUDING REMARKS	12
APPENDIX A/ MAINTENANCE QUALITY STANDARD	13
APPENDIX B/ CODING GUIDE	18
APPENDIX C/ OPERATIONS LIST	20
APPENDIX D/ PERFORMANCE DATA	23

1/ INTRODUCTION

Current emphasis on preserving the highway system in Ontario has placed increased responsibility on the Maintenance Management System and integrating this with rehabilitation activities in the Pavement Management System.

The Ministry's Maintenance Management System (MMS), one of the first to be developed in North America, originated in the mid-60s when a need was identified to manage maintenance activities in a more efficient and effective manner.

The system is based on the concept that rational management of highway maintenance operations is divided into four components:

- Planning
- Organizing
- Directing
- Controlling

The system currently in place and used by MTC was developed with the assistance of a management consulting firm in Ontario. Since implementation of the Ministry's MMS, other highway agencies within the province of Ontario have also developed similar systems, taking advantage of the expertise and experience of the Ministry and Ontario-based consulting organizations. Over the course of time, much has been learned, and from this accumulation of knowledge, the Maintenance Management System has undergone periodic revitalization to ensure the dynamics of the process.

As a result of the initial implementation, managers were able to

- identify the work being done and the associated resources being expended;
- compare efficiencies of the crews to the standards, established by the Head Office Maintenance Branch, within their own District as well as to others;
- re-allocate funds, manpower, and equipment to operations in order to match the established standards, priorities, and levels of service.

This newly acquired capability resulted in improvements to operational efficiency and enabled managers to evaluate the requirements for manpower and organizational needs. It was possible to reduce the work force by some 1900 (out of 5100) persons and streamline the number of local patrols by 75. Through the MMS, substantial expenditure reductions were possible during a period when the highway system was expanding.

The system is used to establish budgets, justify funding levels, improve productivity, and ensure that highway maintenance facilitates safe movement of people and goods on all provincial highways.

MMS places the highest priority on the pavement component and, together with a Pavement Management System (PMS), establishes strategies for maintenance and rehabilitation, to minimize life cycle costs and optimize service provided to the highway users.

This theme paper outlines the concepts and processes developed and used by MTC to manage its highway maintenance program. It also describes revisions which are being implemented to further streamline the MMS.

2/ IDENTIFIED NEED

The province of Ontario consists of a vast expanse of land blessed with abundance and geographic diversity. In the south, the land is relatively flat and fertile. Southern Ontario contains the vast majority of the population in highly urbanized centres. It is in this part of the province where most of the agricultural and industrial activities exist. Northern Ontario has few major population centres, and its vast area of some 810 666 km² (313 000 mi²) is largely uninhabited, supporting an economy of forestry and mining production.

To address the varied roadway transportation needs of these areas, highways of various designs have been constructed. A maintenance organization is required to ensure, in a consistent manner, the continued efficiency and safety of the roadways.

Prior to the development and implementation of MMS, studies identified various inadequacies in the control of highway maintenance operations:

- Objectives were not clearly defined. Maintenance activities were considered unpredictable and difficult to plan. Budgets were based on historical expenditures. Maintenance field personnel were not aware of what was expected of them; thus, service levels varied considerably.
- No criteria existed for assignment of resources. Manpower and equipment were assigned on the basis of road mileage, historical experience, and personal judgement.
- Productivity was appraised on the basis of money spent and the number of complaints received.
- Management action was motivated by complaints and subjective information.

The MMS was therefore designed to resolve these inadequacies and create a process which would standardize maintenance funding and activity throughout the highway system.

3/ PURPOSE OF MMS

The MMS provides a data collection, storage, and analysis system which enables managers to plan, organize, direct, and control maintenance activities. It also gives a clear definition of the kinds and amounts of work maintenance personnel are expected to perform and standardizes work methods, procedures, productivity, and results. It also enables managers to measure maintenance effectiveness and to make "trade-offs" within the various activities to address priority requirements.

4/ DEVELOPMENT OF MMS

There are five main components in the Ministry's MMS which must be integrated in order to provide the managers with the necessary information to effectively manage the maintenance of the highway system:

- standards to regulate the various maintenance activities to ensure uniform levels of service for similar circumstances;
- instructions and procedures to assist work crews in optimizing efficiency, production, productivity, and effectiveness;

- identification and description of work operations in order to facilitate uniform reporting of results;
- reports to enable managers at all management levels to monitor operations and make rational decisions based on the information;
- planning and budgeting procedures to establish what is to be done and enable senior managers to evaluate performance.

All of these components must be co-ordinated to ensure that the MMS is effective. Changing budget levels, new technology, and environmental and social concerns require that these components be reviewed and updated continually.

To satisfy the requirements of the components, a number of processes and operations were accomplished. These are described in the following sections.

Quality Standards

The first step in the development of the MMS was to set a level of service to be provided by field maintenance personnel.

Quality Standards define the level of service to be provided to the various highway types when field personnel perform inspections, maintenance, or repairs. These standards describe end results or distress manifestations that require attention, or set out a timetable for routine or repetitive maintenance activities to ensure maximum life or continued user safety.

In producing Quality Standards, it is apparent that different service levels will be required for different highways. For example, it is reasonable to expect that a higher level of service will be maintained on a major expressway than will apply to a rural secondary highway.

Quality Standards are therefore classified by road type in order that sections of highways exhibiting similar features will be maintained to the same state of maintenance condition (level of service). A typical Quality Standard is illustrated in Appendix A.

Road Type Classifications

The Ministry's highways vary in design, traffic volume, capacity, age, and surrounding topography. To ensure equitable maintenance practices, highways are classified by means of a coding system to pool highways with identical features. Sections of highway with identical road type code exhibit similar conditions or maintenance needs. This facilitates standardization of the planning, controlling, and reporting of the work effort, as well as determination of resource requirements. The MMS highway and road type coding guide is shown in Appendix B.

Activity Classifications

The various maintenance operations required to ensure the safety and efficiency of the highway system are diversified and numerous. They range from roadway patching to drainage repairs, to maintenance of traffic signal systems, etc. Defining specific operations is necessary so that standards will be realistic and useful for planning purposes and monitoring of performance. The Ministry has developed an operation code numbering system which classifies activities within various main groups. A partial listing is shown in Appendix C. Each operation which falls within the various groups is assigned a code number and accomplishment unit. This facilitates orderly collection and retention of information relative to resource expenditures.

Performance Data

A basic objective of MMS is to plan and allocate resources. Ideally, planning and allocating should be based on the work necessary to achieve the desired level of service and on production rates which reflect the best methods available to do the work.

In order to determine the amount of maintenance work to be done, standard values, expressions of basic quantities of work, and rates of production are produced.

Work quantities are determined through analysis of data from MMS, from Quality Standards, or from road inventory information. The result is an expression of the type and amount of work, such as tonnes of patching material required per equivalent two-lane kilometre, hectares of grass to be cut per season, or number of units to be replaced per year, etc.

Once the amount of work is determined, it is then necessary to determine the resources required to do the work in an efficient and effective manner. Each maintenance activity is reviewed, and optimum methods reflecting standard crew sizes, equipment, and material needs are developed. Once work quantities and resource requirements are determined, production rates and unit costs complete the development of performance data.

Production rates are developed from the analysis of either, or both, reported data and work measurement studies. Production rates are expressed in terms of man-hours per accomplishment unit.

Unit costs include all costs related to performing a maintenance activity and costs of human resources, equipment, and material. Unit costs are expressed in terms of dollars per accomplishment unit or man-hour.

The resulting performance data are displayed in Appendix D.

Highway Features Inventory

The highway features inventory consists of a measure or count of significant features within sections of the highway right-of-way. This information is prepared by maintenance field personnel and, when keyed into the computer with performance data and other information, provides the basis for the planning and budgeting process and information required to evaluate and update the planning process.

5/ PLANNING PROCESS

Rational management of highway maintenance operations includes, as a major component part, planning.

The Ministry's Maintenance Management System has been designed to provide managers with appropriate tools to facilitate objective planning of maintenance resources.

The fundamental purpose of planning is to project the amount of work and cost required to achieve or maintain the desired standards or levels of

service. It is also used to facilitate trade-offs between the various maintenance activities or funding categories within the Ministry.

The planning process involves input from Head Office, Region, and District management units, each performing a necessary function in the development, acquisition, and distribution of resources and funds.

The Head Office unit supplies Districts with initial information in the form of a "maintenance management planning work sheet." This document contains productivity rate, accomplishment quantity, man-hour, and cost data for each maintenance activity. The information is arranged to show previous years' actual performance; current, to date, actual performance; and a calculated standard planning value for the coming year. This information represents a complete theoretical plan based on the standard values and is used by field personnel as the basis for their annual plan. The theoretical plan is modified at the local level to reflect local conditions and unique problems, etc.

District planning entails development of a work plan based upon visual inspections of highway conditions by patrol and crew supervisors, with modifications produced by senior District managers to reflect priority needs, necessary trade-offs, and other strategic directions.

Many of the time-consuming mechanical processes are computerized to facilitate quick revision of plans to fit budget allocations.

Planning data compiled by field units are entered into the computer at the District Office. The plan is prepared using a computer program developed by the Ministry to greatly speed up the plan preparation and to afford maintenance managers at all levels the opportunity to make changes easily and quickly to reflect Ministry policy, priorities, and budgets. The program is a spread sheet type with sufficient flexibility to enable the planner to enter unit values or tables, or any combination of the two.

When initial plans have been prepared, a review by Regional and Head Office planners is made to acquire sensitivity to the needs of the various management levels. The review enhances Head Office ability to

develop equitable allocation of funds and provides an opportunity for ensuring that the plans being developed at the District level are in line with the program's overall objectives.

Once the government's budget has been determined by the central funding agency, funds are allocated to the Ministry, which in turn allocates funds to the various Ministry programs. Maintenance funds are then distributed to Regions and Districts, who then update their plan.

The planning process also provides a framework in which managers can react rationally to funding constraints, in-year revisions, and changing priority issues, to ensure effective use of resources.

The completed, or final, plan provides field crews with clear statements identifying the maintenance operations to be performed during the year, the extent of these operations, and the resources which have been allocated for their completion.

6/ ORGANIZING AND DIRECTING

Once the District maintenance plan has been finalized, managers must organize and direct the resources necessary to perform the activities dictated by the plan. To ensure optimum efficiency and effectiveness, managers can

- direct staff and equipment from one work unit to another;
- schedule crews for specific operations which require specialized equipment, such as zone painting, catchbasin cleaning, sweeping, etc.;
- arrange for work which will be provided by the private sector;
- arrange for additional manpower for large operations by hiring additional staff on a seasonal project basis or by employing staff from other Ministry programs;
- in conjunction with the Supply Section, pre-arrange purchase, supply, and delivery of maintenance materials, when required;
- schedule and provide training programs for staff;
- provide direction and supervision.

7/ CONTROLLING

A process has been developed to enable managers to direct, control, and evaluate their plan. This requires that accurate and timely information relative to performance be available to managers. This information is supplied by way of a variety of computer reports generated from data submitted by field units.

The Ministry utilizes an IBM 370 mainframe computer at its Head Office. District information is keyed in via remote mini-computers and transmitted to the mainframe overnight. The mainframe polls, via auto dial, each District and contacts each mini-computer, receiving batches of data keyed in during the day. Daily, each morning at the mainframe, these batches of data are incorporated into the larger Information Management System's data base. Head Office, Regions, and Districts can receive information back from the mainframe in the form of various reports. The reports are structured such that information can be presented in a variety of formats to facilitate the needs of the various management levels.

Patrols and crew supervisors can obtain reports to review unit costs and productivity of their individual operations by activity and location, in order to maintain an awareness and control of their annual work plan.

District and Regional managers can review and compare individual patrol and District programs to ensure adherence to standards and evaluate efficiencies.

Head Office managers utilize reports to monitor the total maintenance budget from a provincial perspective, assessing operational efficiency, evaluating existing standards and policies, and developing criteria for use in planning future maintenance strategies.

8/ TRAINING

In order for any MMS to be an effective, efficient, and responsive management process, it must have commitment and participation from all management levels, especially senior levels. Senior level commitment ensures similar response from the lower levels. Active participation by

managers at the field level ensures reliability of data being fed into the system and willingness to share their experience and wisdom in developing work method improvements and system efficiencies.

In addition to commitment and participation, training is a most important part of the MMS. The system is of limited value if managers do not understand the concept, capabilities, and operation of the system; how to correctly input data into the system; or how to utilize the information. The MMS incorporates a large amount of data, and procedures are in place to enable managers to plan, organize, direct, and control maintenance operations.

During the implementation of MMS in the mid-60s, it was found that field supervisors were not capable of completing the clerical work that was required to support the system. Extensive transfer of data from one form to another created confusion and numerous errors. This also took an inordinate amount of the supervisors' time, which prevented them from working with their crews and supervising the work.

A review of training needs resulted in development of many training courses and programs to increase, not only the clerical skills of managers, but also their management skills. Some of the courses developed by the Ministry or Canadian consultants include a First Line Supervisors Course, Mathematics Course, Metric Courses (the Ministry changed from imperial to metric measure), and various work instructions. This information is provided in many ways -- seminars, instruction packages, audio-video cassettes, etc.

9/ SYSTEM UPDATE

Reviews and revisions have been an ongoing process necessary to maintain the dynamics of the MMS.

Some of the problems noted during the early years included

- reports received too late to be of use in controlling the operations;
- cumbersome reporting documents;
- inaccurate information from field units;

- lack of reports for field managers;
- conflicts between MMS and the Ministry's financial budgeting system;
- insufficient understanding of the system's purpose and function by maintenance personnel at all levels.

Many of these problems were resolved soon after detection by revising documents and processes and through dialogue and training. Other problems, however, required a longer time frame because their solutions impacted upon changes in the Ministry's computer capabilities.

A major in-depth review of the entire MMS process was recently completed. Attention was focussed on the overall value and continued use of MMS as a management tool. There was no hesitation that MMS be retained. However, a number of opportunities were indicated to improve the process and take advantage of advances in computer technology. Projects were set up to address specific issues. Some have been completed; others will be completed by years end. Some of the projects include

- streamlining of the District plan preparation, using the computer to minimize clerical effort required to produce an annual maintenance management plan and facilitate easy modification to this plan to match budget allocations;
- reviewing the statistical techniques used to develop standard values used in the preparation of an annual maintenance plan;
- developing the capability of using higher level computer program language to generate specific enquiry reports from maintenance management data;
- modifying existing reports and developing new reports to respond to identified needs;
- developing and implementing the new reporting documents to minimize clerical work by the working levels;
- expansion of the maintenance management planning and estimating process to include all maintenance cost centres and to cover all maintenance activities, including hired services;

- reviewing data processing hardware capabilities to provide timely information to the various management levels.

10/ CONCLUDING REMARKS

The Ministry was one of the first highway agencies to recognize a need to preserve its highway system in an efficient and effective manner. Together with Ontario-based consultants, its Maintenance Management System was developed and has proven its worth for some 20 years. Vast knowledge and experience has been gained and expertise exists within the Ministry and province to ensure the vitality necessary to maintain the system.

The Ministry's Maintenance Management System is a time-proven tool, facilitating the planning, organizing, directing, and controlling of maintenance activities. It enables managers to participate in developing funding requirements and to ensure that efficient and effective use is made of resource and monetary allocations.

The system enables senior managers to monitor the Ministry's corporate strategic directions, placing a priority of available funds on the maintenance and protection of the infrastructure, as well as system rehabilitation needs.

The Ministry of Transportation and Communications, Ontario, is dedicated to its Maintenance Management System.

APPENDIX A/ MAINTENANCE QUALITY STANDARD



Ministry of
Transportation and
Communications

MAINTENANCE QUALITY STANDARD

M-505-2

BRIDGE CLEANING

APPROVED

C. E. Lergue
Director, Highway Operations Branch

R. A. Roth

Manager, Structural Office

Bridge Cleaning is necessary to remove accumulations of Winter sand/salt mixtures and debris which, if not removed, may cause deterioration of concrete and steel components, impede drainage and create safety hazards.



before



after

Received _____ Read and Noted By _____ Title _____

MAY 1981

RESPONSIBILITY

The Patrolman is responsible for ensuring that the travelled portion of the Bridge roadway is clear of sand/salt and debris.

The District Bridge Foreman is responsible for ensuring that all other designated areas are cleaned, as required.

It should be noted that, when Bridge components are being cleaned, Maintenance Personnel must be aware of, and conform to all Ministry and Government safety regulations.

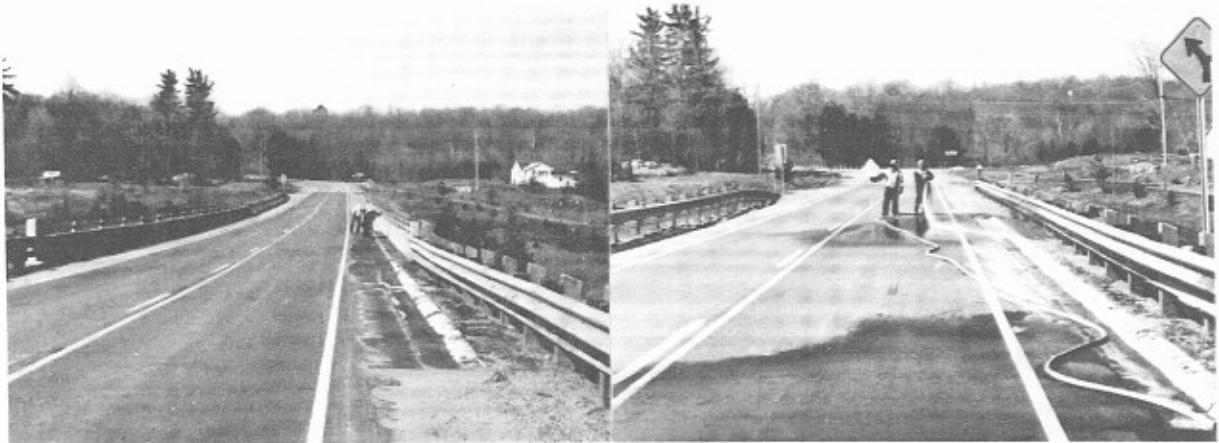
FREQUENCY

1. Travelled portions, including curbs and sidewalks, are to be scheduled for annual sweeping as soon as practical in the Spring.
2. Catchbasins and Drains are to be scheduled for cleaning following the sweeping operation.
3. Washing and Flushing are to be performed after Catchbasin cleaning has been completed.
4. Subsequent removal of sand, gravel and debris is to be scheduled throughout the Summer season, as required.



GENERAL

1. The accumulation of Winter sand, salt and debris is to be removed from the approaches, deck, joints, curb and gutters, sidewalks, etc..

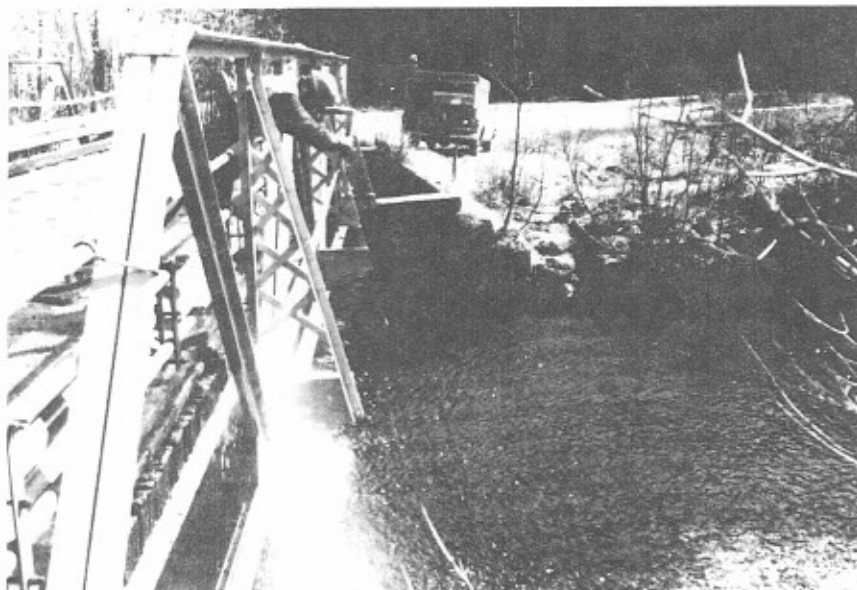


2. Catchbasins are to be cleared of all debris and sand and salt accumulations, so as to ensure that outlets are working effectively.
3. All drainage systems are to be flushed to ensure that they are free flowing. Any blockage of drains is to be removed.



4. The roadside surfaces of hand rails, barrier walls, light standards and sign supports attached to the Bridge, are to be washed to a height of 3 metres above the deck level.

5. Sand/salt accumulations, together with any debris, are to be removed from the abutment bearing seats and pier tops under deck joints. Excess material should be removed with shovels, where possible, and the remaining material removed by means of high pressure water jets or compressed air followed by a thorough flushing with water to remove salt concentrations.
6. Pier columns, abutments and retaining walls adjacent to roadways, which have been subjected to salt spray from passing traffic, are to be washed and flushed to a height of 3 metres above the road surface.
7. Steel truss members are to be washed and flushed, by means of a high pressure waterjet, to a minimum height of 3 metres above roadway level. In addition, particular attention is to be paid to the cleaning and flushing of any pockets formed where vertical and diagonal members connect to the bottom chord. Bottom truss chords, throughout their entire length, are to be cleaned and flushed.



APPENDIX B/ CODING GUIDE



HIGHWAY MAINTENANCE HIGHWAY & ROAD TYPE CODING GUIDE

	<u>DESCRIPTION</u>	<u>CODE</u>
<u>TRAVELLED SURFACE WIDTH:</u>		
	- Two (2) and Three (3) Lane	1
	- Four (4) Lane Undivided	4
	- Four (4) Lane Divided	5
	- Six (6) Lane and Over	6
<u>SURFACE TYPE:</u>		
	- Gravel	1
	- Prime Gravel	2
	- Surface Treated Prime Gravel	3
	- Mulch	4
	- Hot Mix	5
	- Concrete	7
<u>SHOULDER TYPE:</u>		
	- No Shoulder 1/	1
	- Gravel Shoulder	2
	- Fully Paved Shoulder	4
	- Partially Paved Shoulder	6
	- Curb and Gutter	7
<u>AGE OF PAVED & MULCH SURFACE: 2/</u>		
	- No Age of Pavement (Surface Type Codes 1,2,3.)	0
	- Under Five (5) Years	1
	- Five (5) to Under Ten (10) Years	2
	- Ten (10) to Under Fifteen (15) Years	3
	- Fifteen (15) Years and Over	4
<u>AVERAGE ANNUAL DAILY TRAFFIC: 3/</u>		
	- A.A.D.T. 1 to 1,000	1
	- A.A.D.T. 1,000 to 2,500	5
	- A.A.D.T. 2,501 to 10,000	6
	- A.A.D.T. 10,001 to 40,000	8
	- A.A.D.T. 40,001 and over	9

NOTES:

- 1/ A gravel road is considered not to have shoulders.
- 2/ Gravel, prime gravel and surface treated prime gravel are considered not to have any age.
- 3/ Use the latest available A.A.D.T. book.
- 4/ Compute weighted averages where possible, for each section of Highway being coded if there is no predominant TYPE.

APPENDIX C/ OPERATIONS LIST



Ministry of
Transportation and
Communications

HIGHWAY MAINTENANCE

WORK REPORTING OPERATIONS LIST

OPERATION CODE	OPERATION DESCRIPTION	ACCOMPLISHMENT	
		UNIT	CODE
	SURFACE MAINTENANCE		
1001	MANUAL PATCHING: PLACING AND SPREADING The manual placing and spreading of pre-mixed asphaltic materials, (hot or cold mix) to repair potholes, minor depressions, bumps, frost heaves, paved shoulders and other pavement defects. Includes preparation of patching area and compaction. Accomplishment: tonnes of asphalt placed.	tonne (t)	27
1002	MACHINE PATCHING: PLACING AND SPREADING The machine placing and spreading of pre-mixed 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. Accomplishment: tonnes of asphalt placed. Note: See Operation Code 1090 for patching with re-cycled material.	tonne (t)	27
1003	CRACK-FILLING: The preparation *and filling of cracks with asphalt emulsions or liquid asphalt (cut backs) followed by the spreading of aggregate (stone chips or sand). Include <u>minor</u> applications of these asphaltic and aggregate materials to small areas of distressed pavement, when performed during the major operation of crack filling. * Preparation for this operation <u>does not</u> include <u>routing</u> . (See Operation Code 1005) Accomplishment: litres of asphaltic material.	litre (L)	09



Ministry of
Transportation and
Communications

HIGHWAY MAINTENANCE WORK REPORTING OPERATIONS LIST

OPERATION CODE	OPERATION DESCRIPTION	ACCOMPLISHMENT	
		UNIT	CODE
1004	<p>SPRAY PATCHING:</p> <p>The application of asphalt emulsions or liquid asphalt (cut backs) to areas of distressed pavement and pavement-edge defects followed by the spreading of aggregate (stone chips or sand).</p> <p>Accomplishment: litres of asphaltic material.</p>	litre (L)	09
1005	<p>ROUT AND SEAL: CONCRETE AND ASPHALT PAVEMENT</p> <p>The routing of joints and/or cracks in concrete and asphalt pavement and the filling of same with joint fillers or rubberized asphaltic sealing compounds.</p> <p>Accomplishment: metres of joints or cracks sealed.</p>	metre (m)	38
1007	<p>DRAGGING OR GRADING:</p> <p>The grading (blading or re-shaping) of gravel surfaces. Include the removal of rocks or other debris brought to the surface during operation.</p> <p>Accomplishment: kilometres of each lane dragged or graded.</p>	kilometre (km)	39
1009	<p>GRAVELLING: GRAVEL SURFACES</p> <p>The gravelling and/or build-up of gravel roads using pit run and/or crushed gravel.</p> <p>Accomplishment: cubic metres of gravel used.</p>	cubic metre (m ³)	07
1011	<p>DUST LAYING: SURFACE</p> <p>The application of dust-laying material (other than prime) <u>to continuous sections of gravel surface.</u></p> <p>Accomplishment: kilometres of each lane treated.</p>	kilometre (km)	39

APPENDIX D/ PERFORMANCE DATA

1985 - 1986

M.T.C. MAINTENANCE PRODUCTION DATA SHEET									
OPERATION No.		1001		ACCOMPLISHMENT		TONNE			
DESCRIPTION		MANUAL PATCHING PLACING AND SPREADING							
		ROAD TYPE : (3).				ROAD TYPE CODES			
NORTH/SOUTH		TWO & THREE LANE				14 010			
1. SOUTH ONLY		HOT MIX UNDER 5 YEARS				15 010			
2. NORTH ONLY		X							
DISTRICT #s									
MANPOWER						REMARKS			
POSITION	NO. MEN	RATE	HRS. P/DAY	COST	% OF TOTAL	ACCOMPLISHMENT PER E2LK			
1 DRIVER	1		8			1981-82 - .388			
2 SHOVELLERS	2		16			1982-83 - .386			
2 FLAGMEN	2		16			1983-84 - .326 .387			
TOTAL	5	12.50	40	500.00		1984-85 - .366			
						1985-86 - .366			
EQUIPMENT									
TYPE	NO. PCS.	RATE	HRS. P/DAY	COST	% OF TOTAL	MAN HRS. PER ACCOMP.			
5 TON DUMP	1	22.05	8	176.40		1981-82 - 5.502			
3/4 TON	1	8.90	5	44.50		1982-83 - 5.379			
						1983-84 - 5.446			
						1984-85 - 5.457			
TOTAL	2			220.90		1985-86 - 5.457			
MATERIAL									
TYPE	UNIT	UNIT COST	QUANT. P/DAY	COST	% OF TOTAL				
PREMIX	TONNES	52.64	7.3	384.27					
TOTAL				384.27		TOTAL COST PER DAY			
						\$ 1105.17			
ACCOMPLISHMENT PER DAY						7.30			
MAN HOURS PER ACCOMPLISHMENT UNIT						5.457			
DOLLARS PER ACCOMPLISHMENT UNIT						157.39			
ACCOMPLISHMENT PER EQUIV. 2 LANE KM						.3			