

Pavement Management for North Carolina Municipalities

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In the past 3 years, the Institute for Transportation Research and Education (ITRE) has developed and implemented pavement/management systems for more than 80 municipalities in North Carolina. This represents more than one-half of the total municipal street mileage in the state. In Spring 1983, ITRE modified the pavement condition survey for asphalt pavement that it developed for the North Carolina Department of Transportation. Eight pavement distresses are identified and quantified. They are alligator cracking, block/transverse cracking, reflective cracking, rutting, raveling, bleeding, ride quality, and patching. The street system is also completely inventoried. ITRE developed the Pavement Management System software to analyze survey data. Results are calculated using maintenance levels of service and costs that can easily be changed by the user. Management reports available are alphabetical listing, priority listing, and maintenance summary tables. Calculated for each section is an estimated number of square yards of full-depth patching required, pavement condition rating (PCR), estimated maintenance cost and recommended maintenance activity. Results have been used as justification for street maintenance budget increases and resurfacing priorities.

Pavement management may be described as effectively and efficiently directing the various activities that deal with providing and sustaining pavements in a condition acceptable to the traveling public at the least life-cycle costs. In the past 4 years the Institute for Transportation Research and Education (ITRE) has developed and implemented pavement/management systems for more than 80 municipalities in North Carolina. This represents approximately 10,000 miles, or more than one-half, of the municipal street system mileage in North Carolina.

BACKGROUND

The University of North Carolina (UNC) Institute for Transportation Research and Education (ITRE) is a staff function of the UNC General Administration. ITRE coordinates many broad areas of transportation research and education for the sixteen campuses that make up the UNC system. It undertakes research and training with its professional staff and assigns other similar work to many segments of the university.

In 1982, ITRE assisted the North Carolina Department of Transportation (NCDOT) in developing a pavement/management system for its 60,000-mile paved state highway system. ITRE was instrumental in developing the computer software required and in training survey teams across the state.

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Since 1982, ITRE has continued to work closely with NCDOT in improving and updating their pavement management system.

In 1983, several municipal officials approached ITRE concerning the NCDOT pavement management system. The municipalities had determined a need for pavement management on their street systems. ITRE slightly modified the pavement condition survey procedure used by NCDOT to more accurately address the conditions found on municipal streets. Computer software was developed to analyze pavement condition survey data. This program is entitled PMS-ITRE and operates on the IBM PC. Pavement management systems were developed and implemented successfully in seven selected pilot cities during 1983. At present ITRE provides pavement management assistance and training to more than 80 municipalities in North Carolina.

ADVANTAGES OF PMS-ITRE

It became obvious to many municipalities that a pavement management system would provide many advantages to them and provide much valuable information. Primary advantages realized from such a system are as follows:

1. Municipalities analyze and manage their pavement problems in the same manner as NCDOT, allowing for easy exchange of technology and training.
2. Municipalities have a complete inventory of bituminous paved streets with block number; length; width; type of pavement; and shoulder, curb, and gutter information. Additional information may include sidewalks, drainage, right of way, etc.
3. The pavement condition survey results show the pavement distresses by type and magnitude, the pavement condition rating, the recommended maintenance activity, and the repair cost for each section of street. Computer printouts list each section of street alphabetically and by condition rating priority.
4. The pavement condition survey is an objective evaluation measuring eight types of pavement distresses and uses commonly accepted cost-effective maintenance practices for those pavement distresses.
5. The results indicate whether the municipality's streets are in good, fair, or poor condition and the amount of funding needed to preserve the street system. Over time, results indicate whether the municipality is catching up or falling behind in meeting critical street maintenance needs.
6. The pavement condition survey permits the municipi-

pality to use its limited funds more cost-effectively for maintenance and resurfacing by prioritizing these activities.

7. Resurfacing priorities can be justified to jurisdictional authorities as well as the public. An organized and uniform methodology is used to establish these priorities.

8. Increased budget requests can be justified to the controlling entity. These requests are based on objective and factual data.

9. Streets with critical pavement distress, indicating the need for engineering investigation and testing or pavement reconstruction, are easily identified.

10. The computerized approach permits the municipality to vary the level of maintenance service depending on prospective funding.

11. The ITRE pavement management system is appropriate for a municipality of almost any size. It has been successfully implemented on street systems ranging from 10 to 1,400 total miles.

PAVEMENT CONDITION SURVEY

The ITRE Pavement Condition Survey is a visual inspection of 100 percent of the flexible pavement street system. The survey is conducted in a vehicle traveling at a very slow speed (approximately 10 miles per hour). ITRE professional evaluators have been thoroughly trained and produce consistent results.

Eight different pavement distresses are evaluated according to their quantity and severity: alligator cracking, block/transverse cracking, reflective cracking, rutting, raveling, bleeding, ride quality, and patching. Each distress is measured according to well-defined severity levels of slight, moderate, and severe. Alligator cracking is measured in detail as a percentage of the section. The other distresses are measured by overall condition.

Streets are surveyed in short homogeneous sections (0.1–0.3 mile). Many municipalities are surveyed on a block-by-block basis. New sections are formed where changes occur in street width, pavement type, curb and gutter sections, or pavement condition.

Each section of paved street in the municipality is inventoried and the following information is recorded: block number, length, width, type of pavement, shoulders, curb, and gutter. This information is recorded on a survey form in the field along with pavement distress data.

The municipality assigns all streets as either Class A streets, which are low-volume residential streets, or Class B streets, which are more heavily traveled thoroughfares or collector streets. Class B streets generally receive a higher level of maintenance repair than Class A streets.

Subsequent pavement condition surveys can be conducted much faster than the initial survey. Preprinted survey forms are prepared prior to the survey. Inventory data are already available and must only be verified. Most municipalities have their pavement condition survey updated every other year to monitor changing pavement conditions.

PMS-ITRE SOFTWARE

Pavement condition survey data are entered and analyzed using PMS-ITRE software. PMS-ITRE is written in dBase

III, operates on IBM PCs, and is menu driven. At least 512K RAM is required, and use of a hard disk is preferable. More than a dozen municipalities have acquired PMS-ITRE for in-house use. PMS-ITRE allows the user to perform the following functions:

1. Enter and edit pavement condition survey data.
2. Modify deduct values used to calculate pavement condition ratings.
3. Modify maintenance activities and levels of service used to calculate results. Levels of service may be varied for Class A and Class B streets.
4. Modify unit costs of maintenance activities to reflect current or projected figures.
5. Calculate pavement condition rating, estimated maintenance cost, and type of maintenance activities needed for each street section and the entire street system.
6. Print various reports, including alphabetical listing, priority listing, maintenance needs summary table, condition rating and cost summary table, and distress summary table.
7. Maintain historical record of pavement condition and maintenance performed for each street section.

ANALYSIS OF DATA

Several different items are calculated for each street section and summarized for the entire street system: a pavement condition rating (PCR), estimated total cost, estimated cost per mile, estimated square yards of full-depth patching required, and the type of maintenance activity needed.

The PCR may range from 0 to 100, with 100 being a perfect pavement. Deductions are made from 100 based on the amount and severity of pavement distress. The PCR is a relative indicator of the condition of the street section.

Maintenance activities are assigned for each severity of pavement distress. These activities may be easily modified using the appropriate menu in PMS-ITRE. Unit costs for each maintenance activity are also entered. These costs may be easily changed as needed. The program determines the type of maintenance required and calculates a cost for each section based on these maintenance criteria.

PRESENTATION OF RESULTS

The results of the pavement condition survey for a municipality are presented in written technical reports and several computer printouts as described in the following sections.

Pavement Condition Survey Procedures and Results

The Pavement Condition Survey Procedures and Results report details the survey procedure and the eight types of pavement distress measured in the survey, and includes eight pages of color photographs. The recommended maintenance activities and unit costs are defined for each distress, and the pavement condition rating computation is explained. A general priority system for maintenance activities is suggested.

TABLE 1 SUMMARY TABLE OF SUGGESTED MAINTENANCE ACTIVITIES FOR THE MUNICIPALITY

Maintenance Activity	Total Miles	% of Miles	Cost/Mile	Total Cost	% of Cost
Crack Pouring	21.42	7.7	\$ 403	\$ 8,642	0.3
Joint Repair	0.29	0.1	7,800	2,262	0.1
Patching	65.69	23.6	8,335	547,547	22.1
Short Overlay	4.90	1.8	11,313	55,434	2.2
1" Plant Mix Resurfacing	57.64	20.7	30,371	1,750,608	70.6
1.5" Plant Mix Resurfacing	0.00	0.0	0	0	0.0
2" Plant Mix Resurfacing	1.84	0.7	62,867	115,675	4.7
Total Maintenance	151.78	54.6	\$16,341	\$2,480,168	100.0
Total Miles - No Repairs	126.16	45.4	0	0	0.0
Total Street System	277.94	100.0	\$ 8,923	\$2,480,168	100.0

Pavement Condition Survey Analysis of Results

The Pavement Condition Survey Analysis of Results report briefly describes and explains the results of the survey for the municipality. A general analysis is made of the total maintenance needs in the municipality. Those needs are compared with other typical municipalities.

Suggested Maintenance Activities for the Municipality

The table of Suggested Maintenance Activities for the Municipality summarizes the results of the maintenance activities for the municipality. Table 1 is a typical summary table.

Resurfacing Summary

A detailed analysis is made of all of the streets that require resurfacing. This analysis identifies the major pavement distresses that dictate the need for resurfacing. Table 2 is a sample resurfacing summary table. A detailed discussion of each of the pavement distresses that causes the need for resurfacing is also included.

Priority by Type of Maintenance

Often routine maintenance and resurfacing have been deferred. Typically total maintenance need is much more than the municipality can afford in a year. Therefore maintenance needs

are prioritized for the municipality. Table 3 is a typical summary table of high-, medium-, and low-priority pavement maintenance.

Computer Printouts

Several computer printouts are provided for management; these are described below.

Alphabetical Listing: The Alphabetical Listing report lists street sections in alphabetical order by street name and mile-post or block number. The following are shown for each street section: the begin and end description, section length, type and width of pavement, type of shoulder, pavement distress information, pavement condition rating, number of utility cuts, estimated square yardage of full depth patching, estimated maintenance cost, estimated cost per mile, and maintenance activity.

Priority Listing: The Priority Listing report organizes street sections in priority order from the lowest- to highest-pavement condition rating (PCR). The Priority Listing is helpful to both engineering and policy-making staff. It provides a guideline for prioritizing maintenance. Also, a resurfacing program may be developed objectively by using this report.

Pavement Condition Survey Maintenance Needs: The Pavement Condition Survey Maintenance Needs summary table lists the types of maintenance activities by Class A and B streets and for the total street system. Mileage and cost data are summarized for each maintenance activity. Also, percentage of total mileage and total costs are shown for each activity to illustrate the magnitude of the activity.

TABLE 2 RESURFACING SUMMARY TABLE

Pavement Distress	Miles	% Miles	Cost/Mile	Total Cost
Alligator Cracking Plus Moderate or Severe Rutting	1.84	0.6	\$62,867	\$ 115,675
Severe Rutting only Class "B"	0.00	0.0	0	0
Alligator Cracking-Minor Rutting	19.49	7.0	40,722	793,674
Block/Transverse Cracking	24.45	8.8	27,350	668,705
Severe Rutting only Class "A"	0.18	0.1	15,483	2,787
Raveling	9.70	3.5	20,339	197,286
Bleeding	0.00	0.0	0	0
Ride Quality	3.62	1.3	21,999	79,638
Patching Class "B"	0.20	0.1	42,590	8,518
Total	59.48	21.4	\$31,377	\$1,866,283

TABLE 3 PRIORITY BY TYPE OF MAINTENANCE

	Total Miles	Cost/ Mile	Total Cost	% of Cost
HIGH PRIORITY: Preventive Maintenance, Alligator and Rutting Resurfacing	113.81	\$13,408	\$1,526,021	62
MEDIUM PRIORITY: Resurfacing for Severe Block/Transverse, Raveling, Bleeding	20.91	33,180	566,052	23
LOW PRIORITY: Resurfacing for Moderate Block/Transverse, Raveling, Ride Quality and Patching	17.06	22,749	388,095	15
TOTAL	151.78	\$ 16,341	\$2,480,168	100

Pavement Condition Survey Cost and Condition Rating: The Pavement Condition Survey Cost and Condition Rating summary table (Table 4) summarizes the cost and average pavement condition rating by class of street and for the entire street system.

Pavement Condition Survey Distress: The Pavement Condition Survey Distress summary table (Table 5) summarizes the total mileage of each type and severity of pavement distress that exists by class of street and for the total street system. Percentage of miles is also calculated.

Historical List of Pavement Maintenance Activities: The Historical List of Pavement Maintenance Activities report lists previous and current pavement conditions, pavement structure, maintenance performed and resurfacing completed by street section. A historical record allows the condition of a pavement to be monitored and the maintenance effectiveness to be measured.

SUCCESS IN NORTH CAROLINA

The results are discussed with municipal personnel, and numerous presentations have been made before city councils. These presentations have proven to be beneficial in terms of municipal officials' understanding of the survey and the general pavement conditions within their municipality. In some cases, field visits are made with municipal officials to look at critical pavement conditions.

For many North Carolina municipalities, the ITRE-PMS has become an important tool in their street maintenance program. The results have been used successfully to plan and schedule daily work for maintenance crews. With dBase III, customized reports can be generated for any number of conditions. The city of Charlotte typically produces a list of streets needing full-depth patching and assigns their crews to those streets from that list.

Many municipal officials have commented that they like having something in "black and white" to support their budget requests and resurfacing priorities. Street resurfacing is a highly visible activity and is a "hot" issue politically. With the results of the Pavement Condition Survey, many of the municipalities were able to significantly increase their resurfacing program. Maintenance had often been deferred over the past years.

In the city of High Point, for example, resurfacing was budgeted at approximately \$80,000 per year prior to having the ITRE-PMS. The results of the Pavement Condition Survey showed the need for much more resurfacing. Resurfacing is now being funded at more than \$300,000 per year in an attempt to catch up with the backlog of maintenance need. The Pavement Condition Survey results were presented to the city council and justified this increase.

The cities of Fayetteville, Asheville, and Wilmington used the ITRE-PMS to support the need for multimillion-dollar bond issues for streets. The bond issues passed in all three cities. The Pavement Condition Survey reports are currently being used to plan and prioritize the expenditure of that bond money.

The consensus of North Carolina's municipalities is that the ITRE-PMS has saved them many dollars. The city of Charlotte, for example, was able to save over a million dollars of its street resurfacing budget as a result of implementing the ITRE-PMS. They were then able to use this money for other street projects within the city.

FUTURE DIRECTION

Municipal pavements are in a continual state of deterioration. This deterioration rate depends on many factors. Inadequate pavement thickness, unanticipated truck loads, and poor drainage accelerate the deterioration. Therefore, North Carolina municipalities have found it to be reasonable and pru-

TABLE 4 PAYMENT CONDITION SURVEY COST AND CONDITION RATING SUMMARY

Type of Street	Length (Miles)	Length (Lane Mi.)	Average Rating	Avg Cost /Mile	Avg Cost /Lane Mi.	Total Cost
Class A	23.29	46.46	95	\$ 969	\$ 486	\$22577
Class B	1.79	3.58	87	9950	4975	17811
Total	25.08	50.04	95	\$ 1610	\$ 807	\$40388

TABLE 5 PAVEMENT CONDITION SURVEY DISTRESS
SUMMARY: ALLIGATOR CRACKING

	Class A Streets		Class B Streets		Total Street System	
	Miles	%	Miles	%	Miles	%
A. None	13.49	83	1.72	89	15.20	84
B. Slight	0.74	5	0.15	8	0.90	5
C. Moderate	1.18	7	0.06	3	1.24	7
D. Severe	0.84	5	0.00	0	0.84	4
Total	16.25	100	1.93	100	18.18	100

dent to implement a workable pavement management system that monitors the condition of their street system.

Periodic pavement condition surveys indicate the rate of deterioration and indicate the success or failure of existing resurfacing and street maintenance activities. Additionally, these periodic surveys make it possible to build up a history of all maintenance activities to assist in planning for more cost-effective maintenance procedures.

Experience shows that it is highly desirable to conduct the survey again the year following an initial survey. This provides a check on street inventory and pavement distress. The second survey is less time consuming because preprinted forms are used. These forms contain all street inventory data and require only entry of data on pavement distresses.

Future surveys should be conducted at least every other year to update condition data. Those streets with serious structural pavement distress should always be checked annually.

The Pavement Condition Survey provides an overall measure of the condition of the street system. The condition can be monitored over time as future surveys are conducted. This will indicate if the current level of spending for street maintenance is allowing the system to improve, deteriorate, or remain about the same.

Certainly the use of the ITRE-PMS has become widely accepted among North Carolina municipalities.

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