12/13/84
Final.

IOWA'S PAVEMENT MANAGEMENT SYSTEM

TRITSCH, Steven L.
Special Assignments Engineer
Iowa Department of Transportation

Title

IOWA'S PAVEMENT MANAGEMENT SYSTEM

Steven L. Tritsch

The energy crisis of the early 1970s, rising construction costs, and pavements reaching their design lives required major changes in highway programming. A pavement management system was needed to aid management in making the correct decisions for highway programming based on quantitative data.

Iowa's pavement management system was initiated in 1979 and has progressed to the stage where it will be fully implemented in 1985. The planning and implementation of the system has been performed in its entirety within the Iowa Department of Transportation.

In 1979, the pavement management committee formulated the following objectives:

1. Provide current data base for all offices concerned with pavements.

2. Annually update the physical condition status of the rural state highway road network.

3. Provide management with consolidated matrix information from which rational prioritization of projects and programming decisions can be made.

4. Provide a method of evaluating the performance of highways under different design, maintenance, and construction strategies.

The third objective became the focal point of our pavement management system. Management required a tool which would objectively present information based on current pavement conditions. Eight pavement attributes were selected and arranged in an array from which a quantified number is calculated for each highway segment in our rural highway network. A matrix list based on programming criteria is generated which ranks each potential rehabilitation project in descending order of need accomplishment.

pavement management, matrix, attributes, deflection, status report, history plot, history report

IOWA'S PAVEMENT MANAGEMENT SYSTEM

INTRODUCTION

Pavement management has been practiced in the State of Iowa for many years. In years past, pavement programs were developed on an annual basis as directed by the chief engineer with consultation from his staff. During the 1950s and 1960s, there was sufficient highway funding to accomplish the programs as proposed, with emphasis on new construction and system enhancements. This is no longer true.

During the energy crisis in the early 1970's the Iowa Department of Transportation's revenue declined; while at the same time, construction costs were rising. In addition to the financial crisis which was facing all agencies concerned with highways, Iowa's pavements were rapidly approaching and surpassing their original design lives. The era of reconstruction being the solution for our transportation problems was quickly coming to an end. The era of pavement preservation and rehabilitation was beginning and promised to be one of the foremost challenges facing the highway engineer.

PROBLEM STATEMENT

With tight fiscal constraints and many more miles of highways needing rehabilitative action than could be funded, a method of prioritizing the work to be accomplished was dictated. A total pavement management system was needed which would take a rational approach toward programming pavement needs for the future based on quantitative information that had been gathered concerning the condition of the roadway and historical construction records. Development of rehabilitation strategies was needed to optimize public funds and provide the greatest benefit to the user traveling on our public highways.

DEVELOPMENT OF THE SYSTEM

In 1979, a pavement management committee was formed under the direction of the Highway Division Director with representatives from the offices of Road Design, Materials, and Data Processing. The committee was expanded in 1980 to include all offices in the Highway, Administration, and Planning and Research Divisions who would be directly affected by a pavement management system. A coordinator was selected and assigned to the Office of Materials under the direction of the State Materials Engineer to oversee the implementation of the objectives set forth by the committee. The following objectives were formulated:

1. Provide current data base for all offices concerned with pavements.

2. Annually update the physical condition status of the rural state highway network.

3. Provide management with consolidated matrix information from which rational prioritization of projects and programming decisions can be made.

4. Provide a method of evaluating the performance of highways under different design, maintenance, and construction strategies.

The coordinator was directed to evaluate the available information from within the organization and perform a search of existing pavement management systems to ascertain a realistic approach to implementing a pavement management system for the state of Iowa. The Iowa Department of Transportations highway network has 4500 miles of portland cement concrete, 3600 miles of portland cement concrete with asphalt cement concrete overlays, and 2000 miles of asphalt cement concrete pavement. It became apparent that to meet Iowa's pavement management needs, a program would have to be developed within the organization. In order to initiate such a program, a commitment from top management was requested and approved to develop Iowa's pavement management system (IPMS) which would be responsive to the needs of the state of Iowa. The primary responsibility in developing the system was placed in the Highway Division. A secondary development of the IPMS was our involvement in the Federal Highway Administration's Long Term Pavement Monitoring program.

The Long Term Monitoring (LTM) program consists of 21 sites throughout the state of Iowa and has been used as a pilot program for IPMS. Iowa is one of eight states participating in the Federal Highway Administration sponsored program. The program has provided direction and funding assistance to get a formal pavement management process started in Iowa during three years of monitoring. The knowledge gained through the LTM program such as: data collection needs and frequency; correlation of deflection testing to existing pavement condition and design; and the availability of construction history has enabled us to determine what procedures should be followed to gather the information needed for the IPMS in the most expedient and thorough manner without overloading the system with too much information.

Information is certainly the key to any logical process and our data base has become the cornerstone for the pavement management system. A great deal of time and effort was expended in determining what information was essential and where the information could be found. Unfortunately, as with many organizations, much of the information which we deemed essential was available only in paper files. Computer programming, application analysis, and manual transfer of information from paper files to our mainframe computer became a time consuming but a necessary function to establish a workable data base.

The data base includes: construction history, design parameters, material source locations, ride values, deflection testing data, condition survey data, traffic data, friction numbers, rut depth, and accident history. 18K equivalent single axle loads and maintenance costs will be added to the data base in early 1985.

USE OF THE SYSTEM

The data base is structured such that all offices involved with pavements can readily access all available information via computer terminal. Access is gained by inputting the county, system, route number, and beginning mileposts of the section of pavement in question. Figure 1 shows an example of the output illustrating the current condition of US 30 in Clinton county.

IOWA PAVEMENT MANAGEMENT SYSTEM
PAVEMENT STATUS REPORT
12/05/84

LEVEL	ROUTE	COUNTY	SYS	BEG MPOST	END MPOST
B	030	23	01	299.74	311.06

DIR	SURF TYPE	PAVE WIDTH	SHOULDER WIDTH	PSI	EN FN-YR	WS FN-YR	MATRIX RATING
	AC	24	10	3.14	420083	440083	5.16

STR RATING	80% STR	K VAL	RUT DEPTH	IJK RIDE	PSI DEDUCT	ADT	%TRKS
4.15	3.78	130	0.15	3.30	0.16	03980	11

MAINT COST-YR	CUM MAINT COST	6YR PSI	YR PSI	YR PSI	YR PSI	18K	CUM 18K EAL
		.11	843.14	813.35	783.80		

* - SLIPPERY WHEN WET

Figure 1. Pavement Status Report

The pavement status report includes location, pavement condition, and service level. The service level is a classification tool used to prioritize highways based on route continuity and vehicle flow pattern. Iowa utilizes four service levels: A, B, C, and D.

Interstate and freeway highways are included in service level A, expressway and major arterial highways are service level B, arterial highways are service level C, and arterial connectors are service level D. A and B level highways carry approximately 63% of Iowa's traffic. The allotment of funds to the different service level highways is based primarily on vehicle traffic.

The pavement status report is a tool that can be used by all offices concerned with pavements. The information presented can be used for documentation of existing pavement conditions and analytical queries.

The committee insisted on concise and accurate construction histories. Therefore, every highway plan is being inventoried from our vault records and stored in our mainframe computer. Figure 2 illustrates the number and position of projects on a segment of US 30 in Clinton county.

```
                         IOWA PAVEMENT MANAGEMENT SYSTEM
                             PROJECT HISTORY PLOTS
                                   12/05/84


       ROUTE       COUNT       SYS        BEG MPST     END MPST
        030          23         01        305.00       310.00

...........................11122333...5555.................................
...........................////////4..////.................................
666666666666666666666666666////////666////666666666666666666666666666666666
777777777777777777777777777////////777////777777777777777777777777777777777
                           ////////   ////
                           ////////   ////
*______________|_______________|_______________|_______________|__________*
305.00                                                                310.00
```

SEQ	PROJECT NUMBER	DATE OPEN	LENGTH	BMPST	EMPST
1	FN-147	0861	.688	306.83	307.09
2	FN-147	0861	.688	307.09	307.25
3	FN-147	0861	.688	307.25	307.50
4	F-1021-1	0953	.683	307.00	307.40
5	F-1012-1	0953	.683	307.59	307.87
6	F-147(7)	1150	10.227	299.91	310.10
7	FA-147*(1)	0823	16.437	299.66	310.12

Figure 2. Project History Plots

The project history plot is used to visually display construction project limits and locations. If a reconstruction project has been built, the preceding projects are deleted from the history plot and their previous locations are designated by slashes. The milepost scale used for schematically locating projects varies according to the beginning and ending mileposts of the section of highway requested.

Once a specific project has been identified and more detailed information is needed, the sequence number is entered into the computer and another report will be generated. Figure 3 illustrates the detailed information about a specific project on US 30 in Clinton county.

IOWA PAVEMENT MANAGEMENT SYSTEM
PROJECT HISTORY REPORT
12/05/84

ROUTE	COUNTY	SYS	BEG MPOST	END MPOST
030	23	01	299.91	310.10

PROJECT NUMBER F-147(7) — LENGTH 10.227

	TYPE	DEPTH	WIDTH	SIZE	COARSE AGGREGATE SOURCE
SHOULDER		00.00	000.00	00.00	
WIDENING	PCC	09.00	003.42	01.50	DEWEY P.C. CO., LINWOOD
SPRINKLE		00.00	000.00	00.00	
SUBBASE		00.00	000.00	00.00	
BASE	AAC	01.50	024.00	00.75	CONC. MAT'LS CO., BEHR QRY.
SURFACE	AAC	01.50	024.00	00.75	CONC. MAT'LS CO., BEHR QRY.

SURFACE COARSE AGG.:CRUSHED STONE   BED: FRIC: DUR:

FINE AGGREGATE SOURCE	CODE	CEMENT SOURCE	OPEN
BOCK SAND CO., 11-81-1, CO. 23		LAKE ASPHALT & PETROLEUM	1150
DAN ANDERSON, 21-81-2, CO. 23			

TRANS. JOINT   SPACE   LONG. JOINT   REINF

COMMENTS:
LISTED AS F-147(6) IN MATERIALS FILES.

Figure 3. Project History Report

The project history report identifies materials source locations, shoulder and pavement width types and dimensions, steel placement, joints, and any special comments such as a research or new procedures which may have been incorporated into the project. Project history is very valuable in ascertaining how pavement failures relate to material properties and design criteria. The history reports are also very valuable in regard to plans and specifications for rehabilitation projects. Some 4000 man-hours are being expended gleaning construction history from the original plans in the vault and inputting that information into our data base.

The data base is updated biannually to allow the user access to the most current information on a pavement section. Each office responsible for data which is input into the pavement management system has a program which is accessed annually to update the data base. Information gathered during spring and summer is transferred to the data base in the fall. Information gathered during the fall and winter is transferred to the data base in the spring.

PAVEMENT MANAGEMENT MATRIX

A major concern of management was the prioritization of projects and how to achieve a rehabilitation program which was based on objective data rather than subjective criteria. The pavement management committee concluded that a matrix should be composed of the major serviceability attributes. The matrix would be the tool to help prioritize our rehabilitation projects.

The attributes selected for the matrix are: 18 kip equivalent single axle loads (ESAL), PCC D-crack occurrence factor, structural adequacy factor, maintenance costs, rut depth, a crack and patch factor, longitudinal profile value (ride), and a present serviceability index (PSI) decrease per year on a six-year basis. Traffic and pavement width were substituted into the matrix until programs could be developed to integrate 18k ESAL and maintenance costs into our data base.

The eight attributes are arranged in a Pavement Management Matrix array (Figure 4) which assigns a factor value to a measured or computed numeral.

Factor Value

	1	2	3	4	5	6	7
Traffic Factor	>8,000	<8,000	<6,000	<5,000	<4,000	<3,000	<2,000
P.C.C. D-Crack Occurence Factor	>4	4	3	2	1		0
Structural Adeq.	1	2	3	4	5	6	7
Pavement Width	18	20			22		24
Rut Depth	>.50	.40	.30	.20	.10	.05 ~~<.10~~	<.05 ~~.00~~
Crack and Patch	>.80	.60	.40	.25	.15	.05	<.05
Longitudinal Profile Value (I.J.K. Ride)	<3.00	3.20	3.40	3.55	3.65	3.75	>3.75
P.S.I. Decrease/Year 6 year basis	>.20	.20	.17	.14	.11	.08	<.05

Add factors and compute to a 7 point scale.

Figure 4. Pavement Management Matrix

The individual factors are totaled and divided by the number of attributes to calculate an index number which is based on a 7-point scale. The index number ranges from 1 being the worst condition to 7 the optimum condition. The 7-point scale has a direct correlation to our deflection testing program and reflects the range of values which our Road Rater program is finding in actual field conditions. Therefore, the structural adequacy value is not assigned a factor value, but is input directly into the matrix formula.

MATRIX ATTRIBUTES

Traffic is the term used to describe traffic volume on a section of highway and is expressed by annual average daily traffic (AADT), which is the total traffic for the year divided by 365. Traffic volume is based on two lanes of vehicle counts, i.e., divided highways have directional splits for traffic volume. The Office of Transportation Inventory is responsible for obtaining traffic data.

As previously mentioned, 18K ESAL will replace the traffic volume attribute. The 18K ESAL program will also be based on two vehicle lanes of traffic for each roadway segment. We anticipate the program will be operational in the spring 1985. The 18K ESAL will indicate more realistic traffic loading and will aid us in developing performance curves based on the matrix information. The Office of Transportation Research is responsible for developing and maintaining this data.

The PCC D-crack occurrence factor refers to a characteristic crack pattern that develops in certain portland cement concrete pavements which were constructed with aggregates exhibiting poor durability qualities. A visual survey is made and the pavement is rated on a scale of 0 to 5, with 1 being the beginning indications of D-cracking and 5 indicating pavement failure at all distressed areas. The Office of Materials is responsible for obtaining the D-crack occurrence factor which is a part of the crack and patch survey.

Structural adequacy is a term used to describe how a pavement section responds to a dynamic force. A series of sensors measure the pavement deflection and calculations are performed to provide an indication of the structural integrity of the pavement in question. The Iowa DOT uses a Model 400 Road Rater which tests approximately 1000 miles of pavement each spring. The Office of Materials is responsible for the Road Rater testing program.

The pavement width is measured during the crack and patch survey by the Office of Materials. Measurements are from edge of slab to edge of slab. The older narrow 18 and 20 foot pavements have exhibited higher maintenance costs than our 24 foot pavements; therefore, pavement width is used as a broad indication of potential maintenance costs.

Maintenance costs will replace pavement width in the matrix in late spring, 1985. Maintenance costs are tabulated from time sheets kept by the maintenance crews on a milepost basis. Only those activities directly related to maintaining the pavement from edge of shoulder to edge of shoulder will be included in the maintenance costs program. Examples of activities are crack sealing, surface patching, full depth patching, and edge rut repair. Contract maintenance costs will also be included in the program. A three year average will be used in the matrix calculations in order to alleviate extreme variations in a maintenance program which may give a false indication of maintenance trends. The Office of Maintenance is responsible for transferring the information from the maintenance management system to the IPMS data base.

Rut depth is defined as the mean depth of rutting under a 4 foot straight edge , in inches, in the wheel path of the pavement section. The Office of Materials is responsible for obtaining the rut depth during the crack and patch survey.

Crack and patch is the term used to describe the surface condition of the pavement based on the crack and patch survey performed by the Office of Materials on a biennial basis. A representative half mile section (from a five mile section) has a detailed distress survey taken where cracks are measured and counted. Patching is tabulated by square feet, rut depth measurements are taken every 500 feet in both wheel tracks, faulting is measured, shoulder width is measured, pavement width is measured, and the D-crack occurrence factor is determined. A PSI deduction is calculated based on the AASHO formulas and deducted from the longitudinal profile value (ride) to determine PSI. The PSI deduction value is the crack and patch attribute used in the matrix.

Longitudinal profile value (ride) is a measure of the pavement's smoothness at a speed of 50 mph. The Iowa DOT developed the Iowa-Johannson-Kirk (IJK) ride meter based on similar principles used by the Mays and PCA road meter. The IJK ride meter is correlated annually in early June on 50 test sections with the CHLOE profilometer. Six test sections of various roughness are used for weekly checks. One third of the state's mileage is tested each year by the Office of Materials.

The PSI decrease per year on a six year basis is a simple mathematical computation where the most recent PSI value is subtracted from the PSI value of six years ago and divided by six. This value is used as an indication of the slope of the performance curve for each highway segment. The PSI is the longitudinal profile value minus the crack and patch value.

APPLICATION OF THE SYSTEM

Our highway sections are tabulated by surface type and initial construction project limits. There are approximately 1600 control sections in our pavement management system. Each control section has its own unique index number assigned to it, which allows us to generate a listing of control sections by index number.

The Office of Program Management and Department key staff assign programming criteria to the matrix listing and generate a list of potential rehabilitation candidate projects for the upcoming program in a prioritized format. Examples of programming criteria are: number of miles which can be programmed by level of service, availability of funds, and type of work to be performed.

It was recognized that a roadway segment could have a matrix index number which would be high enough to keep it from being considered in a rehabilitation program, yet, need further review because one of the attributes may be in a critical range. A table of critical values (Figure 5) was formulated which can be used to notify management that a specific problem may arise before a project may qualify for the rehabilitation listing based on overall matrix index.

Data Item	Acceptable Level
IJK Ride Value	Not less than 3.2
Asphaltic Concrete Rut Depth	Not greater than 0.25"
Crack & Patch Deduction	Not greater than 0.5
Annual Change in PSI	Not greater than 0.15
D-Crack Occurrence Factor	Not greater than 3

If the value of one or more data items fails the acceptable level criterion, then the highway segment will be listed as a potential candidate for remedial action and will be field reviewed.

Figure 5. Critical Values

The matrix is not the end result to programming. Once we have a candidate list, it is submitted to our district offices for review and comments. The list is then sent to our field review team who develop concept statements for each project. The field review team is comprised of an engineer from each of the Offices of Road Design, Materials, Maintenance, and respective District Engineer where the candidate project is located. The field review team provides valuable feedback to the pavement management system as they compare data we are supplying to actual conditions observed during the project concept statement stage.

Once a concept statement has been developed, it is presented to the highway staff review committee for their approval. Modifications are made as needed and the project then goes to the Office of Program Management and subsequently Commission for final approval.

With the completion of the data base, pursuit of the fourth objective as outlined by the pavement management committee, evaluating the performance of highways under different design, maintenance, and construction strategies is planned. Other areas to be addressed through our pavement management system are: life cycle costs, practical design year (20, 30, 40), where maintenance costs exceed benefits, optimization criteria for network level programming, and optimization for project level programming.

CONCLUSION

Iowa's pavement management system is a dynamic one in that it will be responsive to the needs of our highway system through the diligent and conscientious effort being expended by our highway engineers who maintain the overall program. Highway project decisions should be based on engineering judgement ascertained through a thorough analysis of the available data. A good computer program can sort and furnish reams of data; however, only the professional engineer can make the determination of whether or not the data is of any real value. A pavement management system does not make decisions, but provides the necessary information needed to engineers, commissioners, and administrators upon which to base sound and justifiable decisions.