Illinois Pavement Network Rehabilitation Management Program

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The Illinois Interstate highway network is deteriorating at a rapid rate because of its age and heavy truck loadings. Meanwhile, the funds required for rehabilitation far exceed the available budget. Illinois Department of Transportation (IDOT) administrators and planners are faced with many difficult questions about the consequences of adopting different pavement rehabilitation budgets and policies. To answer these questions, they need information about future rehabilitation needs and pavement conditions for different funding levels and rehabilitation strategies. The Illinois pavement network rehabilitation management program (ILLINET) was developed to provide this capability. The program generates useful results on a personal computer in both summary tables and graphics. Performance prediction and cost models are used together with decision trees to generate several feasible strategies for each pavement section in the network. All strategies for all sections are then analyzed together to find answers to a variety of "what if" questions regarding network budget levels and rehabilitation policies.

The Illinois Interstate system includes 490 different pavement sections totaling 1,700 centerline mi and having a pavement replacement cost of over $7 billion. The majority of these sections were built during the 1960s and early 1970s and have experienced severe climatic conditions and much higher traffic loadings than those for which they were designed. About half of the network has already been rehabilitated and the rest either is currently in need of rehabilitation or will be within the next 10 years. It is estimated that by the year 2000 nearly all of the sections in the network will have been rehabilitated at least once and about half will need another rehabilitation.

Unfortunately, the funds available for rehabilitation of the Interstate pavement sections are very limited. Therefore, not all of the many sections in the network that need rehabilitation can be funded. The rest must be deferred until funding becomes available. By that time, however, not only will the deferred projects be further deteriorated, but more projects will have been added to the backlog, thus requiring a much higher budget to maintain the network condition at an acceptable level. Increased routine/emergency maintenance costs are also incurred as the backlog increases.

The Illinois Department of Transportation (IDOT) has not had available an accurate procedure for estimating future funding needs and pavement conditions. This paper summarizes the pavement management program being developed for IDOT, which has been designed to provide IDOT with these capabilities, and also to meet the current FHWA policy on pavement management.

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ILLINOIS PAVEMENT MANAGEMENT SYSTEM

A joint team of University of Illinois and IDOT personnel was formed to develop the Illinois Pavement Feedback System (IPFS) in 1985. The objective of IPFS is "to provide a formalized data processing structure and process which will collect, store, retrieve, and analyze design, materials, traffic, condition, and performance data for existing pavements" (*1*). A major part of the IPFS project is the development of the IPFS data base, which will provide IDOT districts and central offices with the information they need for various pavement design and planning purposes. Development of analysis routines for purposes such as special studies, research, prediction models, and answers to "what if" questions at the project level and network level to improve management strategies is also part of the IPFS project.

The research objective of this portion of the study was to develop a network rehabilitation management program (ILLINET) to aid IDOT districts and central offices in pavement management decision making for the Illinois Interstate highway network. This program analyzes data regarding pavement, traffic, climate, and other factors to provide answers to critical questions often asked about the network at the planning and administration level before budget allocations are made. ILLINET will also provide IDOT with the optimum rehabilitation program for a certain budget, and also the minimum budget required to maintain the Illinois Interstate network in a desired condition. ILLINET is a totally interactive computer program with user-friendly menus and graphics.

The development of ILLINET includes the use of available predictive models and development of other models needed. Specifically, systems are developed to

1. Provide a variety of methods to generate feasible pavement rehabilitation strategies (treatments and timings) for each pavement section in the Illinois Interstate network over a period of up to 10 years,
2. Provide several network management algorithms and several ways of defining "benefits,"
3. Determine the overall rehabilitation program for a selected budget or the budget required to maintain the network condition at a desired level, and
4. Provide answers for a variety of "what if" questions that are asked before a policy is adopted or budgets are allocated for the rehabilitation of pavements.

PAVEMENT PERFORMANCE PREDICTION MODELS

Performance prediction is essential to a pavement management system. ILLINET uses several models to predict distresses for each pavement type. An overall condition index based on the existing key pavement distresses was also developed as a measure of performance.

Distress Prediction Models

Several distress models were utilized for each of four pavement types considered in the program.

1. Jointed reinforced concrete pavement (JRCP)
   - Faulting
   - Joint deterioration
   - Existing full-depth repair
   - Cracking
   - Pumping
2. Continuously reinforced concrete pavement (CRCP)
   - Failure (punchouts plus steel ruptures plus existing full-depth repairs)
3. Asphalt concrete (AC) overlays of JRCP
   - Reflective cracking
   - Rutting
4. Asphalt concrete (AC) overlays of CRCP
   - Reflective cracking
   - Rutting

The JRCP models used in the program were developed under NCHRP Project 1-19: Concrete Pavement Evaluation System (COPES) (*2*). The CRCP and asphalt overlay models were developed as a part of this research project.

Pavement Condition Models

A condition index (CRS) ranging between 1 and 9 was developed for each pavement type as a function of various pavement distresses. The CRS is used for different pavement rehabilitation trigger values. It is also used to measure the effectiveness of a pavement rehabilitation strategy. The following equations were derived based on engineering judgment.

$$\text{JRCP CRS} = 9 - a_1 * \text{FAULT} - a_2 * \text{CRACK} - a_3 * \text{JTDET}$$

where

FAULT = average joint faulting per mile (inches),
CRACK = linear feet of deteriorated cracks per mile,
JTDET = number of deteriorated joints per mile, and
a_i = coefficients based on judgment of experienced engineers.

$$\text{CRCP CRS} = 9 - b_1 * \text{FAIL} - b_2 * \text{PATCH}$$

where

FAIL = number of failures per mile,
PATCH = number of full-depth repairs per mile, and
b_i = coefficients based on judgment of experienced engineers.

$$\text{AC overlay CRS} = 9 - c_1 * \text{NCRACK} - c_2 * \text{RUT}$$

where

NCRACK = number of deteriorated reflected transverse cracks per mile,
RUT = average rutting (inches),
c_i = coefficients based on judgment of experienced engineers.

These equations are being further verified in the field with experienced IDOT engineers.

PAVEMENT REHABILITATION COST AND TRAFFIC MODELS

The cost of each rehabilitation technique is needed to calculate the overall cost of a rehabilitation strategy. Unit costs for various techniques can be entered into the program. All cost items are expressed on a lane-mile basis. Detailed distress data are available for each traffic lane from the pavement survey. These data are used to estimate patching quantities. Shoulder and subdrainage costs are included. The statewide average unit cost of pavement rehabilitation in 1987 for both lanes is as follows:

1. JRCP patch (one 12- × 6-ft patch), $1,200;
2. CRCP patch (one 12- × 10-ft patch), $2,300;
3. 3 in. asphalt-concrete overlay (2 lane-mi plus shoulders), $178,000;
4. 5 in. asphalt-concrete overlay (2 lane-mi plus shoulders), $277,000; and
5. Reconstruction (2 lane-mi, 10 in. CRCP), $600,000.

All future costs are adjusted using an inflation rate. Future annual average daily traffic (AADT) and 18-kip equivalent single-axle loads (ESALs) are predicted for user-input growth factors.

BENEFITS OF PAVEMENT REHABILITATION

An estimate of the benefits of pavement rehabilitation must be made to determine how well the funds are being spent and to optimize the expenditures. There has never been a consensus on how to define "benefit." Several ways were examined.

Pavement Rehabilitation Life

The longer a pavement rehabilitation performs adequately, the higher the user benefit derived, because the pavement will carry additional traffic. Thus, benefit is directly proportional to pavement life. Pavement life can be defined as the length of time the pavement functions adequately or the amount of ESALs it can carry adequately.

Pavement Usage (VMT)

Pavement usage can be defined as the number of vehicle miles a pavement section carries over a time period. A familiar terminology for pavement usage is vehicle-miles traveled (VMT). VMT for 1 year for a section of pavement is calculated as follows:

$$\text{Yearly VMT} = \text{AADT} * \text{length (miles)} \times 365$$

Thus, VMT for a given section is a direct measure of the use of that section and could be considered as a pavement benefit. For example, the percentage of travel on a highway network on pavements in good condition would give an estimate of the adequacy of the network. This parameter has been well accepted by IDOT personnel.

Pavement Structural Integrity

Another function of a pavement is to retain its structural integrity under traffic loadings and various climatic conditions. The CRS is a function of key pavement structural distresses and is a good indicator of structural integrity of pavements. The area under the CRS-age curve, or the mean CRS value over the life of the pavement, can be used as another type of pavement benefit. CRS can be weighted by a utility factor to indicate the value to the pavement engineer in improving a pavement at different condition levels.

Summary

Some of the functions that could potentially be used as the measure of pavement benefit are

1. Area under the pavement CRS-versus-age curve,
2. VMT on adequate (or acceptable) pavement,
3. Pavement condition weighted by usage.

The first item is not weighted by pavement usage; however, this can be used separately as the measure of the benefit if equal usage of all sections is assumed. The second benefit function is simply the product of pavement life and usage:

$$\text{VMT}_{\text{adequate}} = \sum \text{VMT for years the pavement is adequate (acceptable)}$$

The last benefit measure, pavement condition weighted by usage, can be considered an indirect measure of user costs because different unit user costs can be attributed to different condition levels. The VMT and mean CRS measurements of benefit appear to be the most useful and understandable at this time.

PROJECT-LEVEL REHABILITATION SELECTION

Five different pavement rehabilitation alternatives are considered for each section every year in the analysis period as follows:

1. Routine maintenance,
2. Concrete restoration (CPR),
3. 3.0-in. AC overlay,
4. 5.0-in. AC overlay, and
5. Reconstruction (10-in. CRCP).

Three methods for choosing a rehabilitation alternative are available.

1. Engineering judgment (decision trees),
2. Life-cycle cost analysis, or
3. Fixed rehabilitation type (selected by user for all sections).

Engineering Judgment

A decision tree based on engineering judgment was developed to identify the best rehabilitation alternative for a given pavement section condition in a given year. Table 1 shows the decision trees for each of the four pavement types.

This decision tree is based on the present condition of the pavement and whether or not the pavement is D-cracked. For a CRS of 6 or more, no major rehabilitation is selected and only routine maintenance is performed. However, for a CRS less than 3 the choice for all pavement types is reconstruction. This is based on the fact that, due to the poor condition of

TABLE 1 REHABILITATION DECISION TREE: ENGINEERING JUDGMENT

Criteria	JRCP	CRCP	D Cracked	ACOL
CI>= 6	Maintain	Maintain	Maintain	Maintain
6>CI>= 5	Restore	Restore	3" ACOL	3" ACOL
5>CI>= 4	3" ACOL	3" ACOL	5" ACOL	5" ACOL
4>CI>= 3	5" ACOL	5" ACOL	5" ACOL	5" ACOL
CI<3	Reconstruct	Reconstruct	Reconstruct	Reconstruct

the pavement, other major rehabilitations (e.g., AC overlays) can not provide adequate strengthening of the pavement. For a CRS between 3 and 6, restoration, 3-in. asphalt overlay, or 5-in. asphalt overlay is selected based on pavement type and condition. For D-cracked pavements additional pavement strengthening is required.

Life-Cycle Cost

Another way to find the best rehabilitation alternative for a pavement section is by performing a life-cycle cost analysis. In this analysis the rehabilitation alternative that provides the lowest annual rehabilitation cost is selected. The annual cost of pavement rehabilitation is calculated simply as follows:

$$\text{Annual cost} = \frac{\text{total cost of rehabilitation}}{\text{rehabilitation life (years)}}$$

Pavement rehabilitation life is defined as the number of years the pavement condition stays adequate (i.e., CRS greater than 6). This is estimated using the distress prediction models. Total cost of rehabilitation is calculated from the estimated distress and the unit costs.

Fixed Rehabilitation

This option is similar to the decision tree except that only one rehabilitation alternative is considered for all pavements. When the CRS falls below a user-defined minimum condition level, one of the four rehabilitation alternatives specified by the user is applied. For a CRS greater than the minimum condition level, only routine maintenance is performed.

NETWORK MANAGEMENT ALGORITHMS

Three different approaches to pavement-network management are considered; Needs, yearly pavement network rehabilitation management (ranking), and long-range pavement-network rehabilitation optimization.

Needs

"Needs" is an algorithm developed to estimate the unrestrained budget pavement rehabilitation needs for 10 years. Every section in the network whose condition falls below a user-defined minimum condition level is a candidate for pavement rehabilitation. The type of rehabilitation is determined by the choice of project-level rehabilitation selection routine. There is no yearly budget constraint, and all sections in need of rehabilitation receive some kind of rehabilitation.

Yearly Ranking

This algorithm applies when the yearly budget for rehabilitation is limited or a lower performance standard than Needs is accepted. Therefore, not all the sections that need rehabilitation will receive funding. In this approach, the decision about pavement rehabilitation is made each year in the analysis period, independent of any actions that might be taken in the future. The constraint may be either the budget limit or desired performance standard for each year. Three algorithms are available for this approach.

Simple Ranking

Funding is allocated based on a worst-first rule. Those sections that have the lowest CRS will be rehabilitated until the constraint is met for that year. Those sections that do not receive funding are delayed for 1 year. The same algorithm is applied each year in the analysis period.

Ranking by Benefit-Cost Ratio

This is similar to ranking, except that pavements are ranked by their benefit-cost ratio rather than their present condition. In this algorithm future performance of a rehabilitation, rather than its current condition as in the case of ranking, is the criterion for funding. Because the choice of rehabilitation is determined by the rehabilitation selection routine, there is only one rehabilitation choice for each section, the best alternative as defined by the selection routine. As with ranking, rehabilitation for sections that do not qualify for funding is delayed for at least 1 year.

Ranking by Incremental Benefit-Cost Ratio

In this algorithm, the choice of rehabilitation as well as the choice of sections to receive rehabilitation each year is determined at the network level. Thus, unlike the previous algorithms, the choice of rehabilitation is not determined by a rehabilitation selection routine for each section in the network. The objective is to

- Maximize the future benefit of rehabilitation for every year, subject to a yearly budget constraint or
- Minimize the cost of rehabilitation for every year to a yearly desired performance standard.

Long-Range Optimization

This approach consists of project-level and network-level analyses. At the project level, several long-term (usually 10-year) strategies are generated for each section in the network. These strategies can be generated by applying one of the following methods every year in the analysis period:

1. All rehabilitation types,
2. Decision tree,
3. Fixed rehabilitation, or
4. Life-cycle.

At the network level, one strategy for each section is selected such that the network benefit (sum of the benefit for selected strategies) is maximized for a network budget limit. A linear programming package called LINDO is employed to solve the optimization problem.

INPUTS AND OUTPUTS

The ILLINET program is now in its second version. ILLINET is written in ANSI 77 FORTRAN and was originally developed on a DOS-compatible microcomputer; however, it is easily transportable to any other computer. A program written in BASIC provides the user-friendly interface to ILLINET and also displays some of the outputs in graphics. A network that contains all the sections in IDOT District 5 is used for illustration.

ILLINET Inputs

There are two different inputs to the program: section data elements and program analysis parameters. Section data elements are all the data that are required to predict pavement performance for each section in the network (see Table 2 for a listing of variables). These data consist of section identification, design, traffic, climatic, and distress. These data are presently available in the IPFS data base. Data elements are stored in a separate file and can be easily modified. Program network analysis parameters are the user-specified variables shown in Figure 1. The user can enter ADT growth rate, ESAL growth rate, minimum CRS to trigger rehabilitation, and discount rate.

ILLINET Algorithms

The algorithm for analysis can be chosen from the Run Programs option of the main menu as shown in Figures 1 and 2. The choice of Rehabilitation Selection routine, type of benefit, and a yearly network budget limit is also entered. For illustrative purposes the Ranking network algorithm and the

TABLE 2 SECTION DATA ELEMENTS REQUIRED FOR ILLINET

Variable	Description
ROUTE	Interstate route number
DIRECT	Direction (N, E, S, W)
BEGIN	Beginning milepost
END	Ending milepost
TYPE	Type of pavement (JRCP, CRCP, JROL, or CROL)
DIST	District
AGE	Age of the pavement (years)
CESAL	Cumulative ESAL since major rehabilitation
ESAL	ESAL per year
THICK	Thickness of the main pavement layer (inches)
JRCP and CRCP	
DCR	"D" Cracking
SD	Steel diameter (inches)
SS	Steel spacing (inches)
PATCH	Number of patches
FPAT	Number of failed patches
FAIL	Number of cracks for JRCP and punchouts for CRCP
BASE	Base type
Additional items for JRCP	
FI	Freezing Index
PREC	Average annual precipitation
PUMP	Pumping
DRN	Drainage
TJSD	Joint seal damage
FLT	Faulting (inches)
DETJT	Deteriorated joints (number per mile)
ACOL	
OLTHK	Overlay thickness (inches)
RUT	Rutting (inches)
RFC	Number of transverse reflective cracking
PATCH	Number of patches
FPAT	Number of failed patches
RPAT	Number of patches before overlay

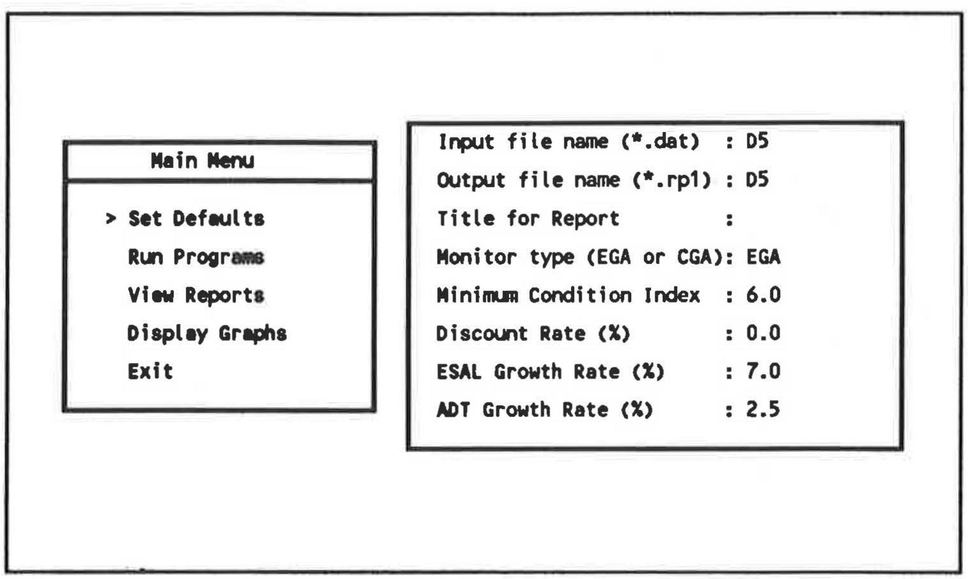

FIGURE 1 ILLINET main menu and Set Defaults option.

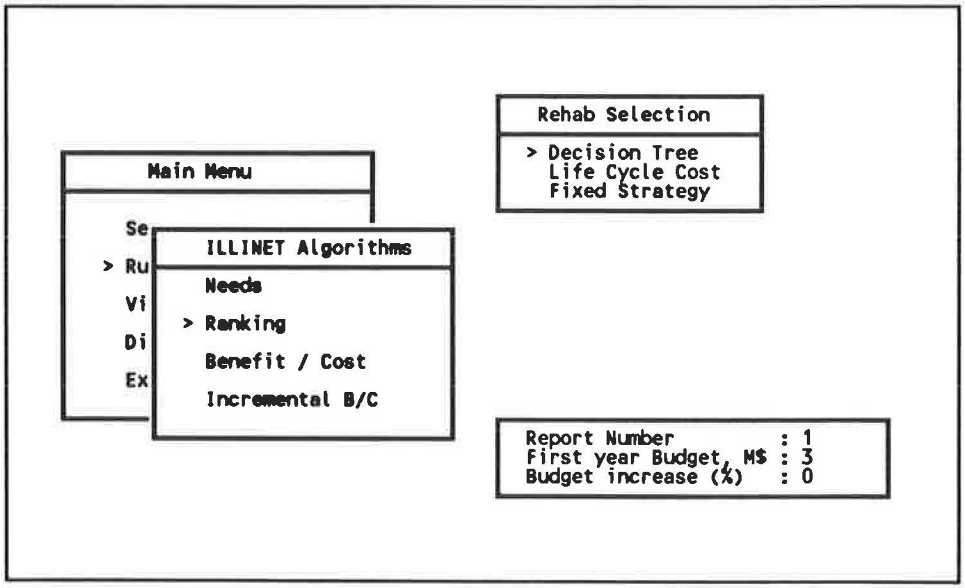

FIGURE 2 ILLINET Run Programs option for ranking.

ILLINOIS PAVEMENT FEEDBACK SYSTEM
NETWORK REHAB MANAGEMENT PROGRAM

ILLINET 2.0
REVISED: 10 JUL 1989

NETWORK SUMMARY FOR:District 5 Sample
REHAB SELECTION: DECISION TREE
NETWORK ALGORITHM: RANKING

NUMBER OF SECTIONS: 53
AVERAGE NETWORK CI: 7.0
TOTAL COST (M$): 27.3

TOTAL LENGTH: 236.7 MI.
TOTAL VMT: 10.3 BIL.
% VMT BACKLOG: 16.6%

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AVERAGE CI	8.6	8.3	7.9	7.6	7.2	6.8	6.4	6.1	5.7	5.3
TOTAL VMT (BILLIONS)	.92	.94	.97	.99	1.02	1.04	1.07	1.09	1.12	1.15
% VMT BACKLOG	0	0	3	2	4	18	21	26	39	42
% BACKLOG MILES (CI<5)	0	0	4	2	4	15	18	23	39	40
% ACCRUING MILES (5<CI<6)	3	6	4	6	19	7	12	24	17	19
% ADEQUATE MILES (CI>6)	97	94	92	92	77	79	70	53	43	41
RECONSTRUCTED MILES	0	0	0	0	5	4	5	4	5	4
3 IN AC OVERLAY MILES	4	7	0	0	0	1	0	3	1	2
5 IN AC OVERLAY MILES	4	0	5	5	0	0	0	0	0	0
PATCH - MILES	0	0	0	6	0	0	2	0	0	0
MAINTAIN ONLY - MILES	229	230	232	225	232	231	230	230	231	231
ANNUAL COST (M$)	2.9	1.8	2.3	2.8	3.0	2.9	2.9	2.9	2.9	2.9
BUDGET (M$)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

FIGURE 3 Sample network summary report.

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*     ILLINOIS PAVEMENT FEEDBACK SYSTEM      *
*      NETWORK REHAB MANAGEMENT PROGRAM      *
*               ILLINET 2.0                  *
*          REVISED: 10 JUL 1989              *
**********************************************
* PROJECT SUMMARY FOR:District 5 Sample      *
* REHAB SELECTION:    DECISION TREE          *
* NETWORK ALGORITHM: RANKING                 *
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PROGRAM PARAMETERS
MINIMUM C.I. = 6.0
DISCOUNT RATE = .0%
ESAL GROWTH RATE = 7.0%
ADT GROWTH RATE = 2.5%

REHAB DECISION LEGEND
- = MAINTENANCE ONLY
P = PATCHING
3 = 3 IN AC OVERLAY
5 = 5 IN AC OVERLAY
R = RECONSTRUCTION

ALL COSTS ARE IN THOUSANDS.

ROUTE BMP	LENGTH	LANES	TYPE	AGE	C.I.	REHAB DECISIONS & COST FOR YRS 1-2		YEARS 3-5		YEARS 6-10	
057-N-168.30	3.59	2	10" JRCP	24	4.9	3-	1041	---	0	-----	0
057-N-171.89	5.00	2	10" JRCP	24	6.1	--	0	--R	3000	-----	0
057-N-176.89	4.21	2	10" JROL	5	9.1	--	0	---	0	-----	0
057-N-183.79	6.81	2	8" CRCP	22	5.2	-3	1806	---	0	-----	0
057-N-190.60	8.62	2	7" CROL	9	8.2	--	0	---	0	-----	0
057-N-199.22	4.62	2	7" CRCP	19	7.8	--	0	---	0	---R-	2772
057-N-203.82	3.85	2	7" CRCP	19	10.0	--	0	---	0	-----	0
057-N-207.67	4.28	2	7" CRCP	19	10.0	--	0	---	0	-----	0
057-N-211.95	3.84	2	7" CRCP	18	9.3	--	0	---	0	----R	2304
057-N-215.79	3.70	2	7" CRCP	18	9.4	--	0	---	0	-----	0
057-N-219.49	4.65	2	10" JRCP	24	7.8	--	0	-P-	459	-R---	2790
057-N-224.14	4.04	2	10" JRCP	25	8.5	--	0	---	0	--R--	2424
057-N-228.18	5.40	2	10" JRCP	25	8.2	--	0	---	0	-----	0
057-N-233.58	3.22	2	10" JROL	2	9.4	--	0	---	0	-----	0
057-N-236.80	.91	2	10" JROL	2	9.4	--	0	---	0	-----	0
057-N-237.71	5.39	2	7" CROL	4	8.1	--	0	---	0	-----	0
057-N-243.10	2.12	2	7" CRCP	19	10.0	--	0	---	0	-P--3	720
057-N-245.22	5.23	2	7" CRCP	18	7.7	--	0	---	0	-----	0
057-N-250.45	5.38	2	7" CRCP	17	10.0	--	0	---	0	-----	0
070-E-106.70	1.80	2	8" CROL	2	9.1	--	0	---	0	-----	0
070-E-108.50	1.20	2	8" CROL	2	9.3	--	0	---	0	-----	0
070-E-109.70	7.28	2	8" CROL	2	9.1	--	0	---	0	-----	0
070-E-118.40	.72	2	8" CRCP	17	10.0	--	0	-5-	262	---3-	138
070-E-119.12	2.33	2	8" CROL	5	9.5	--	0	---	0	-----	0
070-E-121.45	4.05	2	8" CRCP	17	9.7	--	0	---	0	R----	2430
070-E-129.50	4.90	2	8" CROL	0	10.0	--	0	---	0	-----	0
070-E-134.40	2.50	2	8" CROL	3	8.0	--	0	---	0	--3--	480
070-E-136.90	4.30	2	8" CROL	0	10.0	--	0	---	0	-----	0
070-E-141.20	5.50	2	8" CRCP	17	10.0	--	0	---	0	-----	0
070-E-146.70	9.05	2	8" CROL	8	9.2	--	0	---	0	-----	0
072-E- 21.24	7.86	2	8" CRCP	12	10.0	--	0	---	0	-----	0
072-E- 29.10	2.29	2	8" CRCP	12	10.0	--	0	---	0	-----	0
072-E- 31.39	2.97	2	8" CRCP	12	8.8	--	0	---	0	-----	0
072-E- 34.36	3.19	2	8" CRCP	12	10.0	--	0	---	0	-----	0
072-E- 37.55	4.32	2	8" CRCP	15	10.0	--	0	---	0	-----	0
072-E- 41.87	6.53	2	8" CRCP	12	9.7	--	0	---	0	-----	0
072-E- 48.40	5.02	2	8" CRCP	12	10.0	--	0	---	0	-----	0
072-E- 53.42	4.64	2	8" CRCP	12	10.0	--	0	---	0	-----	0
072-E- 58.06	4.82	2	8" CRCP	12	10.0	--	0	---	0	-----	0
072-E- 62.88	4.78	2	10" JRCP	26	7.6	--	0	---	0	-----	0
072-E- 67.66	5.19	2	7" CROL	5	9.2	--	0	---	0	-----	0
072-E- 72.85	5.40	2	7" CROL	5	9.0	--	0	---	0	-----	0
074-E-155.04	5.18	2	8" CROL	3	9.8	--	0	---	0	-----	0
074-E-160.22	2.85	2	8" CRCP	17	7.8	--	0	---	0	-----	0
074-E-163.07	3.80	2	7" CROL	5	6.9	--	0	---	0	-----	0
074-E-166.87	4.63	2	7" CRCP	17	10.0	--	0	---	0	-----	0
074-E-171.50	6.99	2	7" CROL	7	8.8	--	0	---	0	-----	0
074-E-178.49	1.42	2	10" JRCP	24	8.7	--	0	-P-	135	3----	427
074-E-179.91	4.24	2	10" JRCP	30	3.4	5-	1864	---	0	-----	0

FIGURE 4 Sample project summary report.

Decision Tree project rehabilitation selection are chosen with a $3 million first-year budget as shown in Figure 2.

ILLINET Output Reports

There are three different types of outputs from the program:

1. Network summary (big picture of results on one page),
2. Project summary (more detailed results), and
3. Project detailed (very detailed results, many pages).

The Network summary report for District 5 is shown in Figure 3 and contains information about the network 10-year performance and quantity of rehabilitation for every year. This shows that $27.3 million was expended over 10 years, the mean network CRS was reduced from 8.6 to 5.3, and 16.6 percent of all VMT was on backlog (or deteriorated) pavements. That means that about 1 in every 6 mi driven was in poor condition. The project summary report contains the rehabilitation program (timing and type) and the cost of rehabilitation for each section in the network (Figure 4). The project detailed report contains all the detailed data for each section in the network, as shown for three sections in Figure 5.

ILLINET Graphics

ILLINET also displays the key report data in graphic form. Figure 6 shows the ILLINET menu item for graphics. Four different graphical displays were of interest to IDOT.

1. Network summary graph: Network summary report key data are displayed in this graphic (see Figure 7). Note how

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                  *     ILLINOIS PAVEMENT FEEDBACK SYSTEM       *
                  *     NETWORK REHAB MANAGEMENT PROGRAM        *
                  *                                             *
                  *              ILLINET 2.0                    *
                  *         REVISED: 10 JUL 1989                *
                  *                                             *
                  ***********************************************
                  *                                             *
                  * DETAILED REPORT FOR:District 5 Sample       *
                  * REHAB SELECTION:    DECISION TREE           *
                  * NETWORK ALGORITHM: RANKING                  *
                  *                                             *
                  ***********************************************

PROGRAM PARAMETERS                                      REHAB DECISION LEGEND

MINIMUM C.I.       =  6.0                               - = MAINTENANCE ONLY
DISCOUNT RATE      =   .0%                              P = PATCHING
ESAL GROWTH RATE   =  7.0%                              3 = 3 IN AC OVERLAY
ADT GROWTH RATE    =  2.5%                              5 = 5 IN AC OVERLAY
                                                        R = RECONSTRUCTION
ALL COSTS ARE IN THOUSANDS.
FAULT AND RUT ARE IN 100THS OF ONE INCH.
PATCHES AND FAILURES ARE IN NO. PER MILE.

                    1987  1988  1989  1990  1991  1992  1993  1994  1995  1996
******************************************************************************
ID# 057-N-168.30     10" JRCP      LENGTH =  3.59      AGE = 24        ADT = 10.2
------------------------------------------------------------------------------
AVG 7.98      CI    4.9   9.4   9.0   8.7   8.3   8.0   7.6   7.3   6.9   6.6
           REHAB    3      -     -     -     -     -     -     -     -     -
SUM 1041    COST  1040     0     0     0     0     0     0     0     0     0
            ESAL   9.1    .7   1.4   2.1   2.9   3.8   4.7   5.7   6.8   7.9
         PATCHES   44     44    44    44    44    44    44    44    44    44
        FAILURES   56      3     4     4     5     5     6     6     7     7
    FAULT OR RUT   28      6    11    16    20    25    29    34    39    44
******************************************************************************
ID# 057-N-171.89     10" JRCP      LENGTH =  5.00      AGE = 24        ADT = 10.2
------------------------------------------------------------------------------
AVG 7.77      CI    6.1   5.4   4.6   3.7   2.8  10.0  10.0  10.0   9.9   9.9
           REHAB    -      -     -     -     R     -     -     -     -     -
SUM 3000    COST    0      0     0     0  3000     0     0     0     0     0
            ESAL   9.1   9.8  10.5  11.3  12.1    .9   1.8   2.8   3.8   5.0
         PATCHES    0      0     0     0     0     0     0     0     0     0
        FAILURES   48     60    74    89   106     0     0     0     0     1
    FAULT OR RUT   18     20    21    22    24     0     0     0     0     0
******************************************************************************
ID# 057-N-176.89     10" JROL      LENGTH =  4.21      AGE =  5        ADT = 10.9
------------------------------------------------------------------------------
AVG 7.89      CI    9.1   8.9   8.7   8.4   8.2   7.9   7.7   7.4   7.1   6.8
           REHAB    -      -     -     -     -     -     -     -     -     -
SUM    0    COST    0      0     0     0     0     0     0     0     0     0
            ESAL   3.0   3.5   4.2   4.9   5.6   6.4   7.2   8.1   9.0  10.0
         PATCHES    0      0     0     0     0     0     0     0     0     0
        FAILURES    8      8     8     8     8     9     9     9     9     9
    FAULT OR RUT    6      9    13    16    19    23    27    31    35    39
******************************************************************************
```

FIGURE 5 Sample project detailed report.

the amount of backlogged (or poor) pavements develop over time for this budget level.

2. Strip chart: This screen displays the condition of every section in the network on a straight-line diagram (see Figure 8). There is one line for every year in the analysis period. This screen can be used for observing network and section condition trends.

3. Project-level graph: This graph displays the data in the project detailed report. There is one graph for every section in the network (see Figure 9).

4. Network map: This screen displays a map of the network with sections color coded for different pavement types, ESALs, condition index, and the type of rehabilitation for every year in the analysis period (see Figure 10). The user is able to select a section in the network and view the project-level graphs for that section (Figure 7) at the touch of a key.

CONCLUSIONS

ILLINET is a computer program developed to aid the IDOT Central Office and districts in various pavement network rehabilitation decisions. Several key questions can be answered with ILLINET, as listed earlier. One of the most interesting is, What type of rehabilitation selection procedures will provide the most benefits to the pavement network for the funds spent? Another interesting question is, What network rehabilitation algorithm (simple ranking or incremental benefit-cost ratio) will provide the most benefits to the pavement network for the funds spent? These and other questions are currently being examined for the Interstate system. ILLINET is currently developed for the Interstate network; however, it can be developed to address all other state routes in the future.

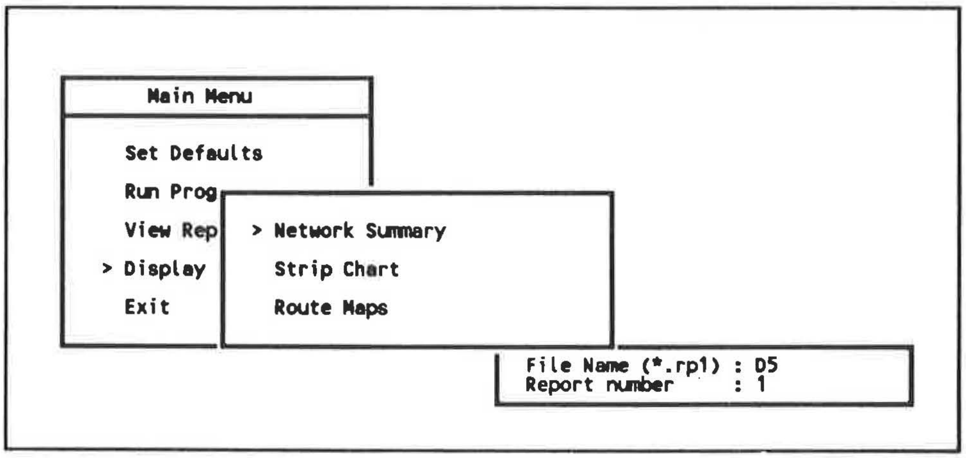

FIGURE 6 ILLINET Display Graphs menu option.

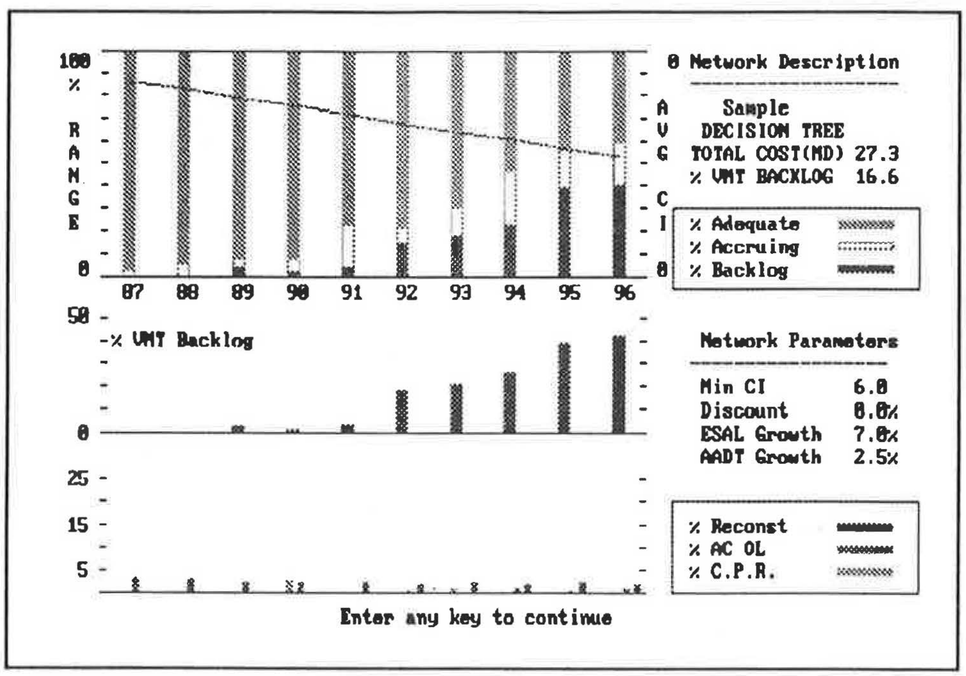

FIGURE 7 Sample network summary graph.

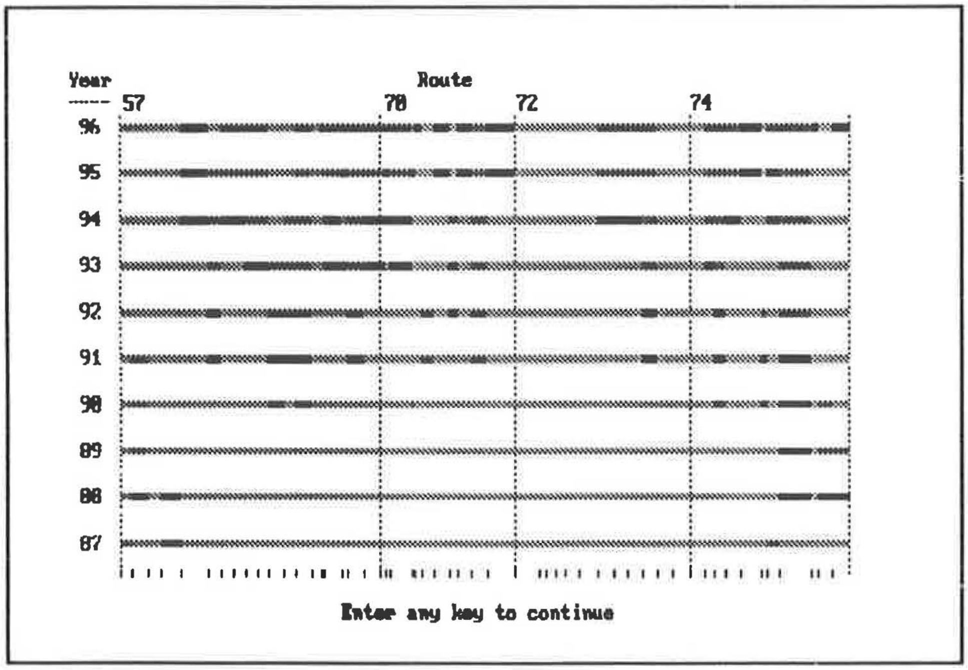

FIGURE 8 Sample strip chart graph.

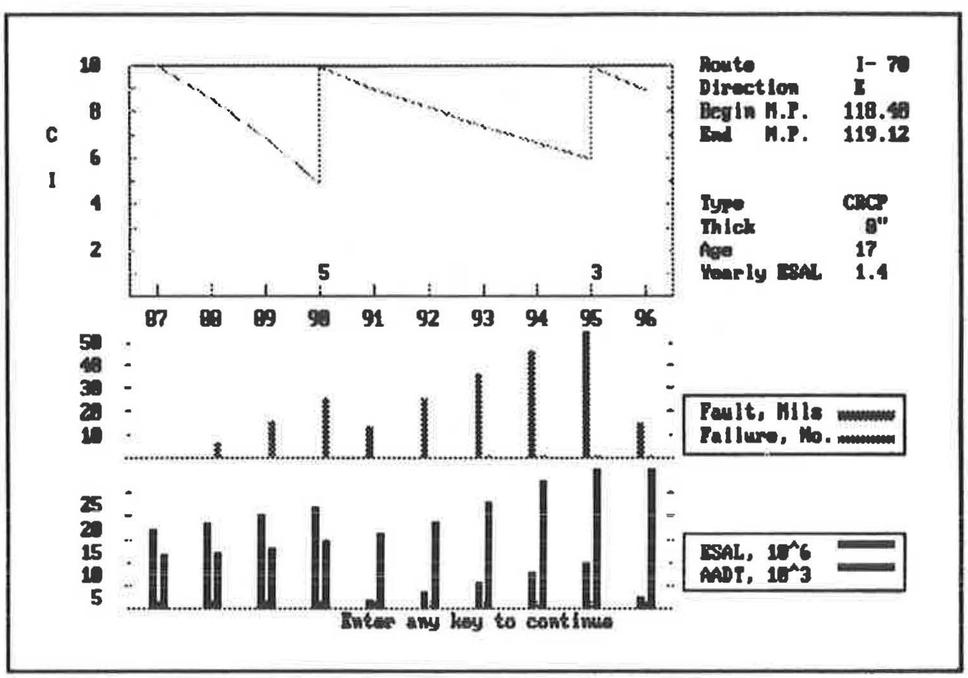

FIGURE 9 Sample project-level graph.

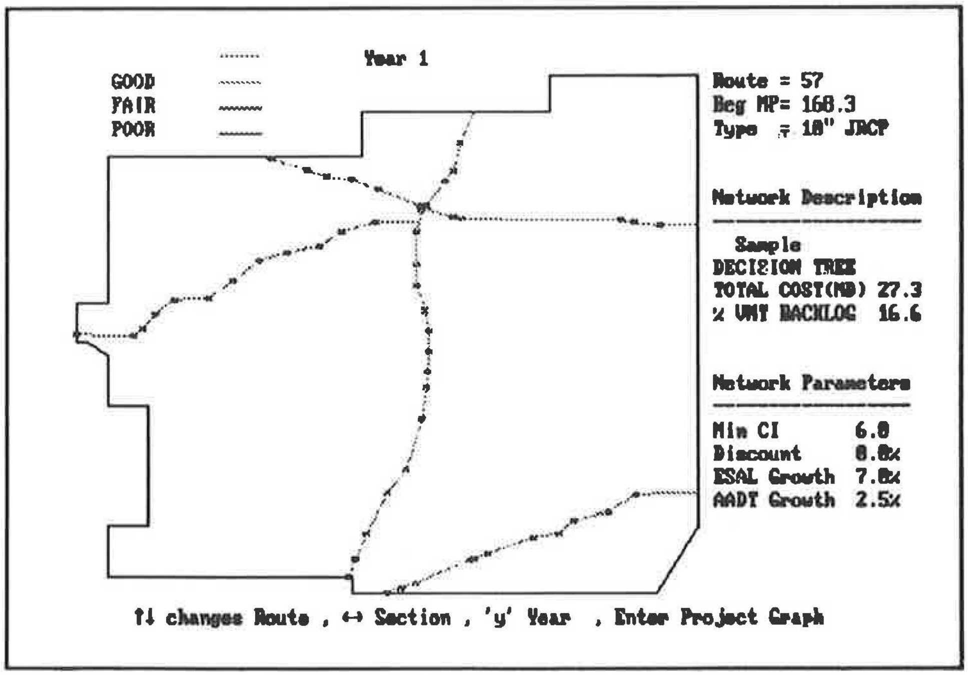

FIGURE 10 Sample network map.

The ILLINET program is currently undergoing extensive field testing by IDOT. The user-friendly program and the combination of text and graphical outputs will make ILLINET a practical tool for managers and engineers in the IDOT.

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REFERENCES

1. M. I. Darter et al. *An Illinois Pavement Feedback System: Feasibility and System Requirements*. Report 517-1. Department of Civil Engineering, University of Illinois at Urbana-Champaign, August 1985.
2. M. I. Darter, J. M. Becker, and M. B. Snyder. Concrete Pavement Evaluation System (COPES). NCHRP Report No. 277. TRB, National Research Council, Washington, D.C., 1985.

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