Pavement Loading/Design Relationships in Iowa

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ABSTRACT

The issue of truck impacts on the pavements is a major factor in the development of the Iowa Pavement Management System. An extensive data base covering the 10,000-mile Primary Road System provides traffic, construction, and performance in terms of ride and distress information on each segment of highway data back as far as the 1930's. Iowa is now ready to relate the various pavement performance measures to the traffic and environmental aspects of the highway system.

The analysis of the Equivalent Single Axle Loadings to date on the pavements has pointed out a need for more detailed and unbiased samples of the actual traffic stream in understanding the performance of the pavements. The results of four years of study on 21 separate road segments as part of the FHWA sponsored Long Term Pavement Monitoring Program has provided insight into the traffic and environmental relationships relating to pavement performance. They are providing information on the prediction of portland cement concrete faulting due to variations in the truck traffic stream and the value of truck information in the prediction of remaining pavement life for programming rehabilitation needs.

Iowa is participating in a SHRP pavement instrumentation demonstration project to assist in answering pavement performance problems. The Iowa plan calls for measuring the dynamic loads imparted to the pavement by a traffic stream and comparing it to these static loads used in the design to answer some of the performance questions. A second area of effort in the collection of truck data is included in two studies underway on the development of weigh-in-motion devices for sampling the traffic stream and its impact on bridge and pavements. The results of a study on the use of a bridge weigh-in-motion system and the development of a low cost weigh-in-motion system by Iowa, Minnesota, and FHWA will assist in the ability of the planners and designers to meet the pavement rehabilitation needs of the future.

INTRODUCTION

In 1979 Iowa began the development of a pavement management system to aid the Department of Transportation in the administration of the 1,000 mile primary road system.

Several factors play a major part in the performance of our pavements. To understand them, one must understand the characteristics and environment in which they act. Iowa is relatively small compared to other states with 56,000 square miles of area. The elevation of the state varies between 480 and 1670 feet above sea level. The average rainfall of 32 inches and snowfall of 30 inches are significant factors in the environment surrounding each pavement. The other environmental factor is the abundance of rich topsoil that forms much of the subgrade for the highways. It is essential to Iowa's farm economy, but provides several pavement performance problems related to subgrade stability and drainage.

Iowa has a variety of pavement surface types and pavement ages in place to provide research data. Much of the system was paved between 1930 and 1960 other than the addition of the Interstate between 1956 and 1985. The primary road system consists of 4,376 miles of asphaltic concrete, 5,654 miles of portland cement concrete, and 90 miles of surface treated or gravel surfaced roads. The asphaltic concrete mileage includes some 3,700 miles of composite pavement where an existing portland cement concrete pavement has been overlaid to extend the life of the original pavement. Some 3,000 miles of the original pavement are still in place providing service in an as-built condition or serving as a part of a composite pavement. The last 30 miles of our 780 mile interstate highway in Iowa was open to traffic in late 1985, some 81 years after the first pavement was cast in 1904 in Iowa. Much of the system miles have reached their design life and are in need of varying amounts of rehabilitation from patching to complete reconstruction.

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Travel in Iowa is not considered heavy in terms of vehicular volumes compared to the eastern states. It does serve as one of the major East-West highway links with I-80, US 30 and US 20 and North-South links with I-35, I-29, US 63 and US 218 for trucks. Each of these routes is a major truck route and in the case such as I-80 may carry from 30 to over 50 percent commercial trucks on many sections that were designed for 10 to 15 percent trucks. In 1982 the rural primary roads accounted for 9.3 percent of the total state mileage, carried 56.5 percent of total travel and 93.2 percent of the combination or heavy truck travel annually. This truck traffic includes the vehicles with three axles or more and has a very dramatic effect on the life of the pavement due to the large number of 18 kip equivalent axle loadings they produce.

The agricultural industry in Iowa also has a heavy impact on the performance of our pavements. Currently vehicles used by the farmer in transporting raw materials to the farm and products to market and considered "implements of husbandry" and exempt from many of the commercial truck regulations. Many of these vehicles consist of converted semi-trailer wagons and single axle wagons hauling as much as 1,200 bushels of corn and beans per load over the pavements. They play a dominant role in the performance of our existing pavements.

IMPORTANCE OF TRUCK INFORMATION

In 1986, two percent of the primary roads are more than 60 years old. An additional 75 percent are between 20 and 60 years old. Less than 23 percent of the mileage is under 20 years (design life) of age. Projecting this analysis ahead to the year 2002, the mileage of roads over 60 years of age will account for over 30 percent of the total mileage. Nine percent of the system will fall within its 20 year design life. The system can also be viewed as currently having an average age of 35 years and an average age of 46 years in 2002 if no reconstruction program increases take place during that time. Conflicting with the need to replace at least 160 miles per year to maintain a 60 year cycle is the ability of the department to only replace approximately 50 miles per year under the current budget limits.

With the current budgetary constraints, age and condition of the pavements, and the growth in the use of trucks in Iowa, it is imperative that we understand the impacts of changes in the truck size, weight, length, and axle configuration on the performance of our pavements.

PAST SOURCES AND USES OF TRUCK DATA

Truck weight, size and commodity information has been gathered in the past through biennial truck weight surveys. The surveys are conducted using both pit and portable scales and large crews of personnel during summer months on various parts of the highway system. Enforcement officers are not used in an attempt to gain representative data. The information is supplemented by the results of automatic traffic recorders located across the system that gather vehicle classification on a daily basis. It is both an expensive and time consuming process and the results may or may not represent the true truck traffic stream.

The resulting truck weight survey information was used in two major areas of programming and design. The programming of highway improvements prior to the 1980's has relied on the use of a 100 point sufficiency system. It provided ways of numerically rating each of segment of the rural and urban primary roads in terms of relative safety, service, and condition. Project programming was directed toward the improvement of those miles with sufficiency ratings of less than 50. Over the years the rehabilitation programming has targeted ratings between 30 and 60 and reconstruction for values of 0 to 30. Currently about 27 percent of the system is in the range of 0 to 50. The system two weaknesses associated with trucks and pavement performance. First it relies on the percent of trucks in the stream rather than number and characteristics. Secondly many of the trigger values for reduction in sufficiency ratings are related to the traffic factors rather than the condition ratings.

The same truck traffic information has been supplied to the road and bridge design offices for use in the development of alternative pavement and bridge designs. In this case the accuracy of our truck surveys and future predicted truck volumes have played a large part in our pavement successes and failures.

In both the programming and design areas it is evident that there is a real need for accurate information on the current truck usage and vehicle configuration for the Department to continue to provide the desired pavement performance.

IMPROVED TRUCK DATA COLLECTION AND USE

Iowa is committed to improving its truck data collection and the understanding of how the trucks interact with the pavement. This can be seen in the way we are using the historical data and how we plan to gather and analyze future data.

Much of the change came about during the conduct on a Federal Highway Administration sponsored Long Term Pavement Monitoring program that began in 1981. A pilot program involving eight states including Iowa, have identified the types of data required for a pavement data bank and methods for the collection of each data type. It provided Iowa with the seed money to develop new ways of using the truck and pavement condition data to improve our programming process.

Iowa has been fortunate in having large amounts of traffic data and pavement condition data dating back to the time many of the pavements were constructed. The detail in each area improved as a result of the 1958-1960 AASHO Road Test. Our objective became one of how to make use of the data that had been collected.

A pavement management matrix (Table 1) has provided the way to use the truck data and combine it with pavement condition data to identify pavement rehabilitation needs on an annual basis. The matrix contains eight factors including: percent remaining 18 kips, D-crack occurrence factor, structural adequacy, pavement width, rut depth, PSI deduction, longitudinal profile, and change in PSI over a six year period. Critical values for ride (greater than or equal to 3.2), rut depth (less than or equal to 0.25 inches), PSI deduction (less than or equal to 0.5 units), annual change in PSI (less than or equal to 0.15), and D-crack occurrence factor (less than or equal to 3), are also analyzed to assure that no defect is masked over in the matrix by the final index value. The 18 kip factor replaces a traffic volume factor that was used in the original matrix.

The loading factor is developed from the historical traffic volume and vehicle distribution and weight data. The pavement layer coefficients developed at the road test are used with the traffic data to develop a history of equivalent axle passages over time on each segment of the primary road system. A computer program analyzes the new traffic, truck weight, and pavement rehabilitation data annually to update the record and provide a total number of loadings to date with regard to the original construction and the latest overlay. In this way we are able to begin to understand the reasons for the particular performance of a pavement as it relates to pavement materials, environment, and the effect of truck traffic and configurations.

The Long Term Pavement Monitoring project and the use of the matrix have directed more attention to the use of truck prediction information in the design process. Pavement thickness, joint design and aggregates used in the pavement rely heavily on the accuracy of the truck data.

The department's rigid pavement design utilizes an analysis of the accumulated stress from the heaviest axle loads, the desired terminal serviceability or ride and the load carrying capacity of the pavement materials over the design

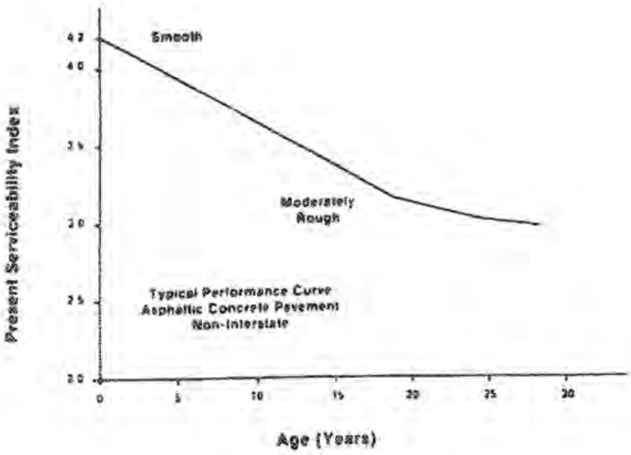
Table 1 — Pavement management matrix

	Factor value						
	1	2	3	4	5	6	7
Percentage remaining 18 Kips	< -19	-19	0	10	25	45	>70
P.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	.05
PSI deduction	>.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 y point scale.
If PSI <2.0, the Δ_6 in PSI will reflect a factor of 0

period to determine pavement thickness. The information for the expected traffic loadings is obtained from the truck weight surveys and a prediction of the truck volume growth rates. The estimate of daily truck activity is also used to determine the need for special load transfer devices in the pavement joints.

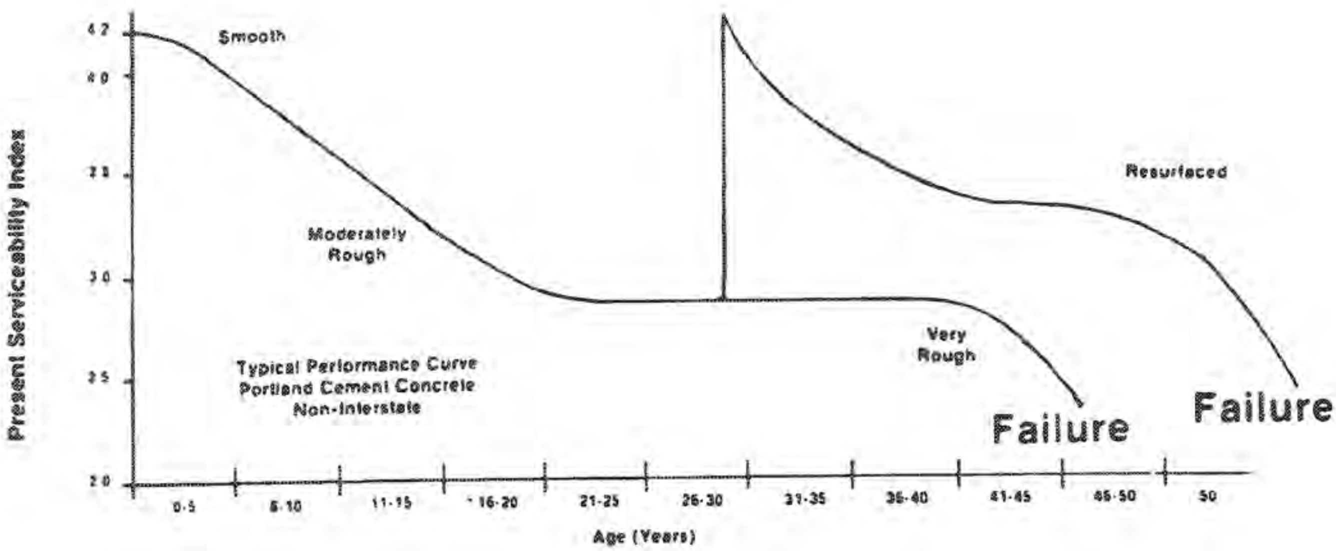
Flexible pavement designs utilize the AASHTO design method which employs the layer coefficients from the road test and a measure of the estimated equivalent axle loadings to enter the design thickness nomographs. The sensitivity of changes in equivalent axle load volumes over the design period on the thickness can easily be demonstrated.



PAVEMENT DESIGN/ PERFORMANCE ANALYSIS

The Long Term Pavement Monitoring (LTM) project and the development of the rehabilitation matrix have provided an insight into the relationships of pavement design and truck traffic to ride and pavement performance. Twenty-one sections of pavement have been monitored in the LTM project since 1981. During that time some 200 pavement cores and subgrade soil samples have been tested for thickness, strength, gradation, moisture and density. The ride, deflection and loading history have all been recorded and made available for study.

In 1981 the Department staff conducted a manual survey of the ride histories of all pavements in the primary road system. The results of that analysis provided the generalized performance curves for asphaltic concrete and portland cement concrete shown in Figure 1. From that study predictions of the 10 year rehabilitation needs of the system were made. Those predictions are meeting the test of time in terms of the pavement performance and rehabilitation timing. The curves comprise pavements of varying thickness from a uniform six to ten inches to those with seven to seven-and-one-half-inch centerline thickness and outer edges of eight to ten or more inches.

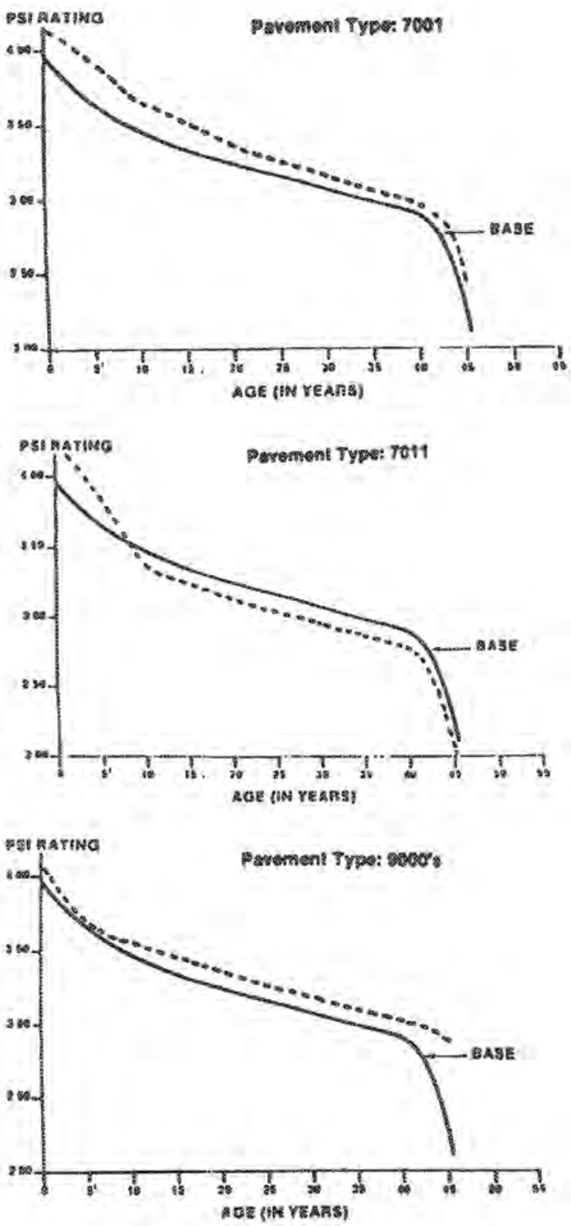


Iowa typical pavement performance curves (non-interstate)

FIGURE 1

The information shown on Figures 2 and 3 represents an analysis of all pavement surface types relative to ride in PSI vs pavement age in years. The surface codes are defined as follows:

Series	General Description
5000	Bituminous penetration on graded earth or gravel with or without admixture and at limited depths.
6000	Bituminous concrete over graded and drained earth, soil surface base, or gravel base with or without admixture. It also includes the overlays of portland cement concrete base or surface and brick pavements.
7000	Portland cement concrete over graded earth or gravel with or without admixture. Includes overlay of old concrete bases with concrete and bituminous overlays of less than one inch.
9000	Combinations of asphaltic concrete, portland cement concrete and or brick in the same roadway.



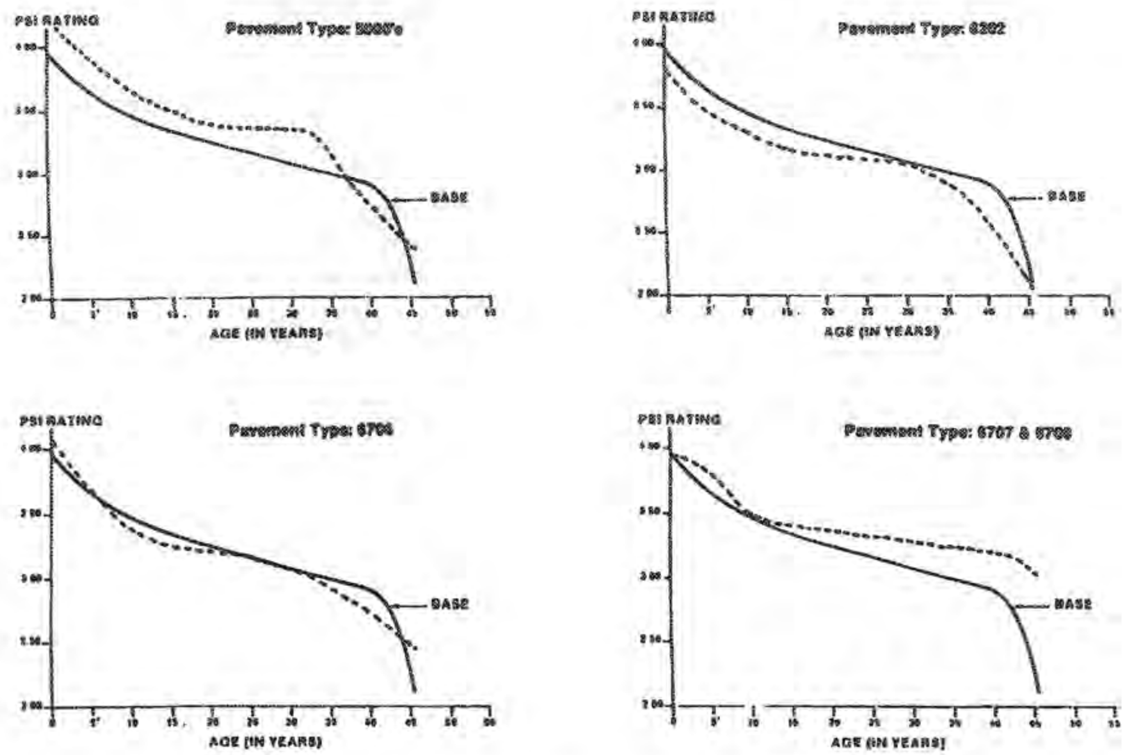
PSI vs age curve – January 1, 1984

FIGURE 2

The solid line in each graph represents the composite or base for all pavements in the system. The dotted line represents the performance of the particular surface type pavement histories. This same type of history has now been computerized to provide individual graphs for each pavement section in the primary road system. The key points to note in these graphs are the ability of each type of pavement to perform equally well in the Iowa situation and to outlive the 20 year design period by a margin of over 2:1. None of the pavement types varies substantially from the base curve. These graphs led us to the conclusion that we could easily provide 40 to 60 year pavement lives with proper maintenance and rehabilitation. The rehabilitation or addition of an overlay near the end of the design life of 20 years and the reduction of truck traffic by the construction of alternate routes has allowed many of the pavements represented to have their lives extended past the 40 year mark.

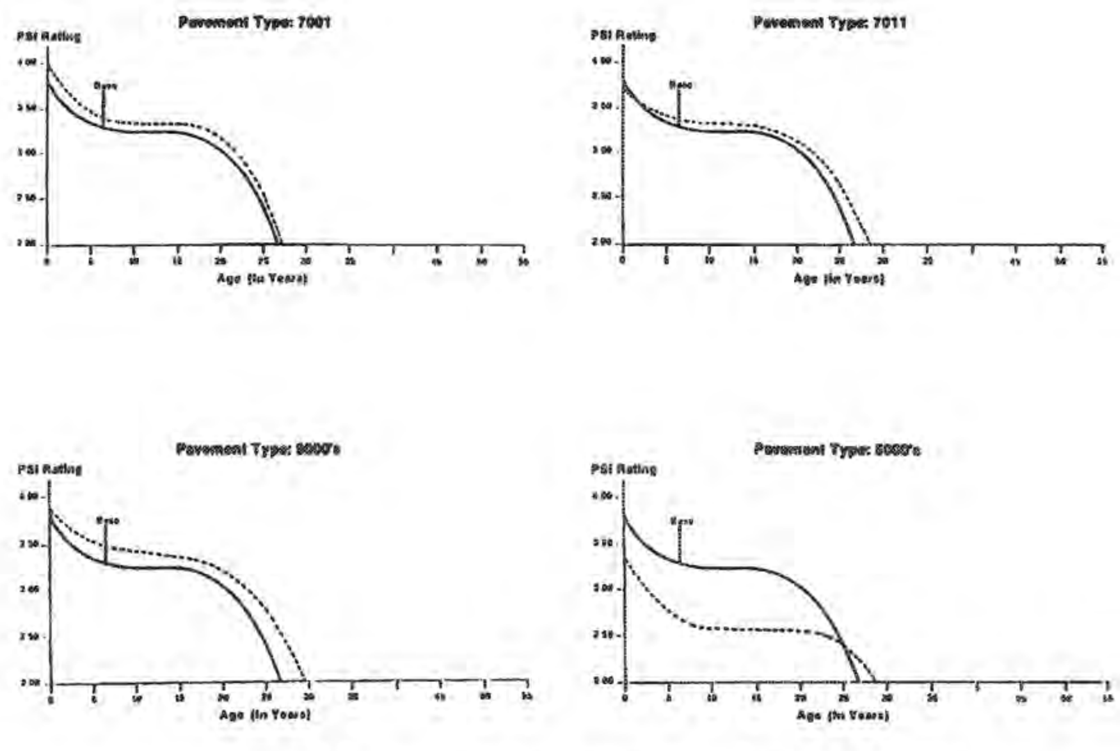
Similar results in performance of the overlays can be seen in Figures 4 and 5. The reduced performance in the 5000 series overlays is due to the minimal pavement design thickness and the introduction of heavier trucks during the design period. Many of these original surfaces were placed to control dust and became pavements over time through the application of several surface treatments. The application of heavier agricultural vehicles has had a devastating effect on these pavement and has directed the addition of a proper pavement or the reduction of the surface to a gravel to meet the current needs and funding constraints.

The resurfacing curves do point out that many of our pavements have gained up to 25 years of additional life with the overlays. The amount of life gained and the number of successive overlays required to get the added life has varied with the truck traffic requirements. In many cases the results represent one three inch overlay while in some cases they represent from one to three overlays of varying thickness of one to three inches per overlay. Our pavement management system is directing us away from the traditional three inch thickness to variable thickness designed to correct



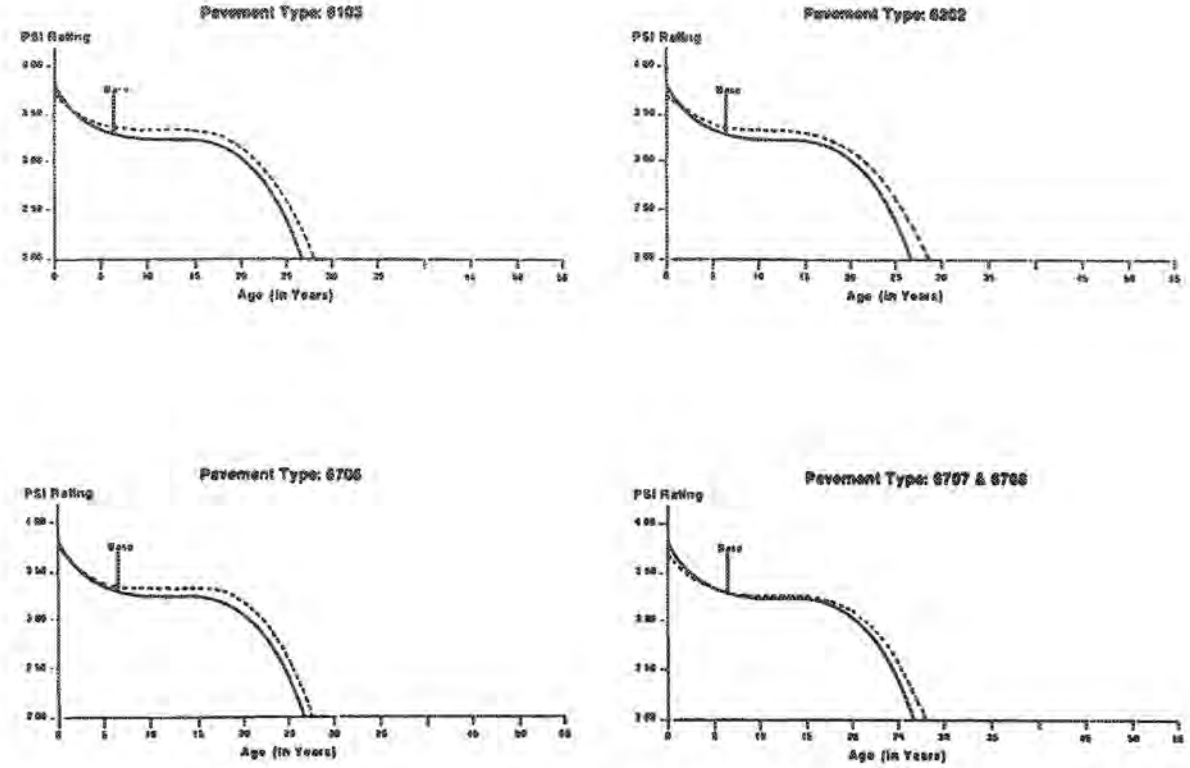
PSI vs age curve – January 1, 1984

FIGURE 3



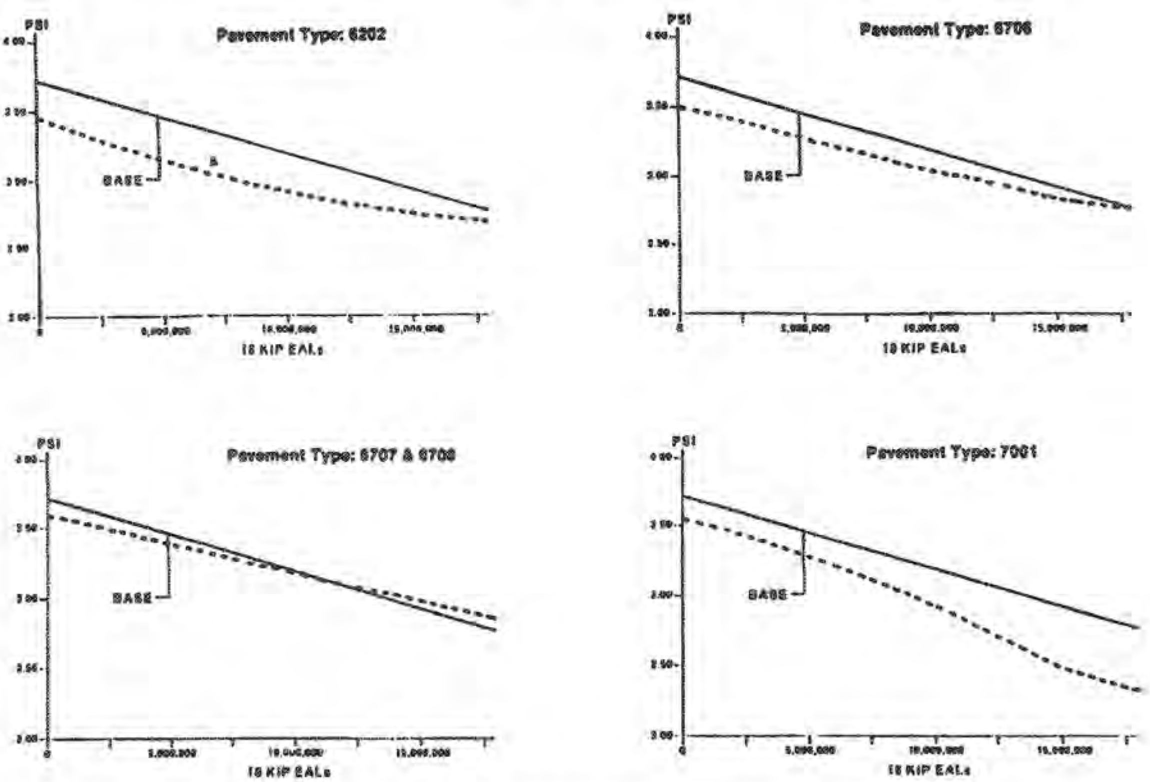
Overall PSI vs resurface age curve – January 1, 1984

FIGURE 4



Overall PSI vs resurface age curve - January 1, 1984

FIGURE 5



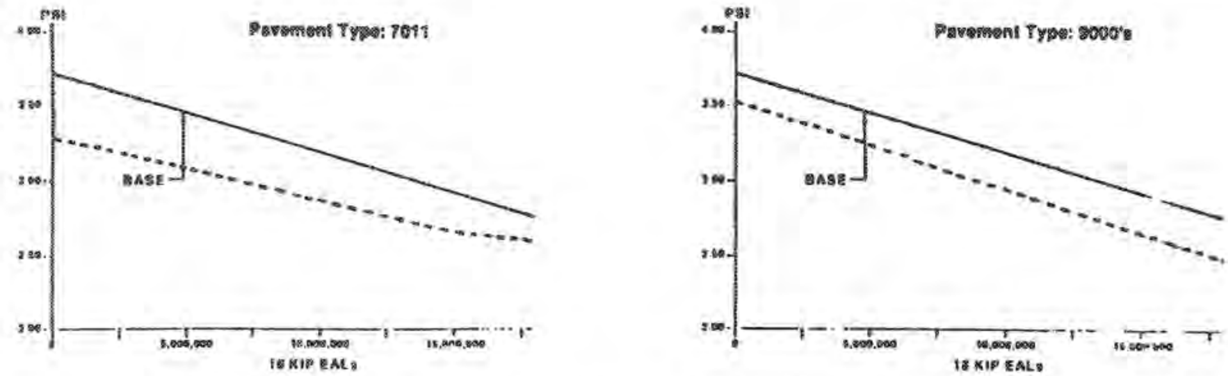
PSI vs pavement loadings (18 kip EALs) - January 1, 1984

FIGURE 6

identified pavement distresses for a designated analysis period for a given truck traffic prediction.

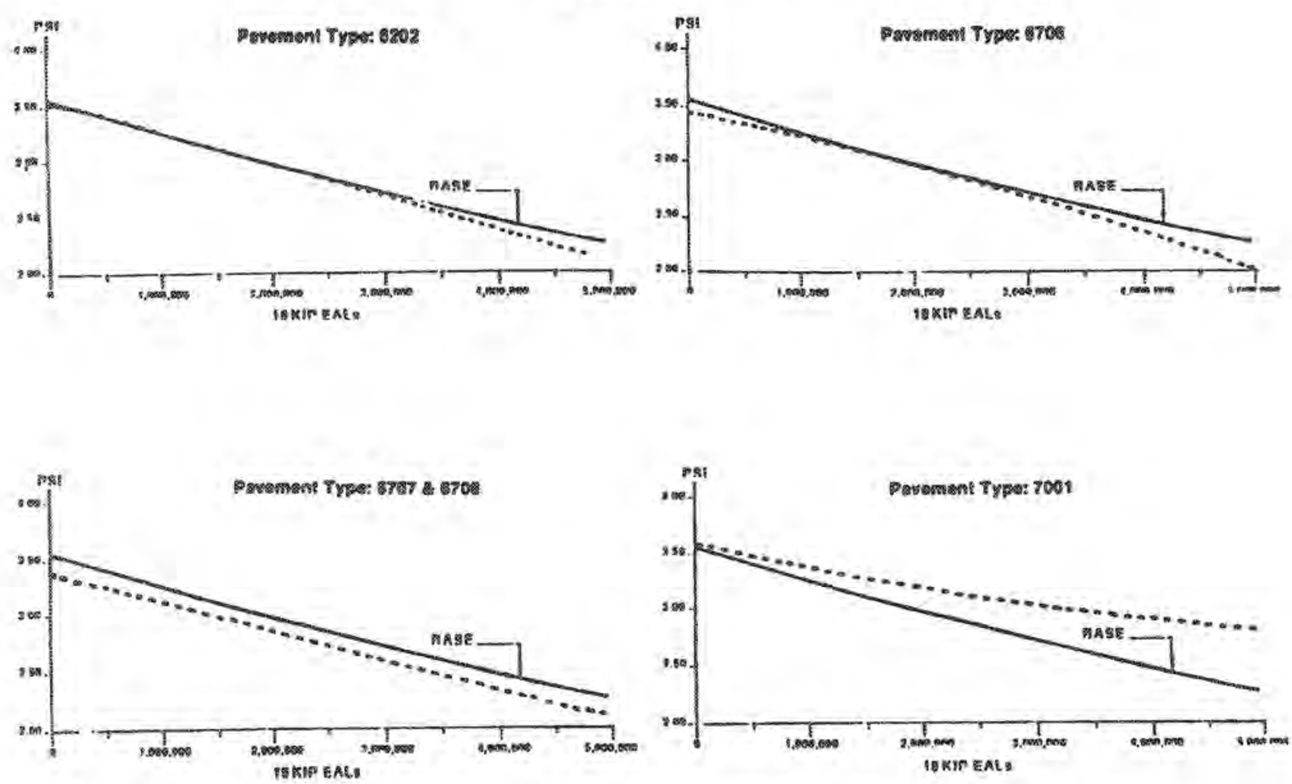
Similar graphs relating the 18 kip equivalent axle loadings to the ride are shown in Figures 6-9 for the primary road system surfaces. At the time the graphs were constructed the pavement loading information for the complete histories of the pavements were under study. Updated graphs of the information has not been compiled but should show similar relationships for the original pavement and resurfaced sections.

A special study has been made of the 11 sections used in the LTM study work. A map showing the locations of each of the sections selected is shown in Figure 10. Specific location identification data is shown in Table 2 for each section monitored. Columns one through four identify the section by county, route, literal description and the compass direction of the survey. Columns five and six of the table represent the beginning and ending physical milepost while columns seven and eight represent the milepoint termini. The roughness, skid and deflection testing is shown in columns nine and



PSI vs pavement loadings (18 kips EALs) - January 1, 1984

FIGURE 7



PSI vs pavement loadings since resurfacing (18 kip EALs) - January 1, 1984

FIGURE 8

Table 2 – LTM site identification

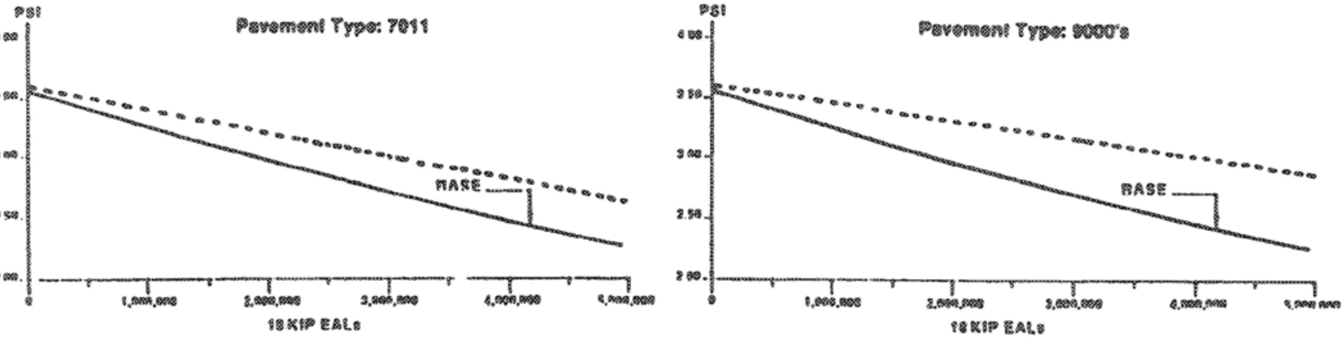
County	Route	Location	Dir surv	Beg MP	End MP	Beg mpnt	End mpnt	Materials beg test sec	Materials end test sec	Trk weight sta.	Vehicle count location	Dir constr	Surf. type
Floyd	US 18	N Jct 218 - Beg 22' Section	WB	208.00	209.00	15.76	16.76	208.00	208.50	85J	ME-34-33-3751	1966	7001
Worth	I-35	Kensett - IA 105 Intch	NB	211.00	212.00	9.22	10.22	211.00	211.50	94Q	ME-98-22-6726	1972	7222
Woodbury	I-29	IA 141 - Salix Intch	NB	131.00	132.00	4.37	5.37	131.00	131.50	95R	ME-97-11-8568	1959	7222
Allamakee	IA 51	NCL Postville north 4.63 mi	NB	2.00	3.00	2.04	3.04	2.00	2.50	85J	ME-03-11-4733	1968	7001
Monroe	US 34	Co Rd H-35 - WCL Albia	WB	162.00	163.00	9.59	10.59	162.50	163.00	85J	ME-68-22-3173	1963	7001
Emmet	IA 4	Palo Alto Co Line - Beg 24' Sec	NB	128.30	129.30	1.31	2.31	128.30	128.80	85J	ME-32-12-1522	1936	7011
Montgomery	US 71	Villisca - US 34	SB	27.00	28.00	2.86	3.86	27.00	27.50	85J	ME-69-14-4649	1972	7001
Boone	US 30	Asph Div Sec - Conc Div Sec	EB	141.79	142.79	23.68	24.68	142.00	142.50	85J	ME-08-24-8164	1973	7001
Marshall	US 30	Conc Reinf Sec - Non Reinf Sec	EB	174.00	175.00	5.12	6.12	174.00	174.50	24B	ME-64-21-6567	1963	7333
Polk	I-80	Altoona - Mitchellville Intch	EB	146.50	147.50	24.04	25.04	147.00	147.50	92N	ME-77-24-8653	1960	7222
Buena Vista	IA 3	Cherokee Co Line - US 71	WB	75.00	76.00	5.41	6.41	76.00	75.50	76M	ME-11-32-1703	1958	7001
Boone	US 30	Asph Div Sec - Conc Div Sec	WB	140.00	141.00	20.90	21.90	140.00	140.50	85J	ME-08-24-8264	1930	6706
Washington	US 218	Crawfordsville - IA 92	SB	63.00	64.00	5.91	6.91	63.00	63.50	24B	ME-92-24-1253	1930	6706
Boone	US 30	W Jct US 169 - Beg Conc Sec	WB	123.00	124.00	3.88	4.87	123.00	123.50	74H	ME-08-31-0192	1929	6706
Warren	I-35	Truro - St. Charles Intch	SB	49.00	48.00	6.15	5.15	49.00	48.50	97U	ME-91-21-3309	1958	6708
Pottawattamie	I-29	Honeycreek - I-680 Intch	SB	66.50	67.50	22.92	23.92	67.00	66.50	96T	ME-78-41-3169	1968	6708
Hamilton	US 20	Webster Co Line - W Jct IA 17	EB	135.00	136.00	0.78	1.79	135.00	135.50	24B	ME-40-41-0235	1929	6706
Black Hawk	IA 21	Tama Co Line - SCL Waterloo	NB	91.00	92.00	3.97	4.97	91.00	91.50	85J	ME-07-12-4757	1962	6202
Cedar	I-80	Springdale - Atalissa Intch	EB	260.50	261.50	6.90	7.90	261.00	261.50	91S	ME-16-12-6737	1968	6202
Montgomery	US 71	Jct US 34 - SCL Grant	SB	31.00	32.00	6.87	7.88	31.00	31.50	76H	ME-69-24-3143	1971	6202
Pottawattamie	I-80	E Lts Shelby - E Lts US 59 Intch	EB	38.00	39.00	37.96	38.96	38.00	38.50	93P	ME-78-45-8957	1966	7730

Notes: MP - Milepost
Mpnt - Milepoint
Dir Surv - Direction of Survey

ten. The closest truck weight station to the test site and the vehicle classification site on the test site identification numbers are shown in columns eleven and twelve. The year of original pavement construction and the existing surface type codes are shown in columns thirteen and fourteen.

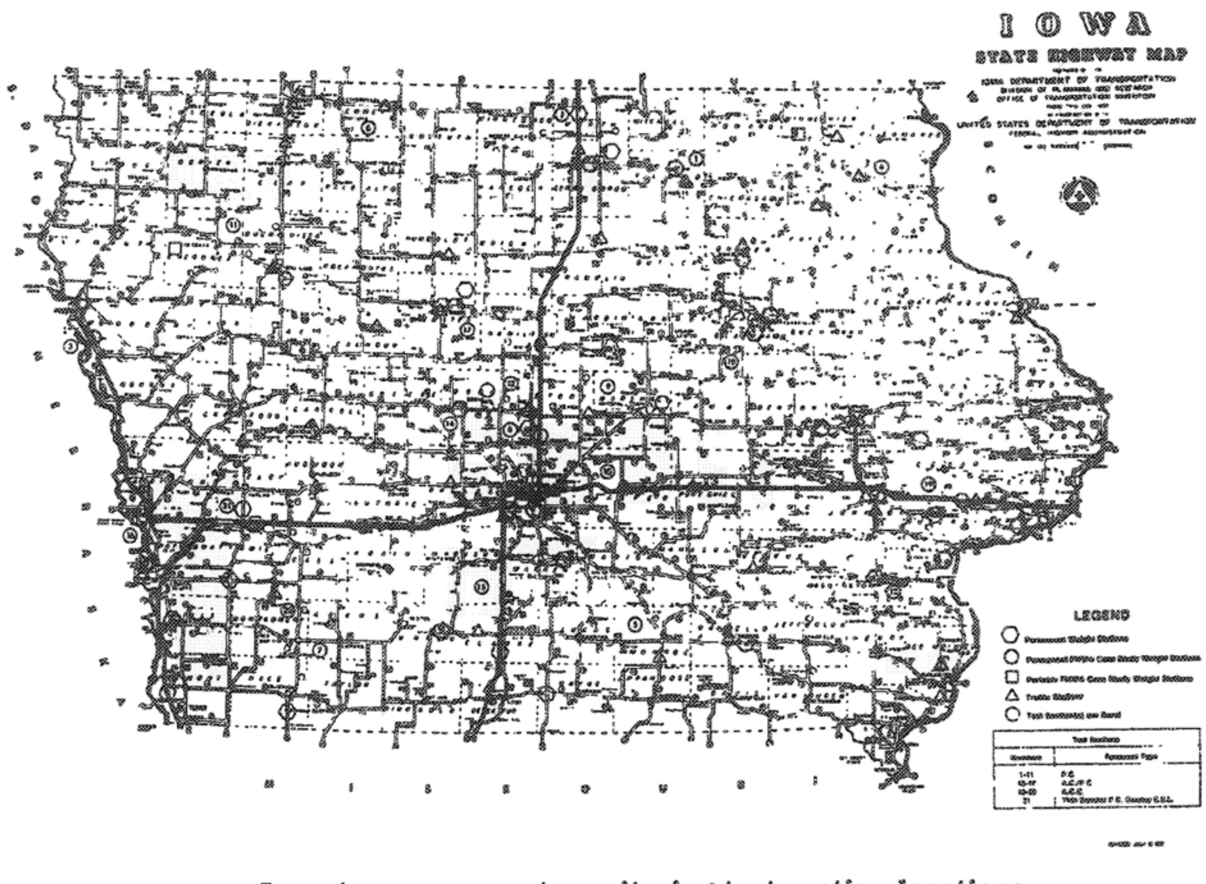
The theoretical performance of one of those pavements and the actual performance is shown in Figure 11. The solid curvilinear line represents the performance of the system wide pavements over time. The dotted line represents the actual performance of the pavement measured. The trend of many of the pavements follows the system trend in ride deterioration. The variations have been traced to things such as maintenance practices, soil support and truck usage.

The truck portion of the deterioration is evident in the growth rate of axle loadings on each pavement.



PSI vs pavement loadings since resurfacing (18 kip EALs) - January 1, 1984

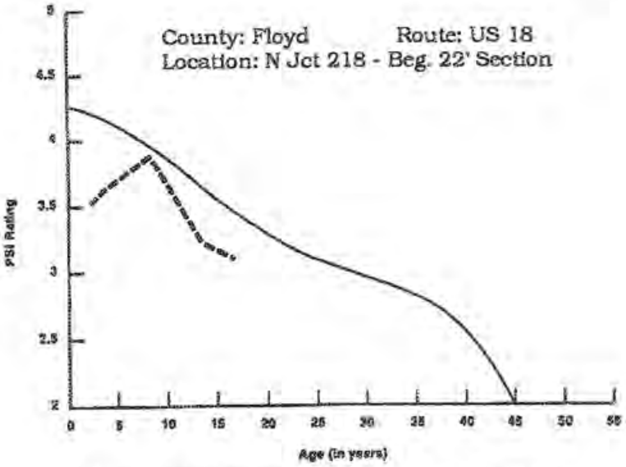
FIGURE 9



Long term pavement monitoring test section locations

FIGURE 10

The information in Table 3 illustrates the relationships between the pavement age, ride, and pavement loadings to date. The rate of loading growth is the average increase per year based on the truck traffic during the first year of use. The growth rate in traffic volumes in Iowa averages between 0-3 percent per year. In the past we have assumed a similar relationship in the loadings. The table indicates that several of our pavements are experiencing much greater rates of increase in the range of 5-10 percent per year. Those pavements will bear close monitoring as time passes with the need for rehabilitation coming sooner than other pavements with like construction, but lighter truck traffic. It should also indicate a need to consider the addition or modification of joint load transfer devices as part of future rehabilitation projects on these pavements.



Iowa pavement performance curve

FIGURE 11

The evidence of low ride scores and current rehabilitation of some of the pavements in Table 3 is a reflection on the design of the pavement base and the environment in Iowa. Many of these sections have been constructed in a manner that inhibits movement of subsurface water from the slab and freeze thaw action or poor pavement aggregates have created joint faulting or surface spalling. In either case the rehabilitation has included an overlay and correction of the drainage problems.

In a separate analysis, some 13 comparable asphaltic concrete and portland cement Interstate highway road segments in Iowa were compared to measure the relative performance and annual cost of each material. The tests indicated that both materials are providing truck axle loading service equal to or greater than that called for in the

Table 3 – Long term pavement monitoring performance

Section	County	Route	Sufficient type	Age 1983	DL	PSI 1983	Estimating loading construction thru 1983	Loading growth rate
1	34	US 18	PC	15	10	3.2	1,661,000	6.7%
2	98	I-35	PC	10	10	3.8	3,640,000	10.0%
3	97	I-29	PC	23	10	3.5	5,131,000	4.3%
4	3	IA 51	PC	14	9	3.5	541,000	7.1%
5	68	US 34	AC	19	5	3.4	794,000	5.3%
6	32	IA 4	PC	50	5	2.4*	967,000	2.0%
7	69	US 71	PC	10	8	2.8	491,000	10.0%
8	8	US 30	PC	10	9	3.6	1,358,000	10.0%
9	64	US 30	PC	19	8	3.7	2,661,000	5.3%
10	77	I-80	PC	22	10	2.9	15,562,000	4.5%
11	11	IA 3	PC	24	8	3.1	988,000	4.2%
12	8	US 30	AC	53	5	3.2*	2,914,000	1.9%
13	92	US 218	AC	53	5	2.9	1,874,000	1.9%
14	8	US 30	AC	53	5	3.6*	2,914,000	1.9%
15	91	I-35	AC	24	6	3.7*	3,688,000	4.2%
16	78	I-29	AC	25	6	4.0*	4,926,000	4.0%
17	40	US 20	AC	54	4	4.2*	3,688,000	1.9%
18	7	IA 21	AC	15	6	3.6	287,000	6.7%
19	16	I-80	AC	20	6	3.2	10,890,000	5.0%
20	69	US 71	AC	11	5	3.6*	342,000	9.0%
21	78	I-80	PC	16	8	3.5	10,099,000	6.3%

* Section has been rehabilitated.

original designs. The tests included both single lift construction and stage construction techniques with each providing the loading capacity estimated from the AASHO Road Test information and the anticipated soil and traffic conditions. The only difference noted was the rate of loading for each pavement. Several attained the design number of loads earlier in their life due to the unanticipated growth in truck traffic. They point out the need to improve the predictive techniques for truck number, size and weight for use in the design of pavements.

FUTURE TRUCK RELATED ACTIVITIES

The department is exploring several ways of improving its knowledge of the number, size and weight of trucks using the highway system. Included are the application of existing computer software for predicting the number, size and weight of the trucks, a pavement instrumentation demonstration project and two research projects into the application of low cost weigh-in-motion devices and techniques.

In the field of computer software, the department is testing the "Truck Weight Shifting Methodology for Predicting Highway Loads" developed at the University of Texas. This program seeks to predict the distribution of truck weights based on the current and anticipated legislation. This can be helpful in predicting the number of axle loads to be accommodated by a pavement over an anticipated analysis or design period. The rehabilitative techniques should be geared to respond not only to correct current pavement problems, but to anticipate the future truck needs. Several years of truck data have been entered into the program to begin to see the trends in truck weights as they relate to changes in legislation. We look forward to the results of the Canadian studies to supplement this work and indicate what can be expected in future axle repetitions and weights due to changes in legislation.

A second approach being studied has been developed by the Minnesota Department of Transportation and is identified as "Forecasting Cumulative ESALs Using Probabilistic Prediction". This method seeks to predict the number of ESALs from samples of each of the random variables involved in the design performance of pavements. It has the possibility of extending the Texas research for the planner/designer truck predictions.

Both the Texas and Minnesota research indicates the need for weigh-in-motion data to properly sample the traffic stream. Manual truck weight studies have in inherent possibility for bias due to the truck operators ability to bypass these sites. The weigh-in-motion provides a real time and place look at the truck stream and the distribution of axle spacing, axle weights and traffic speeds. The results provide designers with the knowledge of differences in loadings due to season, time of day and weather conditions. The analysis of the different pavement related factors is unlimited with this data and the pavement performance data combined.

The Iowa Department of Transportation is currently conducting two weigh-in-motion projects. The first is a rural technical assistance program weigh-in-motion demonstration project involving evaluation of a permanently installed bridge weigh-in-motion system. The second project involves the evaluation and preparation of procurement specifications for a low-cost automatic weight and classification system.

The bridge weigh-in-motion project involves the instrumentation of bridge beams to measure the strain created by heavy truck movement and convert that strain into a measure of axle, axle group and vehicle gross weights.

The low cost automatic weight and classification project involves the evaluation of a preproduction piezo-electric cable based automatic weight and vehicle classification system that will have a purchase price of not more than $5,000 per system.

Both the bridge weighing system and the low cost automatic weight and classification system will also have the capability of gathering data on vehicle classification based on axle spacing and vehicle speed at the same time the vehicle is weighed.

These projects are key elements in improved prediction of traffic using the pavements. A purchase price of not more than $5,000 per system will improve the feasibility of establishing a heavy vehicle monitoring system capable of both weighing and classifying vehicles and sufficient to make reasonable predictions of truck traffic characteristics.

A separate research project is getting under way at this time to understand the behavior of the pavements under loading and environmental conditions. The "Pavement Instrumentation" project. The work is being accomplished under as a Federal Highway Administration and Iowa Highway Research Board demonstration project in preparation for the major efforts in pavement research of the Strategic Highway Research Program. The study has several objectives including the evaluation of the magnitude and frequency of the dynamic loads applied to a portland cement concrete pavement in relationship to the static loads for which the pavement was designed. It also seeks to demonstrate the use of instrumentation techniques for answering current pavement performance questions. Additional objectives are aimed at providing more insight into the behavior of the pavement in relationship to loads under various temperature and moisture conditions in the subgrade.

The study will utilize instrumentation of a bridge, three pavement joints and two consecutive slabs to provide the data. The information will be telemetered to Ames for analysis. The only manned testing at the site will involve the periodic measurement of subgrade moisture and density via nuclear gauges. The instruments will be placed in the fresh concrete as part of a pavement replacement project in the Summer of 1986 on I-80 in Pottawattamie County. The project will allow the investigators to sample the strains being imparted to the pavement at any time during the year to analyze seasonal changes and traffic related variations. The major data collection will take place in the Fall of 1986, but additional information will be gathered as long as the instruments continue to perform in an effort to document the reliability of the instruments.

Co-principal investigators for the project include:

- James K. Cable, P.E., Iowa Department of Transportation
- Dr. D.Y. Lee, Civil Engineering Dept., Iowa State University
- Dr. Thomas Christison, Civil Engineering Dept., Alberta Research Council, Edmonton, Alberta

  Dr. Thomas White, Civil Engineering Dept., Purdue University, West Lafayette, Ind.

Several other staff from the Department and Iowa State University will be used in the installation and analysis of the data.

SUMMARY

Iowa has recognized the need to improve its methods of truck data collection and analysis of current pavement designs. The current constraints on funding and manpower coupled with the change from a construction to rehabilitation phase of highway programming, have created a need for the use of high technology. Weight in motion and pavement instrumentation coupled with ongoing research in the area of pavement materials performance and the development of a pavement management system provide the analysis base. We are confident that the developments of the 1980's will both validate much of the current practice as well as point to areas where change will result in more and better pavement performance in the future.

REFERENCES

Cable, James K., "Iowa Pavement Performance", July 1985.

Cable, James K., and Given, R.H., "Pavement Management Practices in Iowa", ASCE Denver Colorado Conference, 1985.

Benson, George P., "Forecasting Cumulative ESAL's Using Probabilistic Prediction", Minnesota DOT, April 1984.

Walton, C. Michael, Yu, Chien-pei and Ng, Paul, "Truck Weight Shifting Methodology For Predicting Highway Loads", Research Report 241-5, Center for Transportation Research, The University of Texas at Austin, April 1983.