LTPP-DISTRESS DUE TO ENVIRONMENT

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ABSTRACT

The paper titled 'LTPP - Distress due to Environment' presents the deterioration and distress in the pavement due to environment. Long Term Pavement Performance (LTPP) deals with various experiments in General Pavement Studies (GPS) and Specific Pavement Studies (SPS). The environmental effects are dealt in SPS8 experiments. Data Pave is the software available to extract the history data from the LTPP database for the experiments. The paper tries to analyze the pavements subjected to different environmental conditions. Data is extracted from the database for different states whose environments are significantly different. The International Roughness Index (IRI) values for the experimental sections in the different states are collected and analyzed in relation with the temperature. The linear regression on this data reveals the effect on the pavements due to the change in the temperature. The performance of the pavement is predicted based on the results obtained. The results can be implemented in the design of new pavements.

INTRODUCTION

Long Term Pavement Performance program is initiated as part of Strategic Highway Research Program (SHRP) in 1987 and is monitored by the Federal Highway Administration (FHWA). As part of the program 2,500 asphalt and Portland cement concrete pavement test sections are monitored and tested through many experiments. The basic idea is to understand why some pavements perform better than the others do *(1)*. As part of the program data relating to elements that may influence pavement performance is collected. Data for IRI, pavement thickness, annual and monthly precipitation totals and equivalent single-axle loads (ESALs) is collected in the past decade on the experimental sections and stored in the LTPP database. The data will be collected for the 20 year span and the database will be updated to help the highway engineers to get the information in ready to use format. The experiments and their results help the highway engineer to understand the pavement performance in the long run and design the new highways to perform effectively and for longer life periods.

The LTPP program essentially is initiated to effectively use the resources with in the available amount of funds. This study is going to become the primary source of performance indicator for the North American Highway

Community. The data for LTPP sections is collected extensively for the inventory, material testing, pavement performance monitoring, climatic, traffic, maintenance, rehabilitation, and seasonal testing modules. The data is managed through an Information management System (IMS) called the LTPP database, which is the world's largest pavement performance database *(3)*.

LITERATURE REVIEW

As part of the LTPP program the entire US is divided into four regions, North Central, Western, Southern and North Atlantic. The regions are shown in the *Figure 1*.

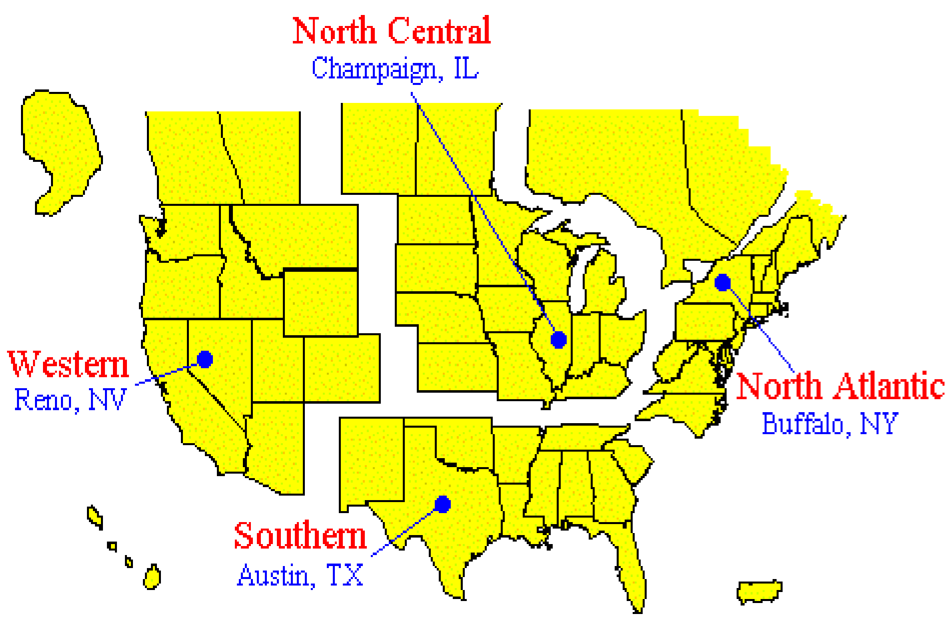

FIGURE 1 Regions and Monitoring Locations for LTPP *(2).*

Each region is having a monitoring center to monitor the experiments performed on the sections with in each zone. There are two types of studies performed as part of LTPP, General Pavement Studies (GPS) and Specific Pavement Studies (SPS).

The GPS experiments focused primarily on commonly used structural designs for pavements. Eight types of existing in-service pavements — in either original or rehabilitated condition — are being monitored throughout North America. The performance levels of structural designs are tested against an array of climatic, geologic, maintenance, rehabilitation, traffic, and other service conditions. Each GPS site has a single test section *(4)*.

SPS test sections are specially constructed to investigate certain pavement engineering factors. Critical design factors are controlled by special construction and performance to be monitored from the initial date of construction. Each test site has multiple test sections, each with a different set of design factors. This makes it possible to compare the performance of different design factors, both within and between sites. The results will provide a better understanding of how selected maintenance, rehabilitation, and design factors affect pavement performance *(4)*.

As of October 1999 there were 2500 asphalt and Portland cement concrete pavement test sections throughout the US and Canada. Of these sections 791 test sections are in GPS category and the remaining 1,714 are in the SPS category. The SPS test sections are divided into 9 sub categories, the description of each and the participating states are described in Table 1. *(4,6)*.

ENVIRONMENTAL EFFECTS

The paper mainly concentrates on SPS-8 sections, which describe the 'Study of Environmental Effects in the Absence of Heavy Loads'. The effects of climatic factors, sub grade type on pavement sections having different designs of flexible and rigid pavements, under limited traffic are studied as part of SPS8 experiments. The test sections may be at the same or different locations. Currently there are 16 SPS8 projects. The International Roughness Index (IRI) values are affected by the change in the weather conditions like the average annual temperature, number of high temperature days.

DATA PAVE SOFTWARE AND DATA DESCRIPTION

DataPave is new easy to use software to retrieve and present data from a CD-ROM. DataPave is one of the software to explore the LTPP data. This software is chosen for the data retrieval, for the current paper from the DataPave CD-ROM. The main objective of the DataPave software is to provide a user-friendly format for exploring and presenting the LTPP data to provide easy-to-use presentation techniques which present the value of LTPP data *(3,6)*.

DataPave provides the utilities to select the LTPP sections from the database through a Geographical Information System (GIS) based map or through specification of the criteria. After this step section specific information like the location and experiment type is provided through the Presentation module. Individual experimental data can then be extracted and exported to convenient formats like Excel-97 or delimited text formats. DataPave also has a powerful graphics engine to present data in graphs. In the future everyone in the field of design, construction and maintenance is to benefit through the products and research made possible by the DataPave software.

TABLE 1 Description of SPS Experimental Sections and the Participating States ***(4,5)***

SPS No.	Description & Participating States
SPS 1	**Strategic Study of Structural Factors for Flexible Pavements:** Alabama, Arizona, Arkansas, Delaware, Florida, Iowa, Kansas, Louisiana, Michigan, Montana, Nebraska, Nevada, New Mexico, Ohio, Oklahoma, Texas, Virginia, and Wisconsin.
SPS 2	**Strategic Study Of Structural Factors For Rigid Pavements :** Arizona, Arkansas, California, Colorado, Delaware, Iowa, Kansas, Michigan, Nevada, North Carolina, North Dakota, Ohio, Washington, And Wisconsin.
SPS 3	**Preventive Maintenance Effectiveness Of Flexible Pavements:** Alabama, Arizona, Arkansas, California, Colorado, Florida, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Manitoba, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New York, Oklahoma, Ontario, Pennsylvania, Quebec, Saskatchewan, Tennessee, Texas, Utah, Virginia, Washington, And Wyoming.
SPS 4	**Preventive Maintenance Effectiveness of Rigid Pavements:** Arizona, Arkansas, California, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Minnesota, Mississippi, Missouri, Nebraska, Nevada, Ohio, Oklahoma, Pennsylvania, Quebec, South Dakota, Texas, and Utah.
SPS 5	**Rehabilitation of Asphalt Concrete Pavements:** Alabama, Alberta, Arizona, California, Colorado, Florida, Georgia, Maine, Manitoba, Maryland, Minnesota, Mississippi, Missouri, Montana, New Jersey, New Mexico, Oklahoma, and Texas.
SPS 6	**Rehabilitation of Jointed Portland Cement Concrete Pavements:** Alabama, Arizona, Arkansas, California, Illinois, Indiana, Iowa, Michigan, Missouri, Oklahoma, Pennsylvania, South Dakota, and Tennessee.
SPS 7	**Bonded Portland Cement Concrete Overlays on Concrete Pavements:** Iowa, Louisiana, Minnesota, and Missouri.
SPS 8	**Study of Environmental Effects in the Absence of Heavy Loads:** Arkansas, California, Colorado, Mississippi, Missouri, Montana, New Jersey, New Mexico, New York, North Carolina, Ohio, South Dakota, Texas, Utah, Washington, and Wisconsin.
SPS 9	**Validation of SHRP Asphalt Specification and Mix Design (Superpave):** Alberta, Arizona, Arkansas, Connecticut, Florida, Indiana, Kansas, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Jersey, New Mexico, North Carolina, Ohio, Ontario, Quebec, Saskatchewan, Texas, and Wisconsin.

DATA EXTRACTION

The data is extracted form the database supplied along with the DataPave software. The first step is to select the region in consideration. The north central and southern LTPP regions are selected for the case study. LTPP experiments are sub grouped into climate, general, inventory, monitoring, maintenance, test sections, SPS sections, and traffic. Data from the climate, inventory, monitoring and SPS8 sections is extracted and exported to Excel 97 format. The required parameters like average annual temperature, IRI average value, number of days the temperature is above 32 degrees centigrade is extracted from Excel file and is presented here in Table 2. The data is collected for the states of Arkansas, Ohio, Texas, South Dakota, New Mexico, and Mississippi.

DATA

The data collected for the analysis is presented in Tables 2 & 3. Metadata is provided in Table 4.

TABLE 2 Experimental Data

STATE_CODE	SHRP_ID	AWS_ID	YEAR	AVG_ANN_TEMP	PAVE_TYPE	ABOVE_32	IRI_AVG
5	0803	050803	1998	17.00	1	64	1.14
5	0804	050804	1998	17.00	1	64	1.39
5	0809	050809	1998	17.00	0	64	1.70
5	0810	050810	1998	17.00	0	64	1.71
28	0805	280805	1997	16.50	1	52	0.97
28	0805	280805	1999	17.00	1	52	1.45
28	0806	280806	1997	16.50	1	52	0.82
28	0806	280806	1999	17.00	1	52	0.98
35	0801	350801	1997	14.64	1	83	1.06
35	0802	350802	1997	14.64	1	83	0.91
39	0803	390803	1994	10.40	1	10	1.23
39	0803	390803	1996	10.80	1	10	3.19
39	0803	390803	1997	9.48	1	10	1.15
39	0803	390803	1998	11.51	1	10	1.24
39	0804	390804	1994	10.40	1	10	1.18
39	0804	390804	1996	10.80	1	10	2.68
39	0804	390804	1997	9.48	1	10	0.91
39	0804	390804	1998	11.51	1	10	0.97
39	0809	390809	1994	10.40	1	10	1.93
39	0809	390809	1996	10.80	1	10	1.92
39	0809	390809	1997	9.48	1	10	2.02
39	0809	390809	1998	11.51	1	10	2.03
39	0810	390810	1994	10.40	0	10	1.63
39	0810	390810	1996	10.80	0	10	1.76
39	0810	390810	1997	9.48	0	10	1.79

TABLE 3 Experimental Data

STATE_CODE	SHRP_ID	AWS_ID	YEAR	AVG_ANN_TEMP	PAVE_TYPE	ABOVE_32	IRI_AVG
46	0803	460803	1993	5.5	1	25	0.81
46	0803	460803	1994	6.1	1	25	0.73
46	0803	460803	1995	6.2	1	25	0.76
46	0803	460803	1996	4.7	1	25	0.77
46	0803	460803	1997	6.24	1	25	0.88
46	0803	460803	1998	7.83	1	25	0.92
46	0804	460804	1993	5.5	1	25	0.82
46	0804	460804	1994	6.1	1	25	0.83
46	0804	460804	1995	6.2	1	25	0.82
46	0804	460804	1997	6.24	1	25	0.85
46	0804	460804	1998	7.83	1	25	0.89
48	0801	480801	1997	19.31	1	99	0.77
48	0802	480802	1997	19.31	1	99	1.05

TABLE 4 Metadata for Terms in Experimental Data

Term	Description & Units
STATE_CODE	Unique code identifying the state in which the section is
SHRP_ID	Unique code for the test section
AWS_ID	Code for the Automated Weather Station, combination of STATE_CODE
YEAR	Year of IRI data collection
AVG_ANN_TEMP	Average annual temperature in degrees centigrade
PAVE_TYPE	Pavement type in numerals. Asphalt=1and PCC=17
ABOVE_32	Number of days the temperature is above 32 degrees
IRI_AVG	IRI average values in mm/km

ANALYSIS & RESULTS

The effect of temperature and type of pavement on the IRI values for the test sections is analyzed through regression analysis. Multiple regression analysis of IRI is performed and the results are tabulated below.

TABLE 5 Results

Regression Statistics	
Multiple R	0.648
R Square	0.420
Adjusted R Square	0.369
Standard Error	0.453
Observations	38

	Coefficients	***Standard Error***	***t Stat***	***P-value***
Intercept	1.029	0.324	3.179	0.00314
AVG_ANN_TEMP	0.096	0.0257	3.734	0.00069
PAVE_TYPE	-0.290	0.224	-1.294	0.20441
ABOVE_32	-0.017	0.0041	-4.322	0.00013

The best-fit lines equation for the multiple regression is given by

IRI = Intercept + β_1(AVG_ANN_TEMP)+ β_2 (PAVE_TYPE)+ β_3 (ABOVE_32)

IRI = 1.029 + 0.096(AVG_ANN_TEMP) - 0.29(PAVE_TYPE) - 0.017(ABOVE 32 C)

CONCLUSIONS

- The regression analysis resulted in the equation
- **IRI = 1.029 + 0.096(AVG_ANN_TEMP) - 0.29(PAVE_TYPE) - 0.017(ABOVE 32 C)**
- IRI values vary significantly with average annual temperature, pavement type and number of days the temperature is above 32 degrees centigrade in a year.
- Increase in average annual temperature increases the IRI values.
- Increase in number of days with temperature above 32 degrees centigrade decreases IRI values.
- IRI value is more for Asphalt pavements.
- States with high annual average temperature can design the pavements as flexible to reduce the IRI value. Example Texas
- States with low annual average temperature can design the pavements as rigid to reduce the IRI value. Example Wisconsin
- Further analysis of the LTPP data should be done to determine the accuracy of the current predicted model

REFERENCES

1. In the Document, LTPP: The Next Decade. http://www.bts.gov/smart/DOCS//decade/decade.htm Accessed March 17, 2000.

2. In the Monitoring Schedule page of TFHRC-LTPP page, Monitoring Schedule. http://www.tfhrc.gov/pavement/ltpp/schedule.htm Accessed March 17, 2000.

3. In DataPave page of TFHRC-LTPP page, DATAPAVE 2.0. http://www.tfhrc.gov/pavement/ltpp/datapave.PDF Accessed March 18, 2000

4. In FAQ page of TFHRC-LTPP page, FAQ. http://www.tfhrc.gov/pavement/ltpp/faq.htm Accessed March 18, 2000

5. In LTPP-Database Page, Specific Pavement Studies. http://www.ltppdatabase.com/sps.htm Accessed March 18, 2000

6. SHRP. *Distress Identification Manual for the Long-Term Pavement Performance Project.* SHRP-P-338. Washington, D.C., USA: U.S. Department of Transportation (USDOT), May 1993.