USE OF UNIVERSITY OF ILLINOIS TEST TRACK TO EVALUATE PAVEMENT PERFORMANCE

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This paper correlates performance of pavements in the University of Illinois Pavement Test Track with findings from the AASHO Road Test and examines some of the fundamental factors influencing performance of flexible pavements. Forty test pavements were placed in the test track facility in 10 test sets and tested to failure under 4 and 6-kip (17.8 and 26.7-kN) axle loads on single-tire wheels. Serviceability trends for the pavements were recorded in terms of slope variance, rutting, cracking, and patching. Physical responses of the pavements to load were also recorded. Deflection under load and serviceability trends were compared with findings from comparable pavements in the AASHO Road Test. Regression analyses were made on the comparable data, and weighting functions were established between the AASHO Road Test and the University of Illinois Pavement Test Track for two service conditions: as placed and at a high degree of saturation. Results indicated that the University of Illinois Pavement Test Track is a useful tool for evaluating behavior and relative performance of pavement systems and that, within reasonable bounds, the facility can be used to predict performance of pavements in service. Moisture and density of the base, subbase, and subgrade materials all had a significant effect on the performance and behavior of the pavements. The effect of moisture in the granular base and subbase materials on pavement performance was profound; for example an increase of 1 percent in the moisture content in the granular layers resulted in a ratio of the number of loads to failure of more than 700 to 1. Thus, even one load applied when the base and subbase are saturated would do as much damage as 700 loads applied at approximately optimum moisture content. This fact should be considered when regional environmental factors are established for pavement design.

•THE AASHO Road Test provided valuable results that help in the understanding of pavement performance. More basic information is needed, however, to explain certain behavior characteristics such as the severe loss in serviceability that occurs in flexible pavements immediately following the spring thaw. Since additional full-scale road tests such as the AASHO Road Test are too costly and time-consuming, a model is required in which the variables affecting pavement performance can be controlled and studied. The University of Illinois Pavement Test Track (1) is a model suitable for this purpose (Figure 1). It is large enough so that materials normally used in pavement construction can be tested under realistic loads without modification, and small enough so that construction techniques can be used that permit close control on the materials and their placement. It is, however, still a model, and results from models must be verified to be valid. The purpose of this study was to establish the validity of the University of Illinois Pavement Test Track as an acceptable model for evaluating pavement performance.

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A correlation must exist between the model and the prototype to prove the validity of a model. For this study, pavements in the AASHO Road Test were considered to be the prototype for comparison with model pavements tested in the test track. The model to prototype correlation can be used as a basis to extrapolate findings from the AASHO Road Test to other conditions.

The influence of environmental conditions on flexible pavements makes it necessary to identify and control those conditions that have a significant influence on pavement behavior and performance. In many cases, however, the conditions that existed in the AASHO Road Test pavements were not sufficiently documented to provide adequate guidance for constructing model pavements. Thus, it was necessary to study the behavior and performance of the model pavements in the test track over a range of conditions that likely existed in the AASHO Road Test.

Correlations between pavements tested in the University of Illinois Pavement Test Track and those in the AASHO Road Test can be based on several criteria. They can be based on the behavioral patterns of the pavements, the modes of failure, the primary causes for distress, and on the relative performance of pavements in the two programs. Each of these criteria is examined, and some correlations are made with each. Greatest emphasis is placed on the performance correlations.

OBJECTIVE

The objective of this study was to investigate the correlation among the findings from the AASHO Road Test and the results obtained from tests on pavements in the pavement test track and to evaluate fundamental factors influencing pavement behavior and performance so that correlation or lack of correlation among the tests from these facilities can be understood and explained and the results applied to other conditions.

A summary of the findings from the study is presented in this paper. More complete details on the test procedures and results are given elsewhere (2).

EXPERIMENT DESIGN

The test pavements in the test track were designed for a one-to-one correspondence with pavements in the AASHO Road Test. Wheel loads of approximately 3,200 lbf (14.2 kN) on a single tire inflated to 80 psi (551 kPa) were used on most of the tests on the test track pavements and were considered to be approximately equivalent to the 3,000-lbf (13.3-kN) wheel loads on dual tires applied to the AASHO Road Test pavements. A few pavements in the pavement test track were tested under 2,000-lbf (8.8-kN) wheel loads for comparative purposes. The test track facility was divided into quadrants for each set of tests, and a different pavement section was placed in each quadrant. The four test pavements under test at one time were referred to as a test set. The thicknesses of the pavement layers in a test set were chosen so that all pavements in a test set had approximately the same structural number (SN), where the appropriate value for SN is given by the following equation (1 in. = 25.4 mm):

$$SN = 0.44D_1 + 0.14D_2 + 0.11D_3 \quad (1)$$

where

D_1 = thickness of surface, in inches;
D_2 = thickness of base, in inches; and
D_3 = thickness of subbase, in inches.

This equation for the SN is based on the reported findings from the AASHO Road Test (3). Pavement thicknesses were chosen to provide pavements with SN values ranging

Figure 1. University of Illinois Pavement Test Track.

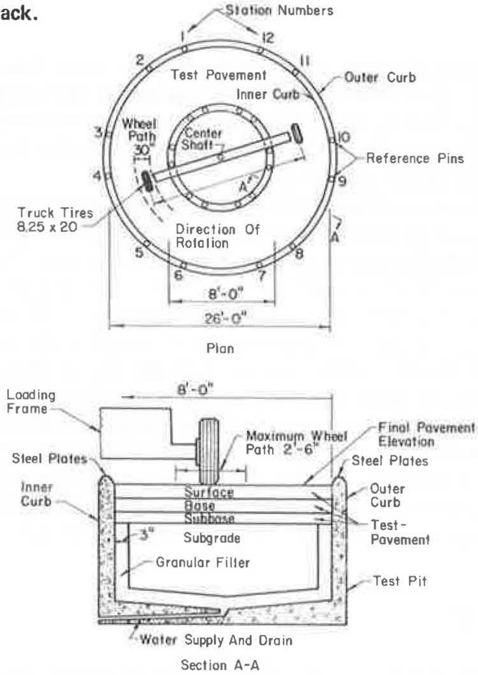


Table 1. Thicknesses and structural numbers of pavements tested in University of Illinois Pavement Test Track.

Test Set No.	Pavement No.	Planned Thickness (in.)			Planned SN[1]	Actual Average Thickness (in.)			Actual SN[1]
		Surface	Base	Subbase		Surface	Base	Subbase	
1	1	2	3	—	1.30	2.23	3.18	—	1.43
	2	1	6	—	1.28	1.37	5.90	—	1.43
	3	2	3	—	1.30	2.43	2.75	—	1.45
	4	3	—	—	1.32	3.15	—	—	1.39
2	1	2	3	—	1.30	1.75	2.34	—	1.10
	2	3	—	—	1.32	3.22	—	—	1.42
	3	2	3	—	1.30	2.59	2.94	—	1.54
	4	1	6	—	1.28	1.84	4.94	—	1.50
3	1	2	3	4	1.74	2.17	2.94	4.00	1.81
	2	3	—	4	1.76	3.01	—	4.10	1.78
	3	2	3	4	1.74	2.17	2.68	4.25	1.80
	4	1	6	4	1.72	0.80	6.61	3.62	1.68
4	1	2	3	4	1.74	1.81	2.96	3.26	1.57
	2	3	—	4	1.76	3.08	—	3.06	1.69
	3	2	3	4	1.74	1.59	2.95	3.67	1.51
	4	1	6	4	1.72	0.75	5.67	3.32	1.49
5	1	2	6	—	1.72	2.69	5.46	—	1.93
	2	2	3	4	1.74	2.21	2.75	4.24	1.83
	3	3	—	4	1.76	3.14	—	4.26	1.86
	4	3	3	—	1.74	3.53	3.06	—	1.97
6	1	2	6	4	2.16	1.99	6.14	3.68	2.14
	2	2	3	8	2.18	1.84	3.65	7.44	2.14
	3	3	3	4	2.18	2.88	3.38	3.71	2.15
	4	3	6	—	2.16	2.77	5.91	—	2.05
7	1	2	6	4	2.16	2.15	5.34	4.10	2.15
	2	2	3	8	2.18	2.13	2.86	7.82	2.20
	3	3	3	4	2.18	3.53	2.36	4.32	2.36
	4	3	6	—	2.16	2.93	6.08	—	2.14
8	1	2	6	4	2.16	2.51	5.40	3.67	2.26
	2	2	3	8	2.18	2.27	2.81	7.43	2.21
	3	3	3	4	2.18	3.32	2.90	4.15	2.32
	4	3	6	—	2.16	3.25	5.73	—	2.23
9	1	2	6	—	1.72	2.12	5.80	—	1.74
	2	2	3	4	1.74	2.09	2.85	4.05	1.77
	3	3	—	4	1.76	3.17	—	4.00	1.83
	4	3	3	—	1.74	3.55	2.64	—	1.93
10	1	1	6	—	1.28	0.87	5.88	—	1.20
	2	1	3	4	1.30	1.00	2.88	3.93	1.27
	3	2	3	—	1.30	1.62	3.12	—	1.25
	4	3	—	—	1.32	3.22	—	—	1.42

Note: 1 in. = 2.5 cm.

[1] Based on the coefficients suggested by the AASHO design committee, see equation 1.

from about 1.3 to 2.2. Thicknesses for the pavements tested are given in Table 1.

MATERIALS

The materials used in the pavements tested were similar to those used in the AASHO Road Test. The subgrade soil [A-6 (8) clay] was obtained from the AASHO Road Test borrow pit 1. Properties of the subgrade soil are given in Table 2. Gravel for the subbase materials was obtained locally and was blended to produce a granular material with approximately the same mean gradation as the subbase in the AASHO Road Test. The crushed limestone for the base materials was obtained from the same quarry as the crushed stone used in base course for the AASHO Road Test. Physical characteristics of the crushed stone base and gravel subbase materials are given in Table 2. The surface materials used in the test pavements were high-quality asphalt concretes that were either obtained from a local supplier or mixed in the hot-mix plant (Barber-Greene 804 mixall) in the University of Illinois laboratory. Physical characteristics of the surface materials are given in Table 2.

GENERAL AND CONTROLLED TEST CONDITIONS

Since the pavement test track is indoors, the test pavements were not subject to the detrimental effects of the environment. The temperature inside the laboratory was controllable within a reasonable range and was generally maintained between 50 and 80 F (10 and 26.7 C). Frost action in the pavements was not a factor in this study. The water table under the pavements was controlled by an underground supply system (1). During testing, the water table was varied from well below the top of the subgrade to the top of the base course to simulate changes in moisture conditions experienced by pavement in the AASHO Road Test during spring thaw. More specifically, the water table was kept well below the base and subbase during initial loading and was raised to the level of the base course later in the loading program for each test site. The arbitrary number of load applications at which the water table was raised was randomly selected at a time when the pavement's behavior was relatively stable.

LOADING

Dynamic loads were applied with the loading frame shown in Figure 1, which is described in more detail elsewhere (1). Ballast was added to the loading frame to bring its effective weight to 6,400 lb (29 000 kg) or slightly greater than a 6-kip (26.7-kN) axle load. The speed of the wheels during loading was varied from approximately 7 to 15 mph (11 to 24 km/h) depending on the pavement roughness. At these speeds, the rate of application ranged from 24 to 48 load applications/min. All wheel loads were distributed over a wheel path approximately 30 in. (76.2 cm) wide with a normal distribution in the transverse direction.

Static plate load tests were conducted on various layers of the pavement in accordance with standard procedures for plate load tests.

PROCEDURE

Construction of Test Pavement

Before the test pavements for each test set were placed, the subgrade was removed to a depth of approximately 1 ft (0.3 m) below the top of the existing subgrade, partially dried, pulverized with a hammer mill, replaced in the test pit at optimum moisture content, and compacted to the desired density with a J-Ram impact tamper. The soil was placed in 3-in. (7.6-cm) lifts with each lift extending completely around the track.

Table 2. Physical characteristics of subgrade soil, crushed stone base, gravel subbase, and surface.

		Subbase			Base			Surface		
			Test Track			Test Track			Test Track	
Characteristic	Subgrade	AASHO	Avg	SD	AASHO	Avg	SD	AASHO	Avg	SD
AASHTO classification	A-6(8)									
Optimum moisture content, percent	13.0	7.0	6.9	0.18	7.0	6.3	0.4			
Maximum dry density, lb/ft^3	120.0	137.5	133.6	1.48	140.9	144.1	3.3	151.5	149.5	2.3
Specific gravity, g/cm^3	2.72									
Liquid limit, percent	25									
Plastic limit, percent	14									
Plasticity index, percent	11	<6	<6	—	—	—	—			
CBR, 0.1-in. penetration		<60	<60	—	—	—	—			
Marshall stability								2,000	2,545	435
Marshall flow								11.1	17.0	4.0
Grain size distribution, percent passing sieve size										
1½ in.		100	100	—	100	100	—			
1 in.		100	99.5	0.3	90	90.6	1.6			
¾ in.		96.9	93.6	1.7	81.0	83.1	5.6			
½ in.		89.7	68.1	7.5	68.0	69.6	4.4			
No. 4	98	71.2	63.7	4.2	48.0	49.9	5.4			
No. 10	96	—	51.5	3.6	35.0	36.3	3.7			
No. 40	92	27.2	23.6	1.5	20.0	18.5	2.6			
No. 100	85	—	9.7	1.6	13.5	13.2	1.8			
No. 200	79	7.5	8.4	1.6	10.0	11.1	1.8			
0.02 mm	61									
0.005 mm	39									
0.002 mm	27									

Note: 1 lb/ft^3 = 1.6 kg/m^3. 1 in. = 25.4 mm.

Figure 2. Performance versus number of load applications for pavement 2 of test set 6.

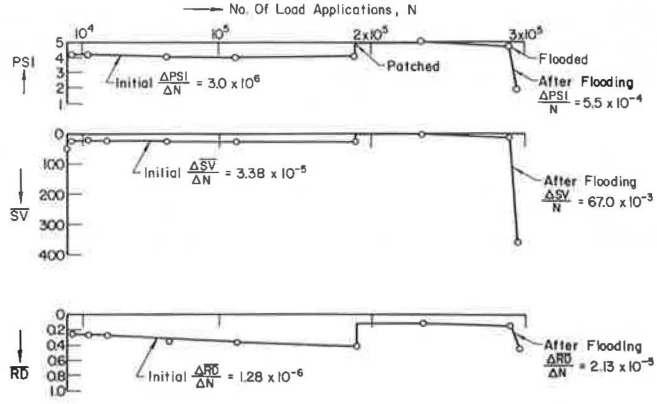
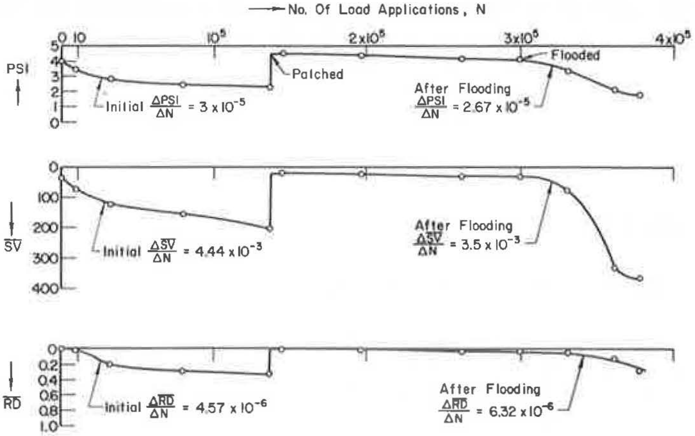


Figure 3. Performance versus number of load applications for pavement 1 of test set 10.



Moisture and density tests were conducted on the material in each lift to determine the properties of the soil in place. The final layer was trimmed to a preselected elevation (±0.005 in. or 0.1 mm) with a subgrade planer (2).

Locations for the moisture and density tests on the subgrade were selected in a random manner, and the test locations were noted. Statistical analyses were made on many of the test results from the individual sections.

The granular base and subbase materials were blended in a pugmill mixer with enough water added to bring the materials up to optimum moisture content as determined by AASHO T99. The materials were placed in the test pit in 4-in. (10-cm) lifts and compacted to the desired density by using a vibrating plate compactor. Moisture and density tests were conducted on each lift to determine the in situ properties of the base and subbase materials.

A tack coat (MC-30) was applied to the base course before the surface layer was applied. The asphalt concrete surface was leveled with a manually operated screed and was compacted by using vibrator plate and vibratory roller compactors.

The tests on the in situ paving materials indicate that, except for some minor problems in compacting the surface material, the construction control on placement of the materials for pavement in the test track was generally as good as or better than is normally expected in the field and was of the same level as that obtained in construction of the AASHO Road Test pavements. Detailed data are given elsewhere (2).

Type of Information Collected

To accomplish the objectives of this study, several types of information were collected. Information that described the physical response of the pavement system to load, the physical condition of the materials at various stages of testing, and the surface characteristics had to be collected for determining the pavement serviceability index (PSI) and performance trends.

The longitudinal and transverse profiles were recorded at intervals during the study to determine the PSI values of the pavements. The longitudinal profile was determined by taking a continuous recording of the longitudinal slope and by using a profilometer similar to that used in the AASHO Road Test, and the transverse profile was evaluated in terms of rut depth measurements.

In addition to the pavement responses associated with dynamic loading, data on several other intrinsic properties of the pavement system were also collected at critical periods during the testing program. These include the following:

1. Dry density of the subgrade, subbase, base, and surface layers before and after testing;
2. Moisture content of the subgrade, subbase, and base layers before testing, before flooding, and after testing;
3. California bearing ratio (CBR) of the subgrade layer before and after testing;
4. Modulus of reaction k for the subgrade, subbase, base, and surface layers before and after testing; and
5. Marshall stability and flow for the asphalt concrete used in the surface course before and after testing.

Detailed data and statistical analyses of these data are given elsewhere (2).

RESULTS

Pavement Performance and Analysis

The performance of a pavement under dynamic loading depends on several factors. Generally, the following four groups can include nearly all variables that are responsible for the performance of a pavement: thickness of the layers, i.e., SN; physical properties of the materials in individual layers as well as their characteristics under composite action; intensity and frequency of loading; and environmental factors. Since all pavements tested in the test track were constructed with materials identical or similar to those used in the AASHO Road Test and all but four were tested under nearly identical axle loads [6.4 kips (28.5 kN) for the test track and 6 kips (26.7 kN) for the lane 2/loop 2 pavements in the AASHO Road Test], a comparison of the relative performance of pavements in the two systems can be undertaken with a limited number of variables. If an independent parameter can be found, in which these variables are intrinsically reflected, that promises to be an associating function of performance, then this parameter can be a suitable criterion to correlate and predict the relative performance of the pavements.

Findings from the AASHO Road Test have shown that deflection under creep-speed wheel load can be such an independent parameter. Many other studies have also found deflection to be a reliable indicator of pavement performance. Therefore, creep-speed deflection was selected as an independent variable that would reflect the performance of the pavements tested during this program and that could be used as a basis for correlating performance of pavements in the test track with those in the AASHO Road Test. Since performance, as reflected by the PSI, is a function of rut depth $\overline{RD}$ and slope variance $\overline{SV}$, the rates of change of $\overline{RD}$, $\overline{SV}$, and PSI with the number of loads applied N were selected as dependent variables for regression, and deflection was chosen as the independent variable. Such regressions were attempted for two critical stages of the testing period: (a) the initial stage of loading and (b) the loading period immediately after flooding of the test pavements. The initial stage and the after-flooding stage of testing for the test track pavement are assumed to correspond respectively to the fall 1958 and the 1959 spring-thaw periods of the AASHO Road Test pavements. These two periods of testing were selected because they were critical for the deterioration of the pavements' serviceability. Figures 2, 3, and 4 show typical performance curves developed during this study. Table 3 gives the main variables used in the regression analysis.

Slopes of curves representing PSI versus N provide an indication of the rates of change of pavement performance with load; they also provide information about the nature of pavement performance at critical periods but do not provide the actual number of loads sustained by the pavements to failure. Findings from the AASHO Road Test, however, showed a strong correlation between the springtime deflection and the number of loads sustained by the pavements up to failure. The equation (3) for this correlation was as follows (1 kip = 4.4 kN, 1 in. = 2.5 cm):

$$\log W_{2.5} = 9.40 + 1.32 \log L_1 - 3.25 \log d \qquad (2)$$

where

$W_{2.5}$ = number of applications of axle load sustained by pavement at time PSI is at 2.5;
L_1 = single-axle load, in kips; and
d = normal springtime deflection in 0.001 in. (0.025 mm) under a wheel load of (L_1/2).

Equation 2 can be used with the springtime deflection data to estimate the number of loads a pavement will sustain before its PSI drops to 2.5. An attempt to develop a similar type of equation for pavements tested in the test track was negated because pavements tested in the test track were flooded at different times in the loading sequence; however, the frost action and saturation occurred at the same relative time in the loading sequence for all pavements in the AASHO Road Test. A regression analysis was made with data from the test track pavements by taking the actual number of wheel loads N′ required to produce a unit drop in PSI as the dependent variable and deflection as the independent variable. Similar data from 15 pavements from the AASHO Road

Test were also analyzed in the same manner to produce regression analyses from both facilities (serial no. 7, Table 3).

Results from the seven regression analyses are given in Table 3. Figures 5 and 6 show the data points and the regression lines developed when the rate of change in the PSI and the pavement surface deflections for pavements are analyzed in the test track and the AASHO Road Test respectively. These curves are typical of the data and regression curves found for the other six regression analyses. More details on the regression curves are given elsewhere (2). The results indicate a wider scatter band in the results from the test track than in those from the AASHO Road Test.

As given in Table 3, findings from the test track are significant at the 0.5 (99.5) percent level; however, the findings from the AASHO Road Test are generally significant at the 2.5 (97.5) percent level. The reason for the higher level of confidence in the test track data despite the greater amount of scatter in the data is the larger data base available from the test track study. The greater variation in the test track data may be attributed to several causes and is worth further consideration.

Two factors were determined to have a particularly significant effect on the behavior and performance of pavements tested in the pavement test track: (a) the degree of saturation of the base and subbase materials and (b) the moisture content and dry density of the subgrade soil.

Table 4 gives the effect of subgrade stiffness on the performance of replicate pavement sections in the pavement test track. The data in Table 4 clearly illustrate the substantially reduced performance associated with the reduced density of the subgrade and slightly higher moisture content. Of the two factors, the difference in the dry density appears to have a greater effect than the difference in the moisture content.

Data on the effect of degree of saturation of the base and subbase materials are too voluminous to present in this paper and did not lend themselves to concise summation. However, when the degree of saturation of the base and subbase materials was raised to greater than approximately 80 or 85 percent, there was a substantial increase in the rate of loss of serviceability. These findings are substantiated by the data from the AASHO Road Test.

Based on these factors and their effect on pavement performance, the greater scatter in the data from the pavement test track pavements can be attributed to characteristics of the materials, duration of tests, and the interrelationship between these two factors. The materials for the AASHO Road Test pavements were placed, allowed to set over a winter period, and then tested over a period of about 3 years. This time span allowed the soil to come to some moisture and density equilibrium so that each set of test pavements in the test track were placed and tested over a relatively short period of 4 to 6 months. Ten sets of pavements were placed and tested in this manner over a 5-year period. The short period of time used in placing and testing each test set did not allow the moisture and density in the soil to come to equilibrium and become uniform. In addition, placing the pavements in 10 subsequent sets would likely produce more variability than if the pavement had been laid in one continuous placement as was done at the AASHO Road Test.

Despite the greater variability, the data from the test track pavements are highly significant and provide a reliable indicator of pavement performance.

CONCLUSIONS

Based on the findings from this study and the correlations obtained between pavements tested in the AASHO Road Test and the University of Illinois Pavement Test Track, it is concluded that the pavement test track is a useful tool for evaluating factors that influence pavement behavior and performance. Further, by careful evaluation and application of the findings from the test track, it is possible to predict performance of pavements in service, and thus the test track is a tool that can provide meaningful input for development of design procedures for highway pavements.

Significant relationships were obtained between creep-speed rebound deflection and the rate of change of $\overline{\text{RD}}$, $\overline{\text{SV}}$, and PSI for the initial loading as well as during the criti-

Figure 4. Performance versus number of load applications for section 732 of lane 2/loop 2 pavement in AASHO Road Test.

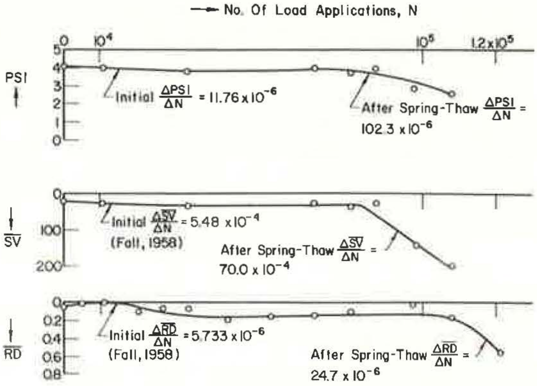


Table 3. Independent and dependent variables and results of regression analyses.

Serial No.	Variables: Independent	Variables: Dependent	Program	Regression Equation	Significance Level by F-Test (percent)
1	Initial creep-speed deflection, δ	Corresponding ($\Delta\overline{RD}/\Delta N$)	Test track AASHO Road Test	$\log[(\Delta\overline{RD}/\Delta N) \times 10^0] = -0.21 + 30.29\delta$ $\log[(\Delta\overline{RD}/\Delta N) \times 10^6] = 0.72 + 5.05\delta$	0.5 5.0
2	Initial creep-speed deflection, δ	Corresponding ($\Delta\overline{SV}/\Delta N$)	Test track AASHO Road Test	$\log[(\Delta\overline{SV}/\Delta N) \times 10^5] = 1.20 + 27.38\delta$ $\log[(\Delta\overline{SV}/\Delta N) \times 10^4] = 0.50 + 12.31\delta$	0.5 0.5
3	Initial creep-speed deflection, δ	Corresponding ($\Delta PSI/\Delta N$)	Test track AASHO Road Test	$\log[(\Delta PSI/\Delta N) \times 10^6] = 0.57 + 19.42\delta$ $\log[(\Delta PSI/\Delta N) \times 10^6] = 0.95 + 9.56\delta$	0.5 0.5
4	Creep-speed deflection δ after flooding or spring thaw 1959	Corresponding ($\Delta\overline{RD}/\Delta N$)	Test track AASHO Road Test	$\log[(\Delta\overline{RD}/\Delta N) \times 10^0] = 0.13 + 22.00\delta$ $\log[(\Delta\overline{RD}/\Delta N) \times 10^6] = 0.71 + 10.80\delta$	0.5 5.0
5	Creep-speed deflection δ after flooding or spring thaw 1959	Corresponding ($\Delta\overline{SV}/\Delta N$)	Test track AASHO Road Test	$\log[(\Delta\overline{SV}/\Delta N) \times 10^5] = 1.96 + 24.43\delta$ $\log[(\Delta\overline{SV}/\Delta N) \times 10^4] = 0.49 + 25.66\delta$	0.5 1.0
6	Creep-speed deflection δ after flooding or spring thaw 1959	Corresponding ($\Delta PSI/\Delta N$)	Test track AASHO Road Test	$\log[\Delta PSI/\Delta N) \times 10^6] = 1.10 + 19.23\delta$ $\log[\Delta PSI/\Delta N) \times 10^6] = 1.09 + 11.93\delta$	0.5 2.5
7	Creep-speed deflection δ after flooding or spring thaw 1959	Corresponding N′, no. of loads sustained for unit drop in PSI	Test track AASHO Road Test	$\log N' = 1.26 - 1.91 \log \delta$ $\log N' = 3.11 - \log \delta$	0.5 2.5

Note: All logarithms are to the base 10.

Figure 5. Rate of change of PSI with load versus deflection in test track after flooding.

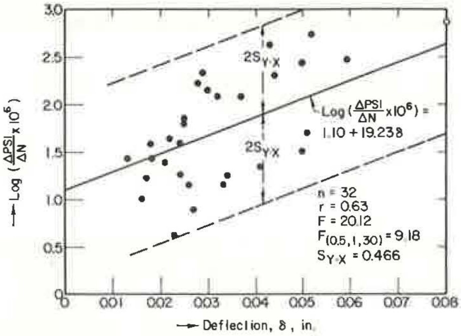


Figure 6. Rate of change of PSI with load versus deflection in AASHO Road Test after spring thaw 1959.

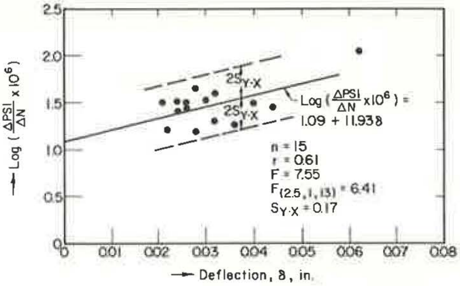
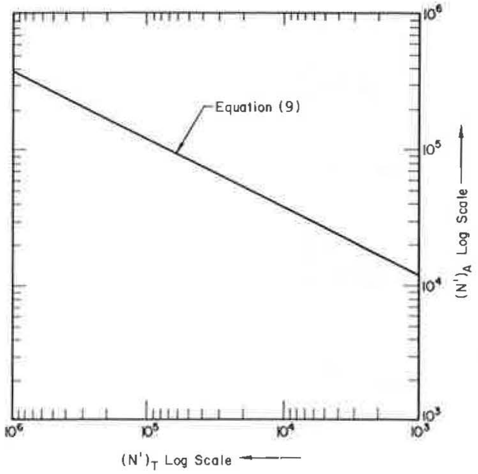


Table 4. Different effects of soft and stiff subgrades on performance of pavement test track.

Pavement No.	Test Set	In-Place Dry Density of Subgrade (percentage of standard)	In-Place Moisture Content of Subgrade (percent)	$(\Delta PSI/\Delta N)$		$(\Delta \overline{RD}/\Delta N)$		$(\Delta \overline{SV}/\Delta N)$	
				Initial ($\times 10^{-6}$)	After Flooding ($\times 10^{-6}$)	Initial ($\times 10^{-6}$)	After Flooding ($\times 10^{-6}$)	Initial ($\times 10^{-6}$)	After Flooding ($\times 10^{-6}$)
1	6	110.9	10.35	8.0	170.0	2.08	5.74	70.0	5,250.0
	8	98.5	12.02	14.5	437.5	3.40	77.60	417.0	48,300.0
2	6	107.8	11.77	3.00	550.0	1.43	21.3	7.7	67,000.0
	8	93.8	12.18	12.50	750.0	7.08	364.0	263.0	190,000.0
3	6	109.1	10.80	2.73	210.0	1.67	28.7	50.0	11,000.0
	8	101.9	12.20	20.00	120.0	7.73	38.4	468.0	13,000.0
4	6	103.4	10.78	2.94	140.0	2.50	4.36	100.0	4,710.0
	8	98.1	12.40	8.90	120.0	6.67	34.80	714.0	7,000.0

Figure 7. Number of loads for unit change of PSI after flooding or spring thaw for test track versus AASHO Road Test pavements.



cal moisture-condition period. High rebound deflection is a reasonably reliable indicator of the rate of serviceability loss for test pavements in the test track as well as for pavements in service. Another significant relationship was obtained between the rebound deflection at the beginning of the soaked condition and the number of loads required to produce a unit drop in PSI.

If creep-speed rebound deflection is assumed to be the same in the test track and in in-service pavements, the serviceability characteristics of the in-service pavements can be estimated from those of the test track pavements.

Infiltration of moisture into the granular base caused a significant increase in the rebound deflection of these pavements accompanied by an increase in the rate of loss of pavement serviceability. Little change in moisture content was noted in the subgrade soil for pavements in both the pavement test track and the AASHO Road Test.

Density of the subgrade soil is an important factor in pavement behavior and performance. For subgrade densities below about 94 to 95 percent of the standard, there was a substantial increase in the rate of serviceability loss.

APPLICATION OF FINDINGS

Regression analyses of the data yielded seven significant linear relationships between the parameters indicative of pavement performance and creep-speed rebound deflection. These relationships are given in Table 3.

The variables of these equations have been defined earlier. As indicated in Table 3, the equations are each statistically significant at 5 percent level or less. Each pair of equations correlating pavement behavior or performance and creep-speed deflection in the AASHO Road Test and the pavement test track were then combined to produce an equation correlating the pavements tested in the AASHO Road Test with those tested in the University of Illinois Pavement Test Track. These equations take the form of weighting functions between the two facilities for the different test conditions and are expressed as follows:

$$\frac{\Delta N}{\Delta \overline{RD}_A} = 17{,}793 \times \left(\frac{\Delta N}{\Delta \overline{RD}}\right)_T^{0.167} \tag{3}$$

$$\frac{\Delta N}{\Delta \overline{SV}_A} = 61.73 \times \left(\frac{\Delta N}{\Delta \overline{SV}}\right)_T^{0.45} \tag{4}$$

$$\frac{\Delta N}{\Delta PSI_A} = 237.9 \times \left(\frac{\Delta N}{\Delta PSI}\right)_T^{0.49} \tag{5}$$

for initial service conditions.

$$\frac{\Delta N}{\Delta \overline{RD}_A} = 888.8 \times \left(\frac{\Delta N}{\Delta \overline{RD}}\right)_T^{0.491} \tag{6}$$

$$\frac{\Delta N}{\Delta \overline{SV}_A} = 2.04 \times \left(\frac{\Delta N}{\Delta \overline{SV}}\right)_T^{1.05} \tag{7}$$

$$\frac{\Delta N}{\Delta PSI_A} = 74.1 \times \left(\frac{\Delta N}{\Delta PSI}\right)_T^{0.62} \tag{8}$$

$$(N')_A = 282 \times (N')_T^{0.52} \tag{9}$$

for after-flooding or spring-thaw conditions.

In the equations above, the subscripts A and T represent AASHO Road Test and test track pavements respectively. These equations can be useful in extrapolating results from the test track pavements to the performance of the AASHO Road Test pavements. There are, however, several limitations to the application of these equations:

1. That the material characteristics for the pavements in the test track be close to those used in the AASHO Road Test;
2. That the axle loading be around 6 kips (26.7 kN);
3. That the rebound surface deflection for in-service pavement under creep-speed load be the same as that for the test track pavement;
4. That the thickness and combination of layers for the in-service pavement be similar to those for the test track; and
5. That the dry density of the base, subbase, and subgrade be above 95 percent of standard and the in-place degree of saturation in the base be below 80 percent.

This study was to develop correlations between pavement performance in the University of Illinois Pavement Test Track and the AASHO Road Test so that the pavement test track could be considered as a tool to evaluate the relative performance of pavement systems. Since the trend in the PSI is a primary indicator of pavement performance, the correlation equations having (Δ PSI/Δ N) or N′ as their parameters (equations 8 and 9) are more useful than the others.

It was recognized even before the study began that the pavement test track imposed more severe loading conditions on the pavements than they would likely experience in service or had experienced in the AASHO Road Test. From equation 9 it is seen that the number of loads required to cause a unit reduction in PSI in pavements in the AASHO Road Test is approximately 280 times the number required to cause a unit drop in PSI in the test track raised to the 0.52 power. Use of this information can best be demonstrated by calculating the answer to the following example question: How many 6-kip (26.7-kN) axle loads will an average in-service pavement sustain with a unit drop in PSI during spring thaw, if a structurally similar pavement withstood 1,000 load applications in the test track after flooding?

Based on equation 9 and assuming that the deflection under creep-speed wheel load for the in-service pavement is the same as that for the test track pavement, the following calculations are made. From equation 9,

$$\begin{aligned}(N')_A &= 282 \times (1{,}000)^{0.52} \\ &= 282 \times 10^{1.56} = 282 \times 36.2 \\ &= 10{,}200 \qquad (10)\end{aligned}$$

That is, 10,200 loads are estimated as being required to produce a unit drop in PSI for in-service pavements. This is approximately 10 times the number required in the pavement test track.

As indicated by the coefficient 0.52, equation 9 does not represent a linear relationship between $(N')_A$ and $(N')_T$. It was found that the value of $(N')_T$ varied from approximately 2,000 to 160,000 for the 32 pavements tested in the test track. Thus, equation 9 is presented graphically in Figure 7 for a range of $(N')_T$ and $(N')_A$ values.

From Figure 7, the expected numbers of loads required to produce a unit drop in PSI during the frost-melt period can be determined from a corresponding number of loads to produce unit loss in PSI in the pavements in the pavement test track after saturation of the pavements. Thus, if it required 10^4 load applications to produce a unit loss in PSI in the pavement test track, it would require approximately 40,000 loads during the spring-thaw period to produce a corresponding loss in the prototype pavements. Figure 7 and equation 9 thus represent weighting functions between the test track and in-service pavements.

In a similar manner equations 3 through 8 can be used to estimate the rate of change of $\overline{\text{RD}}$, $\overline{\text{SV}}$, and PSI with loads in prototype pavements from the results of pavements tested in the test track. There is probably not much practical use in knowing the rate of change of $\overline{\text{RD}}$ and $\overline{\text{SV}}$ individually because both of these properties are reflected in the PSI value, which represents the overall performance of the pavement. Hence the equations 3, 4, 6, and 7 have not been presented in the reduced format. One can, however, solve these equations to determine the average relationship between the rate of change in $\overline{\text{RD}}$ and $\overline{\text{SV}}$ between the test track and in-service pavements.

CONCLUDING REMARKS

The many factors that affect pavement behavior and performance practically negate the possibility of developing models (either physical or mathematical) that will have a one-to-one correspondence with pavements in service. Indeed, it is often impossible to accomplish a one-to-one correspondence in performance between apparently identical pavements in service. Thus, a model such as the University of Illinois Pavement Test Track is most suited for isolating factors that have a significant effect on pavement behavior and performance and for developing information on the relative performance of similar pavement systems.

The weighting functions developed in this paper are probably valid for evaluating the effects on performance of flexible (unbound) pavement systems and the factors that influence performance. Extreme caution should be used when applying these weighting functions to other pavement systems such as flexible pavements with stabilized bases. Earlier studies with the test track facility clearly showed a nearly one-to-one correspondence among pavements with stabilized bases tested in the test track and similar pavements in service. Thus, the weighting function between the model and the prototype is a function of the pavement system as well as the conditions existing within the pavement system.

Despite these drawbacks, much useful information can be obtained by evaluating pavements in a facility such as the pavement test track. Factors that influence pavement behavior and performance can be isolated so that the relative effect of such factors can be evaluated. The real problem is to accurately evaluate the findings from such a test program and to extrapolate the conclusions to prototype conditions.

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The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented. The contents do not necessarily reflect the official views of the Illinois Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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