Influence of Stress Levels and Seasonal Variations on In Situ Pavement Layer Properties

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Presented is a small-scale investigation of how stress levels and seasonal variations affect pavement layer characteristics. Monitoring such effects is basic to the effort conducted under the Strategic Highway Research Program (SHRP) Long-Term Pavement Performance (LTPP) studies currently under the FHWA jurisdiction. Illustrated are the influences of stress levels, seasonal temperature variations, seasonal moisture variations, and accumulated equivalent single axle loads (ESALs) on (*a*) center deflection (D_o) measured by the falling-weight deflectometer; (*b*) in situ asphalt concrete modulus (E_{AC}); (*c*) in situ granular layer modulus (E_g); (*d*) in situ subgrade resilient modulus (*MR*); (*e*) in situ AASHTO effective structural number (SN_{eff}); and (*f*) variability within a section for each of the structural factors above. Analysis of results suggests that *MR* is the parameter most affected by a change in stress level, followed by E_g, E_{AC}, and SN_{eff}. On the other hand, E_{AC} is the parameter most affected by the change in temperature, followed by D_o, SN_{eff}, E_g and *MR*. Variations in *MR* and E_g with temperature are believed to be associated indirectly with variations in E_{AC} and temperature. Changes in E_{AC} and temperature result in changes in stress levels imposed on the underlying pavement layers that cause variations in *MR* and E_g. Accumulation of ESALs under dry conditions affect E_{AC}, followed by D_o, E_g, SN_{eff}, and *MR*, in order of diminishing effect. In addition, seasonal moisture variations affect D_o and *MR*, followed by E_g, E_{AC} and SN_{eff}. And variability within a section for each of the structural factors increases with an increase in temperature, moisture level, or accumulated ESALs. Among the structural factors, SN_{eff} has the lowest within-section variability, whereas E_g has the greater within-section variability.

Nondestructive deflection testing using the falling-weight deflectometer (FWD) is part of an ongoing monitoring effort planned by the Strategic Highway Research Program (SHRP) for the Long-Term Pavement Performance (LTPP) studies (*1*). Nondestructive deflection testing provides data necessary for in situ material characterization for the various pavement layers as well as information on material variability that became an explicit independent variable in the 1986 (AASHTO) design equations (*2*). Backcalculated moduli from deflection measurements at a number of locations within pavement test sections can be used to establish the mean, minimum, maximum, and standard deviation of moduli for each layer (*1*). Use of different load levels by the FWD at a single location also can provide information regarding variations of layer moduli with stress sensitivity. The effect of seasonal temperature variations on layer moduli may be investigated through successive testing with the FWD at different air temperatures, similar moisture conditions, and within a short time span. Similarly, the effect of seasonal moisture variations may be investigated through successive testing with the FWD at different moisture levels, similar air temperatures, and again, within a short time span. Finally, the effect of accumulated equivalent single axle loads (ESALs) on layer moduli can be investigated through testing at similar air temperatures, similar moisture levels, and during a long time period.

The effects of stress levels and seasonal variations on pavement material properties are simulated in the laboratory; such tests have been reported in many research studies. Hicks, for example, reported the effect of stress level and moisture conditions on the laboratory-determined resilient characteristics of granular materials (*3*). Thompson et al. documented the effect of stress level and degree of saturation on resilient characteristics of subgrade soils (*4,5*). Witczak reported the effect of temperature on the dynamic modulus of asphalt concrete as determined in the laboratory (*6*).

A need still exists to verify that the influence of stress levels and seasonal variations on pavement material characteristics obtained in the laboratory under simulated field conditions is actually, or closely related to, those in situ characteristics. It is hoped that results of the SHRP LTPP studies will help to satisfy this need.

This paper presents a small-scale study that investigates the influence of stress levels, seasonal variations, and accumulated ESALs on in situ pavement layer characteristics.

EXPERIMENTAL DESIGN

The experimental part of this study is designed statistically to provide as many reliable inferences on such effects as possible. Three designs are used.

Design 1

The first design is set to investigate the effects of two main factors: stress levels and seasonal temperature variations.

Stress Levels

The stress-level factor consists of three levels, each of which is the stress induced by a specific load applied by the FWD. The FWD used for this study has seven geophones and a loading plate radius of 15 cm. Load levels selected are 9,000, 14,000 and 18,000 lb (40, 62, and 80 kN). Testing is conducted for pavement sections on the outer wheel path of the truck lane (approximately 90 cm from the shoulder edge).

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Seasonal Temperature Variations

Seasonal temperature variation consists of three levels (hot, cool, and medium), and each level relates to a specific month: August (hot), November (cool), and April (medium). Note that most seasonal variations within Saudi Arabia can be represented by temperature variations; there is neither a frost period nor a spring thaw period to affect pavement. Changes in the moisture level within paving layers are less likely to occur as compared with changes in temperature. The effect of moisture variation is described later (Design 3).

Site conditions, including air temperature, pavement surface temperature, pavement temperature at the mid-point of the asphalt bound layer, temperature at the bottom of the asphalt bound layers, and moisture density characteristics of nonbound paving layers, are obtained at each of the three temperature levels.

Test Locations

Using test section lengths of 1 km, deflection testing is conducted at 50-m intervals (21 points per section) on the outer wheel path of the truck lane. Test locations are marked to ensure that subsequent seasonal testing is conducted at identical locations.

Response Variables

Main response variables measured (or computed) per load level (40, 62, or 80 kN) per seasonal temperature (August, November, or April) for each of 21 locations are

- Center deflection, D_o;
- Overall one-layer modulus, E_o, computed using the load level, the center deflection, and assuming a one-layer system;
- Backcalculated subgrade modulus, *MR*;
- Backcalculated modulus for the asphalt bound layer, E_{AC};
- Backcalculated modulus for the nonbound granular layer, E_g; and
- AASHTO effective structural number, SN_{eff}.

Backcalculated layer moduli and SN_{eff} are obtained for a three-layer system employing a simple modification of the two-layer process developed by the author (7). This process was tested thoroughly, and its accuracy and consistency were verified.

Replicate Segments

Design 1 is repeated for 12 pavement segments representing different regions in Saudi Arabia in order to investigate the variability between sections for the main factors included in the design.

Time Span Between Seasons

Note that the time span between seasons is set to allow as wide a range of temperature variation as possible. However, the time span factor also is adjusted to minimize the effect of moisture and traffic repetition on the response variables during this time span.

Design 2

The second design is prepared to investigate the effect of time in terms of accumulated traffic (fixed season and fixed stress level) on the same response variables described under Design 1. Two levels of this factor are considered, "time zero" and "time four." "Time zero" is November 1988, and "time four" is November 1992. Stress and season levels are fixed in order to make the time factor represent the effect of traffic in terms of loads ESALs as much as feasible. Aging effects would confound the ESAL effect in this case.

Design 3

The third design is set to investigate the effects of seasonal moisture variations on the same response variables described for Design 1. Because large changes in moisture levels within pavement layers are less likely to occur in Saudi Arabia, it was decided to conduct deflection testing on test segments directly after a period of rainfall. Two levels of the seasonal moisture variation factor were obtained, dry (November 1992) and wet (February 1993).

ANALYSIS OF RESULTS

Effect of Stress Levels and Seasonal Temperature Variations

Center Deflection, D_o

Figure 1 illustrates the influence of load level on the center deflections measured for Site 1 during November 1988. Note that the general shape of the center deflection profile is similar for the three load levels (9,000, 14,000, and 18,000 lb). Detailed conditions for Site 1 are given in Table 1.

Figure 2 shows the influence of season (August versus November) on the center deflection measured at a load level of 9,000 lb

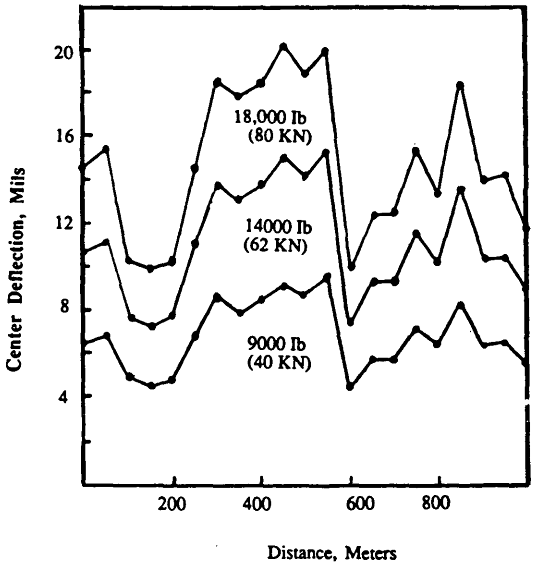

FIGURE 1 Influence of load level on FWD center deflection during November.

TABLE 1 Conditions of Site 1 During FWD Testing (Design 1)

Site Condition	August 1988	November 1988	April 1989	Cross Section
Temperature				
Air	44°C	24.5°C	34.2°C	7.0 Inch Asphalt Concrete
Surface	55°C	30.6°C	42.8°C	10.0 Inch Granular Subbase
Midpoint of AC Layer	49.5°C	27.5°C	38.5°C	
Bottom of AC Layer	44°C	24.5°C	34.2°C	
Subbase Layer				
Classification	A-2-4	A-2-4	A-2-4	
Moisture Content	5.6%	5.7%	5.8%	
Dry Density, t/m³	1.796	1.794	1.792	
Subgrade Layer				
Classification	A-2-6	A-2-6	A-2-6	
Moisture Content	7.6%	7.8%	8.2%	
Dry Density, t/m³	1.728	1.725	1.719	

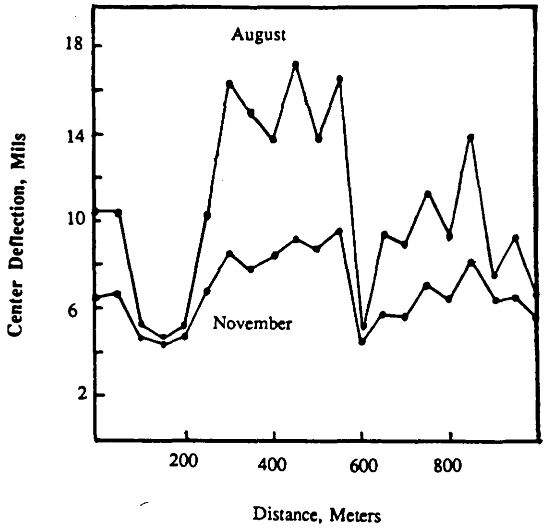

FIGURE 2 Influence of season (temperature level) on FWD center deflection at load level of 9,000 lb.

(40 kN). The seasonal effect is a temperature-related effect because moisture conditions are practically identical, as indicated in Table 1. Points with relatively low deflection values are not as sensitive to temperature as those with relatively high deflection values (Figure 2).

Table 2 presents statistics—means and coefficients of variation (c.o.v.)—of the FWD center deflection during various seasons and load levels for Site 1. Note that the within-section deflection variability represented by the coefficient of variation remains practically the same at various load levels. However, the variability increases with an increase in temperature during testing. Also, the mean center deflection obtained at a load level of 18,000 lb, for example, can be duplicated by simply multiplying the mean center deflection obtained at a load level of 9,000 lb by 2, with a marginal error. The possibility of using a higher load level when testing in cool weather conditions to simulate measurements in hot weather conditions is apparent as one compares the mean center deflection of a 14,000-lb load during the month of November (cool) with the mean center deflection of a 9,000-lb load during the month of August (hot).

TABLE 2 Statistics of FWD Center Deflections in Mils During Various Seasons at Three Load Levels

			Season		
		Statistics	August 1988	November 1988	April 1989
Load Level	9000 Pounds	Mean c.o.v.	10.47 39.5%	6.78 23.3%	7.90 28%
	14000 Pounds	Mean c.o.v.	16.29 39.5%	10.98 23.5%	13.32 27.6%
	18000 Pounds	Mean c.o.v.	21.34 37.30%	14.75 23.6%	17.77 26.9%

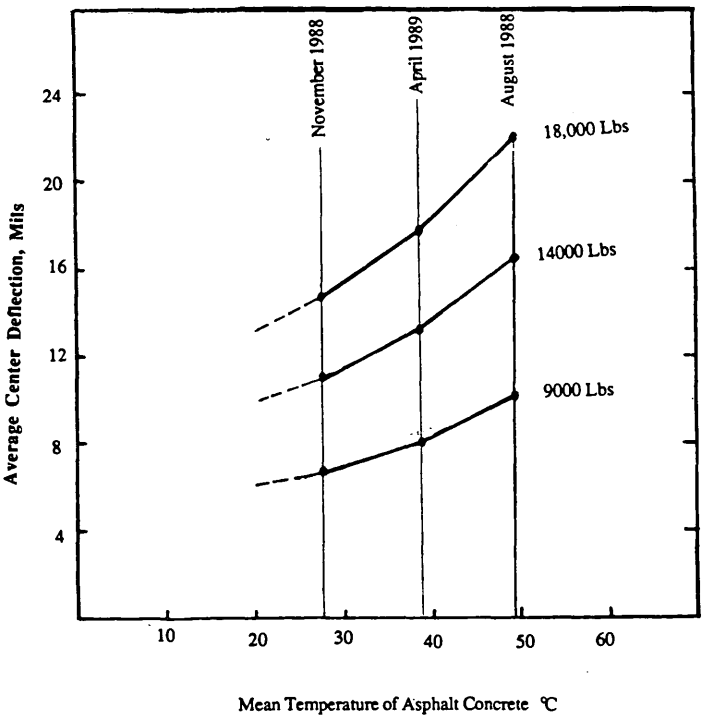

FIGURE 3 Center deflection and temperature relationship at various FWD load levels.

Figure 3 graphically represents data given in Table 2; the horizontal axis represents the mean temperature of asphalt concrete (measured at the mid-depth of the asphalt bound layer), and the vertical axis represents the average center deflection for Site 1. It is suggested that there is no effect of temperature and load level interaction on the center deflection, as indicated by the parallel lines.

Overall One-Layer Modulus, E_o

The overall one-layer modulus is computed using the load level, the center deflection, and by assuming that the pavement is a one-layer system.

Table 3 presents the statistics of E_o during the various seasons (August, November, and April) at load levels of 9,000, 14,000 and 18,000 lb for Site 1. It can be noted that the E_o value at a load level of 18,000 lb is 93 percent (on average) of its value at a load level of 9,000 pounds. On the other hand, the E_o value in August—when the average temperature of asphalt concrete is 49.5°C, (Table 1)—is (on average) 67 percent of its value in November, when the average temperature of asphalt concrete is 24.5°C (Table 1).

Asphalt Concrete Modulus, E_{AC}

Figure 4 (*top*) shows the influence of load level on the backcalculated asphalt concrete modulus. A slight but consistent (and statistically significant) effect is present. Moduli obtained at a load level of 18,000 lb (80 kN) are lower than those obtained at a load level of 9,000 lb (40 kN), indicating a slight, consistent, stress-softening pattern. In fact, the roadway from which the test site was selected does show signs of rutting and is currently scheduled for repair.

Figure 5 (*top*) illustrates the influence of season (August versus November) on the backcalculated asphalt concrete modulus. The reduction in moduli with temperature is apparent when the modulus profile in November (when the mean asphalt concrete temperature is 24.5°C) is compared with the modulus profile in August (when its average temperature is 49.5°C).

Table 4 presents statistics for the backcalculated asphalt concrete modulus during various seasons and load levels. Variability in terms of the coefficients of variation increases slightly with load level; it increases considerably with temperature.

TABLE 3 Statistics of Overall One-Layer Modulus, E_o, in Pounds per Square Inch During Various Seasons at Three Load Levels

			Season		
		Statistics	August 1988	November 1988	April 1989
Load Level	9000 Pounds	Mean c.o.v.	69,500 39.5%	107,300 23.3%	92,100 28%
	14000 Pounds	Mean c.o.v.	69,500 39.5%	103,100 23.5%	85,000 27.6%
	18000 Pounds	Mean c.o.v.	68,200 37.3%	98,700 23.6%	81,900 26.9%

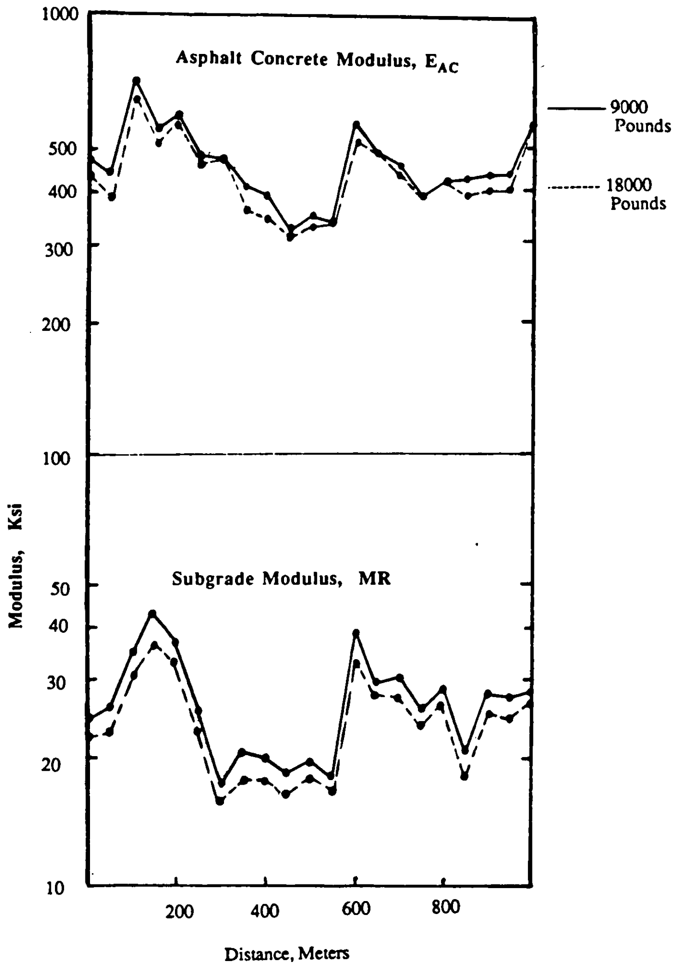

FIGURE 4 Influence of load level on backcalculated subgrade and asphalt concrete moduli during November 1988.

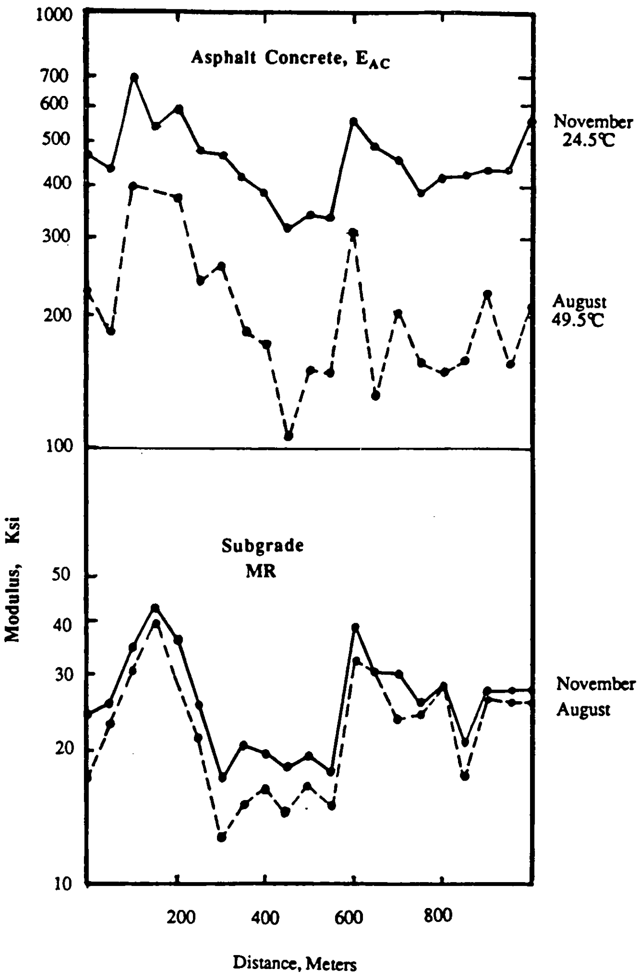

FIGURE 5 Influence of season (temperature level) on backcalculated subgrade and asphalt concrete moduli at load level of 9,000 lb.

TABLE 4 Statistics of Backcalculated Asphalt Concrete Modulus, E_{AC}, in Pounds per Square Inch During Various Seasons at Three Load Levels

			Season		
		Statistics	August 1988	November 1988	April 1989
Load Level	9000 Pounds	Mean c.o.v.	207,500 37.6%	461,000 20.5%	401,400 31.5%
	14000 Pounds	Mean c.o.v.	207,600 37.7%	449,300 20.1%	381,700 32.1%
	18000 Pounds	Mean c.o.v.	205,100 41.8%	448,600 22.4%	361,800 29.3%

TABLE 5 Statistics of Backcalculated Subgrade Modulus, *MR*, in Pounds per Square Inch During Various Seasons at Three Load Levels

			Season		
		Statistics	August 1988	November 1988	April 1989
Load Level	9000 Pounds	Mean c.o.v.	23,000 31.4%	26,700 27%	25,100 25.1%
	14000 Pounds	Mean c.o.v.	23,000 31.4%	25,300 26.3%	22,600 25.6%
	18000 Pounds	Mean c.o.v.	21,900 31.1%	23,900 25.9%	21,500 25.8%

Subgrade Modulus, MR

Figure 4 (*bottom*) shows the influence of load level on the backcalculated subgrade modulus. Moduli obtained at a load level of 18,000 lb (80 kN) are lower than those obtained at a load level of 9,000 lb (40 kN), indicating a consistent stress-softening pattern. The subgrade soil classification is A-2-6, as indicated in Table 1.

Figure 5 (*bottom*) illustrates the influence of the season (August versus November) on the backcalculated subgrade modulus. The reduction in subgrade moduli with temperature is also apparent when one compares the modulus profile in November with that in August (refer to Table 1 for site conditions). The sensitivity of subgrade modulus to temperature seems to be an indirect sensitivity to stress level. Reduction in asphalt concrete modulus, with higher temperature, results in an increased stress level on top of the subgrade that might have caused the reduction in the subgrade modulus.

Table 5 presents statistics of the backcalculated subgrade modulus during the various seasons at the three load levels. The largest variability in terms of the coefficient of variation is detected during August (i.e., it is associated with high temperature levels). Stress levels represented by load levels seem to have no effect on the within-section variability of the subgrade modulus (under dry conditions).

TABLE 6 Variations in Granular Subbase Modulus, E_g, in Pounds per Square Inch for Various Seasons at Three FWD Load Levels

Distance, meters	August 1988			November 1988			April 1989		
	9000	14000	18000	9000	14000	18000	9000	14000	18000
0	31,500	31,500	31,000	48,200	45,700	43,600	43,400	39,600	38,800
50	33,400	33,400	32,100	46,300	44,100	41,400	40,400	37,100	35,800
100	81,600	81,600	72,200	63,800	63,000	60,900	65,800	60,200	57,700
150	77,900	77,800	73,200	74,400	70,300	66,500	67,700	62,200	59,700
200	67,200	67,100	63,600	66,700	64,500	62,100	60,800	56,600	54,700
250	32,100	32,100	31,800	46,100	44,600	43,000	35,200	32,400	31,500
300	18,200	18,200	18,100	35,100	33,800	32,400	30,500	27,400	26,100
350	21.300	21,300	20,700	40,000	37,300	34,900	31,000	28,400	27,100
400	23,900	23,900	23,600	37,100	35,500	33,900	31,100	28,700	27,800
450	20,400	20,400	20,400	34,400	32,600	31,000	28,600	26,100	25,200
500	24,900	24,900	25,100	36,400	34,600	33,400	31,100	29,000	28,300
550	19,800	19,800	20,200	32,400	31,400	30,700	26,400	24,600	24,100
600	72,400	72,300	66,300	73,800	69,600	65,800	70,300	65,600	61,800
650	44,800	44,800	43,800	55,200	52,800	51,100	44,800	41,700	40,300
700	39,900	39,800	38,500	56,400	54,100	51,800	52,000	47,000	44,600
750	31,600	31,600	31,700	45,100	43,500	38,800	38,900	36,400	35,600
800	43,000	43,000	42,400	50,900	49,400	48,200	40,800	37,500	36,700
850	23,900	23,900	23,700	37,700	35,600	33,600	32,400	29,200	27,900
900	45,800	45,900	44,300	51,200	48,400	46,000	44,800	40,800	38,900
950	42,000	42,000	40,800	49,500	47,300	45,100	43,100	38,600	36,800
1000	58,000	58,000	54,500	56,600	54,400	53,000	54,700	48,200	46,000
Mean	40,600	40,600	39,000	49,400	47,300	45,100	43,500	39,900	38,400
c.o.v.	49.0%	49.0%	45.5%	25.5%	25.6%	25.8%	31.2%	31.4%	30.8%

NOTE: Three FWD load levels of 9,000, 14,000, and 18,000 lb were used.

TABLE 7 Statistics of Effective Structural Number, SN_{eff}, During Various Seasons at Three Load Levels

			Season		
		Statistics	August 1988	November 1988	April 1989
Load Level	9000 Pounds	Mean c.o.v.	3.33 12.1%	4.06 7.0%	3.85 9.4%
	14000 Pounds	Mean c.o.v.	3.33 12.1%	4.02 7.2%	3.77 9.3%
	18000 Pounds	Mean c.o.v.	3.30 11.8%	3.99 7.3%	3.72 8.7%

Granular Subbase Modulus, E_g

Table 6 presents the complete set of data obtained for the granular subbase modulus. Mean values suggest a general stress-softening pattern indicated by a slight reduction in the moduli with the increase in load level or the increase in temperature (refer to Table 1 for site conditions). However, occasional stress hardening and stress insensitivity patterns are also present. The subbase soil classification is A-2-4, as indicated in Table 1. The within-section variability increases with temperature, as indicated by the coefficient of variation in August compared with that in November. On the other hand, the within-section variability of E_g is the greatest when compared with the within-section variability of D_o, E_{AC}, and *MR*.

Effective Structural Number, SN_{eff}

Table 7 presents statistics of the AASHTO SN_{eff} computed in accordance with the process developed by the author (*7*). Results presented in Table 7 suggest a marginal reduction in SN_{eff} with the increase in load level and a considerable reduction with increasing temperature. Figure 6 presents a graphic representation of the relationship between SN_{eff} and temperature. The within-section variability of SN_{eff}, represented by the coefficient of variation, is obviously much lower than the within-section variability of other response variables (D_o, E_{AC}, *MR*, and E_g).

Adjustment Factors

Table 8 presents the stress-level adjustment factors for the pavement characteristics based on an adjustment factor of 1 at a load level of 9,000 lb. Values presented suggest a general reduction in stiffness associated with the increase in load level. The greatest stress sensitivity is associated with *MR*, followed by E_g, E_o, E_{AC}, and SN_{eff}. However, stress sensitivity for all response variables is generally low, assuming that all adjustment factors are greater than or equal to 0.9.

Table 9 provides temperature adjustment factors for pavement characteristics based on an adjustment factor of 1 at a mean asphalt concrete temperature of 20°C. As expected, the greatest temperature sensitivity is associated with E_{AC}, D_o, and E_o. However, the response variables SN_{eff}, E_g, and *MR* also show signs (probably indirect) of temperature sensitivity.

Effect of Accumulated ESALs

The effect of accumulated ESALs on pavement layer characteristics (D_o, E_{AC}, E_g, *MR*, and SN_{eff}) was investigated by conducting FWD testing in November 1988 and November 1992. A load level of 14,000 lb (62 kN) was employed. Testing during the same month eliminated the effect of temperature and moisture, although similarity of site conditions with respect to moisture and temper-

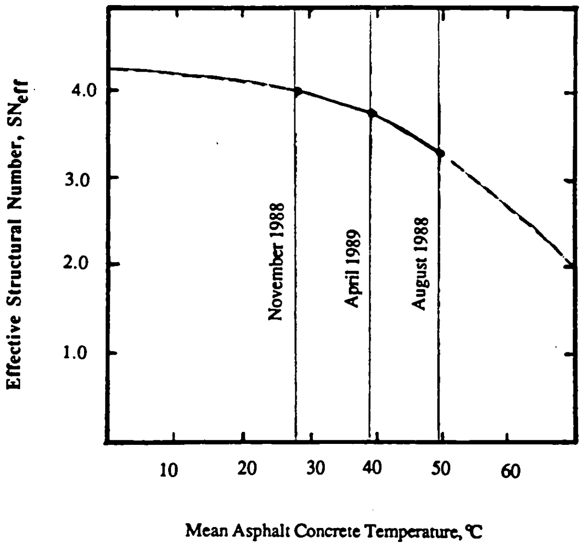

FIGURE 6 Influence of asphalt concrete temperature on effective structural number, SN_{eff}.

TABLE 8 Stress Level Adjustment Factors for In Situ Pavement Layer Properties

	FWD Load Level		
Characteristics	9000 Pounds	14000 Pounds	18000 Pounds
Overall One Layer Modulus, E_o	1.0	0.96	0.92
Asphalt Concrete Modulus, E_{AC}	1.0	0.97	0.95
Granular Subbase Modulus, E_g	1.0	0.96	0.92
Subgrade Resilient Modulus, MR	1.0	0.95	0.90
Effective Structural Number, SN_{eff}	1.0	0.99	0.98

ature levels for November 1988 and November 1992 (Table 10) may not always be that easy to obtain. On the other hand, both aging and the cyclical seasonal-variation effects statistically confound the effect of accumulated ESALs.

Accumulated ESALs during the 4-year period were $4 * 10^6$. ESALs were estimated on the basis of information obtained from the weigh and vehicle-classification stations located on the roadway.

Results provided in Table 10 suggest that accumulated ESALs result in a slight reduction in MR and E_g and a considerable reduction in E_{AC}. These reductions in pavement moduli also were associated with a general drop in the structural capacity of the pavement, as represented by values of D_o and SN_{eff}.

Also, the general reduction in pavement stiffness was associated with an increase in the within-section variability indicated by coefficients of variation.

Effect of Seasonal Moisture Variations

The effect of seasonal moisture variations on pavement layer properties (D_o, E_{AC}, E_g, MR, and SN_{eff}) was investigated by comparing the FWD test results of November 1992 with the results of February 1993. A load level of 14,000 lb (62 kN) was employed. A short time span (4 months) makes the side effect of accumulated ESALs during this time period relatively marginal. Testing in February 1993 was conducted on a sunny day following a week of unprecedented rain. Air temperatures between February and November do not vary much in Saudi Arabia. The authors were able to obtain conditions of similar temperature but different moisture levels, and within a short time span.

Table 10 (bottom) presents site conditions for November 1992 and February 1993. The heavy rain resulted in an increase in moisture content of the subbase and subgrade layers. Moisture content of the subbase increased from 5 to 9 percent, whereas the moisture content of the subgrade increased from 6.8 to 13 percent. Reductions in the field dry density of the subbase and the subgrade layers were 3.5 percent and 6.3 percent, respectively. Associated reductions in the subbase and subgrade layer moduli were 22.4 percent and 35 percent, respectively. Mean center deflection increased by 28.8 percent. Reductions in SN_{eff} and E_{AC} were relatively marginal (5.4 percent and 10 percent, respectively).

TABLE 9 Temperature Adjustment Factors for In Situ Pavement Layer Properties

	Average Asphalt Concrete Temperature			
Characteristics	20°C	27.5°C	38.5°C	49.5°C
Center Deflection, D_o	1.0	1.16	1.39	1.71
Overall One Layer Modulus, E_o	1.0	0.90	0.76	0.60
Asphalt Concrete Modulus, E_{AC}	1.0	0.90	0.76	0.41
Granular Subbase Modulus, E_g	1.0	0.91	0.78	0.77
Subgrade Resilient Modulus, MR	1.0	0.94	0.86	0.84
Effective Structural Number, SN_{eff}	1.0	0.96	0.90	0.79

TABLE 10 Site Conditions and FWD Test Results and Analysis for Designs 1 and 2

Characteristics	Statistics	November 1988	November 1992	February 1993
Center Deflection, D_o, mils	Mean c.o.v.	10.98 23.5%	13.35 29.7%	17.2 38.2%
Asphalt Concrete Modulus, E_{AC}, psi	Mean c.o.v.	449,300 20.1%	295,000 35%	265,500 37.2%
Granular Subbase Modulus, E_g, psi	Mean c.o.v.	47,300 25.6%	43,400 40%	33,700 44.7%
Subgrade Modulus, MR, psi	Mean c.o.v.	25,300 26.5%	23,700 30.5%	15,400 31.7%
Structural Number, SN_{eff}	Mean c.o.v.	4.02 7.2 %	3.68 10.0%	3.48 12.0%
Subbase				
Field Moisture Content		5.71%	5.0%	9.0%
Field Dry Density		1.794	1.774	1.712
Subgrade				
Field Moisture Content		7.8%	6.8%	13.0%
Field Dry Density, t/m^3		1.725	1.711	1.603
Temperature				
Air		24.5°C	23°C	22°C
Surface		30.6°C	29°C	27°C
Midpoint of Asphalt Concrete		27.5°C	26°C	24°C
Bottom of Asphalt Concrete		24.5°C	23°C	20°C

FWD load level used was 14000 pounds (62 kN)

SUMMARY

Understanding the effects of stress levels and seasonal variations on pavement layer properties is important to SHRP's monitoring effort and its LTPP studies.

This paper presents a small-scale study that evaluates the effects of stress levels, seasonal temperature variations, seasonal moisture variations, and the accumulation of ESALs on in situ pavement layer properties. Pavement responses considered were the FWD center deflection D_o, the asphalt concrete modulus (E_{AC}), the granular layer modulus (E_g), the subgrade modulus (MR), and the effective structural number (SN_{eff}), determined through backanalysis of deflection data. The within-section variability of pavement responses that is expected to be an important, independent variable in future pavement performance models was investigated.

The author's analysis of results suggests that MR is the parameter most affected by a change in stress level, followed by E_g, E_{AC}, and SN_{eff}. However, the stress sensitivity of all pavement responses investigated generally was marginal. On the other hand, E_{AC} is the parameter most affected by temperature, followed by D_o, SN_{eff}, E_g, and MR. The temperature sensitivity of MR and E_g is believed to be an indirect stress sensitivity associated with the reduction in E_{AC} with temperature. Accumulation of ESALs under dry conditions affects E_{AC}, as well as D_o, E_g, SN_{eff}, and MR in descending order. An increase in moisture level affects MR, as well as E_g, D_o, E_{AC}, and SN_{eff}. The within-section variability of pavement responses increases with an increase in temperature, in moisture level, or accumulated ESALs. Among pavement responses, SN_{eff} has the lowest within section variability, whereas E_g has the largest.

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