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Monitoring Project for District 24 (El Paso), State of Texas

16. Abstract

Moisture barriers were installed in 1985 and monitored on the eastbound and westbound lanes of IH10 near Sierra Blanca in Hudspeth County in District 24, the El Paso District. The site was overlaid by a layer of silty sand interbedded with a sandy clay, beneath which were strata of sand and gravel, brown plastic clay, and bentonitic clay. It was hoped that the moisture barrier would retard or reduce the movements of the expansive subgrade and the resulting pavement roughness.

Pavement profiles in each wheelpath were measured with the profilometer and suctions were measured both inside and outside the moisture barriers from 1987 on to the present. Both are analyzed to determine the effectiveness of the moisture barriers when compared with pavement sections without them. The fact that water could enter the clay layers through the sandy and gravelly layers, and that water was readily supplied by the sodded median strip made it difficult for the moisture barrier to function as intended. Nevertheless, it reduced the level roughness in the inside lanes by as much as twice that of the unprotected sections.

The experience has shown the importance of conducting a thorough site investigation prior to installing a moisture barrier and of carrying it to a depth equal to the greatest depth where root fibers are found.

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EL PASO MOISTURE BARRIER STUDY

Research Study No. 2-24D-88C-953

by

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Sponsored by the

Texas Department of Transportation

Texas Transportation Institute

Texas A&M University

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August, 1992

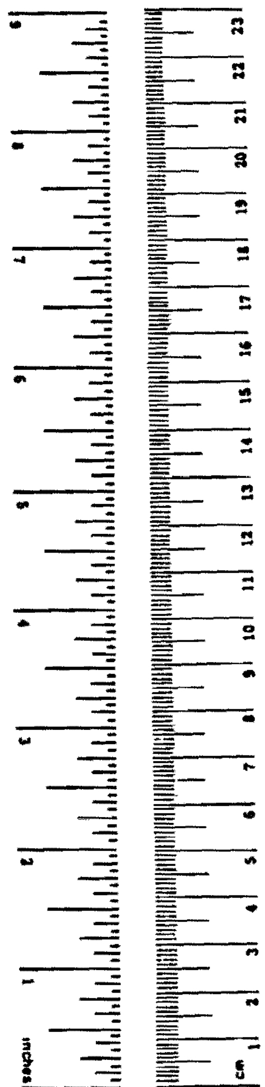
METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	2.54	centimetres	cm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
	AREA			
in²	square inches	645.2	centimetres squared	cm ²
ft²	square feet	0.0929	metres squared	m²
yd²	square yards	0.836	metres squared	m²
mi²	square miles	2.59	kilometres squared	km²
ac	acres	0.395	hectares	ha
	MASS (weight)			
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
	VOLUME			
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft³	cubic feet	0.0328	metres cubed	m³
yd³	cubic yards	0.0765	metres cubed	m³

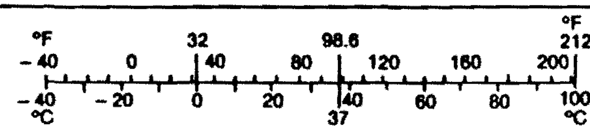
NOTE: Volumes greater than 1000 L shall be shown in m³.

Symbol	When You Know	Multiply By	To Find	Symbol
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
	AREA			
mm²	millimetres squared	0.0016	square inches	in²
m²	metres squared	10.764	square feet	ft²
km²	kilometres squared	0.39	square miles	mi²
ha	hectores (10 000 m²)	2.53	acres	ac
	MASS (weight)			
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
	VOLUME			
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m³	metres cubed	35.315	cubic feet	ft³
m³	metres cubed	1.308	cubic yards	yd³
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

IMPLEMENTATION STATEMENT

The report makes three conclusions that can be implemented. One of these is that a thorough site investigation including soils borings should be conducted prior to installing a moisture barrier. The borings should be carried to a depth that is twice as deep as the expected depth of the moisture barrier. The soils data should include water content, Atterberg limits, and suction measurements with depth in each boring. Suction can be measured using filter paper according to the ASTM Standard on this measurement. This permits a determination of how effective the moisture barrier will be once it is installed.

A second conclusion that can be implemented is to carry the moisture barriers to a depth equal to the greatest depth where root fibers were found in any boring.

A third conclusion that can be implemented is to crown and pave all median strips in expansive clays wherever that is possible in order to reduce the roughness caused by water entering the subgrade in the median.

DISCLAIMER

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INTRODUCTION

Moisture barriers were installed in December, 1985 on IH-10 at a site near Sierra Blanca in Hudspeth County of District 24. This site is located approximately 80 miles east of El Paso along the IH-10 and 2.5 miles due west of the town of Sierra Blanca. The site was known to have a layer of highly active clay in the subgrade, and it was hoped that the installation of moisture barriers would retard, reduce, or eliminate the movements of the subgrade and the resulting pavement roughness.

Figure 1 shows the location of the Sierra Blanca site on a map developed by the U.S. Army Corps of Engineers indicating the presence of clay forming strata. The fact that clay occurs at a location indicated to be non-expansive reflects the fact that the clays on this site are interbedded with sand layers.

Figure 2 shows the layout of the membranes as they were installed along both edges of the eastbound and westbound lanes between station's 575 + 00 and 585 + 00 for a distance of 1000 feet.

Figure 3 shows the soil profile encountered at the site when borings were made to install thermocouple psychrometers used to measure the suction in the soil on the inside and outside of the moisture barriers. A total of eight borings were made as shown in the figure. It is of considerable importance to the interpretation of the measurements that were made to note that the entire area is overlain by a layer of silty sand interbedded with a sandy clay. A stratum of sand and gravel lies between a brown plastic clay and a bentonitic clay. The sand and gravel layers are capable of carrying infiltration water by gravity flow for great distances.

Measurements were made both within and outside the moisture barrier sections with the intention of determining the effect of the moisture barriers on moisture movement and the development of pavement roughness.

MOISTURE BARRIER MATERIALS AND CONSTRUCTION

The geomembranes used in the construction of fabric type barriers are obtained from two different manufacturers with manufacturers designations

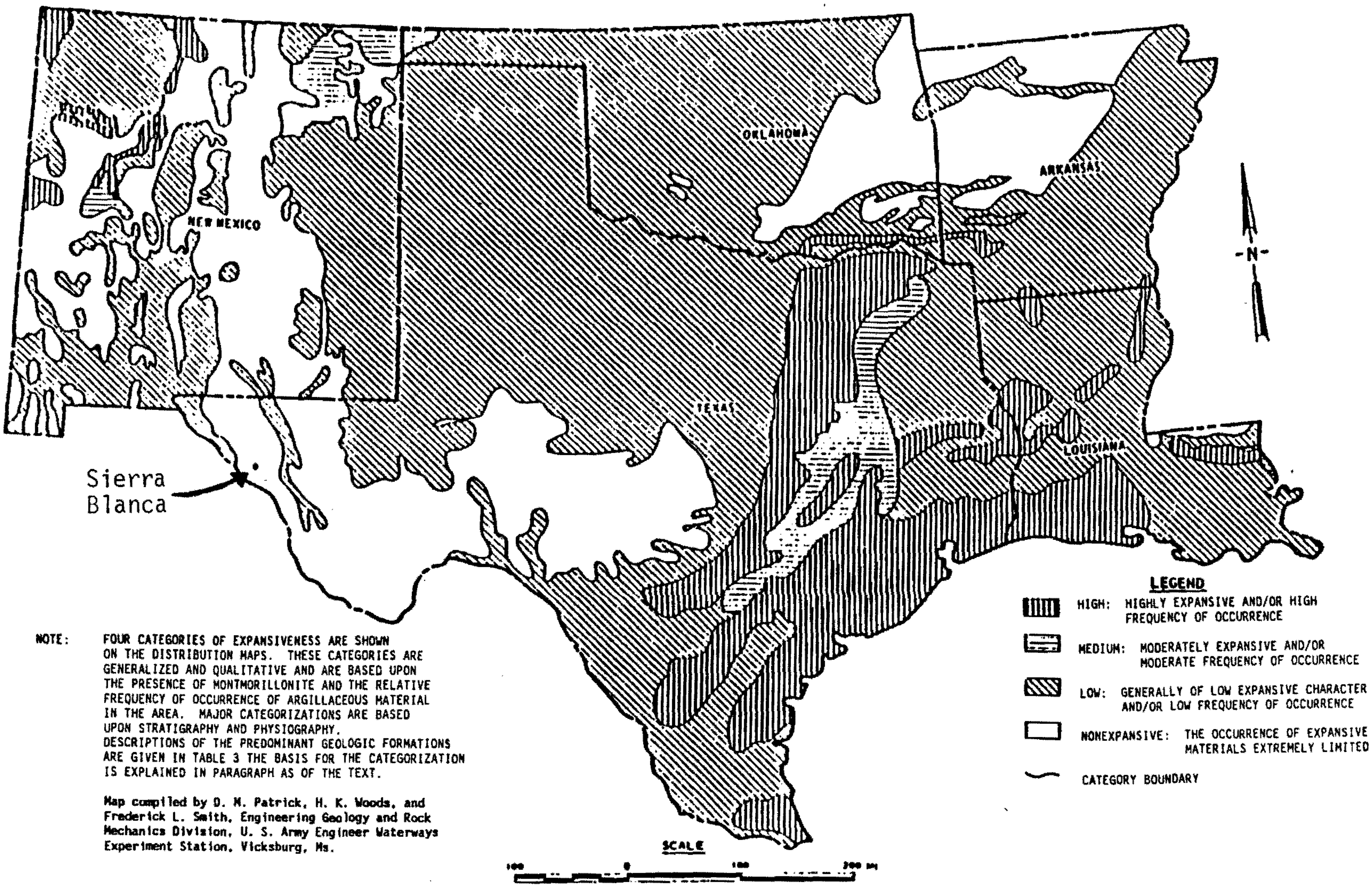


Figure 1. Location of Moisture Barrier Site at Sierra Blanca on IH-10, Hudspeth County, District 24.

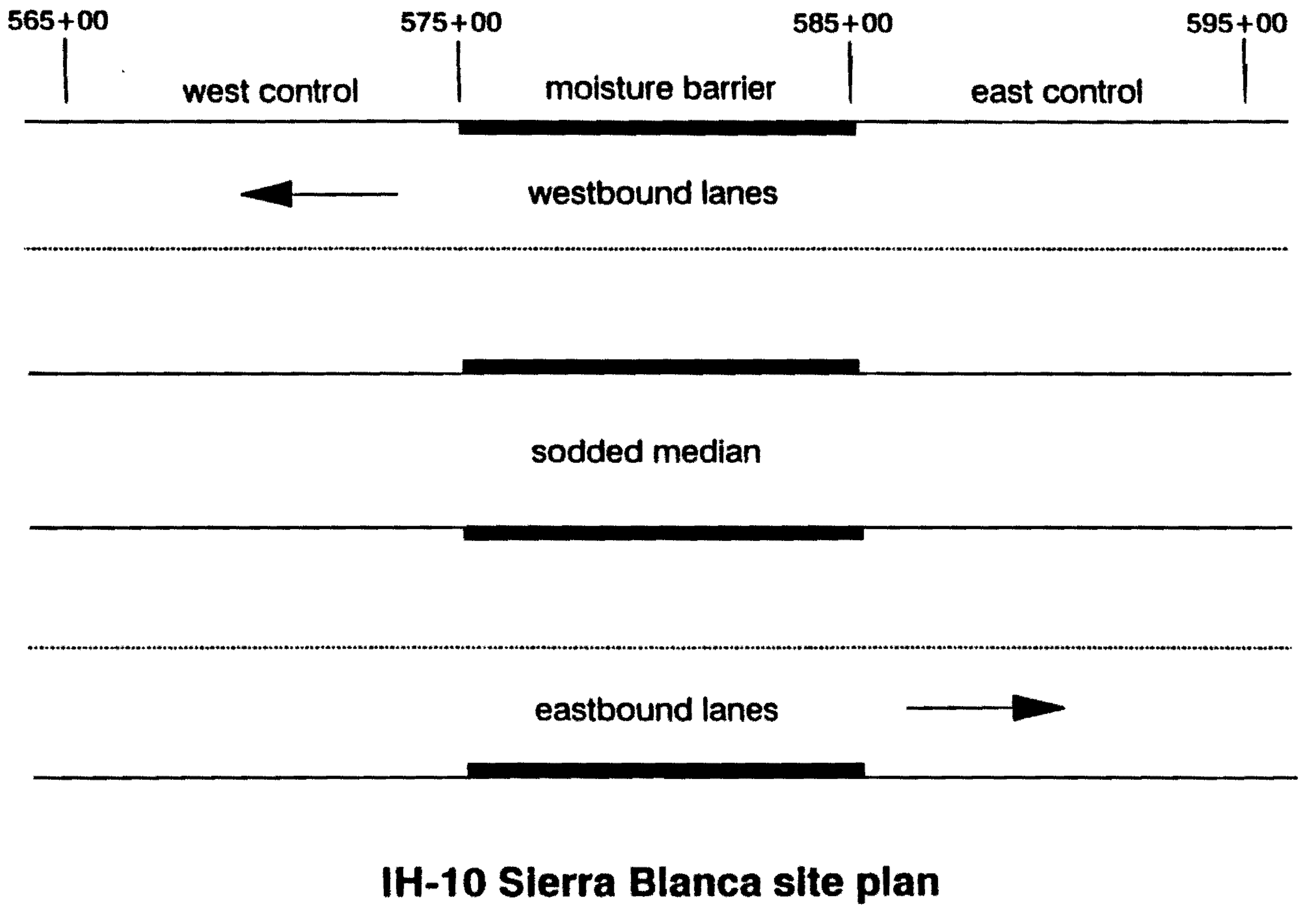


Figure 2. IH-10 Sierra Blanca Site Plan.

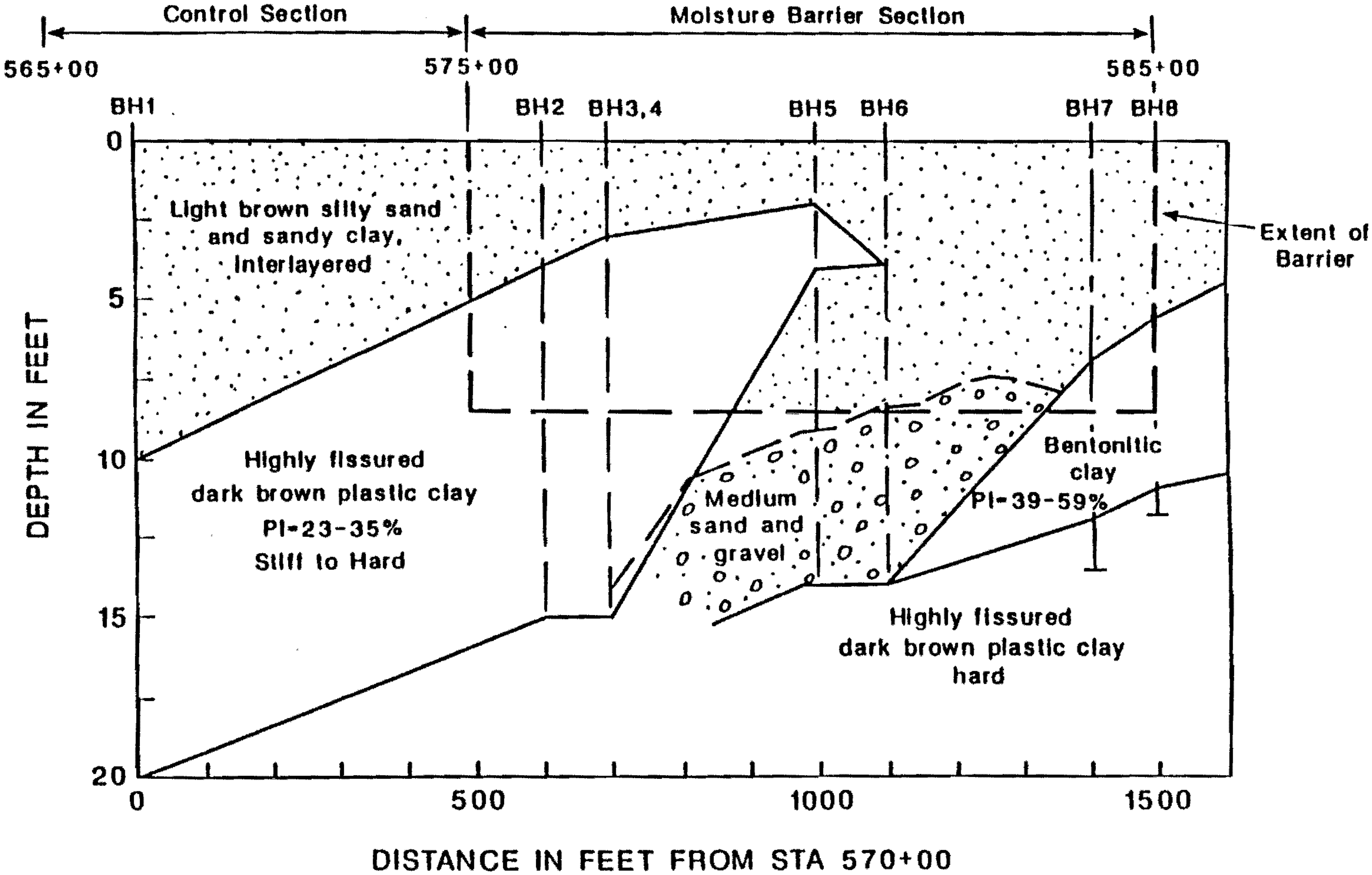


Figure 3. Soil Profile Along Eastbound Lanes IH-10 Sierra Blanca.

Mirafi MCF 500 and TYPAR style T063 by the Du Pont company. These fabrics both meet the specifications of the Texas DOT and were chosen on the basis of the specific contract bid. These materials are essentially similar and made of a spun bonded polypropylene, coated with ethylene-vinyl-acetate (EVA) which provides its water proofing capability. Although these materials are sometimes referred to as "impervious", tests of the permeability of the TYPAR EVA coated membrane indicated a permeability to distilled water of 8×10^{-10} cm/sec.

The construction method for the barriers was developed with experience over time and depends on the condition of the foundation soils at the time of installation. This method varies from the use of backhoe type excavators, which are suitable for relatively dry soils, to trenching machines fitted with sliding shoring devices in soils where the presence of water renders the excavation walls unstable. Methods for holding the fabric roll in a vertical position and placing it as trenching proceeded were also developed to increase the efficiency of operation.

A typical cross section of a moisture barrier arrangement is shown in Figure 4. The fabric barrier is placed vertically against the inside wall of the excavated trench with the top of the fabric folded over and tacked with bitumen to the shoulders at grade. The trench is then backfilled with gravel or sand backfill to within 18 inches of the surface above which a cement stabilized base seal is placed. The entire section is then overlaid with a 1½ inch layer of hot mix.

The moisture barrier test sections are 1000 feet long and were constructed in 1985 along the edges of the inside and outside shoulders of both the east and westbound lanes of the four lane divided highway where

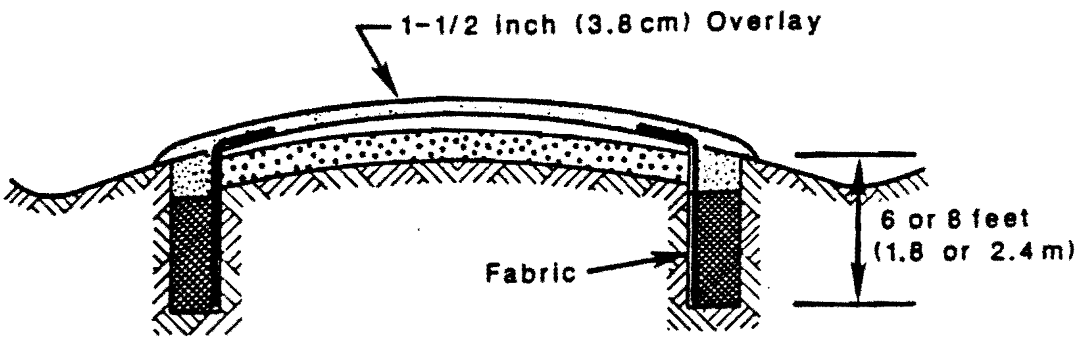


Figure 4. Cross-Section of Vertical Fabric Barrier Placement.

pavement distortions were experienced. Each traveled way comprises two 12 foot driving lanes, 10 foot wide outside and 4 foot inside shoulders separated by a 32 foot wide grassed median drainage ditch.

The original design concept of the barriers was to backfill the trench with compacted original material so that a relatively impervious backfill would be achieved. However, due to construction difficulties in compacting clay in an 18 inch wide, 8 ft. deep trench, a sand backfill was chosen. This practice appears to have had an effect on the performance of barriers placed in soils which were initially not in equilibrium at the time of installation. This is due primarily to the high permeability of the sand, which is capable of readily conducting water to the base of the barrier trench, providing an available moisture source for the enclosed subgrade soils. The way this moisture barrier installation fits into an overall experiment is shown in Table 1.

SOIL CONDITIONS

Detailed soil conditions are interpreted through data obtained from two site investigations. The first was carried out prior to construction of the barriers and comprised a total of twenty boreholes taken to depths of 8 feet. In August 1987, eight additional boreholes were carried out to a maximum depth of 16 feet with the moisture barrier section of the eastbound lanes, primarily for the purpose of installing psychrometers. These boreholes were advanced using continuous core undisturbed sampling techniques which enabled a continuous record of soil information to be obtained throughout the depth of the boring. This technique proved to be greatly informative to the interpretation of the highly variable soil conditions encountered at the site. Three of these boreholes were carried out on the inside of the moisture barrier, four on the outside and the other at the west control section. The locations of the boreholes are shown in Figure 3. Soil information from both investigations is used to develop the idealized soil profile shown in Figure 3, which is representative of the eastbound lanes.

Based on boring information of the first investigation, which provided information to a depth of 8 ft., the soil profile along the westbound lanes

Table 1. Moisture Barrier Site Configuration Summary.

Date of Rehabilitation	Location	Moisture barrier Test sections			Control	Highway section configuration
	Greenville	Length	Type	Direction		
Dec. 1983	IH-30	1,125	8 ft. fabric	eastbound	westbound lanes opposite to test sections	dual traveled ways with **sodded median**, two 12 ft. travel lanes, 10 ft. outside shoulders, 4 ft. inside shoulders.
	IH-30	1,000	6 ft. fabric	eastbound		
	IH-30	1,000	injected lime slurry	eastbound		
	IH-30	1,000	injected lime flyash	eastbound		
	Sierra Blanca					
Dec. 1985	IH-10	1,000	8 ft. fabric	eastbound	1,000 ft. east and west of test sections	
	IH-10	1,000	8 ft. fabric	westbound		
	San Antonio					
Jul. 1978	Loop-410	2,500	8 ft. fabric	northbound	southbound opposite to test	
Dec. 1980	IH-37	13,342	8 ft. fabric	north and southbound	2,838 ft. north; 3,082 ft. south of test	dual traveled ways with **paved crowned median**, three 12 ft. travel lanes, 10 ft. outside shoulders, 4 ft. inside shoulders
May 1985	IH-10	8,160	8 ft. fabric	north and southbound	756 ft. north; 1,000 ft. south of test	
Jan. 1984	US-281	2,500	8 ft. fabric	southbound	northbound opposite to test	as above, with banked cross-section
May 1976	General Mc Mullen	600	Horizontal fabric	north and southbound	600 ft. north and south of test	as above, three 11 ft. travel lanes, 6 ft. outside shoulders/curb

is essentially similar, except that the dark brown plastic clay layer is founded at a greater depth of 4 to 5 ft., within the moisture barrier section. This effectively reduces the depth of the potentially expansive clay layer along the westbound lanes.

West of the moisture barrier section the soils mainly comprised coarse sand and silts interlayered with thin lenses of sandy clay up to a depth of 10 feet. Below this depth very stiff dark brown plastic clay with sand lenses was encountered to the maximum depth of the boring at 16 feet. This clay layer was also encountered 600 feet due east of borehole 1 in boreholes 2, 3 and 4 from a depth of 3.0 feet to the maximum depth of these borings. At 400 feet due east of these boreholes at borings 5 and 6, a similar layer of clay was encountered between depths of 2.5 ft. and 5.0 ft. Beyond this depth layers of silty and sandy clay were found up to 8.0 ft. depth beyond which sand and gravel was found. This highly fissured dark brown plastic clay indicated liquid limits between 47 and 60 and plasticity indices between 23 and 35 percent.

At the location of boreholes 7 and 8, the layers of silty sands and sandy clays were encountered to depths of 6.5 to 7.0 feet. Below this depth a 5 foot thick layer of very fine gray bentonitic, highly plastic clay was encountered. The liquid limits obtained from samples of this clay varied from 63 to 84 percent and the plasticity index varied from 39 to 59 percent. Below this depth the highly fissured plastic clay predominated to the end of the boreholes.

The size of fissures in the dark brown plastic clays varied in width from approximately 0.5 inches to fully closed at 12 feet. These fissures were usually filled with sand and crystalline deposits of caliche. Root fibers were also encountered in the borings in which fissured clays were predominant, and these were generally found within fissures attached to the surfaces of the soil peds at depths of up to 12 feet.

The site is atypical of all other sites studied due to its highly variable stratigraphy. The test and east control sections are founded on soils which vary from highly plastic clays to non-plastic silty sands and sandy clays, and the west control sections are founded on the latter soil type only. This unique condition is fully exploited, as it provides a basis for the comparison of the behavior of pavements over expansive clay to that over non-plastic subgrades in the same climatic environment and under the same traffic loading conditions. The control sections, therefore, may not be statistically significant but they do serve as a reference by which the effectiveness of the barriers may be judged.

LOCAL CLIMATE

The climate is typical of an arid desert region where dry periods of several months without rainfall are not unusual. Almost half of the precipitation occurs in the three month period July through September, from brief but at times heavy thunderstorms. Between 1963 and 1988 a weather station was operated at Sierra Blanca for agricultural purposes from which records of precipitation and temperature, over the 26 year period, were made available through the Texas State Climatologist (1989). Based on this data the mean annual rainfall was 12.51 inches with a mean and standard deviation of the Thornthwaithe Moisture Index of -37.8 and 6.2 respectively, for an available moisture depth at field capacity of 10 inches. The maximum annual rainfall over the period of record was 20.3 inches, which occurred in 1974, 9.6 inches of which fell in October of that year. The minimum annual rainfall of 5.52 inches occurred in 1964. The mean monthly rainfall and potential evapotranspiration (PET) over the period of record is illustrated in Figure 5.

METHOD OF ANALYSIS

The computer program for the analysis of pavement roughness on expansive clays (PAPREC) is used to quantify the roughness of surface profiles in terms of three roughness parameters: Serviceability Index (SI), International Roughness Index (IRI) in units of inches/mile and Maximum Expected Bump Height in inches.

The changes in these roughness parameters over time and their distribution over the pavement surface is evaluated using the following criteria:

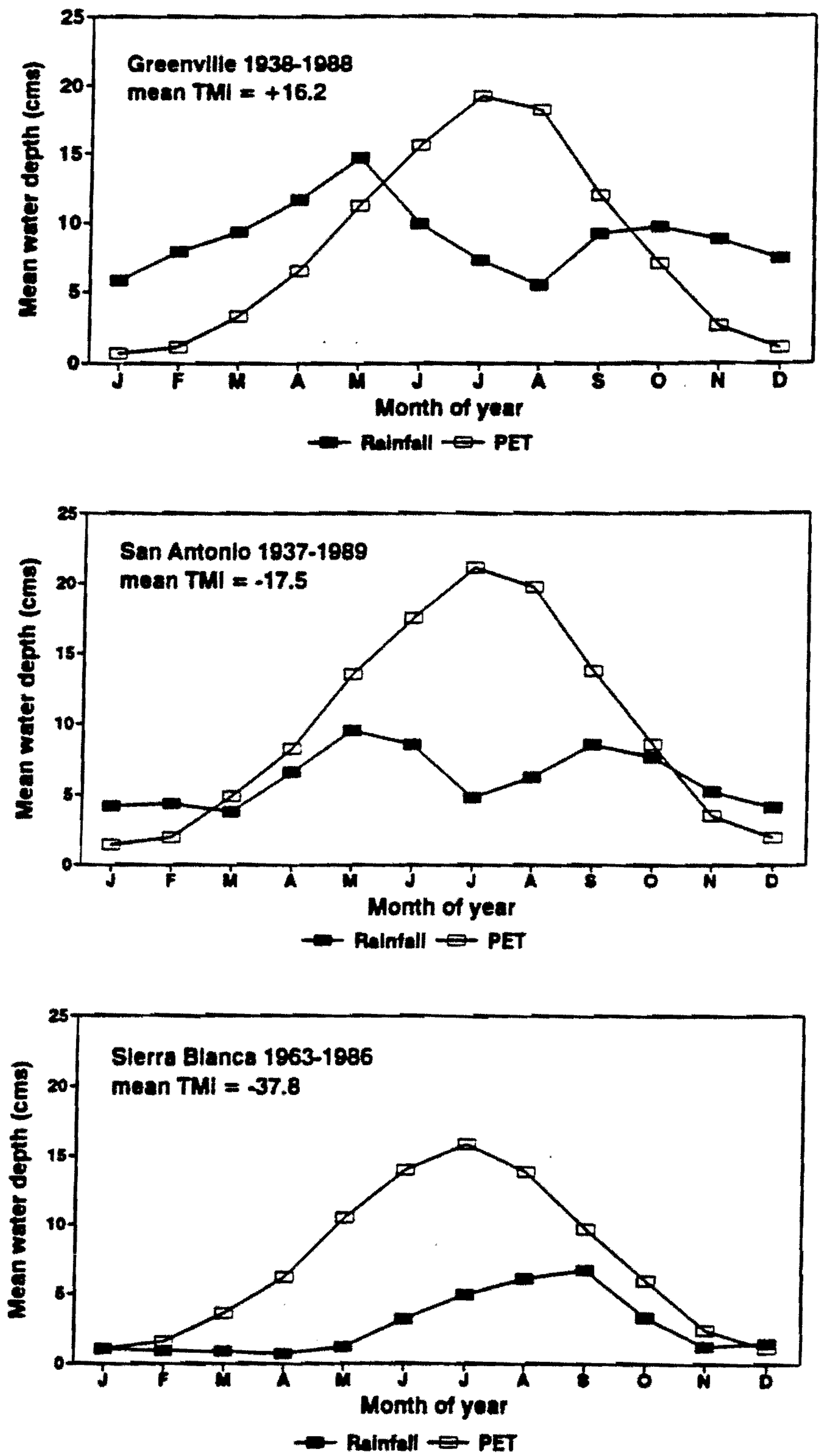


Figure 5. Mean Monthly Rainfall and PET at Moisture Barrier Sites.

(1) **Changes in mean pavement roughness over time.** The value of mean roughness describes the sum of all values of roughness of each 128 foot section measured in the wheel paths of each lane and averaged over the total length of the section.

(2) **The distribution and changes in roughness across the pavement cross section.** This distribution is characterized by the mean values of roughness in each wheel path, obtained by averaging over the length of section. This type of analysis is particularly useful in demonstrating the extent to which edge moisture variation may affect the development of roughness across the pavement surface.

(3) **The distribution and changes in roughness over the longitudinal pavement section.** This distribution is obtained by averaging the values of roughness of each 128 foot interval across the width of the pavement and plotting these values as a function of distance over the length of section. This establishes the spatial distribution of roughness by which the relative activity of the underlying soils or subsurface conditions may be examined. With distributions of this type, plotting the value of roughness in each wheelpath across the pavement section reveals a three dimensional surface.

The transient development of pavement roughness is a nonlinear process that may extend over a period of up to 10 years from the time of construction to a point that may be defined as failure. As a consequence, a continuous record of the development of roughness over time is desirable. However, due to datum changes caused by rehabilitation of the pavement surface and modification of instrumentation over the period of measurement, discontinuity of the data over time is unavoidable. As a result, a continuous record of roughness is not possible at many sites. A method of adjusting the data to compensate for these changes was developed and used in a nonlinear model of roughness development.

The method used in the current section to compare the effectiveness of different barriers is based on mean linear changes in roughness per unit time evaluated over each continuous data segment. This is done by fitting a linear relationship between roughness and time over each continuous segment, where the slope of this relationship represents the rate of roughness change over the time period. These rates of change in roughness are then averaged over the period of record from which the mean linear change in roughness is obtained. In cases where the quality of the data is statistically meaningful, a simple t-test is also carried out to establish whether the rates of change in roughness between the test and control were significantly different at the 5% level of significance.

RESULTS OF ANALYSIS

Initial conditions: For the three years prior to the construction of the moisture barriers, the Thornthwaite Moisture Indices (TMI) at the site were -33.4, -35.3 and -35.0 which indicate marginally wetter years than the mean characterized by a TMI of -37.8. The construction of the barrier began in April 1985 and was completed in December, 1985.

Changes of mean roughness with time: Profilometer measurements began in August 1987 and continued to the present time. The mean values of the roughness for this period, in terms of SI, IRI and Bump Height computed for test and control sections are illustrated in Figures 6 through 8.

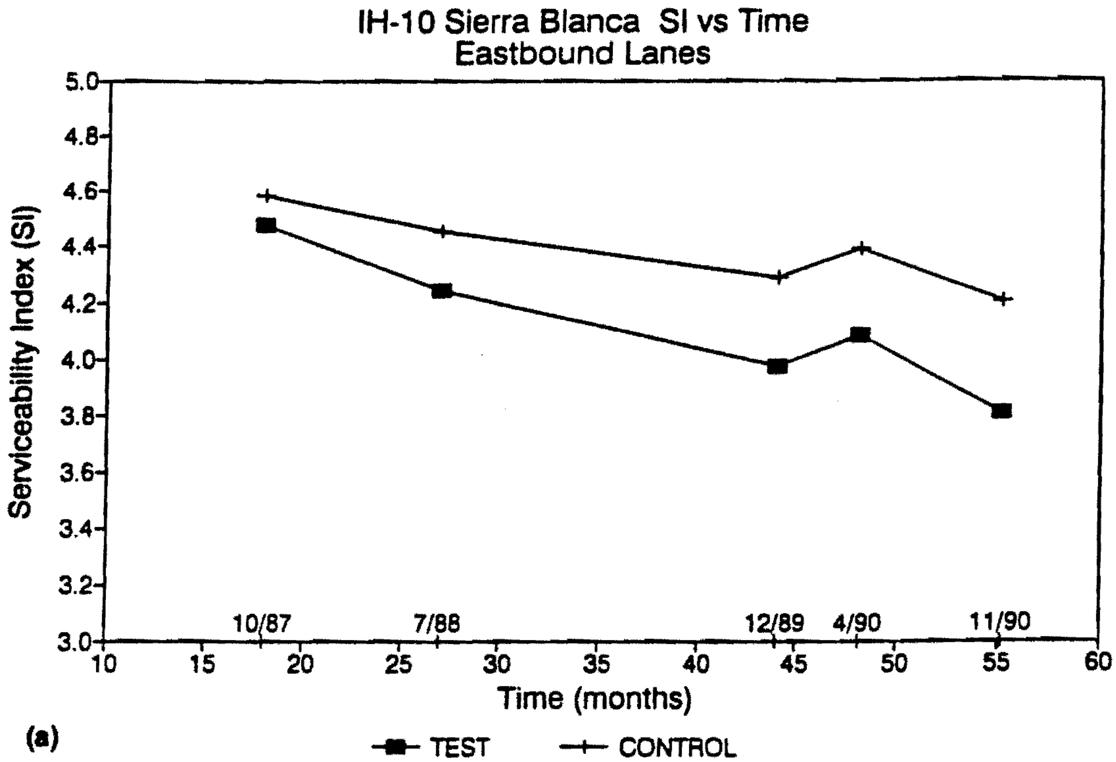
Both the SI and IRI indicate that all sections are becoming rougher with time and the eastbound lanes are becoming rougher at a rate of approximately twice that of the westbound lanes, as indicated in Table 2. These rates of change are consistent with the subgrade soil conditions provided by the borehole investigations, which indicate that the depths of expansive clay generally occur at a shallower depth on the eastbound lanes. The depth to the expansive clay layer at the eastbound moisture barrier test section is approximately 2.5 ft. compared to 4.5 ft. along the westbound section. As potentially active clays are found at greater depths, confining stresses become sufficiently high to limit the magnitude of swell.

TABLE 2. Mean Rates of Change of Roughness IH-10 Sierra Blanca.

Serviceability Index (SI/year)		
IH-10 Sierra Blanca	Test	Control
Eastbound	0.2276	0.1286
Westbound	0.1079	0.0456
International Roughness Index (inches/mile/year)		
IH-10 Sierra Blanca	Test	Control
Eastbound	11.287	6.292
Westbound	3.840	1.572
Maximum Expected Bump Height (inches/year)		
IH-10 Sierra Blanca	Test	Control
Eastbound	0.03257	0.05255
Westbound	0.07328	0.02981

The moisture barrier test sections indicate rates of roughness development of approximately twice that of the control sections as indicated by the SI and IRI parameters. This occurs as the barrier sections are found in areas where clays are predominant and closest to the surface. This is illustrated in Figures 6 and 7 and demonstrated more clearly in Figure 9, where the longitudinal distribution of roughness is examined. Due to the sensitivity of the SI to short wavelengths and the IRI to both short and medium wavelengths, it may be concluded that roughness in this wavelength range is developing over areas of expansive clay.

The Maximum Expected Bump Height parameter in Figure 8 indicates that the eastbound barrier test section is becoming rough at a slower rate than the control sections, which is opposite to that indicated by the SI and IRI parameters. This may be attributed to the fact that the Bump Height parameter is particularly sensitive to longer wavelengths (> 32 ft.) which is likely to occur as the expansive clay activity is initiated at greater depth. This phenomenon is indicated on the west bound test section where the depth of expansive clay is approximately 4.5 ft. deep and the rate of



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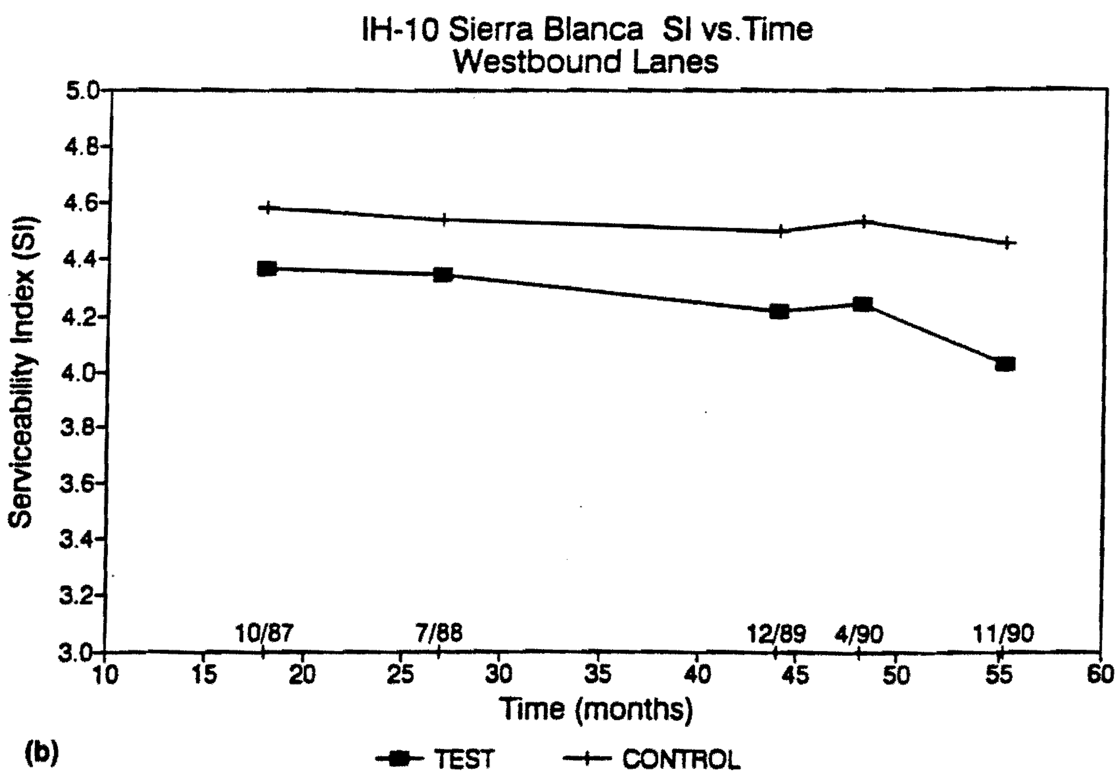
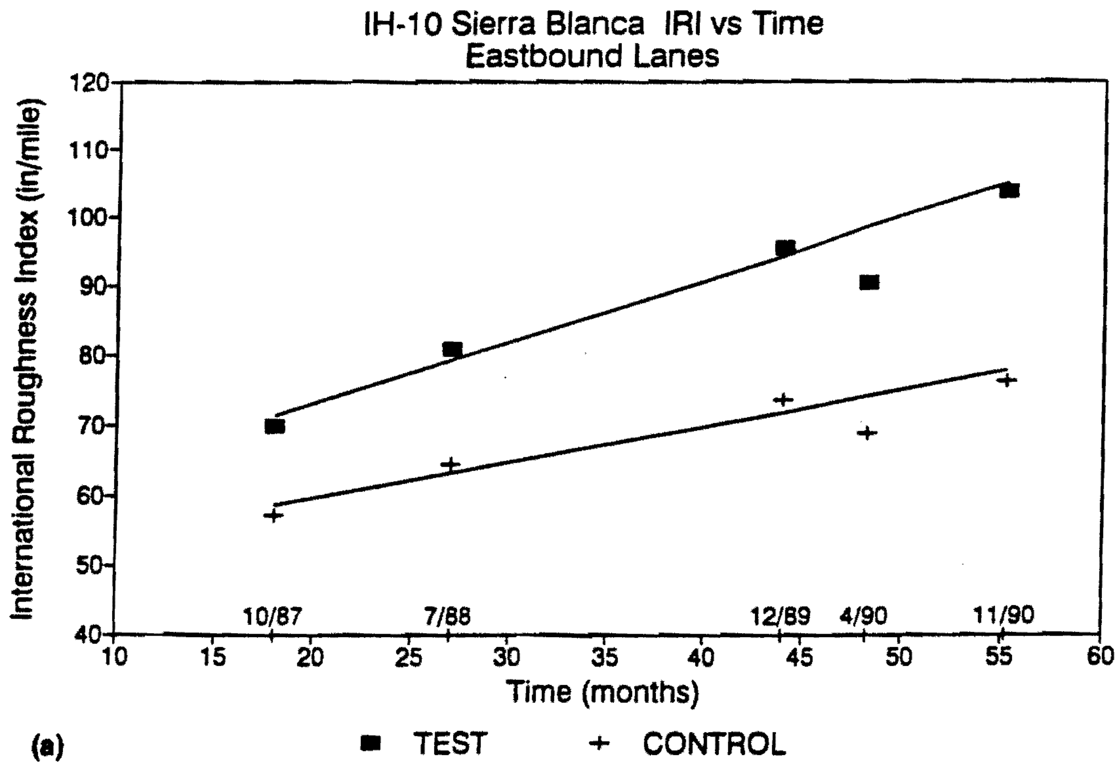


(b)

Figure 6. IH-10 Sierra Blanca SI vs Time, (a) Eastbound Lanes, (b) Westbound Lanes.



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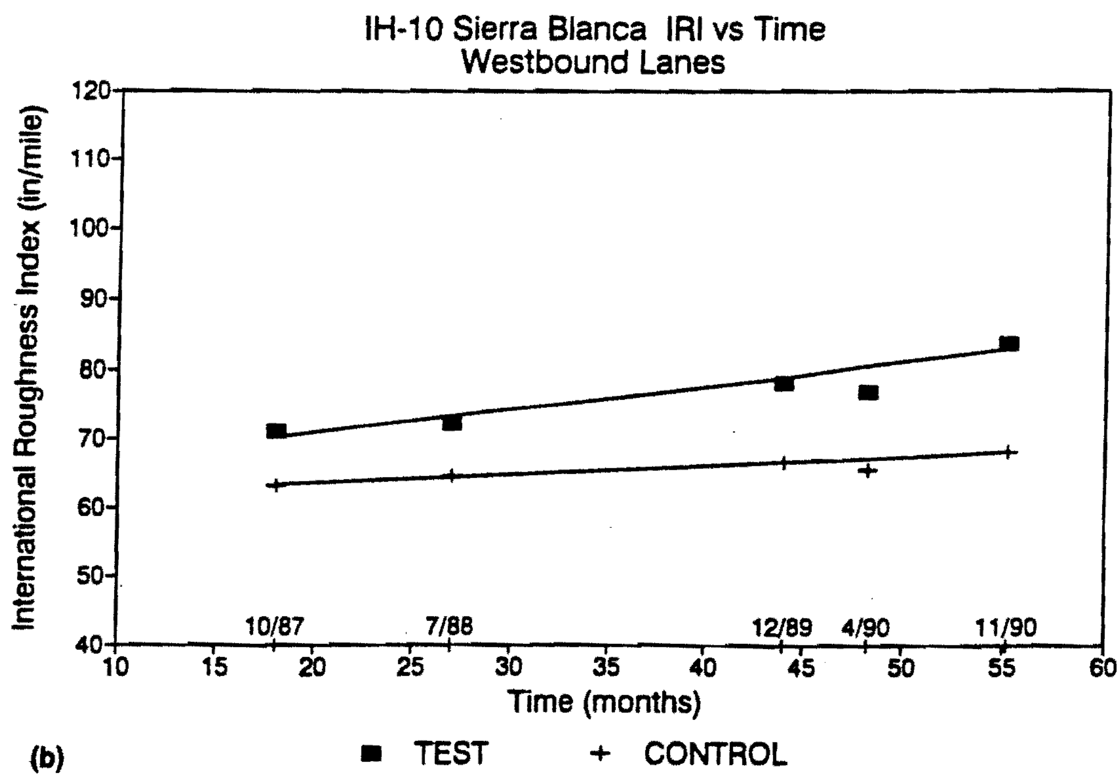
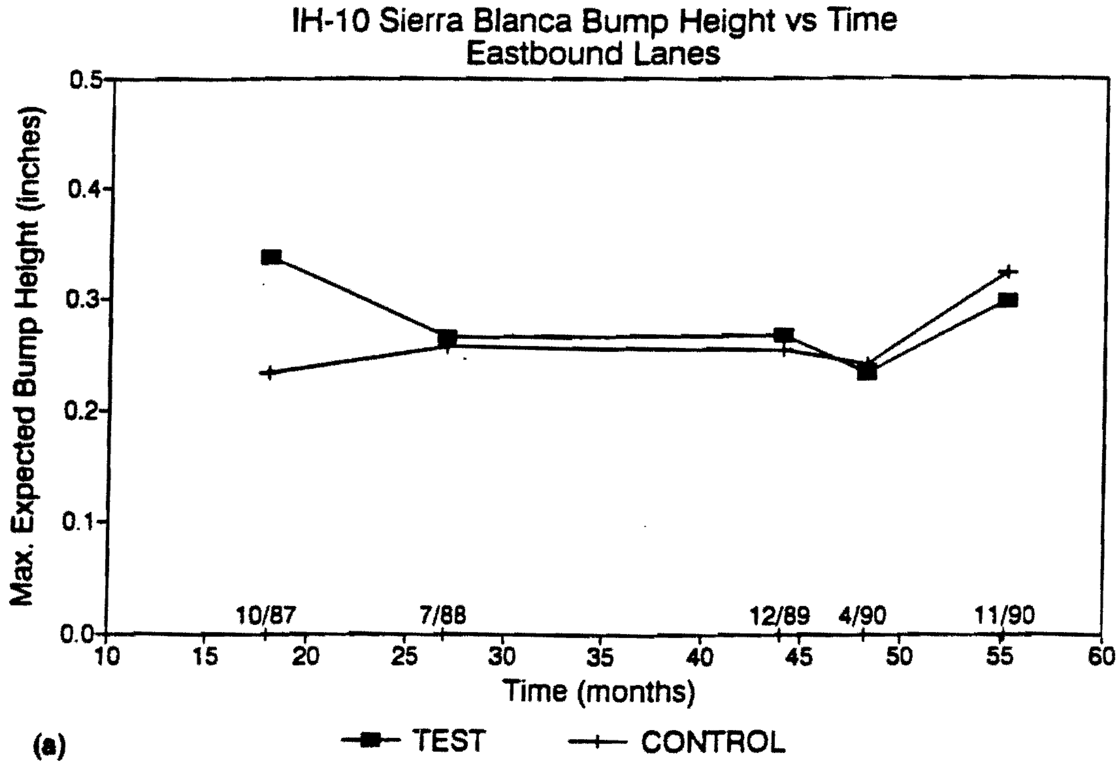


(b)

Figure 7. IH-10 Sierra Blanca IRI vs Time, (a) Eastbound Lanes, (b) Westbound Lanes.



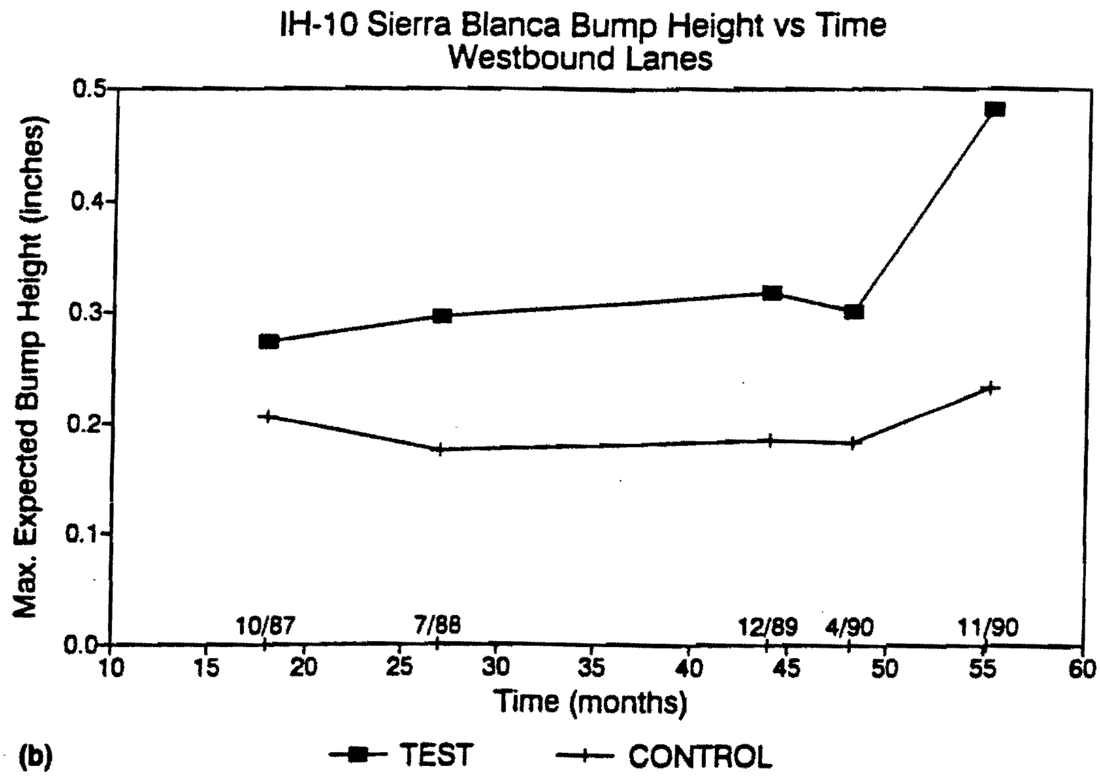
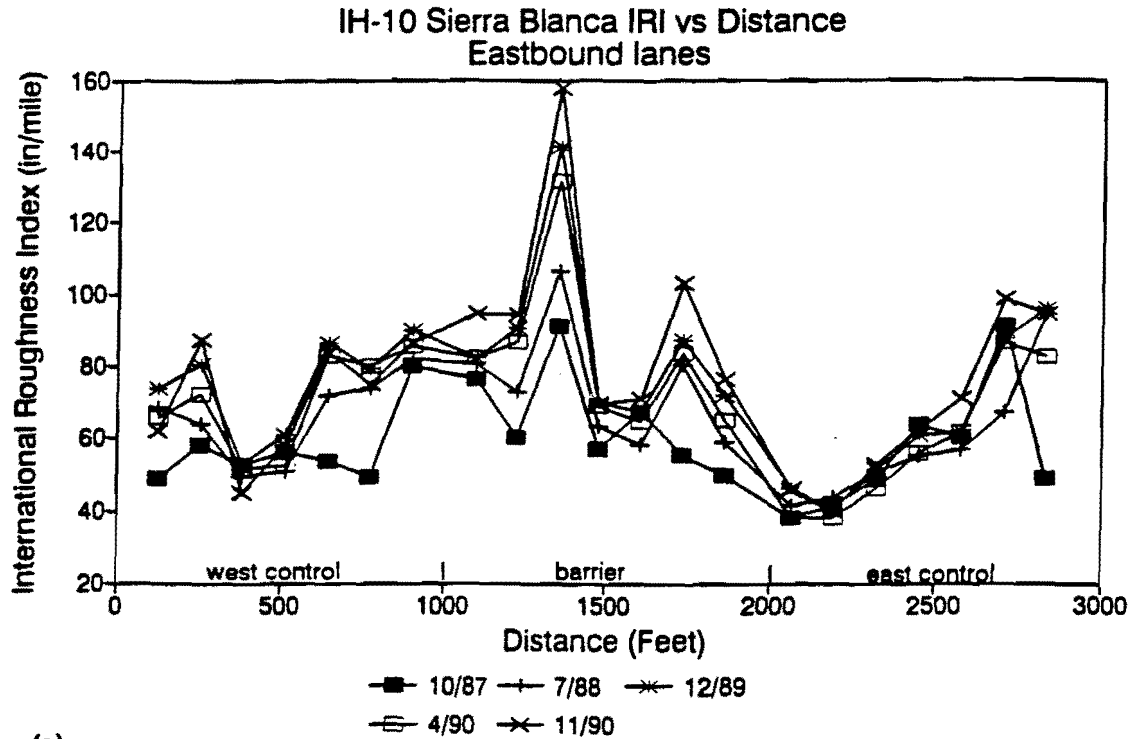


Figure 8. IH-10 Sierra Blanca Bump Height vs Time, (a) Eastbound Lanes, (b) Westbound Lanes.



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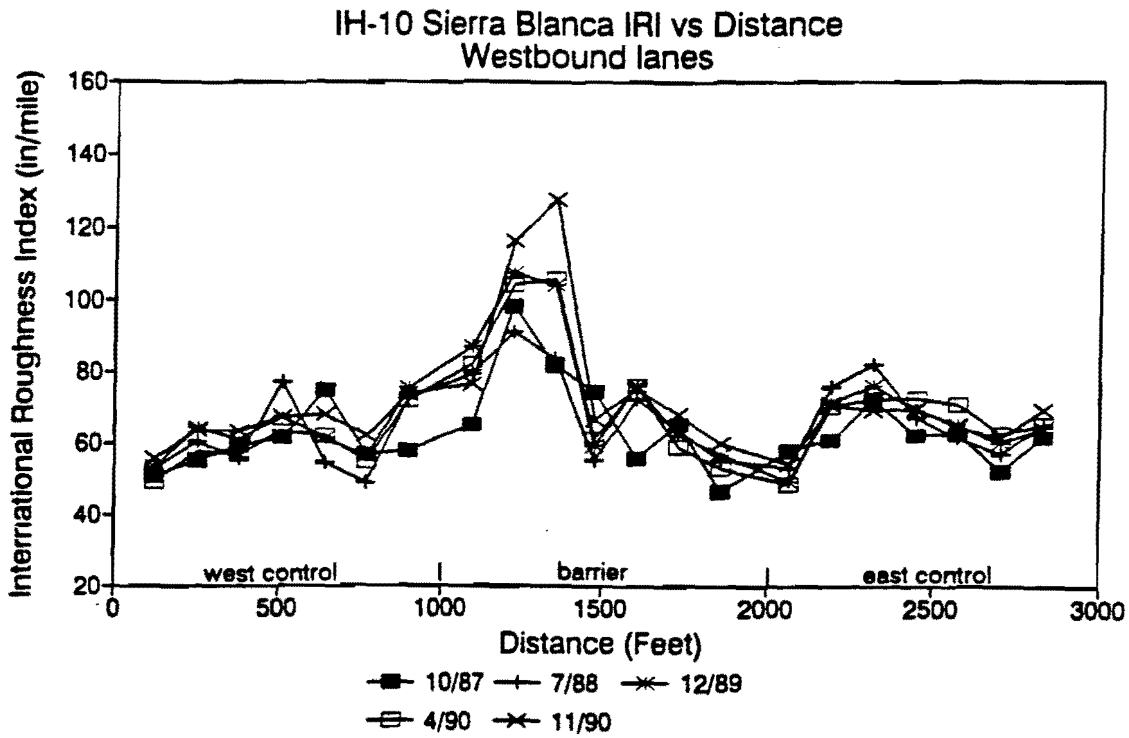


(b)

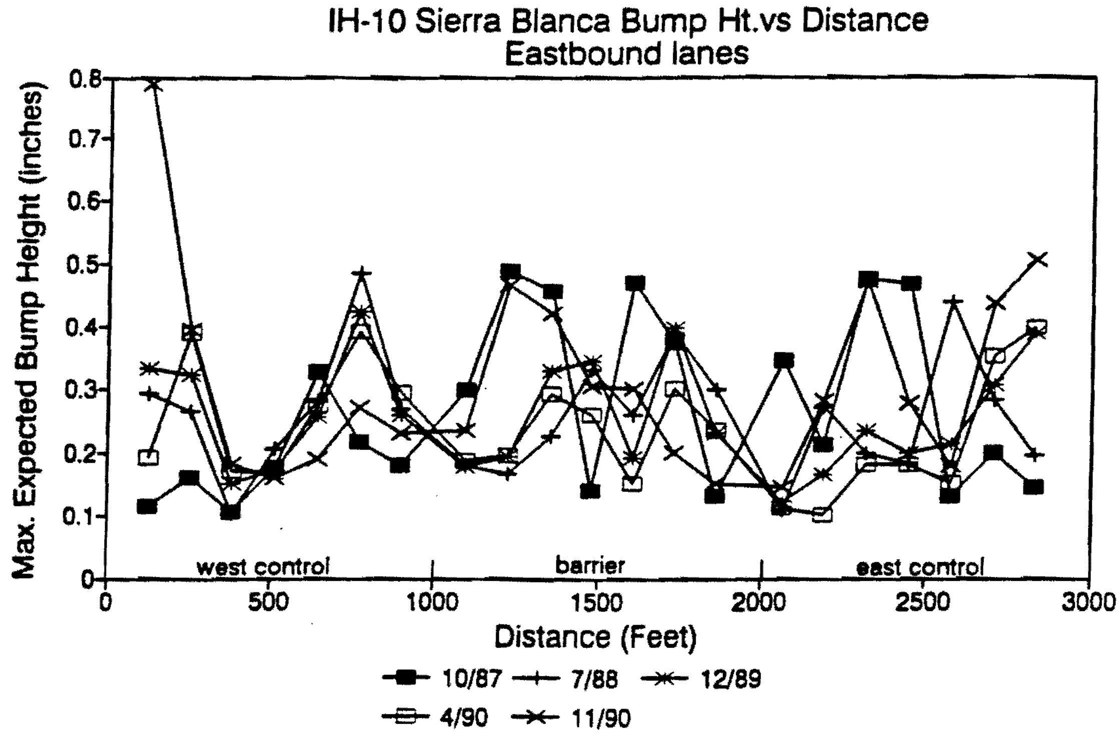
Figure 9. IH-10 Sierra Blanca IRI vs Distance, (a) Eastbound Lanes, (b) Westbound Lanes.

increase of Bump Height is .073 inches/year compared to .033 inches/year in the eastbound test section where the clay depth is 2.0 ft closer to the surface. However, over the period of observation the Maximum Expected Bump Height remains relatively constant except for the changes between April 1990 and November 1990 as illustrated in Figure 8.

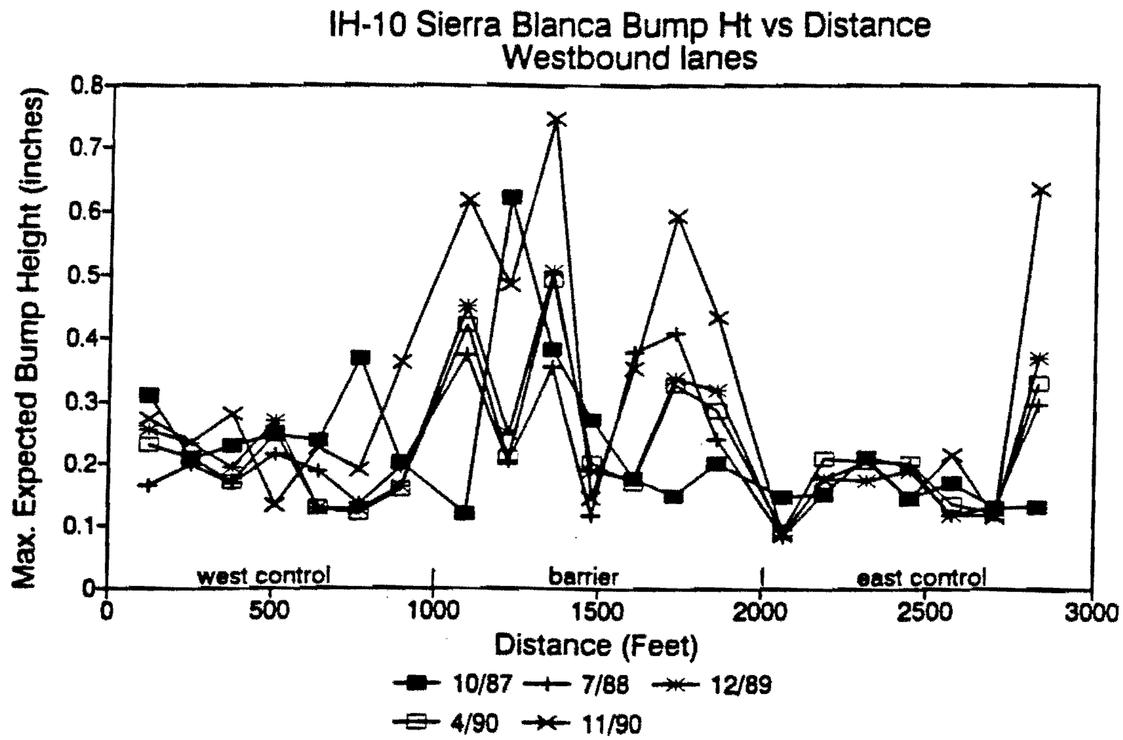
Longitudinal distribution of roughness: The distribution of roughness over the length of the test and control sections as indicated by the International Roughness Index and Bump Height are illustrated in Figures 9 and 10. From these distributions the activity of the underlying clay is clearly illustrated, as the sections on which clays are found closest to the surface indicate significantly higher levels of roughness compared to sections founded primarily on sandy subgrade soils. Both of the roughness distributions of the eastbound and westbound lanes indicate the presence of the active clays, with the eastbound profile indicating a higher level of roughness, consistent with the relative depths of the clay layer. Roughness development is therefore spatially correlated to the soil conditions as illustrated in Figure 11, where the soil profile along the eastbound lanes is superimposed under the values of IRI.

These observations illustrate the effect of environmentally induced roughness as opposed to load related roughness development, as the configuration of the test and control sections ensure that both experience exactly the same traffic loading conditions.

Distribution of roughness across lanes: The distribution of roughness across traffic lanes is characterized by the mean value of roughness of 128 ft. lengths in the wheelpaths of each lane. The SI distributions across lanes for the test, east control and west control sections are illustrated in Figures 12a through 12c, respectively. The IRI distributions are illustrated in the same order in Figures 13a through 13c and similarly, the Bump Height distributions in Figures 14a through 14c. The trend of roughness observed at the barrier test and east control sections indicate an increase in roughness from the outside to the inside wheelpaths. In the west control sections this trend is reversed and in some cases appears to be relatively constant over the pavement surface.



(a)



(b)

Figure 10. IH-10 Sierra Blanca Bump Height vs Distance, (a) Eastbound Lanes, (b) Westbound Lanes.

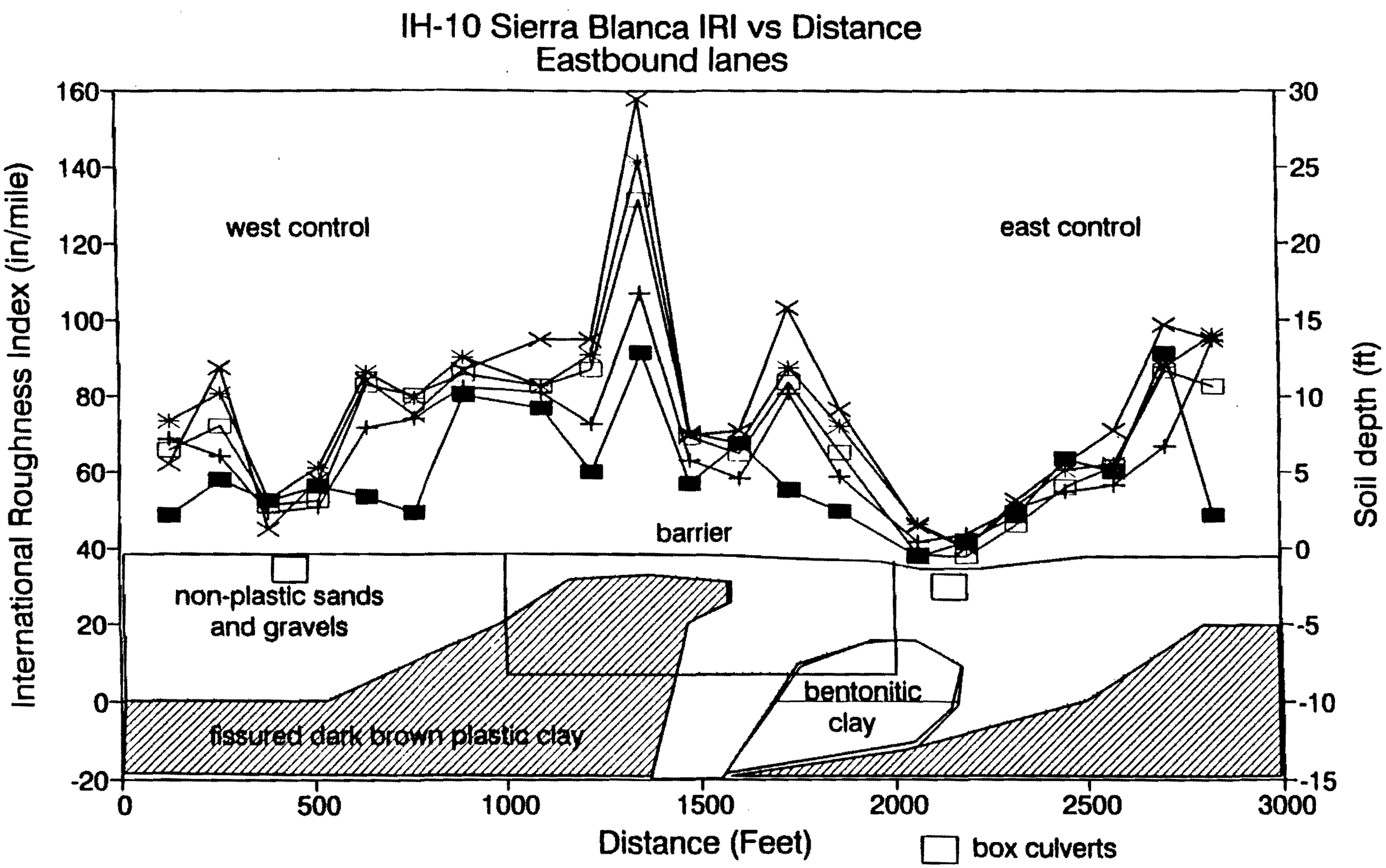


Figure 11. Spatial Correlation of Roughness and Expansive Clay Subgrade Soils IH-10 Sierra Blanca.

(a)

(b)

(c)

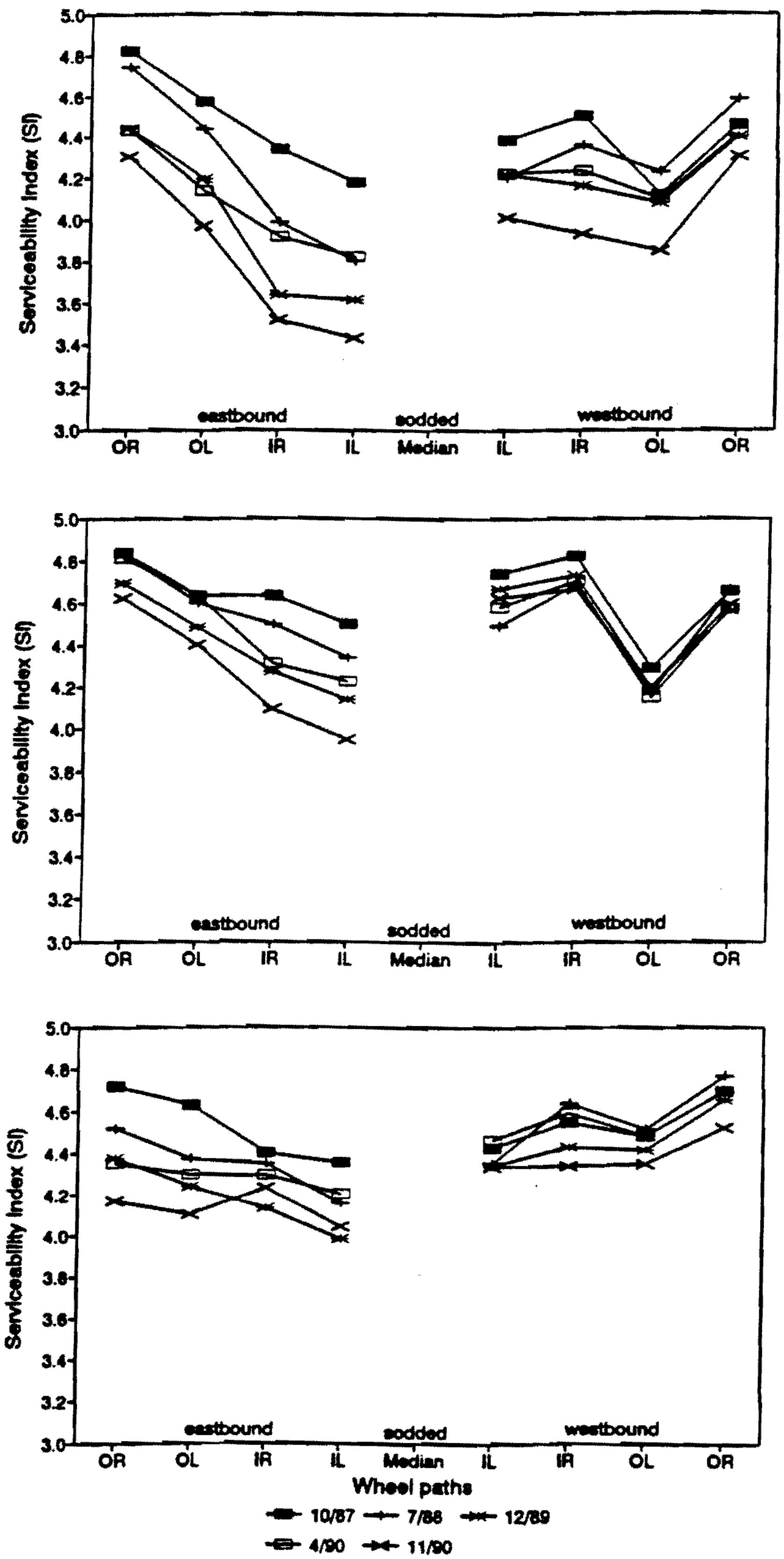


Figure 12. IH-10 Sierra Blanca SI Cross-Section, (a) Test, (b) East Control, (c) West Control.

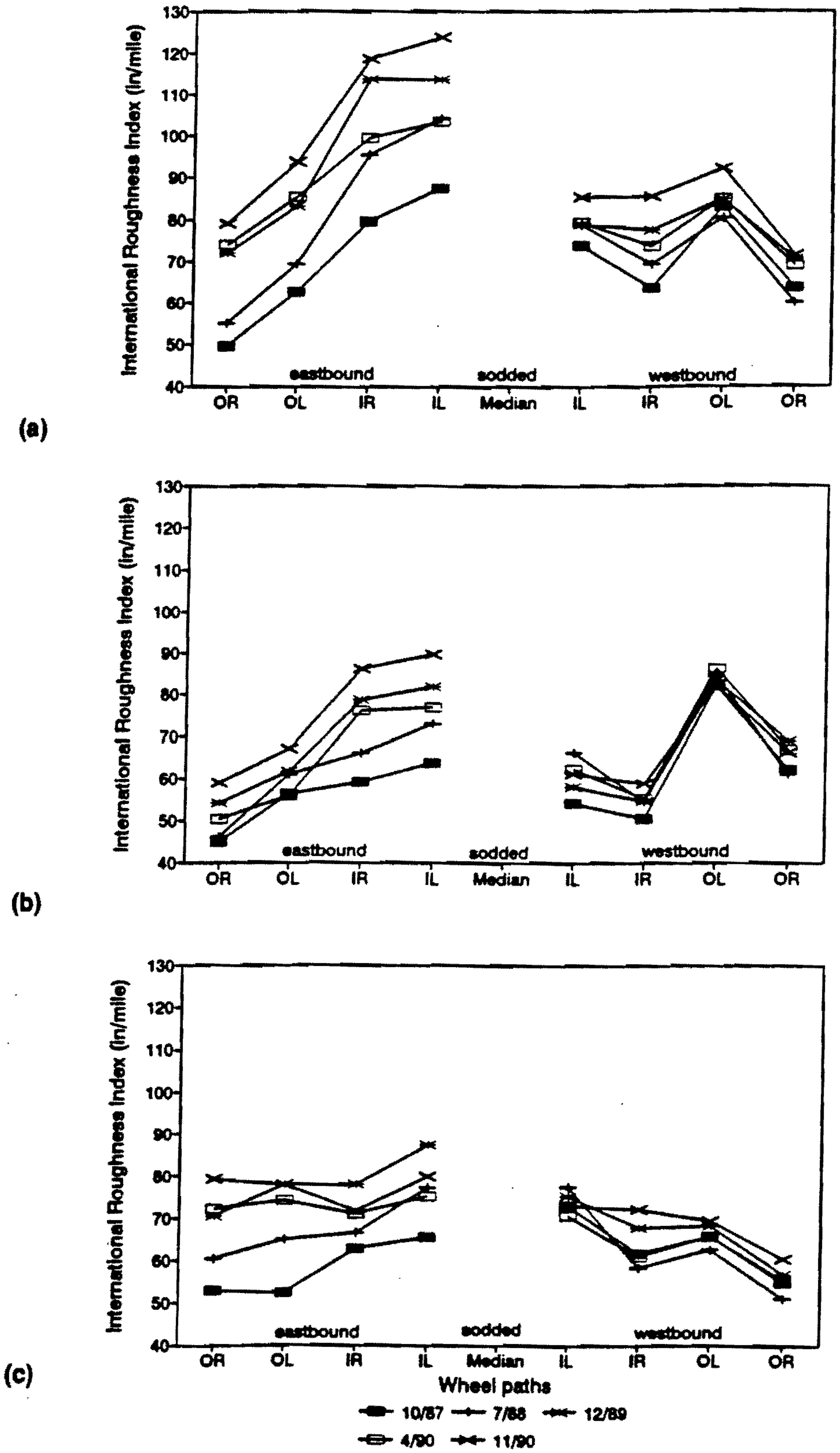


Figure 13. IH-10 Sierra Blanca IRI Cross-Section, (a) Test, (b) East Control, (c) West Control.

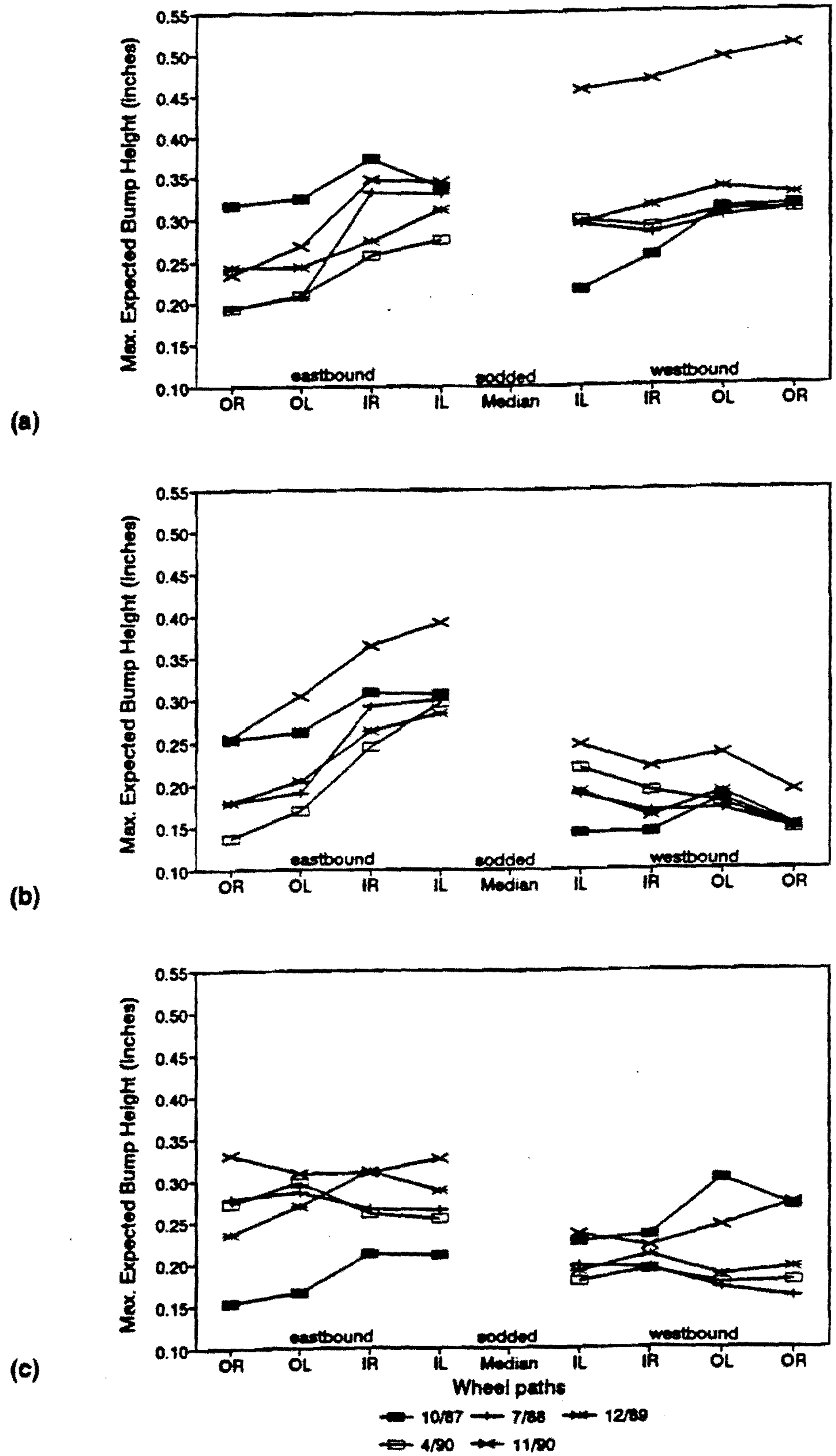


Figure 14. IH-10 Sierra Blanca Bump Height Cross-Section, (a) Test, (b) East Control, (c) West Control.

In order to examine the roughness development more closely, the changes in roughness in each wheelpath are determined by evaluating the difference in roughness values between August, 1987 and November, 1990. These results are illustrated in Figures 15 through 17 for the SI, IRI and Bump Height parameters respectively. All three roughness measures indicate that changes of roughness in the inside wheelpaths of the test and east control sections are greater than changes in the outside wheelpaths, with changes along the eastbound lanes being consistently greater than those of the westbound lanes. The greater changes of the eastbound lane sections are consistent with soil conditions as previously indicated. However, this pattern of roughness development also indicates that moisture variation is taking place to a greater degree beneath the inside lanes of the highway section, despite the presence of the moisture barrier. It should be noted that this trend of roughness development is opposite to that expected from traffic loading, where the outside lanes generally experience a higher rate of roughness development due to the greater number of equivalent 18 Kip. axle loads to which outside lanes are usually subjected.

The changes in roughness on the west control sections which are founded predominantly on sandy subgrade soils, indicate a pattern of roughness development that is consistent with traffic loading, as illustrated in Figures 16 and 17. In these sections the increase in roughness of the outside wheelpaths is greater than that of the inside wheelpaths. It is significant that the pattern of roughness development is completely reversed over a distance of 2,000 ft. where the predominant subgrade soils change from expansive clays to non-plastic soils.

This reversal of the pattern of roughness development is not due only to the presence of clays but appears to be associated with the effect of the sodded median and drainage ditch. Sodded highway medians are usually constructed with gradients to allow the efficient collection and runoff of water. However, under relatively heavy rainfall, ponding of water generally occurs due to poorly maintained landscaping or the presence of debris. In areas where expansive clays predominate, the infiltration is generally high due to the presence of surface cracks. At this site, the surface soils comprise coarse sands overlying fissured clays. This configuration is also conducive to the efficient passage of moisture to the underlying clays, due

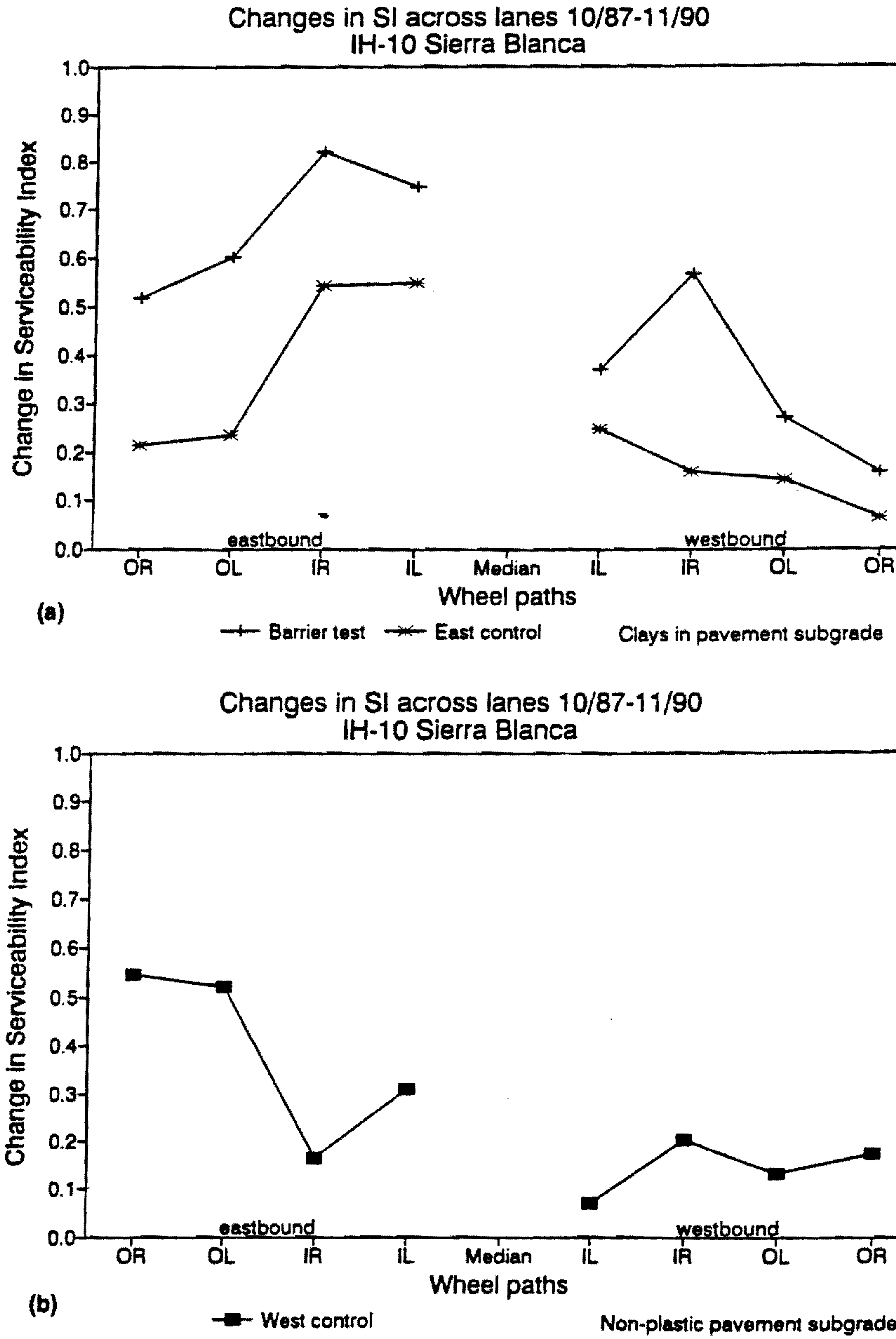
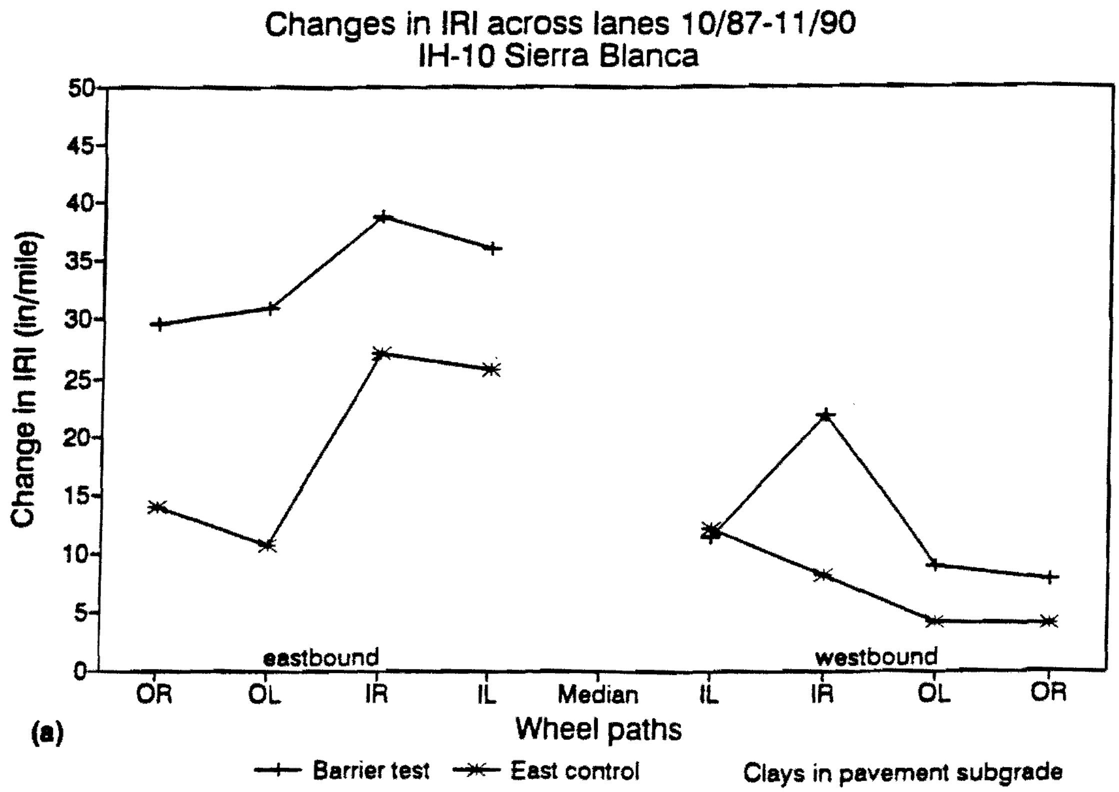


Figure 15. IH-10 Sierra Blanca Change in SI Across Section, (a) Clay Subgrade, (b) Sand Subgrade.



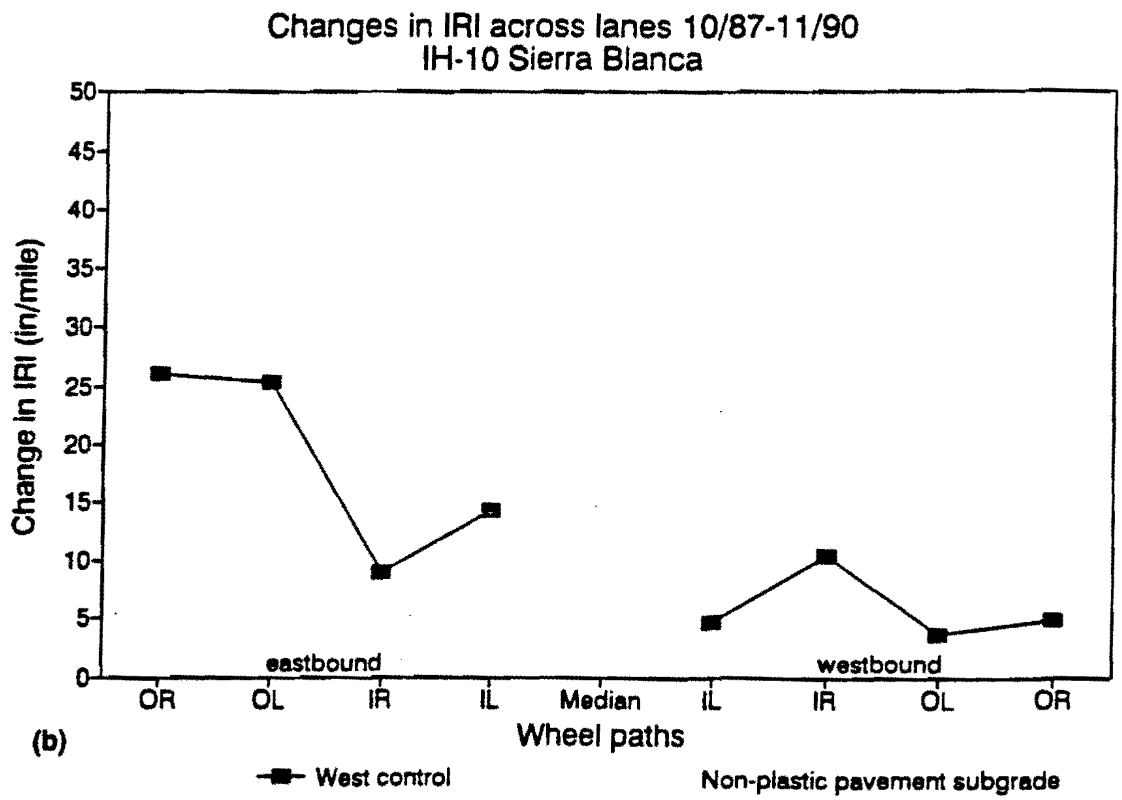


Figure 16. IH-10 Sierra Blanca Change in IRI Across Section, (a) Clay Subgrade, (b) Sand Subgrade.

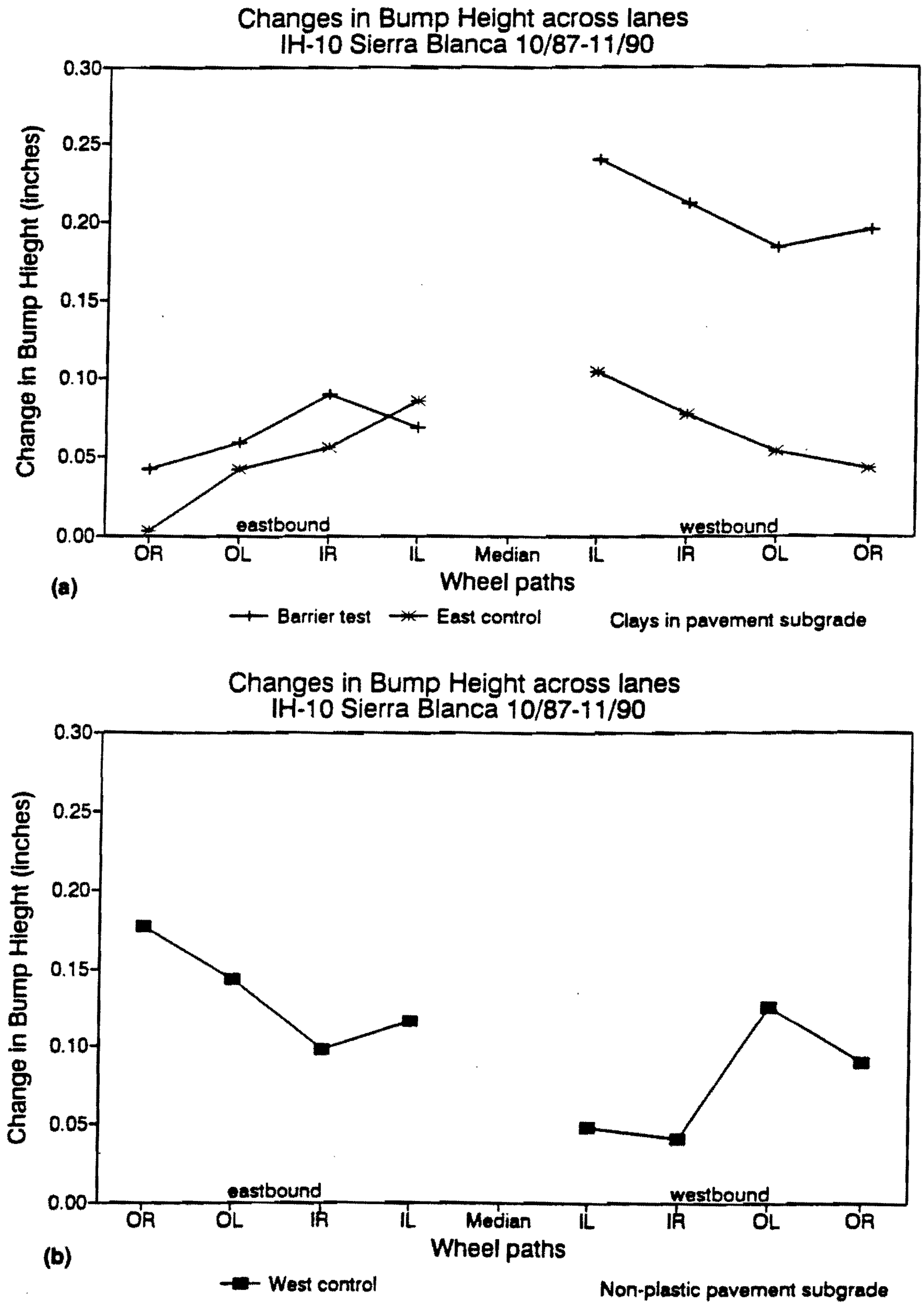


Figure 17. IH-10 Sierra Blanca Change in Bump Height Across Section, (a) Clay Subgrade, (b) Sand Subgrade.

to the high permeability sands. Also, it is noted that the inside shoulder of this highway section is 4 ft. wide and the outside shoulder 10 ft. wide. This configuration places the left wheelpath of the inside lane just 4 ft. away from the zone of potential edge moisture variation.

SUCTION MEASUREMENTS

As is apparent from the analysis of pavement roughness, the moisture barriers appeared, by comparison with the control sections, not to retard or reduce pavement roughness. This is a hasty conclusion, however, since it does not account for the differences in the subgrade soils in the control and test sections, nor does it account for the amount of moisture change that occurred in the two types of sections. The efficient operation of the moisture barriers was hampered by the presence of the highly pervious layers of sands and gravels which can conduct water so easily around the ends and beneath the bottoms of the barriers. It is for this reason that suction measurements were made so as to provide an independent observation of the effectiveness of the barriers.

Figure 18 shows the suction bounds that are expected by the predictions made with the model developed in Study 1165. Comparisons are shown in that figure with the suction bounds expected in other locations included in that study: San Antonio and Greenville. The pF scale is a commonly used way of reporting suction, which is a negative pore water pressure in the soil. Suction is recorded in centimeters of water and its pF-value is the power to which 10 must be raised to give the measured value of suction.

$$\text{Suction (cm)} = 10^{pF}$$

The scale in Figure 19 shows several familiar points of reference for the moisture condition of soils in the field as they are related to the pF-scale.

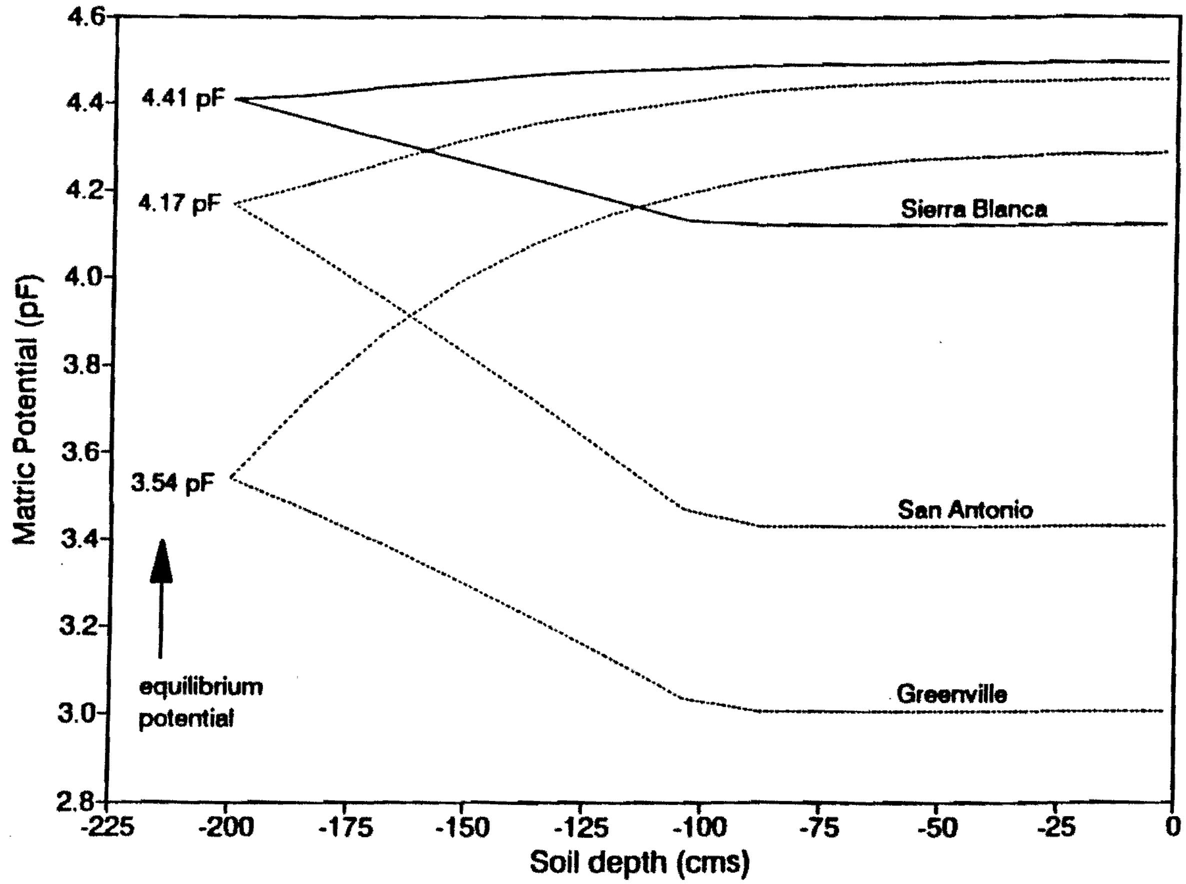


Figure 18. Wet and Dry Matrix Potential Profiles at Moisture Barrier Locations.

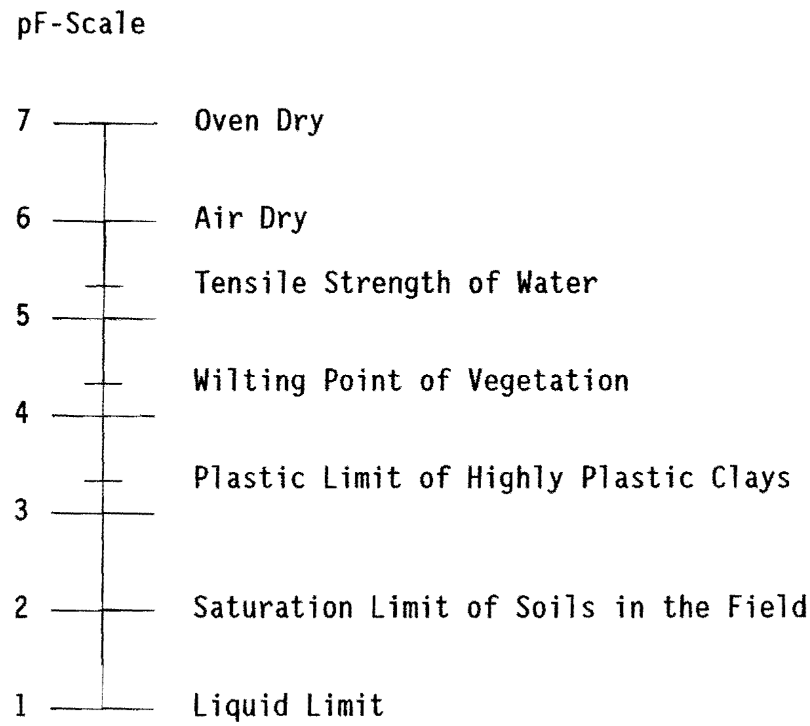


Figure 19. Mileposts Along the pF-Scale.

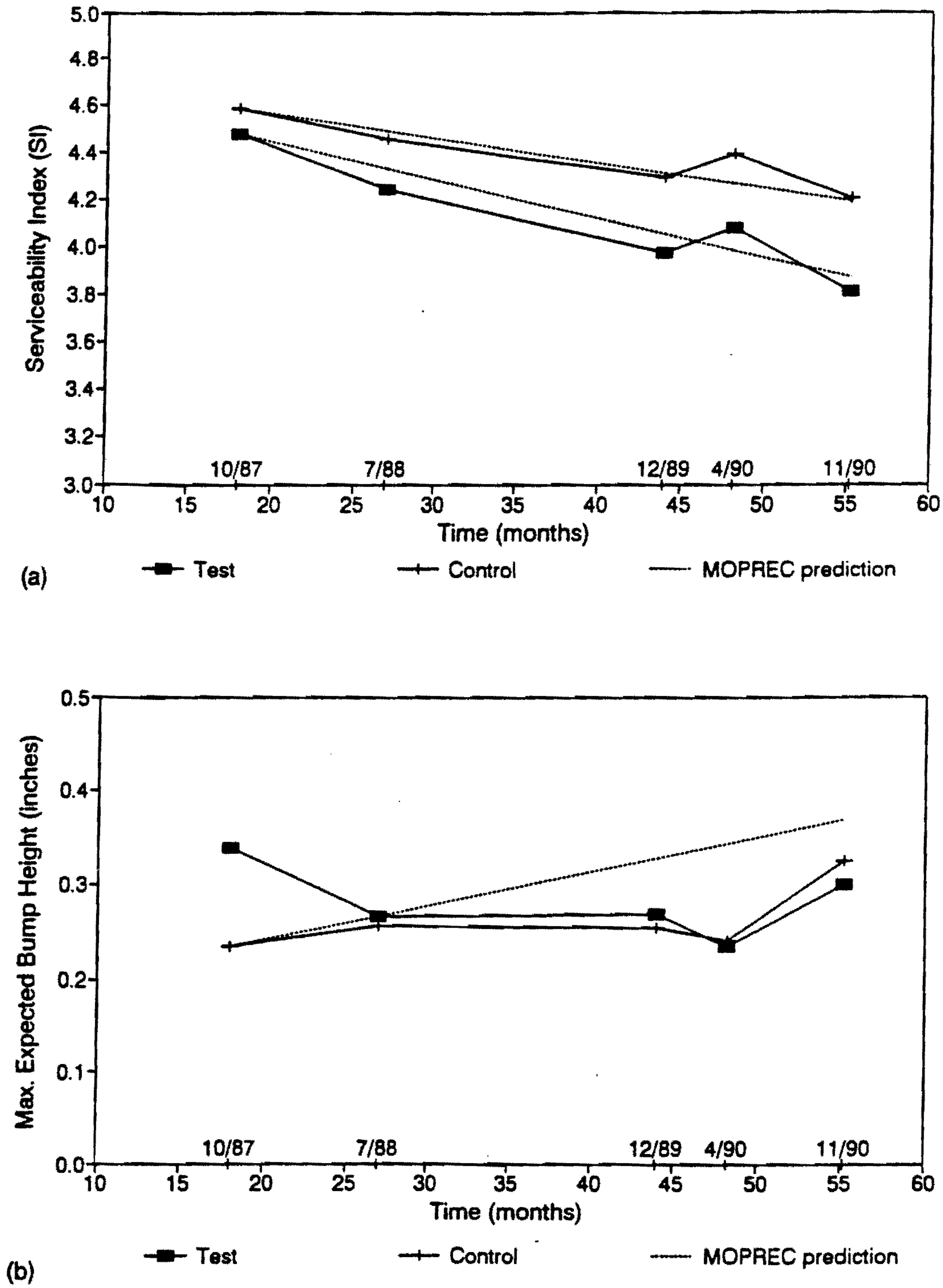


Figure 20. Comparison of MOPREC Predictions and Field Results, IH-10 Sierra Blanca Test Sections (a) SI, (b) Bump Height.

MODEL PREDICTIONS

Models developed in Study 1165 were used to predict the Serviceability Index and the Bump Height expected at the Sierra Blanca site. The results are shown in Figure 20. The models predict the expected loss ofServiceability Index in both the control and Moisture Barriers Test sections very well, while overpredicting the Maximum Expected Bump Height.

This indicates that the effects of the moisture barrier on this site can be anticipated prior to its installation if the local soil, ground water, and climatic conditions are known.

From these measurements it is seen that the moisture barriers were effective in reducing the range of moisture fluctuation beneath the pavement, despite the disadvantage afforded by the pervious sand and gravel layers interbedded with the clays.

CONCLUSIONS

A summary of the significant findings of the study of the moisture barrier and pavement performance on IH-10 near Sierra Blanca is as follows:

a. Before installing a moisture barrier, it is important to conduct a site investigation of the soils on site. Borings should be taken to twice the expected depth of the moisture barrier.
b. If there are interbedded sands or gravels and clays or if the soils on site are dry of equilibrium, the installation of a moisture barrier may not retard the development of roughness to any significant degree.
c. Moisture barriers should be installed to a depth equal to the depth of cracks in the clay soil. This can be approximated from the boring logs by noting the greatest depth where root fibers were found.
d. Highway sections with median drains showed increased levels of roughness in the inside lanes of unprotected sections of 2 to 4 times more than over the outside lanes. Sections in which moisture barriers were installed showed a similar trend where the difference in roughness levels was approximately 2 times.

e. Highway sections which were rehabilitated after significant damage from expansive clay activity showed the lowest levels of subsequent roughness development. This suggests that the foundation soils had reached their equilibrium condition in which the presence of the moisture barrier was instrumental in maintaining over time.

f. Moisture barrier sections at which equilibrium conditions were not reached prior to the installation of the moisture barrier exhibited roughness development rates similar to that of unprotected sections.