Measurement of Serviceability Indices for New, Overlay, and Terminal Pavements in Texas

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Serviceability Index (SI) relates to the riding comfort that a section of pavement provides to highway users and is a required input parameter for several design methods. Accurate pavement design requires good estimates of the SI value at key points in the pavement's life: (*a*) immediately after construction of a new pavement, (*b*) just before rehabilitation, and (*c*) just after rehabilitation. The analysis used to find the mean values and the variability of the SI for pavements in Texas during each stage is described.

The measurement of pavement serviceability has increased in importance since the development of the concept at the AASHO Road Test, because it defined performance and it relates directly to the road user and vehicle operating costs.

Serviceability index (SI) relates to the riding comfort that a section of pavement provides to highway users and is a required input parameter for several design methods. The AASHTO design method for both flexible and rigid pavements uses a formula to predict SI loss as a function of traffic, structural, and environmental variables (*1*).

In Texas, SI is an important input for the Flexible Pavement Design System (FPS) (*2*) and the Rigid Pavement Design System (RPS) (*3*). In these two methods, the initial serviceability index (pi), the terminal or minimum serviceability level (pt), and the serviceability index after overlaying (po) are used to predict pavement life and performance.

The initial serviceability index is related to different factors; some of them are: quality of construction procedures, specifications, and equipment. If the assumed initial serviceability is not achieved during the construction, the design life will be less than predicted. Better estimates of pavement performance can be achieved by more accurate initial serviceability estimates.

The terminal serviceability index is a value set by the design engineer and depends on when rehabilitation activity needs to be specified. The serviceability index which is achieved after an overlay is related to the serviceability before the overlay, the thickness of the overlay, and the quality of the rehabilitation technique. If the assumed serviceability index after the overlay is not achieved, the actual performance life of the pavement could be lower than predicted.

Accurate pavement design requires good estimates of the SI for at least three stages (see Figure 1): (*a*) SI immediately after a new construction or new pavement, (*b*) SI of worn out pavement or just before rehabilitation, and (*c*) SI restored in the pavement or just after rehabilitation. Therefore, the main objective of the project was to measure the present SI of both rigid and flexible pavements to determine: (*a*) mean values and variability of initial serviceability index immediately after construction, (*b*) mean values and variability of serviceability index before scheduled rehabilitation projects, (*c*) mean values and variability of the serviceability index of the pavements resulting after rehabilitation, and (*d*) mean values and variability of SI of pavements just after reconstruction.

This study followed a combination of the systems method recommended by Haas, Hudson and Zaniewski (*4*) and the design of experiment concept recommended by Anderson and McLean (*5*). The main steps of this approach are:

Step 1. Problem recognition exists—This step resulted in the proposal for this research.

Step 2. Problem formulation—In the research proposal, the problem was formulated and the objectives were presented.

Step 3. Experiment design—An experiment was designed to collect and to analyze efficiently all the information required for this study. The main aspects considered are: (*a*) factors and levels to be used in the experiment, (*b*) variables to be measured, (*c*) definition of the inference space for the problem, (*d*) amount of replication to be used, and (*e*) random selection of the experimental units.

Step 4. Data collection—The success of scientific research depends on the validity of all data obtained; therefore special care was given to this particular aspect of the study.

Step 5. Data analysis—The analysis of the data depends on the experiment design. Basically, there were three stages during the analysis: (*a*) check that all the assumptions required for the statistical analysis were met, (*b*) analysis of the main factors, and (*c*) analysis of the of the secondary factors.

Step 6. Conclusions and recommendations—Once the analysis of the data has been completed, the conclusions are formalized and the recommendations for implementation are reported.

This paper includes a summary of references about past serviceability indices, a description about the design of experiment used on the study, a discussion of the results, findings, conclusions, and recommendations.

PAST SERVICEABILITY INDICES

Average SI values, based on the AASHO Road test experience for new pavements is 4.2 and for new rigid pavements is 4.5. On the other hand, AASHTO recommends a terminal SI of 2.5 for major highways and 2.0 for highways with lesser traffic volumes (*1*).

A survey in fall and winter of 1961 sponsored by the Bureau of Public Roads (BPR) (*6*) found the average SI values indicated in Table 1.

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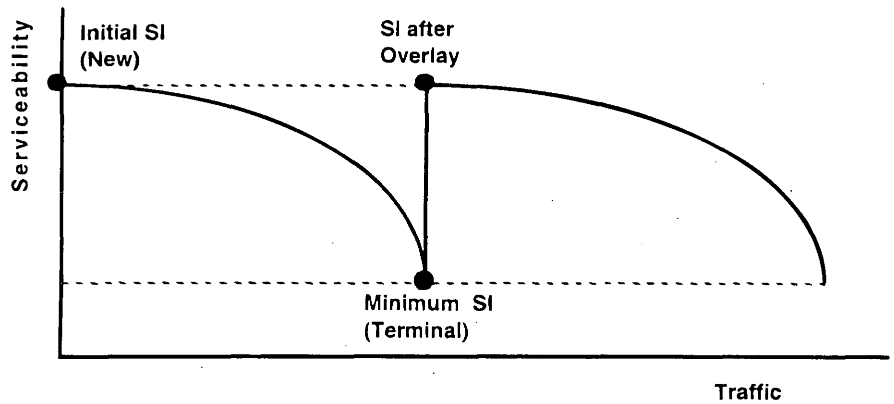


FIGURE 1 Points of interest on pavement performance curve.

A study done by the Center for Transportation Research (CTR) at The University of Texas at Austin shows that the average Texas resident deems the quality of ride acceptable for pavements sections on an interstate highway is 3.06 and the corresponding value for pavements sections on a secondary highway is 2.20 (*7*).

For the design of flexible pavements, the state of Texas recommends the following serviceability for different categories of use in FPS (*2*):

(a) Initial Serviceability Index (pi): "This input depends on the materials used and construction practices. Initial serviceability indices have a statewide average of about 4.2. Surface treatments may be near 3.8 and a very smooth asphalt concrete pavements (ACP) or continuous reinforce concrete pavements (CRCP) might be as high as 4.8" (*2*).

(b) Minimum Serviceability Index (pt): "It is recommended that a minimum serviceability index of 3.0 be used on highways with "Legal Posted Speeds" in excess of 72 km/hr) (45 mph) and 2.5 for those posted 72 km/hr (45) mph or less. If signal spacing, stop signs, dips, etc. prevent drivers from operating faster than 32 km/hr (20 mph) the minimum serviceability index may be relaxed to 2.0" (*2*).

(c) po: "In general, the serviceability index after an overlay should be about the same as that of initial construction. In this design system it must be specified by the engineer" (*2*).

DESIGN OF EXPERIMENT

The main objective of a design of experiment is to determine the effect of various factors (independent variables) on some characteristic of a variable of interest (dependent variable). The factorial approach is efficient and results in a considerable savings of time and resources, when compared to the alternative procedure of conducting separate experiments where each of these deals with a single factor. Moreover, in a factorial experiment, the effects of each factor are examined for every combination of all other factors (interaction) included in the experiment.

TABLE 1 Average Terminal SI Based on BPR Survey

Highway Surveyed	Terminal SI values Based on BPR Survey	
	Rigid	Flexible
Major	2.2	2.1
Lesser	--	1.8

The main objective of this analysis is to estimate the SI (dependent variable) of the Texas highways at different time intervals. The inference space, defined as the space where the results of the study may be applied, is the highway system in Texas. This concept is important and it is necessary to keep it in mind when applying the results or the conclusions of the study.

According to Anderson and McLean (*5*), the experimental or elemental unit is the type of experimental material used to receive the application of various treatments and is of the desired inference space. For this study, any road is an experimental unit.

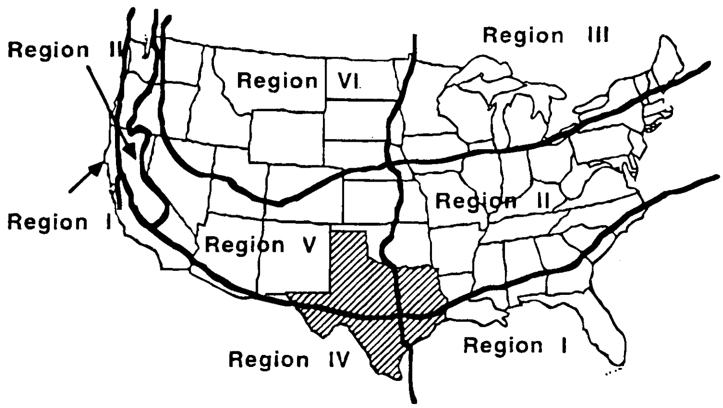
There are many independent variables that could be studied for example: environmental condition, construction procedure, structural design, surface materials, traffic, and many others. After statistical, timing, and economical considerations, a three-factor experiment was developed. Three main factors were selected: (*a*) environmental-geographical regions, (*b*) type of pavement, and (*c*) category of use. These are fixed factors because the levels of interest were selected by the experimenter.

The first factor, "environmental/geographical regions," has four levels. This factor was developed from the six climatic regions in the United States, which are differentiated on the basis of moisture availability and freeze-thaw activity (Figure 2) (*8*). This study shows that Texas is divided into four areas according to this national classification. To keep a uniform system, it was decided to use this division for this study. Therefore, the levels on this factor are the four climatic zones present in Texas: (*a*) Climatic Zone I, which is wet but does not freeze; (*b*) Climatic Zone II, which is wet but has freeze-thaw cycling; (*c*) Climatic Zone IV, which is dry but does not freeze; and (*d*) Climatic Zone V, which is dry but has freeze-thaw cycling.

The second factor, "type of pavement," has two levels and it was considered from the two most representative pavement types: rigid pavements and flexible pavements.

The third factor, "category of use," has four levels. These four levels are: (*a*) serviceability immediately after construction (new pavements), (*b*) serviceability before scheduled overlay projects (terminal pavements), (*c*) serviceability immediately after rehabilitation (resurfaced pavements), and (*d*) serviceability after reconstruction (reconstructed pavements).

Finally, with these three main factors, it is possible to build a factorial design matrix that we will use for the analysis. This matrix is presented in Figure 3.



REGION	CHARACTERISTICS
I	Wet and no freeze
II	Wet and freeze-thaw cycling
III	Wet, hard freeze and spring thaw
IV	Dry and no freeze
V	Dry and freeze-thaw cycling
VI	Dry, hard freeze and spring thaw

FIGURE 2 Six climatic regions in United States (*8*).

Two other variables were selected as secondary fixed factors: highway classification (*H*), and surface type (*S*). Highway classification has two levels: primary highways and secondary highways. Surface type has different levels for each pavement type. Rigid pavements have continuous and jointed surfaces. On the other hand, flexible pavements have asphalt concrete and surface treatment.

The selection method adopted in this study was a screening process that used the monthly list of bids and construction reports from the Texas Department of Transportation (TxDOT).

To determine the pavement type of each section, there are two basic sources of information needed. First, the tabulation of bids, which normally shows the type of work to be be done; second, the report of the Pavement Evaluation System in Texas (PES), which indicates the type and pavement condition existing before the work was completed.

If the profile was obtained before the rehabilitation work, the pavement is in "terminal" condition. On the other hand, if the profile was obtained after the overlay, the pavement is in the "resurfaced" category.

Climatic Zones		Region I		Region II		Region IV		Region V	
Pavement Types		Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	Rigid	Flexible
Category of Use	New								
	Reconst.								
	Resurfaced								
	Terminal								

FIGURE 3 Factorial design matrix.

RESULTS

Data Processing

Ideally, the analysis should include all the factors of interest to the researcher in one single model; but when this condition is not possible, the data may be divided using more than one model.

The procedure followed during the analysis is summarized in Figure 4. The first step was to verify if the data met the assumptions required for the analysis. The second step in this analysis was to run an analysis of variance (ANOVA) with a complete model, using SAS (*9,10*); including the dependent variable (SI), and all independent factors of interest: region (*R*), pavement type (*P*), category of use (*C*), highway classification (*H*), and surface type (*S*). The results of this analysis were unsatisfactory. Some of the sum square (*SS*) were undefined, mainly, because there was not enough data to run this complete model.

The third step of the analysis considered only the main factors of interest, that is, *R* and *C*. After obtaining the results of that model, some of the factors that were nonsignificant at a predetermined level could be discarded. The fourth step was to run a separate ANOVA for rigid and flexible pavements. In both cases, the model included factors *C, H,* and *S*.

The fifth step, a multiple comparison test among the significant factors found in the previous steps, enabled the final conclusions over the factors of interest. The next step of this analysis involved interpreting the results, but this step will be discussed in the following section.

Finally, the variability of the SI was studied. To achieve this new task an ANOVA was run using as the dependent variable the coefficient of variation and as the independent variables the climatic region, the pavement type, and the category of use.

There were 145 sections around the state of Texas selected and profiled for this study. Of these, 36 are on rigid pavements and 109 are on flexible pavements. The information collected for all sections is presented in two parts. The first part contains a general description and location of the sections. The second part mainly includes the roughness information.

A summary of the data collected is presented in Figure 5. Each cell of that figure contains the sample size, the average SI value, and

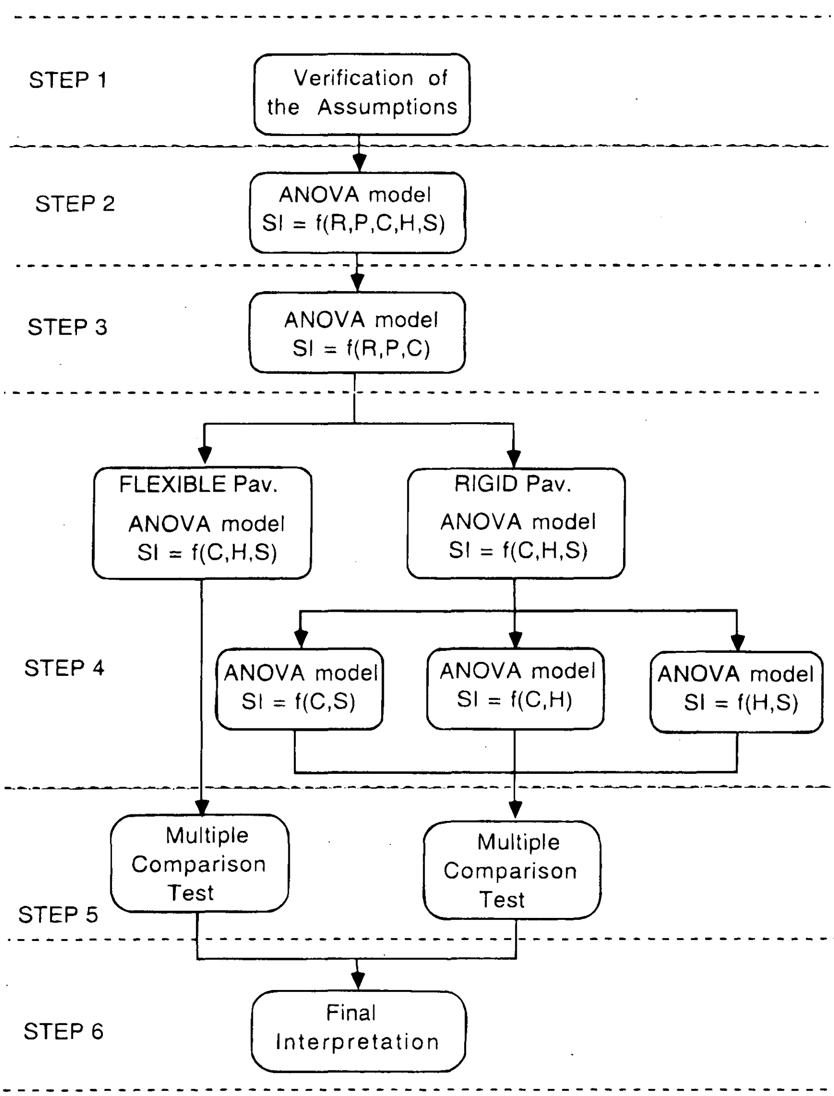


FIGURE 4 Summary of steps used in analysis.

Climatic Zones	Region I		Region II		Region IV		Region V	
Pavement Types	Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	Rigid	Flexible
Category of Use: New	5 3.71 0.62	- - -	4 3.67 0.28	3 3.47 1.14	1 4.04 - - -	1 3.84 - - -	3 3.94 0.08	4 3.64 0.58
Reconst.	- - -	- - -	- - -	- - -	- - -	1 3.73 - - -	- - -	1 4.13 - - -
Resurfaced	2 4.02 0.45	7 4.06 0.15	6 3.71 0.41	4 3.52 0.21	1 4.16 - - -	14 3.95 0.20	2 4.15 0.10	18 3.81 0.59
Terminal	4 3.25 0.34	12 2.85 0.72	4 3.67 0.12	13 3.01 0.65	2 3.26 0.89	17 3.24 0.55	2 4.12 0.04	14 3.07 0.77

FIGURE 5 Summary of results.

the standard deviation for all the studied sections located in that specific condition.

From that figure it is possible to conclude that the second category of use, "reconstruction," does not contain sufficient sections to allow a good statistical analysis. Therefore, this category was not considered for further analysis.

Data Analysis

Before performing the ANOVA, we must check the fundamental assumptions that are required in the analysis. The four traditional assumptions are: (*a*) variable of interest (*y*) is a random variable, (*b*) variances are homogeneous, (*c*) model used for the analysis is additive, and (*d*) response variable (*y*) is normally and independently distributed (*11*).

The analysis of the main factors (*R, P,* and *C*) was performed using the Generalized Linear Model (GLM) procedure available in SAS (*9, 10*). The GLM procedure is used in data from an unbalanced design, such as the one in this study. The ANOVA variance model can be written as a linear model, in the form of an equation that predicts the response variable (SI) as a linear function of the design variables (*R, P,* and *C*) and their interactions (*R*P, P*C,* and *R*P*C*). In other words:

$$SI_{ijkl} = \mu + Ri + Pj + R{*}Pij + Ck + R{*}Cik + P{*}Cjk + R{*}P{*}Cijk + e(ijk)l$$

where:

SI_{ijkl} = serviceability index of section located on region "*i,*" for pavement type "*j*", and category of use "*k*";
μ = overall mean;
Ri = effect of region "*i*";
Pj = effect of pavement type "*i*";
$R{*}Pij$ = effect of interaction of region "*i*" with pavement type "*j*";
Ck = effect of category of use "*k*";
$R{*}Cik$ = effect of interaction of pavement type "*j*" with category of use "*k*";
$P{*}Cjk$ = effect of interaction of pavement type "*j*" with category of use "*k*";
$R{*}P{*}Cijk$ = effect of interaction of region "*i*" pavement type "*j,*" and category of use "*k*"; and
$e(ijk)l$ = random error of "*lth*" section in region "*i,*" with pavement type "*j,*" and in category of use "*k.*" Where "*e*" is Normally and Independently Distributed with zero mean and variance s2, NID (0,s2).

The factors included in this analysis, besides the main factors (*P* and *C*), are the highway classification (*H*) and the surface type (*S*).

This part of the analysis will consider separately the flexible pavements from the rigid pavements. The main reason for that decision is that the two levels of surface types selected in this study for flexible pavements are completely different from the ones for rigid pavements (*12*).

Analysis of the Results

The previous section reported the statistical analysis of the data collected during the study. This section focuses on the physical interpretation of the results obtained.

Step 3 of the analysis concluded that climatic region does not have any influence in the variation of the SI around Texas (*12*). This conclusion confirms the initial assumption that the climatic zone does not appear to affect the quality of new or overlaid pavements, or how the engineers decide when to overlay a pavement. However, the climatic regions were included in the analysis mainly to provide a broader inference space for the results.

All cells in the factorial were filled except the one corresponding to a new flexible pavement located in Region I and under the category of use "reconstruction." Therefore, the conclusions obtained herein are good inferences for pavement conditions in Texas.

This section presents a discussion of the results obtained for flexible pavements, followed by the interpretation of the results for rigid pavements, then, a discussion of the variability of the serviceability index within section. Finally, a comparison among the SI values found in this research and the SI values reported in previous studies is presented.

Flexible Pavements

The analysis shows that the following pairs of average SI are statistically different (*12*): (*a*) Terminal SI of flexible pavements located on principal highways is higher than terminal SI of flexible pavements located on secondary highways, (*b*) SI of new flexible pavements located on principal highways is higher than terminal SI of flexible pavements located on principal highways, (*c*) SI of resurfaced pavements located on principal highways is higher than the terminal SI of pavements located on principal highways, and (*d*) SI of resurfaced pavements located on secondary roads is higher than the terminal SI of pavements located on secondary roads.

Furthermore, we may infer that the following pairs of average SI are statistically equivalent (*12*): (*a*) SI of new flexible pavements located on principal highways and SI of new flexible pavements located on secondary highways, (*b*) SI of resurfaced flexible pavements located on principal highways and SI of resurfaced flexible pavements located on secondary highways, (*c*) SI of new flexible pavements located on principal highways and SI of resurfaced flexible pavements located on principal highways, (*d*) SI of new flexible pavements located on secondary highways and SI of resurfaced flexible pavements located on secondary highways, and (*e*) SI of new flexible pavements located on secondary highways and terminal SI of flexible pavements located on secondary highways.

On the other hand, the analysis also shows that the following pairs of average SI are statistically different: (*a*) SI of resurfaced flexible pavements with asphalt concrete is higher than SI of resurfaced flexible pavements with surface treatment, (*b*) SI of new asphalt concrete pavements is higher than terminal SI of asphalt concrete pavements, (*c*) SI of resurfaced flexible pavements with asphalt concrete is higher than terminal SI of asphalt concrete pavements.

Furthermore, the following pairs of average SI are statistically equivalent (*12*): (*a*) SI for new asphalt concrete pavements and SI for new surface treatment pavements, (*b*) terminal SI for asphalt concrete pavements and terminal SI for surface treatment pavements, (*c*) SI of new asphalt concrete pavements and SI of resurfaced pavements, (*d*) SI of new surface treatment pavements and SI of pavements resurfaced with surface treatment, (*e*) SI of new surface treatment pavements and terminal SI of surface treatment pavements, and (*f*) terminal SI of surface treatment pavements and SI of pavements resurfaced with surface treatment.

Therefore, the conclusions for flexible pavements are: (*a*) principal highways, in general, have a better average SI than secondary roads, and (*b*) surface treatment does not improve the SI of a road. The average SI values for flexible pavements found in the analysis are summarized in Table 2.

TABLE 2 Average SI Values for Flexible Pavements

a) Category of use and highway classification

Category of Use	Highway Classification	
	Primary	Secondary
	mean	mean
New	4.0	3.0
Resurfaced	3.9	3.5
Terminal	3.2	2.8

b) Category of use and surface type

Category of Use	Surface Type	
	Asphalt Concrete	Surface Treatment
	mean	mean
New	4.0	3.0
Resurfaced	4.0	2.9
Terminal	3.2	2.9

Rigid Pavements

The average SI values for rigid pavements are shown in Table 3. The SI values of new, resurfaced, and terminal pavements are similar to each other, mainly, because their terminal condition has a high serviceability index. This situation is caused by the characteristic of the performance curve of rigid pavements and the criteria used by the engineers to decide when a rigid pavement needs rehabilitation. The main conclusion for rigid pavements is that the three levels of category of use on rigid pavements appear to be statistically equivalent.

TABLE 3 Average SI Values for Rigid Pavements

a) Category of use

Category of Use	Average SI - value
New	3.8
Resurfaced	3.9
Terminal	3.5

b) Highway classification

Highway Classification	Average SI - value
Principal	3.8
Secondary	3.3

c) Surface type

Surface Type	Average SI - value
Jointed	3.7
Continous	3.7

Variation of the SI Within a Section

The variation within a section was studied using the coefficient of variation (CV) of the SI values obtained in that particular section. According to Figure 6, the following pairs are statistically different: (*a*) CV for terminal rigid pavements is smaller than CV for terminal flexible pavements, (*b*) CV of new flexible pavements is smaller than CV for terminal flexible pavements, and (*c*) CV of resurfaced flexible pavements is smaller than CV of terminal flexible pavements. All the other combinations presented in Figure 6 show no significant differences.

The conclusions for the variability of the SI within section are: (*a*) rigid pavements have low variability at all three categories of use (new, resurfaced, and terminal) than flexible pavements; (*b*) terminal flexible pavements show an important variation in serviceability index; and (*c*) both rigid and flexible pavements have a low variability in the categories "new" and "resurfaced."

Comparison of SI Values

This part of the section presents a comparison among the SI values obtained in this study and the SI values recommended in the literature.

SI of New Pavements Table 4 summarizes the new SI values recommended by AASHTO (*1*), the state of Texas (*2*), and this study. The last row of this table shows the difference in percentage between the SI obtained in this research and the SI previously recommended by the state of Texas.

This table shows that the SI assumed on the design of new pavements has, on the average, never been reached in the field. For flexible pavements, the difference between the average SI value found in this study and the SI recommended in the Texas design manual is only about 5 percent for asphalt concrete, but it increases to 21 percent for surface treatment. For rigid pavements, the difference between the average SI found in this study and the SI recommended in the manual is, in general, higher than for flexible pavements. Specially, for CRCP, the average SI found in this study is 20 percent lower than the SI recommended in the Texas design manual.

SI of Resurfaced Pavements Table 5 summarizes the SI values recommended by the state of Texas (*2*) and the SI values found in this research. The state of Texas does not have any special recommendation for resurfaced pavements. For resurfaced pavements, in general, the present rehabilitation techniques do not produce pavements with the SI assumed in the design models.

For flexible pavements, the difference between the SI value found in this research and the SI assumed on the design is not so critical for asphalt concrete pavements, but it is important for surface treatment, where this difference is on the average 24 percent. For rigid pavements with an asphalt concrete overlay, the difference is 19 percent.

SI of Terminal Pavements Table 6 presents a summary of the terminal SI recommended in previous studies and compares them

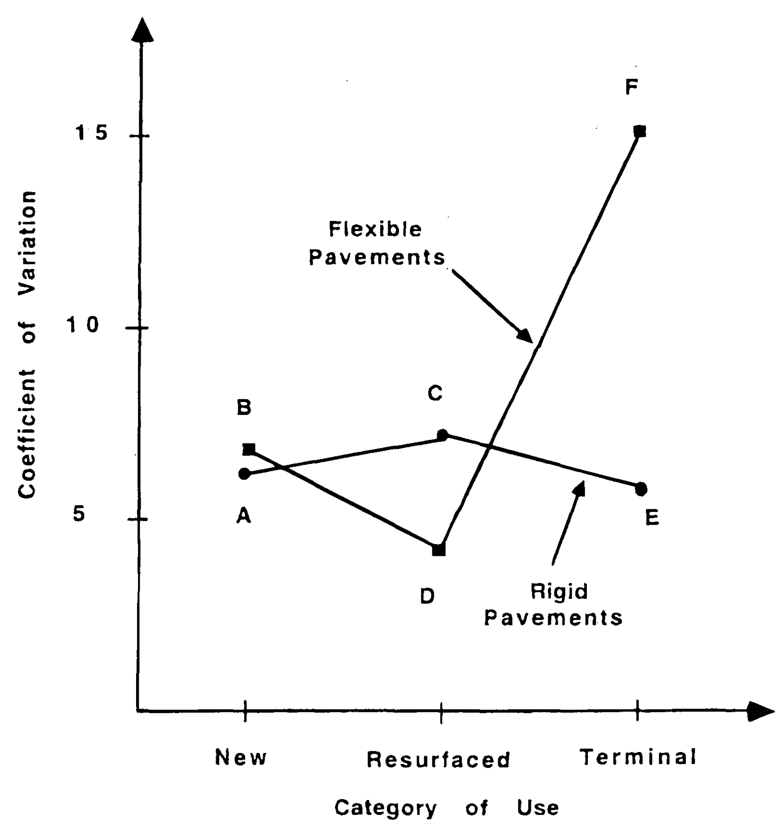


FIGURE 6 Pavement type and category of use—CV interaction.

TABLE 4 Comparison of New SI by Pavement Type

AGENCY	FLEXIBLE		RIGID	
	Asphalt Concrete	Surface Treatment	Jointed	Continuous
(1) AASHTO	4.2	- - -	4.5	- - -
(2) Texas (T)	4.2	3.8	4.5	4.8
(3) This Study (S)	4.0	3.0	3.8	3.8
Δ [S - T] (%)	-5%	-21%	-16%	-20%

TABLE 5 Comparison of Resurfaced SI by Pavement Type

AGENCY	FLEXIBLE		RIGID	
	Asphalt Concrete	Surface Treatment	Jointed	Continuous
(1) Texas (T)	4.2	3.8	4.5	4.8
(2) This Study (S)	4.0	2.9	3.9	3.9
Δ [S - T] (%)	-5%	-24%	-13%	-19%

TABLE 6 Comparison of Terminal SI by Pavement Type

AGENCY	FLEXIBLE		RIGID
	Primary	Secondary	Primary
(1) AASHTO	2.5	2.0	2.5
(2) BPR	2.1	1.8	2.2
(3) Project 354	3.1	2.2	3.1
(4) Texas (T)	3.0	2.5	3.0
(5) This Study (S)	3.2	2.8	3.5
Δ [S - T] (%)	+7%	+12%	+17%

with the SI obtained in this study. The previous terminal SI values shown in this table are recommended by: AASHTO (*1*), BPR (*6*), CTR—Project 354 (*7*), and the state of Texas (*2*).

This table shows that the Texas standards recommend higher terminal SI than the terminal SI recommended by the AASHTO. The terminal SI values found in this research are higher than the SI recommended by the State of Texas.

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The main objective of this study was to obtain better estimates of the serviceability indices (SI) of the Texas highway system to be used in the Texas pavement management system. Three levels of SI were finally selected: new pavements, resurfaced pavements, and terminal pavements.

This section is divided in two sections. The first part summarizes the findings and the conclusions obtained during the study. The second part presents the recommendations derived from these findings.

The findings and conclusions are presented in four different categories: (*a*) general findings about the SI, (*b*) conclusions about flexible pavements, (*c*) conclusions about rigid pavements, and (*d*) conclusions about the variability of the SI.

General Findings

The findings of this research can be summarized as follows:

- SI for New Pavements: When the pavement is located on a principal highway, the initial SI is 4.0 for flexible pavements and 3.8 for rigid pavements. For secondary roads, the new SI is 3.0. The SI for new surface treatment is 3.0.

- SI after Resurfacing: When the pavement is located on a principal highway, the SI of resurfaced pavements is 4.0 for flexible pavements and 3.9 for rigid pavement resurfaced with asphalt concrete. For secondary roads, the SI is 3.5. When a surface treatment is used to resurface a pavement, the SI is 2.9.
- Minimum SI: When the pavement is located on a principal highway, the minimum SI of 3.2 was found for flexible pavements and 3.5 for rigid pavements. For secondary roads, the SI is 2.8. The terminal SI for surface treatment pavements is 2.9.
- Climatic regions do not affect the variability of the SI in Texas.
- The initial serviceability index (pi currently used by TxDOT) in its pavement design system is higher than the average SI observed in the field. This difference is 5 percent for asphalt concrete pavement and 20 percent for rigid pavements.
- The serviceability index after resurfacing (po used by the TxDOT) in its current pavement design system is higher than the average SI observed in the field. This difference is 5 percent for asphalt concrete pavements and 19 percent for rigid pavements.
- The minimum or terminal serviceability index pt currently used by TxDOT in its pavement design system is lower than the average SI observed in the field. This difference is 7 percent for asphalt concrete pavements and 17 percent for rigid pavements.

Conclusions

Flexible Pavements

The conclusions obtained in this research about the SI on flexible pavements can be summarized as follows:

- Surface treatment does not improve the SI of pavements.
- Principal highways, in general, have a better average SI than secondary roads.

Rigid Pavements

The conclusions obtained in this research about the SI on rigid pavements can be summarized as follows:

- There are no important differences in SI among the three levels of the category of use in rigid pavements (new, resurfaced, and terminal).
- The study shows no differences in SI between jointed pavements and continuous pavements.

Variability of the Serviceability Within a Section

The conclusions obtained in this research about the variability of the SI within section or project can be summarized as follows:

- Rigid pavements do not show an important SI variability in the three levels of the category of use analyzed.
- Flexible pavements show an important SI variability in terminal pavements.
- The SI variability of resurfaced flexible pavements is, in general, smaller than the SI variability of resurfaced rigid pavements.
- Both rigid and flexible new pavements have a low SI variability.

Recommendations

The following recommendations can be derived from the findings of this study:

- It is recommended that the SI values found in this study be implemented in all activities of the Texas pavement management system.
- It is not recommended to divide the state of Texas by climatic regions when analyzing serviceability.
- It is not recommended to use surface treatment to improve the SI of a pavement.
- The CV of the SI of a section could be used as a complementary tool to the decision making process when studying the alternative to rehabilitate flexible pavements.
- The CV of the SI of a section could be used as a complementary tool for the quality control of new pavements (rigid and flexible pavements).

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