Procedure for Design of Overlays for Rigid Pavements for Texas State Department of Highways and Public Transportation

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The Texas State Department of Highways and Public Transportation method for the design of overlays for rigid pavements described in this paper is a design method that consists of fatigue- and reflection-cracking subsystems. The fatigue-cracking subsystem considers the remaining life of the existing pavement, uses fatigue principles, and determines the required overlay thickness for a specific design life. Miner's linear damage hypothesis is used in the process. The reflection-cracking subsystem provides a rational way of analyzing an overlay for the possible occurrence of reflection cracking. This design procedure was developed by adapting (through evaluation, modification, improvement, and simplification) the recently developed Federal Highway Administration overlay-design procedure for rigid pavements. The revisions include modifications to (a) the computer programs, (b) the input guides for the computer programs, and (c) the materials-characterization procedures. This procedure provides a rational way to design a wide variety of overlays on rigid pavements.

Many of the pavements in the Interstate system are approaching the end of their originally programmed design lives. In recognition of the fact that rehabilitation and overlays will become increasingly important in the future, the Federal Highway Administration (FHWA) recently sponsored a research effort (1) to develop a new method of overlay design. This method had the following goals:

1. To develop overlay thickness design procedures for rehabilitation of all common pavement types and
2. To develop design procedures for eliminating or reducing reflection cracking of pavement overlays.

Subsequently, the Texas State Department of Highways and Public Transportation (SDHPT), with the goal of developing and implementing design, construction, and rehabilitation methods for rigid pavements, modified and adapted the FHWA method for flexible and rigid overlays on rigid pavements for specific use in Texas (2).

This paper highlights the main features of the resulting Texas SDHPT rigid-pavement overlay-design method, discusses some of the interesting results of the evaluation of the FHWA method, touches on some of the features included in the User's Manual for the Texas method, and describes the usefulness of this procedure as a research and design tool.

OVERVIEW OF DESIGN METHOD

The design method discussed herein (2) is based on an FHWA procedure developed by ARE Inc. (2,3). The FHWA method was first evaluated and then modified, simplified, and adapted to Texas needs. The procedure, which is outlined in Figure 1, contains three basic steps:

1. Evaluation of the existing pavement,
2. Determination of the design inputs, and
3. Overlay thickness analysis.

Evaluation of the Existing Pavement

The existing pavement is evaluated by a deflection survey and a condition survey. The deflection-survey information is used to divide the roadway under consideration into design sections that will behave differently from one another under load and to select design deflections for each section. The condition-survey information is used to classify the pavement into one of three categories:

1. Pavements that have remaining-life potential,
2. Pavements so severely cracked that they would not be considered to have remaining life, and
3. Pavements that will be mechanically broken up before being overlaid.

For pavements where reflection cracking is a problem, additional condition-survey information is needed, such as differential vertical deflection and the amount of horizontal movement with temperature change at joints or cracks.

Determination of Design Inputs

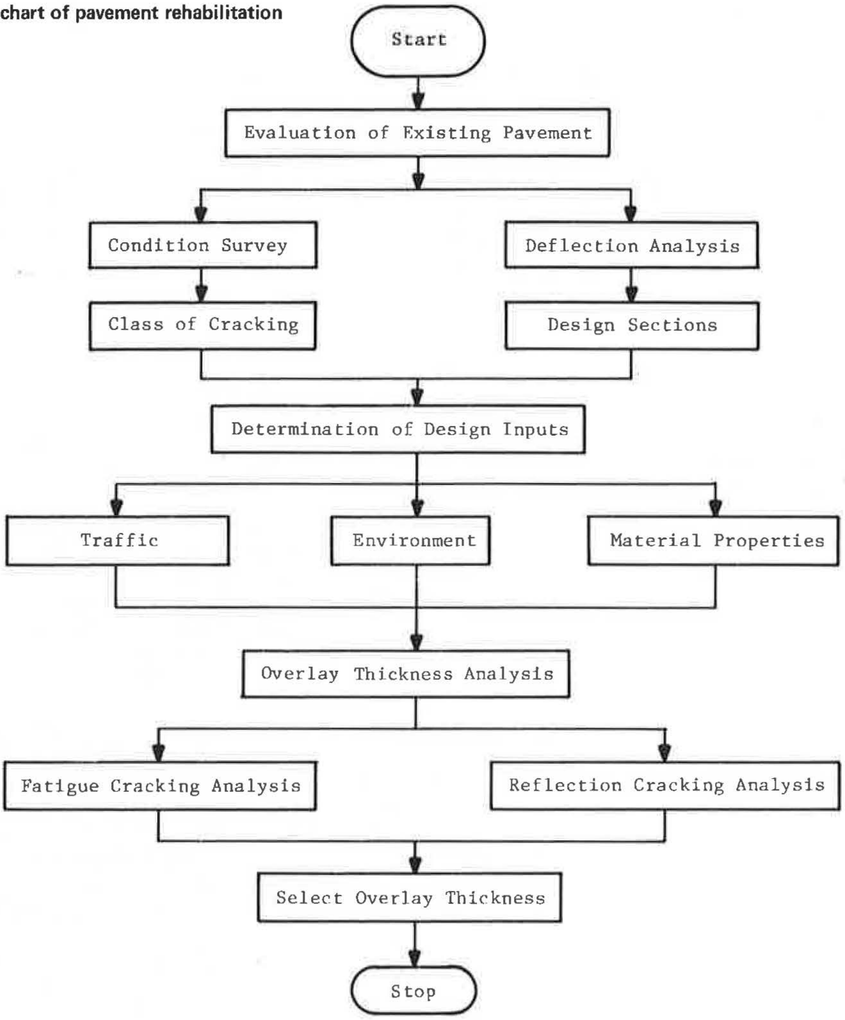
The required design inputs include estimations of past and projected future traffic in terms of number of 80-kN [18 000-lbf/in^2 (18-kip)] equivalent single-axle loads (ESALs), environmental considerations, material properties, and dimensions of layers. Elastic properties of various pavement materials are determined in the laboratory. Deflection measurements and a laboratory determination of the resilient modulus at different levels of deviator stress are used to characterize the subgrade material. For the reflection-cracking analysis, additional data such as creep modulus of asphalt materials, thermal coefficients, and temperature information are also required.

Overlay Thickness Analysis

The overlay thickness analysis involves two subsystems: (a) a fatigue-cracking analysis and (b) a reflection-cracking analysis.

The fatigue-cracking analysis involves the use of linear elastic-layer theory to characterize the subgrade material and to compute stresses, strains, and deflections. McCullough (4) showed in 1969 that "a computer-oriented solution to layered theory is the most appropriate solution for overlay design." He found that the results of the layered-theory approach were favorably correlated with the results of the generally accepted Westergaard theory over a wide range of parameters for rigid pavements. The remaining life of the existing pavement is taken into account by using Miner's linear

Figure 1. Flowchart of pavement rehabilitation procedure.



damage hypothesis. The governing stresses are assumed to be the horizontal tensile stresses due to applied wheel loads; they are assumed to be at the bottom of the overlay for pavements that do not have remaining life and at the bottom of the existing pavement for pavements that do. Stresses computed by the linear elastic-layer program are taken to be interior stresses, and stress factors derived by using a discrete-element theory program [Westergaard and Picket theory (1)] are used to determine the maximum stress at the critical point for a specific type of pavement-overlay combination. Continuous pavements are designed for edge loading, and jointed pavements are designed for corner loading. Void factors derived by using slab theory (1) are used to account for increased stresses due to voids under the pavement.

The fatigue-cracking analysis is computerized by the program RPOD2, which can handle both asphalt concrete (AC) and portland cement concrete (PCC) overlays on concrete pavements. The output of the program is the required overlay thickness for a specific design life.

The reflection-cracking analysis is primarily intended for AC overlays on rigid pavements (5) although other types of overlays can be analyzed by reviewing the procedure. The RFLCRI computer program provides a rational procedure for evaluating the susceptibility of an overlay to reflection cracking. At joints or cracks in the existing pavement, the program computes (a) the horizontal tensile strain in the overlay due to thermal movement and (b) the vertical-load-associated shear strain in the overlay. These computed strain values are then compared with allowable maximum values. The program provides for the possible use of bond breakers, intermediate layers, or reinforcement in the overlay if these maximum criteria are violated.

EVALUATION OF FATIGUE-CRACKING SUBSYSTEM

In the process of developing the Texas SDHPT procedures from the FHWA procedure, various studies were conducted on the fatigue-cracking subsystem, RPOD1. Subsequently, the revised computer program RPOD2 was developed for Texas SDHPT.

Nayak and others (6) have conducted an extensive sensitivity analysis of the program RPOD1. Both fractional-factorial and single-factorial results are reported. The pavement conditions used in the analysis are described in Table 1, and the sensitivity results are summarized in Table 2. In general, the following were concluded to be important variables:

1. The modulus of the subbase is a very important variable. This rather surprising result indicates one of the advantages of using layered theory in the analyses, i.e., that factors outside the slab are accounted for more accurately.
2. Design deflection is another very important variable. The design deflection is also used to characterize the subgrade material. In this sensitivity study, the

Table 1. Description of pavement conditions for sensitivity analysis.

Pavement Condition	Type of Overlay	Type of Existing Pavement	Bonding Condition	Voids	Cracking Condition
1	Continuously reinforced concrete pavement	Continuously reinforced concrete pavement	Bonded	No	Classes 1 and 2
2	Jointed concrete pavement	Jointed concrete pavement	Unbonded	No	Classes 1 and 2
3	Asphalt concrete pavement	Continuously reinforced concrete pavement	Bonded	No	Classes 1 and 2
4	Continuously reinforced concrete pavement	Continuously reinforced concrete pavement	Unbonded	No	Mechanically broken
5	Jointed concrete pavement	Continuously reinforced concrete pavement	Unbonded	No	Classes 1 and 2
6	Continuously reinforced concrete pavement	Jointed concrete pavement	Unbonded	No	Classes 1 and 2
7	Jointed concrete pavement	Jointed concrete pavement	Unbonded	No	Classes 3 and 4
8	Jointed concrete pavement	Continuously reinforced concrete pavement	Unbonded	Yes	Classes 1 and 2
9	Jointed concrete pavement	Jointed concrete pavement	Unbonded	Yes	Classes 1 and 2

Table 2. Results of sensitivity analysis.

	Pavement Condition								
	Fractional-Factorial Experiment				Single-Factorial Experiment				
Input Variable	1	2	3	4	5	6	7	8	9
Modulus of subbase	1	2	2	4	1	6		2	5
Design deflection	2	1	1	2	2	5	1	1	2
Thickness of surface	3		3		5			5	
Modulus of surface	4	4			6	1	2	6	1
Thickness of subbase	5		4		3			3	
Poisson's ratio of surface	6				4			4	
Modulus of subbase times design deflection		3		6					
Poisson's ratio of overlay		5		3		4	4		3
Modulus of overlay		6		1		2	3		4
Modulus of surface times thickness of subbase			5						
Modulus of subbase times thickness of base			6						
Modulus of bond breaker				5		3	5		6
Poisson's ratio of bond breaker					6				
Thickness of bond breaker							6		

stress sensitivity of the subgrade material was not a factor because the design load was the same as the deflection load. The importance of the design deflection therefore indicates that the stress sensitivity of the subgrade material might be an important factor (and this proved to be so under certain circumstances).

3. Other variables that are important are the thickness and modulus of the surface layer, the modulus of the overlay, the thickness of the subbase, and the modulus and thickness of the bond breaker or stress-relieving layer, if used.

4. The Poisson's ratios of the overlay, surface layer, and bond breaker are important variables in some instances.

5. It can be assumed that flexural strength is an important variable: In this study, concrete modulus and flexural strength were varied together [which is feasible because an increase in modulus will normally be accompanied by an increase in flexural strength (1, 7)] and therefore the effect of the concrete modulus represents the combined effect of both variables.

Effect of Remaining Life on Overlay Thickness

The concept of using the remaining life of the existing pavement in designing overlays was introduced by McCullough in 1969 (4) and is used in the Shell method for overlay design on flexible pavements (8), the FHWA method for flexible pavements (9), and by Zaniewski (10). The remaining-life concept is defined as follows:

$$R_L(x,t,l,e,m) = 1 - \Sigma\,(n_i/N_i)\,(x,t,l,e,m) \qquad (1)$$

where

R_L = remaining life;
n_i = number or load applications of level i experienced from the beginning to time t;
N_i = number of load applications of level i required to cause failure in simple loading; and
(x, t, l, e, m) = notation to describe the subject relations as a matrix function of space, time, loading, environment, and materials properties.

The effect of the percentage of remaining life on the required overlay thickness for a 203-mm (8-in) concrete pavement that has a 203-mm stabilized subbase on a subgrade is shown in Figure 2. The moduli for the concrete (both pavement and overlay) and for the subbase were taken to be 31.7 and 3.45 GPa (4 600 000 and 500 000 lbf/in^2), respectively, and Poisson's ratios of 0.2, 0.2, and 0.4 were assumed for the concrete, stabilized subbase, and subgrade, respectively.

By varying the assumed traffic before overlay, the percentage of remaining life can be varied. It should be noted that, when the remaining life of the existing pavement is taken into consideration, the required overlay thickness is significantly reduced. On the other hand, if the fact that some of the life of the existing pavement has already been consumed by traffic is not recognized, the resulting overlay may be too thin.

The remaining-life concept is used in conjunction with the fatigue equation:

For PCC,

$$N = 23\,440\,(f/\sigma)^{3.21} \qquad (2a)$$

where

N = number of 80-kN ESALs until failure,
f = flexural strength of concrete (lbf/in^2), and
σ = computed tensile stress due to design load (lbf/in^2).

For AC,

$$N = 9.7255 \times 10^{-15}\,(1/\epsilon)^{5.16267} \qquad (2b)$$

where ϵ = computed strain due to design load (in/in). (The equations given in this paper are designed for U.S. customary units only.)

These equations indicate that, for very low values of remaining life, it might be more economical to consider the existing pavement not to have any and the governing stress to be at the bottom of the overlay. For pavements that have remaining life, the governing stress is considered to be at the bottom of the existing pavement. In the Texas method, there is a modification where the existing pavement is considered both to have remaining life and to not have remaining life so that the more economical overlay thickness can be selected.

Effect of Subgrade Resilient Modulus on Overlay Thickness

In this study, the pavement structure was the same as that described above except for the use of an unbonded overlay. The stress-relieving layer was taken to be 50.8 mm (2 in) thick and to have an elastic modulus of 689 MPa (100 000 lbf/in^2). Overlay thicknesses were determined for different subgrade resilient moduli. Both RPOD1 and manual (by using the linear elastic-layer program ELSYM5 to calculate stresses, strains, and deflections) calculations were made. Figure 3 shows the relationship between overlay thickness and subgrade resilient modulus. It can be seen that the overlay thickness for an existing pavement that has remaining life is much more sensitive to a change in subgrade resilient modulus than is that for an existing pavement that does not have remaining life. Schnitter and others (2) have pointed out that this reduction in overlay thickness with increase in subgrade resilient modulus when the existing pavement has remaining life is due to the combined effects of having the governing stress lower down in the pavement system and the increase in remaining life.

Effect of Stress Dependency of Subgrade Resilient Modulus on Overlay Thickness

The resilient moduli of subgrade materials are generally stress dependent. In the Texas method, as in the FHWA method, the subgrade modulus is determined by a combination of repetitive-load triaxial testing and deflection measurements.

When plotted on a log-log scale, the relationship between the modulus and the deviator stress for subgrade soils is generally close to a straight line (1, 5, 9, 10). Zaniewski (10) indicates that, as the confining pressure increases, the resilient modulus of a subgrade material increases, but in such a way that individual curves for different confining pressures are parallel. Mathematically, the relationship can be expressed as follows:

$$M_R = a(\sigma_1 - \sigma_3)S_{SG} \qquad (3)$$

where

M_R = resilient modulus (lbf/in^2),
a = intercept on the subgrade-modulus axis,
S_{SG} = slope of the line determined by the log-log plot of the resilient modulus versus deviator stress,
σ_1 = applied vertical stress (lbf/in^2),
σ_3 = applied horizontal stress (lbf/in^2), and
$\sigma_1 - \sigma_3$ = deviator stress (lbf/in^2).

The slope (S_{SG}) is generally negative for clayey materials and positive for granular materials (2). For materials that included clays, silty clays, sandy silts, clayey silts, and very fine-grained sand, a practical range for S_{SG} was found to be between -1.2 and 0.

Figure 4 shows the required overlay thicknesses for different values of S_{SG} for the pavement structure shown in Figure 5. A Dynaflect design deflection of 0.014 mm (0.000 565 in) was used and traffic before overlay was kept constant on 4 million 80-kN ESALs. The overlay was designed for 7 million 80-kN ESALs. The results of this study indicate that, if the existing pavement does not have remaining life, the predicted overlay thickness is relatively insensitive to variations in S_{SG}. For pavements that have remaining life, the variation in S_{SG} has a considerable influence on overlay thickness.

The reason for this phenomenon is that, in characterizing the subgrade material by using the measured deflection, different resilient moduli are obtained for materials that have different stress dependencies (S_{SG}). The more stress dependent the material, the lower the resilient modulus to be used with the design load (for negative values of S_{SG}). This also affects the remaining life of the existing pavement.

These results suggest that relatively more effort should be spent in characterizing the subgrade materials of pavements that have remaining life than of those that do not.

Effect of Change in Stress Level in Subgrade, Due to the Overlay, on Overlay Thickness

In the fatigue-cracking subsystem, the subgrade modulus is determined under the design load on the existing pavement and then used throughout the rest of the overlay-design process. The overlay, however, will reduce the stress level in the subgrade, which will result in a higher subgrade modulus, for a soil that has a negative S_{SG}. This will cause the design to be conservative. This effect is illustrated in Figure 6. The computer program used in the FHWA method (RPOD1) was used to determine overlay thicknesses for different values of S_{SG}, and these results were compared with values obtained by manual calculations that included the effect of the reduction in subgrade stress due to the overlay. However, although the RPOD1 results are somewhat conservative as expected, it was decided that the increased computer time an additional iteration process would require would not be justified.

Asphalt Concrete Overlays on Portland Cement Concrete Pavements

The RPOD1 computer program (1) does not include provision for the design of AC overlays on PCC pavements that do not have remaining life. Schnitter and others (2) have shown that, for these pavements, the effective modulus (3.45 GPa) assumed for a pavement that exhibits classes 3 and 4 cracking can easily be higher than the modulus of the overlay. The governing stress is considered to be at the bottom of the overlay, which can, according to layer-theory solutions, even be in compression and have significant stresses at the bottom of the cracked pavement. This is not an easy problem to deal with by using layer theory.

In the Texas method, this problem is solved by characterizing the subgrade material in the normal way of using measured deflections and laboratory testing and then determine the modulus of a semi-infinite half space that will have the same deflection under design load as the existing pavement structure. The overlay is then designed on this half space.

EVALUATION OF REFLECTION-CRACKING SUBSYSTEM

The reflection-cracking subsystem was evaluated by a limited sensitivity analysis (2) and will not be discussed here.

IMPLEMENTATION OF RESULTS OF EVALUATION STUDIES

After the evaluation studies of the RPOD1 computer

Figure 2. Relationship between overlay thickness and remaining life of existing pavement.

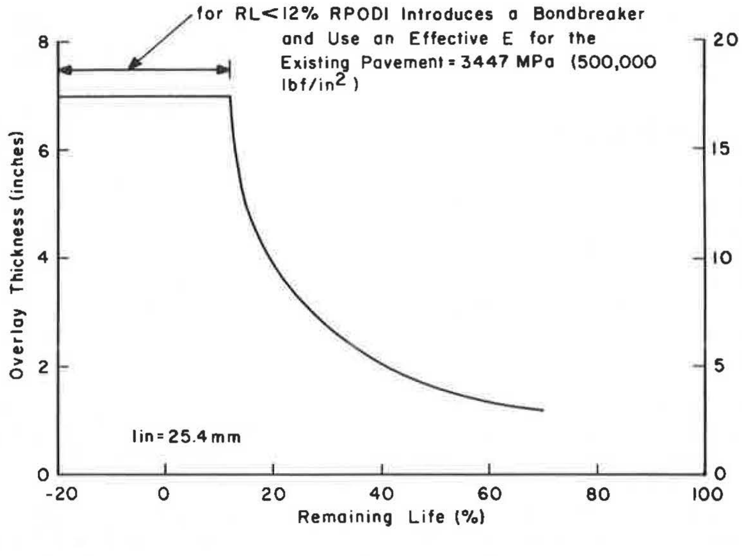


Figure 3. Relationship between overlay thickness and subgrade resilient modulus.

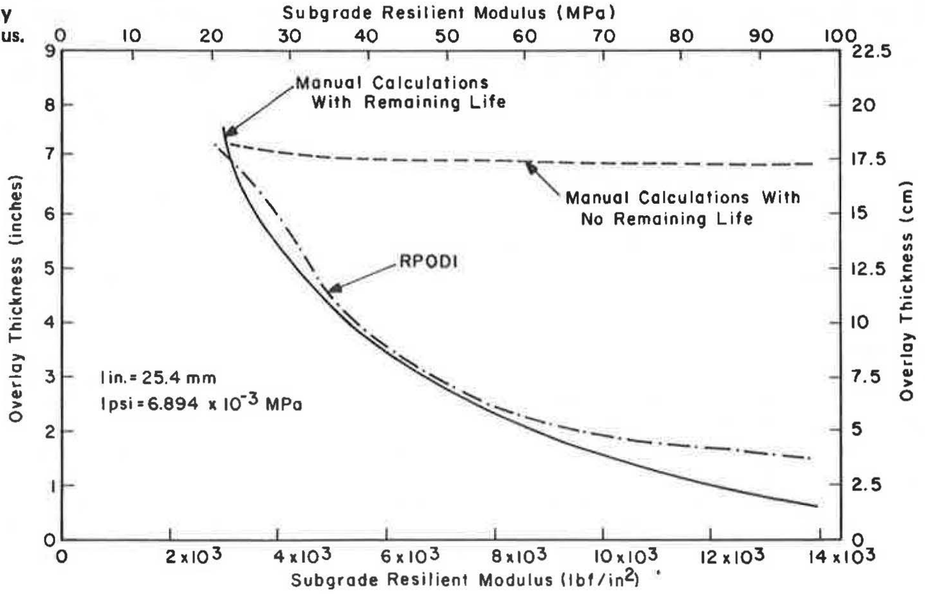
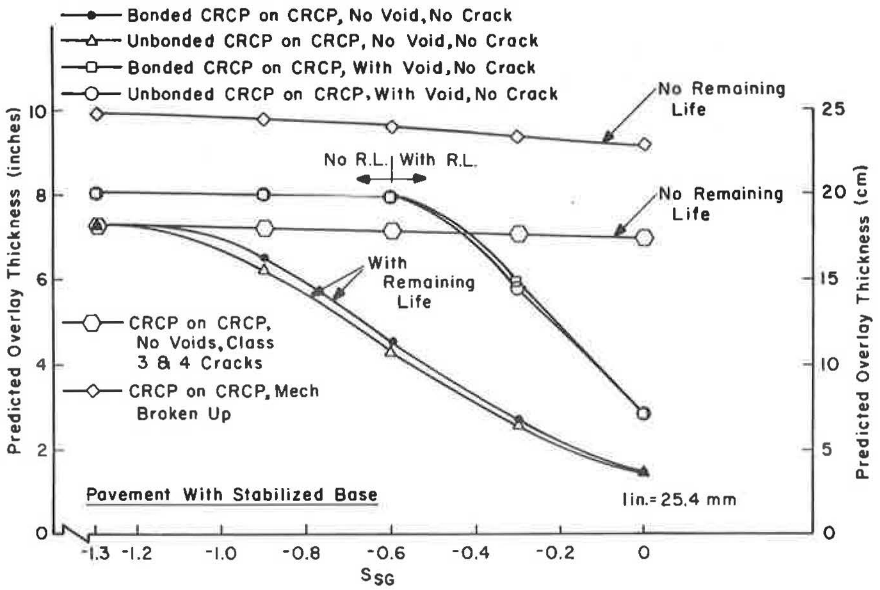


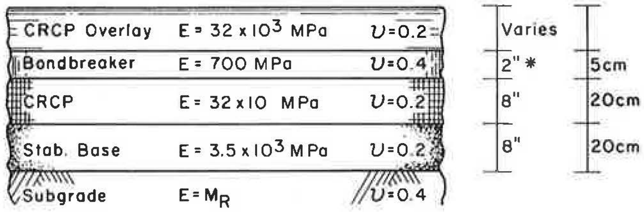
Figure 4. Sensitivity of RPOD1 response to slope of line that describes relationship between subgrade resilient modulus and deviator stress (on log-log scale).



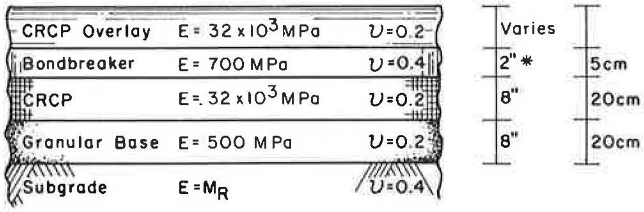
program, a revised program called RPOD2 was developed that includes the following modifications:

1. RPOD2 includes the design of AC overlays on pavements that do not have remaining life by using the concept of a semi-inifinite half space that results in the same deflection under the design load as the existing pavement.
2. RPOD2 allows for the input of values of flexural strength of both the existing pavement and the overlay (in RPOD1 only a single value could be specified).
3. Because it is more economical under certain conditions to consider a pavement that has a low percentage of remaining life to not have any, RPOD2 considers both possibilities for selection of the more economical thickness.
4. Because overlay thicknesses on pavements that do not have remaining life are less sensitive to the stress dependency of the subgrade modulus, RPOD2 provides an alternative way to describe the relationship between the laboratory-determined resilient modulus and the deviator stress.
5. Because the Dynaflect is widely used in Texas for deflection measurements, Dynaflect loads are used as default values in RPOD2.
6. RPOD2 sets limiting elastic-modulus values for subbases of pavements that have classes 3 and 4 cracking and mechanically broken up pavements because it is unlikely that, for example, a cement-stabilized base under a mechanically broken up pavement would be intact.

Figure 5. Pavement structures used to study effect of S_{SG} on overlay thickness.



a. Pavement structure with stabilized subbase.



b. Pavement structure with granular subbase.

* Dimension in Cases Where a Bondbreaker Has Been Used

in.= 25.4 mm
1 psi = 6.894×10^{-3} MPa

Table 3. Input variables for program RPOD2 for different existing-pavement conditions.

Variable	Pavement Condition[a] A	B	C	D
Traffic before overlay	R	R	-	-
Existing pavement				
Concrete flexural strength	R	R	-	-
Condition	R	R	R	R
Modulus	R	R	F	F
Poisson's ratio	F	F	F	F
Thickness	R	R	R	R
Subbase				
Modulus	R	R	R	R
Poisson's ratio	F	F	F	F
Thickness	R	R	R	R
Subgrade				
Modulus	-	-	-	-
Poisson's ratio	F	F	F	F
Thickness[b]	R[b]	R[b]	R[b]	R[b]
Laboratory data (M_R versus σ)	R	R	E	E
Design deflection	R	R	R	R
Deflection-load magnitude	F	F	F	F
Deflection-load positions	F	F	F	F
Corner-to-interior stress ratio[c]	R[c]	R[c]	R[c]	R[c]
Overlay				
Modulus	R	R	R	R
Poisson's ratio	F	F	F	F
Concrete flexural strength	-	R	R	R
Bonding condition	R	R	-	-
Bond breaker[d]				
Modulus	R[d]	R	R	R
Poisson's ratio	F	F	F	F
Thickness	R	R	R	R
Design traffic	R	R	R	R

Note: R = required, F = fixed (can be changed by using supplement to input guide), and E = estimate (a good estimate of this value is sufficient).

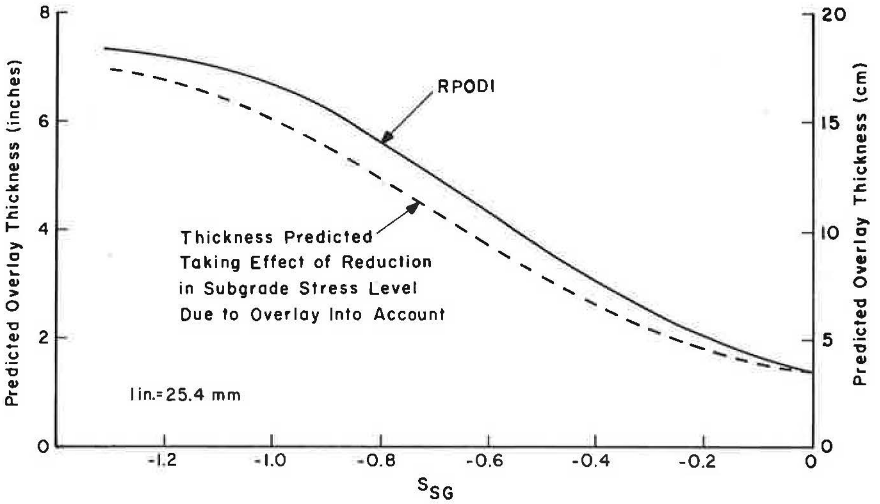
[a] Pavement condition: A = has remaining life; B = uncracked or classes 1 and 2 cracks, does not have remaining life; C = classes 3 and 4 cracks; D = mechanically broken up.

[b] If bedrock is specified.

[c] If existing pavement is JCP.

[d] If bond breaker is specified.

Figure 6. Comparison of predicted thicknesses: by RPOD1 program and by manual calculations that include effect of reduction in level of subgrade stress due to overlay.



The limited sensitivity analyses of the reflection-cracking program RFLCR1 indicated that it gives reasonable results; therefore, no modifications were required to that program.

TEXAS SDHPT USER'S MANUAL

A step-by-step User's Manual has been provided for the use of the Texas State Department of Highways and Public Transportation. The manual is divided into four sections:

1. Evaluation of the existing pavement,
2. Fatigue-cracking analysis,
3. Reflection-cracking analysis, and
4. Selection of overlay thickness.

Input guides for the computer programs are also provided. For simplicity, several of the less sensitive variables required by the procedure have been assigned default values and need not be input. A supplement to the input guide provides a way to change these default values should the designer so desire. Such variables include the Poisson's ratio values, the deflection loads, and the positions for the deflection measuring device.

The manual also contains

1. An indication of the variables that are required for each combination of overlay and pavement (see Table 3),
2. A way of determining S_{SG} by using deflection measurements at two different deflection loads, and
3. A tentative way of determining a maximum allowable value for the repeated shear strain due to traffic loads used in the reflection-cracking analysis.

IMPLEMENTATION OF TEXAS SDHPT OVERLAY-DESIGN PROCEDURE

Because field verification is always an important aspect of a new design procedure, this procedure will be implemented for trial use on real overlay-design problems as soon as possible. This will be done by designing a number of overlay sections, constructing them, and then monitoring their performance.

Because the procedure is computerized, it can be easily adapted to rigid-pavement management systems also (11). Future research will be directed toward this goal.

This overlay design method can also be a useful research tool for parameter and sensitivity analyses and is currently being used by personnel of the Center for Highway Research, University of Texas at Austin, and the Texas SDHPT in a study to determine the most economical time or condition to overlay pavements.

It is hoped that this overlay-design procedure will eventually provide pavement designers in Texas with a sound practical method of designing structural overlays in all classes of rigid pavements.

CONCLUSIONS

In the process of adapting the FHWA procedure for the design of rigid pavement overlays for the Texas SDHPT, the FHWA method has been thoroughly evaluated. Some of the evaluation studies on the fatigue-cracking subsystem are discussed in this paper, and the following can be concluded:

1. In general, the most important input variables are design deflection and the elastic moduli and thicknesses of the various layers.
2. Taking the remaining life of the existing pavement into consideration reduces the required overlay thickness considerably.
3. The subgrade modulus has a much larger effect on required overlay thicknesses for existing pavements that have remaining life than for those that do not.
4. The effect of the stress dependency of the subgrade resilient modulus is much greater for existing pavements that have remaining life than for pavements that do not.
5. Relatively more effort should be given to the determination of the subgrade modulus of pavements that have remaining life than of pavements that do not.
6. The effect of ignoring the reduction in the subgrade stress due to the overlay is to make the design conservative for subgrades that have negative S_{SG} values.
7. The problem of modeling AC overlays on PCC pavements by using elastic-layer theory has been overcome.

ACKNOWLEDGMENT

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Overlay Design Based on Visible Pavement Distress

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Data collected on 111 Interstate highway projects in Virginia were analyzed by using a multiregression procedure, and the rating coefficient for each type of distress was determined. From these coefficients, the total distress and the resultant maintenance rating for each pavement were calculated. The types of distress that were found to affect the maintenance rating are longitudinal cracking, alligator cracking, rutting, pushing, raveling, and patching. A method for designing the required thickness of an overlay was developed based on taking the thickness equivalency of an asphalt concrete overlay in Virginia as equal to 0.5 and the overlay thickness as a function of the ratio of the traffic, in terms of the number of 80-kN [18 000-lbf (18-kip)] equivalent loads, carried by the pavement before the overlay to the traffic it would carry after the overlay, depending on the durability of the asphalt mix. This design method does not require the use of a deflection-measuring device.

In Virginia, the decision to provide an overlay over a flexible pavement conventionally is based on a visual inspection that does not make reference to any defined criterion for pavement evaluation. However, to comply with the Reconstruction, Rehabilitation, and Resurfacing Program of the Federal Highway Administration, the states now need procedures by which the necessity for an overlay can be validated and its required thickness can be estimated so as to obtain federal participating funds.

In Virginia and some other states, mechanistic methods for determining the required thicknesses for overlays have been developed. However, these methods are based on deflection data (1, 2) and their use would require that all districts have deflection equipment such as the Dynaflect available, along with a technician, for the collection of data. Similarly, the methods for quantifying total pavement distress based on rating systems require the use of some technique for measuring distress by mechanical means. Consequently, there is a need for a method by which to establish a relationship between the total pavement distress, the accumulated traffic and the structural strength of the pavement that can be used to design overlays without the necessity of using pavement-deflection (or any other) measuring devices.

OBJECTIVE AND SCOPE

The objective of the investigation reported here was the development of a method for designing the thickness of overlays for flexible pavements that would be based on maintenance ratings of the pavements as determined by visual observations and sound engineering judgment. These overlays would be designed for the sole purpose of improving the structural strength of the pavement. Defects in the pavement surface that did not affect its strength would not be considered.

As outlined in the working plan (3), the study was designed to accomplish the following tasks:

1. To develop a pavement-maintenance-rating system based on the total observed pavement distress;
2. To develop a relationship between the maintenance rating, the accumulated traffic {in terms of 80-kN [18 000 lbf (18-kip)] equivalents}, and the structural strength of the pavement (in terms of its thickness index) that could be used to evaluate the performance of the pavement before and after the overlay;
3. To determine the thickness equivalency of the overlay; and
4. To develop a method for determining the required thickness of the overlay.

PAVEMENT-MAINTENANCE-RATING SYSTEM

The pavement-maintenance-rating technique that was developed is based on the same principle as the serviceability index (SI) included in the American Association of State Highway and Officials (AASHO) Road Test results. The SIs of the new pavements at the AASHO Road Test varied from 3.9 to 4.5, with an average value of 4.2. For the design of overlays in Virginia, it is proposed that a maintenance-rating factor (MR) of 100 for a new pavement be adopted. Thus, an AASHO SI of 4.2 would equal an MR of 100, and an SI of 0 would equal an MR of 0. As distress to the pavement increases, factors assigned to various types and degrees of distress are subtracted and the MR decreases. The MR for a new pavement will decrease from 100 as the accumulated traffic, and hence the distress, increases.

Although the pavement distress over the first few years that a road is open to traffic is so small that it is not discernible to the naked eye, it can be measured by a Dynaflect or a roughometer. However, measurement of this indiscernible distress is not necessary for the design of overlays. In the rating system developed, an SI of 3.9 or an MR of 93 [i.e., (3.9/4.2) × 100 = 93] is