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SPECIAL NOTICE

The *Guide for Design of Pavement Structures*, when it was published in 1986, was published as two volumes. Volume 1 was written as a basic design guide and provided all of the information required to understand and apply the "Guide" to pavement design. Volume 2 was a series of appendices prepared to provide documentation or further explanations for information contained in Volume 1. Volume 2 is not required for design.

This 1993 edition of the "Guide" contains only one Volume. This Volume replaces the 1986 "Guide" Volume 1 and serves the same purpose. The major changes included in the 1993 "Guide" are changes to the overlay design procedure and the accompanying appendices L, M, and N. There are other minor changes and some of an editorial nature throughout the new Volume 1.

Volume 2 of the 1986 "Guide" is still applicable to most sections of Volume 1 of the 1993 "Guide" and is available through AASHTO, 444 N. Capitol Street, N.W., Suite 249, Washington, D.C. 20001; 202-624-5800. Request book code "GDPS3-V2." A copy of the Table of Contents from Volume 2 of the 1986 "Guide" follows.

VOLUME 2 APPENDICES

PREFACE

When construction, maintenance, and rehabilitation costs are considered, the single most costly element of our nation's highway system is the pavement structure. In an effort to reduce this cost, the state highway and transportation departments and the Federal Government have sponsored a continuous program of research on pavements. One output of that research effort was the *Interim Guide for the Design of Pavement Structures* published in 1972 and revised in 1981. It was based largely upon the findings at the AASHO Road Test.

Because this is such an important topic, the Joint Task Force on Pavements—composed of members from the Subcommittee on Design, one member each from the Materials, Construction, and Maintenance Subcommittees, and one from the Planning Committee of AASHTO—was assigned the task of rewriting the Interim Guide incorporating new developments and specifically addressing pavement rehabilitation.

Because many states were found to be using at least portions of the Interim Guide and because no other generally accepted procedures could be identified, it was decided that this Guide would retain the basic algorithms developed from the AASHO Road Test as used in the Interim Guide. Because the Road Test was very limited in scope, i.e. a few materials, one subgrade, non-mixed traffic, one environment, etc., the original Interim Guide contained many additional models to expand the framework so designers could consider other conditions. The new Guide has been further expanded with the following 14 major new considerations:

(1) Reliability
(2) Resilient Modulus for Soil Support
(3) Resilient Modulus for Flexible Pavement Layer Coefficients
(4) Drainage
(5) Improved Environment Considerations
(6) Tied Concrete Shoulders or Widened Lanes
(7) Subbase Erosion for Rigid Pavements
(8) Life Cycle Cost Considerations
(9) Rehabilitation
(10) Pavement Management
(11) Extension of Load Equivalency Values
(12) Improved Traffic Data
(13) Design of Pavements for Low Volume Roads
(14) State of the Knowledge on Mechanistic-Empirical Design Concepts

The Task Force recognizes that a considerable body of information exists to design pavements utilizing so-called mechanistic models. It further believes that significant improvements in pavement design will occur as these mechanistic models are calibrated to in-service performance, and are incorporated in everyday design usage. Part IV of this document summarizes the mechanistic/empirical status.

In order to provide state-of-the-art approaches without lengthy research, values and concepts are shown that have limited support in research or experience. Each user should consider this to be a reference document and carefully evaluate his or her need of each concept and what initial values to use. To most effectively use the Guide it is suggested that the user adopt a process similar to the following:

(1) Conduct a sensitivity study to determine which inputs have a significant effect on pavement design answers for its range of conditions.
(2) For those inputs that are insignificant or inappropriate, no additional effort is required.
(3) For those that are significant and the state has sufficient data or methods to estimate design values with adequate accuracy, no additional effort is required.
(4) Finally, for those sensitive inputs for which the state has no data of methodology to develop the inputs, research will be necessary. Because of the complexity of pavement design and the large expansion of this Guide, it is anticipated that some additional research will be cost-effective for each and every user agency in order to optimally utilize the Guide.

One significant event, the pavement performance research effort being undertaken in the Strategic High-

way Research Program (SHRP), should aid greatly in improving this document.

The Task Force believes that pavement design is gradually, but steadily transitioning from an art to a science. However, when one considers the nebulous nature of such difficult, but important inputs to design considerations such as traffic forecasting, weather forecasting, construction control, maintenance practices, etc.; successful pavement design will always depend largely upon the good judgment of the designer. Finally, the national trend toward developing and implementing pavement management systems, PMS, appears to the Task Force to be extremely important in developing the good judgment needed by pavement designers as well as providing many other elements needed for good design, i.e. information to support adequate funding and fund allocation.

The AASHTO Joint Task Force on Pavements

EXECUTIVE SUMMARY

One of the major objectives of the AASHO Road Test was to provide information that could be used to develop pavement design criteria and pavement design procedures. Accordingly, following completion of the Road Test, the AASHO Design Committee (currently the AASHTO Design Committee), through its Subcommittee on Pavement Design Practices, developed and circulated in 1961 the "AASHO Interim Guide for the Design of Rigid and Flexible Pavements." The Guide was based on the results of the AASHO Road Test supplemented by existing design procedures and, in the case of rigid pavements, available theory.

After the Guide had been used for several years, the AASHTO Design Committee prepared and AASHTO published the "AASHTO Interim Guide for Design of Pavement Structures—1972." Revisions were made in 1981 to Chapter III of the Guide relative to design criteria for Portland Cement Concrete pavements. Evaluation of the Guide by the AASHTO Design Committee in 1983 led to the conclusion that some revisions and additions were required. Representations from government, industry, consultants, and academia led to the conclusion that the Guide should be strengthened to incorporate information developed since 1972 and that a new section on rehabilitation should be added. It is also pertinent to note that, based on responses to a questionnaire sent to the States, there was an indication that the Guide was serving its main objectives and no serious problems were indicated. In other words, the States were generally satisfied with the Guide but acknowledged that some improvements could be made.

Based on the overall evaluation of input from user agencies and the status of research, it was determined by the AASHTO Joint Task Force on Pavements that the revisions to the Guide would retain the AASHO Road Test performance prediction equations, as modified for use in the 1972 Guide, as the basic model to be used for pavement design. This determination also established the present serviceability index (PSI) as the performance variable upon which design would be based.

The major changes which have been included in the revised Guide include the following considerations:

1. *Reliability.* The procedure for design of both rigid and flexible pavements provides a common method for incorporating a reliability factor into the design based on a shift in the design traffic.
2. *Soil support value.* AASHTO test method T 274 (resilient modulus of roadbed soils) is recommended as the definitive test for characterizing soil support. The soil property is recommended for use with both flexible and rigid pavement design.
3. *Layer coefficients (flexible pavements).* The resilient modulus test has been recommended as the procedure to be used in assigning layer coefficients to both stabilized and unstabilized material.

   [NOTE: Guidelines for relating resilient modulus to soil support value and layer coefficients are provided in the Guide; however, user agencies are encouraged to obtain equipment and to train personnel in order to measure the resilient modulus directly.]
4. *Drainage.* Provision has been made in the Guide to provide guidance in the design of subsurface drainage systems and for modifying the design equations to take advantage of improvements in performance to good drainage.
5. *Environment.* Improvements in the Guide have been made in order to adjust designs as a function of environment, e.g., frost heave, swelling soils, and thaw-weakening. Major emphasis is given to thaw-weakening and the effect that seasonal variations have on performance.
6. *Tied shoulders and widened lanes (rigid pavements).* A procedure is provided for the design of rigid pavements with tied shoulders or widened outside lanes.
7. *Subbase erosion.* A method for adjusting the design equations to represent possible soil erosion under rigid pavements is provided.
8. *Life-cycle costs.* Information has been added relative to economic analysis and economic comparisons of alternate designs based on life-

cycle costs. Present worth and/or equivalent uniform annual cost evaluations during a specified analysis period are recommended for making economic analyses.

9. *Rehabilitation.* A major addition to the Guide is the inclusion of a section on rehabilitation. Information is provided for rehabilitation with or without overlays.
10. *Pavement management.* Background information is provided regarding pavement management and the role of the Guide in the overall scheme of pavement management.
11. *Load equivalency values.* Load equivalency values have been extended to include heavier loads, more axles, and terminal serviceability levels of up to 3.0.
12. *Traffic.* Extensive information concerning methods for calculating equivalent single axle loads and specific problems related to obtaining reliable estimates of traffic loading are provided.
13. *Low-volume roads.* A special category for design of pavements subjected to a relative small number of heavy loads is provided in the design section.
14. *Mechanistic-Empirical design procedure.* The state of the knowledge concerning mechanistic-empirical design concepts is provided in the Guide. While these procedures have not, as yet, been incorporated into the Guides, extensive information is provided as to how such methods could be used in the future when enough documentation can be provided.

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PART III PAVEMENT DESIGN PROCEDURES FOR REHABILITATION OF EXISTING PAVEMENTS

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PART I
PAVEMENT DESIGN AND MANAGEMENT PRINCIPLES

CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 SCOPE OF THE GUIDE

This *Guide for the Design of Pavement Structures* provides a comprehensive set of procedures which can be used for the design and rehabilitation of pavements; both rigid (portland cement concrete surface) and flexible (asphalt concrete surface) and aggregate surfaced for low-volume roads. The Guide has been developed to provide recommendations regarding the determination of the pavement structure as shown in Figure 1.1. These recommendations will include the determination of total thickness of the pavement structure as well as the thickness of the individual structural components. The procedures for design provide for the determination of alternate structures using a variety of materials and construction procedures.

A glossary of terms, as used in this Guide, is provided in Appendix A. It is recognized that some of the terms used herein may differ from those used in your local practice; however, it is necessary to establish standard terminology in order to facilitate preparation of the Guide for nationwide use. Insofar as is possible, AASHTO definitions have been used herein.

It should be remembered that the total set of considerations required to assure reliable performance of a pavement structure will include many factors other than the determination of layer thicknesses of the structural components. For example, material requirements, construction requirements, and quality control will significantly influence the ability of the pavement structure to perform according to design expectations. In other words, "pavement design" involves more than choosing thicknesses. Information concerning material and construction requirements will be briefly described in this Guide; however, a good pavement designer must be familiar with relevant publications of AASHTO and ASTM, as well as the local agencies, i.e., state agencies or counties, for whom the design is being prepared. It is extremely important that the designer prepare special provisions to the standard specifications when circumstances indicate that nonstandard conditions exist for a specific project. Examples of such a condition could involve a roadbed soil which is known to be expansive or nonstandard materials which are to be stabilized for use in the pavement structure or prepared roadbed.

Part I of this Guide has been prepared as general background material to assist the user in the proper interpretation of the design procedures and to provide an understanding of the concepts used in the development of the Guide. Detailed information related directly to a number of design considerations, e.g., reliability, drainage, life-cycle costs, traffic, and pavement type selection, will be found in the Appendices. References used in the preparation of the Guide can be found following each of the four major Parts.

Part I, Chapter 3 of the Guide provides information concerning economic evaluation of alternate pavement design strategies. It should not be concluded that the selection of a pavement design should be based on economics alone. There are a number of considerations involved in the final design selection. Appendix B of the Guide on pavement type selection provides an extensive list of guidelines which should be used in comparing alternate design strategies.

Part II of this Guide provides a detailed method for the design of new pavements or for reconstruction of existing pavements on the existing alignment with new or recycled materials.

Part III of this Guide provides alternative methods for pavement rehabilitation with or without the addition of an overlay. The methodology used in this part of the Guide represents the state of the knowledge regarding the deterioration of a pavement structure before and after an overlay has been applied. It is recognized that there are alternate methods for the determination of overlay requirements; a number of these methods are cited in Appendix C. The method included in Part III is somewhat more basic in concept than other existing methods and has the capability for broader application to different types of overlays, e.g., flexible on rigid, flexible on flexible, rigid on rigid, and rigid on flexible type pavements. The method is also compatible with the performance and design concepts used in Part II. In this way, consideration of such factors as drainage, reliability, and traffic is the same for both new and rehabilitated (overlayed) pavement structures.