An Overview of Recent WSDOT Pavement Design Research and Implementation Efforts

WA-RD 170.2

Final Report
August 1992

Washington State Department of Transportation
Washington State Transportation Commission

in cooperation with
U.S. Department of Transportation
Federal Highway Administration

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
WA-RD 170.2		

4. TITLE AND SUBTITLE	5. REPORT DATE
AN OVERVIEW OF RECENT WSDOT PAVEMENT DESIGN RESEARCH AND IMPLEMENTATION EFFORTS	August 1992
	6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Joe P. Mahoney, Newton C. Jackson, Linda M. Pierce, and Keith W. Anderson	

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NO.
Washington State Transportation Center (TRAC) University of Washington, JE-10 The Corbet Building, Suite 204; 4507 University Way N.E. Seattle, Washington 98105	11. CONTRACT OR GRANT NO. GC8286, Task 29

12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Washington State Department of Transportation Transportation Building, MS 7370 Olympia, Washington 98504-7370	Final report
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. WSDOT Contract Manager was Newton C. Jackson

16. ABSTRACT

This report overviews the current status of WSDOT pavement design procedures, analyses, and "manuals" that have culminated with the study entitled "ACP Overlay Design Implementation."

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Pavement design	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None	9	

Final Report

Research Project GC 8286, Task 29
ACP Overlay Design Implementation

AN OVERVIEW OF RECENT WSDOT PAVEMENT DESIGN RESEARCH AND IMPLEMENTATION EFFORTS

by

Joe P. Mahoney
Newton C. Jackson
Linda M. Pierce
Keith W. Anderson

Washington State Transportation Center (TRAC)
University of Washington, JE-10
The Corbet Building, Suite 204
4507 University Way N.E.
Seattle, Washington 98105

Washington State Department of Transportation
Technical Monitor
Newton C. Jackson
Pavement and Soils Engineer

Prepared for

Washington State Transportation Commission
Department of Transportation
and in cooperation with
U.S. Department of Transportation
Federal Highway Administration

August 1992

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Washington State Transportation Commission, Department of Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

TABLE OF CONTENTS

INTRODUCTION

REPORT OBJECTIVE

The objective of this report is to overview the current WSDOT pavement design procedures and the recently completed *WSDOT Pavement Guide.* Much of the reported work was completed within the study entitled "ACP Overlay Design Implementation."

BACKGROUND

WSDOT has used a variety of pavement design procedures over the years. A short summary follows.

1. New/Reconstruction Flexible Pavement Design

The "R-value" method was used from the 1950s well into the 1980s (currently, the flexible pavement design procedure contained in the *WSDOT Design Manual*). The approach required the use of R-values to characterize the strength of the unstabilized pavement layers. The effect of mixed traffic was estimated through the use of Traffic Index (TI). More recently, WSDOT is considering the adoption of the flexible design approach contained in the *AASHTO Guide for the Design of Pavement Structures.* In fact, the recently completed draft of the *WSDOT Pavement Guide* (May 1992) provides detailed information for using the *AASHTO Guide.*

2. New/Reconstruction Rigid Pavement Design

WSDOT does not state in the current Chapter 326 ("Design of Pavement Structure") of the *WSDOT Design Manual* a specific procedure for the design of rigid pavement. The draft *WSDOT Pavement Guide* states that the pavement thickness determination shall be in accordance with the *AASHTO Guide.*

3. Asphalt Concrete Overlays

WSDOT has used a variety of methods over the past 20 years to design structural AC overlays over flexible pavement. These have included

- Engineering Judgment,
- Asphalt Institute Component Analysis,
- Asphalt Institute Deflection Analysis, and
- Mechanistic-Empirical Approaches.

More recently, through WSDOT/TRAC combined efforts on a study entitled "Pavement Design and Performance," a complete system of analysis and design software was developed. The current study ("ACP Overlay Design Implementation") has refined the software and user's guides and combined all necessary background information into the *WSDOT Pavement Guide*. The software includes the following:

- **EVERCALC** A computer program that uses pavement surface deflections from a falling weight deflectometer (FWD) to estimate layer "elastic" moduli. This analysis process is a key element in evaluating an existing pavement structure for the purposes of overlay design.

- **CHEVPC** A computer program (originally developed by the Chevron Oil Company) that was adopted to run on personal computers. This program uses elastic analysis to estimate stresses, strains, and deflections for a pavement structure due to a single, known wheel load, layer elastic moduli, and associated thicknesses.

- **EVERSTRS** A computer program that can use "stress sensitive" moduli inputs to estimate stresses, strains, or deflections for a pavement structure resulting from either a single or dual wheel load. This program is a modified version of CHEVPC.

- **EVERPAVE** A computer program that uses EVERSTRS, layer moduli (from EVERCALC, laboratory tests, or other material correlations) and failure criteria (fatigue cracking and rutting) to estimate AC overlay thicknesses. The traffic input is in terms of 18,000 lb equivalent single axle loads (ESALs).

A second recent overlay design procedure is currently used by WSDOT to check or validate EVERPAVE. This design process is the revised AASHTO approach which, presumably, will replace the current *AASHTO Guide*, Part III, Chapter 5, during 1992 or 1993.

RESULTS

INTRODUCTION

This section will be divided into four sections as follows:

- Software modifications,
- Input data,
- Implementation packages, and
- Case studies.

SOFTWARE MODIFICATIONS

During the course of the current study, extensive modifications have been made to the EVERCALC program. The following changes were made:

- new, more user friendly screens,
- easier, automated data input from the WSDOT FWD,
- complete revision of the moduli convergence routine and convergence error measure,
- modified output formats,
- inclusion of an automatically calculated depth to stiff layer scheme,
- preparation of a revised EVERCALC user's guide, and
- other, miscellaneous program features.

INPUT DATA

For either new or rehabilitation oriented pavement design, using the adopted WSDOT design procedures, certain common input data are required. The progress, to date, for these inputs follows.

1. Traffic Characterization

The review of WSDOT "W-4 Tables," recent WSDOT weigh-in-motion data, conversion of bus weigh data to ESALs and corresponding data from Sweden have been summarized in the recent *WSDOT Pavement Guide*. Essentially, the *Guide* provides a

clear path for WSDOT personnel on how to estimate design period ESALs for new or rehabilitation pavement projects.

2. Material Elastic Moduli

The testing of remolded, unstabilized layer materials for base and subgrade materials were completed by the WSDOT Materials Laboratory during the reported study. This information, along with other methods of estimating layer moduli, are described in both the *WSDOT Pavement Guide* (draft completed May 1992) and the *WSDOT Pavement NDT Data Applications* document (completed September 1991 and revised March 1992).

3. Material Seasonal Variation

A review of the FWD deflection data from 16 test sites located throughout the state of Washington on the WSDOT route system is complete. The results tend to confirm the earlier seasonal moduli variations reported in the "Pavement Design and Performance" study. These new seasonal moduli ratios will be included soon (Summer 1992) in the *WSDOT Pavement Guide*.

4. Failure Criteria

The two fundamental criteria used in EVERPAVE to estimate fatigue cracking and rutting have not been modified since their original development. What has improved is the understanding of the required Shift Factor needed to effectively use the fatigue cracking prediction criterion. Again, this information is incorporated into the *WSDOT Pavement Guide*.

5. Reliability

The reliability scheme used by AASHTO for new flexible, new rigid, and rehabilitation thickness design is recommended for use in the EVERPAVE computer program. Essentially, the use of reliability "shifts" the design period ESALs to higher levels. The use of the AASHTO reliability approach is described in the *WSDOT Pavement Guide*. Without the use of reliability, one should expect about one-half of the

AC overlays designed by use of EVERPAVE to fail prior to the end of the design period since no "fixed" factors of safety are used in EVERPAVE or the input data.

IMPLEMENTATION PACKAGES

The two principal implementation packages that WSDOT has received during 1991-1992 will be briefly overviewed.

1. *Pavement NDT Data Applications* Document

This document was developed in part as a set of course notes for a FHWA training activity and as documentation for WSDOT. The course notes includes the following sections:

SECTION 1.0	ELASTIC MODULI
SECTION 2.0	FUNDAMENTALS OF MECHANISTIC-EMPIRICAL DESIGN
SECTION 3.0	NONDESTRUCTIVE TESTING DEVICES
SECTION 4.0	DEFLECTION/MODULI INTERPRETATION TECHNIQUES
SECTION 5.0	FUNDAMENTALS OF BACKCALCULATION
SECTION 6.0	BACKCALCULATION PROGRAMS
SECTION 7.0	CASE STUDIES

The WSDOT District Materials Engineers and associated technical staff were provided three days of training on the topic during September 1991. A one-day follow-up was provided during March 1992. The WSDOT Materials Laboratory, through the use of this document, associated software, and training, is encouraging their District associates to use the described NDT applications on projects. The WSDOT Materials Laboratory have been using and refining these NDT techniques for about six years.

2. *WSDOT Pavement Guide*

The document was developed as part of the current study ("ACP Overlay Design Implementation"). This was a specific item listed as a product in the project proposal.

Naturally, a "pavement guide" must cover the complete range of pavement design needs and, as such, covers both new/reconstruction (flexible and rigid) as well as rehabilitation (primarily AC overlays). The document contains the following sections:

PART I	SECTION 1.0	AN INTRODUCTION TO THE GUIDE
	SECTION 2.0	PAVEMENT DESIGN POLICY
PART II	SECTION 1.0	AN INTRODUCTION TO PAVEMENT STRUCTURES
	SECTION 2.0	FUNDAMENTAL DESIGN PARAMETERS
	SECTION 3.0	PAVEMENT EVALUATION
	SECTION 4.0	FLEXIBLE AND RIGID PAVEMENT RESPONSES AND RELATED DESIGN PROCESSES
	SECTION 5.0	THE AASHTO FLEXIBLE PAVEMENT DESIGN PROCEDURE (NEW OR RECONSTRUCTED)
	SECTION 6.0	THE AASHTO RIGID PAVEMENT DESIGN PROCEDURE (NEW OR RECONSTRUCTED)
	SECTION 7.0	PAVEMENT REHABILITATION
	SECTION 8.0	LIFE CYCLE COST ANALYSES
	SECTION 9.0	CASE STUDIES (not completed as of June 1992)

The version of the *WSDOT Pavement Guide* completed during May 1992 is still considered a draft document; however, it should be available for full distribution sometime during Fall 1992.

The WSDOT *Guide* was used during May 1992, along with the *AASHTO Guide*, for a 3-1/2 day training activity for the WSDOT Materials Engineers and their associated technical staff. Additional training on specific software is still needed (EVERPAVE, EVERSTRS, and DARWin — at a minimum); however, that activity is not considered part of the scope of the current study but will be accomplished during 1992.

CASE STUDIES

Throughout the conduct of both studies ("Pavement Design and Performance" and "ACP Overlay Design Implementation"), numerous, actual case studies have been done by the study team. These case studies were mainly done to validate the AC overlay approach used in the EVERPAVE program. However, other design processes were examined, such as granular overlays ("cushion courses"). Naturally, the insight that developed was incorporated to the extent possible in the *WSDOT Pavement Guide*.

SUMMARY

The purpose of this short report is to overview the recently completed study entitled "ACP Overlay Design Implementation" and related studies which have resulted in the new analysis and design procedures currently available within WSDOT. By adopting the *AASHTO Guide* for new/reconstruction pavement design, the mechanistic-empirical approach embodied by the EVERPAVE computer program and other, related, analyses, WSDOT has an up-to-date suite of design "tools" which should serve it well.

The close cooperation of the WSDOT Research Office, Materials Laboratory, Districts, and TRAC/UW has resulted in an implemented set of products. More needs to be done, but the majority of the work is at last complete.

Future work could include improvement of the software (EVERPAVE, EVERSTRS, EVERCALC), Volume 1 of the *WSDOT Pavement Guide* (improve content and structure of existing sections, add at least two additional sections on subsurface drainage and case studies) and the addition of a Volume 2 which will contain software documentation, user guides, and related design examples

BIBLIOGRAPHY*

1. Mahoney, J.P., "Asphalt Concrete Overlay Design Implementation," A proposal prepared by the Washington State Transportation Center for the Washington State Department of Transportation, November 17, 1987.

2. Mahoney, J.P., Jackson, N.C., Newcomb, D.E., and Pierce, L.M., "Pavement NDT Data Applications," Course Notes, Washington State Department of Transportation, September 1991 (revised March 1992).

3. WSDOT/TRAC, *WSDOT Pavement Guide*, Washington State Department of Transportation, May 1992.

4. WSDOT, *Design Manual*, Manual 22-01, Washington State Department of Transportation.

5. AASHTO, *AASHTO Guide for Design of Pavement Structures*, American Association of State Highway and Transportation Officials, Washington, D.C., 1986.

6. Mahoney, J.P., Lary, J.A., Pierce, L.M., Jackson, N.C., and Barenberg, E.I., "Urban Interstate Portland Cement Concrete Pavement Rehabilitation Alternatives for Washington State," Research Report WA-RD 202.1, Washington State Department of Transportation, April 1991.

7. Mahoney, J.P., Lee, S.W., Jackson, N.C., and Newcomb, D.E., "Mechanistic-Based Overlay Design Procedure for Washington State Flexible Pavements," Research Report WA-RD 170.1, Washington State Department of Transportation, January 1989.

8. O'Neil, D.J., Mahoney, J.P., and Jackson, N.C., "An Evaluation of Granular Overlays in Washington State," Research Report WA-RD 226.1, Washington State Department of Transportation, May 1991.

9. WSDOT/TRAC, "EVERCALC USER'S GUIDE — Version 3.3," February 1992.

10. WSDOT/TRAC, "EVERSTRS USER'S GUIDE — Version 2.0," August 1988.

11. WSDOT/TRAC, "EVERPAVE USER'S GUIDE — Version 1.1," February 1988.

12. Darter, M.I., Elliott, R.P., and Hall, K.T., "Revision of AASHTO Pavement Overlay Design Procedure," Project 20-7/39, National Cooperative Highway Research Program, Transportation Research Board, Washington, D.C., September 1991.

---

* Reports, etc., that directly relate to the reported study and associated products.