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PAVEMENT OVERLAY DESIGN PROCEDURES AND ASSUMPTIONS

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, Virginia 22101-2296

Vol. II: Questionnaire Responses and Sensitivity Figures

U.S. Department of Transportation
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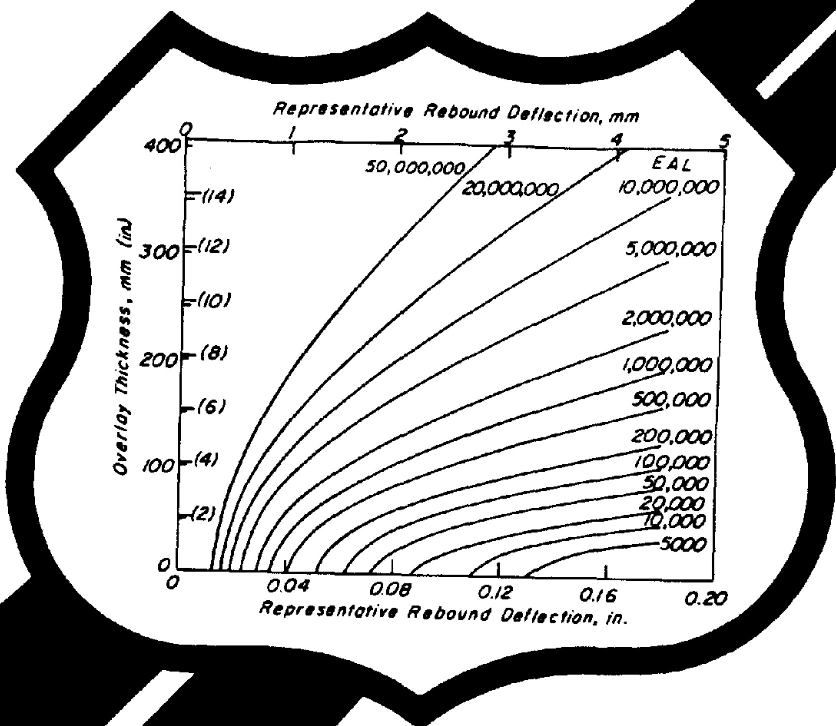

FOREWORD

These reports, FHWA/RD-85/006, 007, 008 provide a ready reference, documenting the development, conceptual basis, and sensitivity of the various overlay design procedures currently available. It was prepared by ERES Consultants, Inc. for the Federal Highway Administration (FHWA), Office of Research, Development, and Technology, under Contract DTFH61-83-C-00042. The work was a part of FCP Project 4A, "Pavement Management Strategies." A discussion of the evaluation techniques and pre-overlay considerations is also included as well as a survey of the methods being used by all State highway departments.

In this study, overlay design procedures for both rigid and flexible pavements were analyzed for their sensitivity to the same or similar key inputs. The State agencies were surveyed for information concerning their approach to pavement evaluation, design, and treatment of reflective cracking. In the reports, recommendations were made concerning pre-overlay repairs, selection of overlay type, and timing of overlay construction.

Copies of the report are being given widespread distribution by FHWA Bulletin. Additional copies may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

Richard E. Hay, Director
Office of Engineering
and Highway Operations
Research and Development

NOTICE

Technical Report Documentation Page

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16. Abstract This is the second of a three volume report prepared to provide highway engineers a ready reference on overlay design procedures. It contains the results of a questionnaire concerning use of overlay design procedures by State agencies and appendices for the first volume including the figures for the sensitivity analysis. The first volume summarizes major overlay procedures, documenting their development and the conceptual basis of each and analyzing their sensitivity to required input data. It contains sample designs and discusses how to "calibrate" an overlay design procedure for local use. The third volume contains a discussion of the evaluation procedure needed for determining if an overlay is required, the basic requirements of an overlay design procedure, reflection crack concerns, preoverlay repair recommendations, selection of the proper overlay type, and timing of overlay construction.

These reports were designed to provide assistance in determining what overlay design procedures are available for adoption, conversion, and use by an agency. In particular, this volume provides an insight as to what procedures are presently being used by State highway agencies. The sensitivity figures were placed in this volume so that they could be reviewed at the same time the reader is reading volume one.

The other reports in this series are:

FHWA/RD-85/006	Vol. I	Analysis of Existing Procedures
FHWA/RD-85/008	Vol. III	Guide for Designing an Overlay

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CHAPTER I

INTRODUCTION

This report is the second volume of a three volume report on overlay design procedures. It contains the results of a questionnaire concerning use of overlay design procedures by State agencies and appendices for the first volume including the figures for the sensitivity analysis.

The first volume summarizes major overlay design procedures documenting their development and the conceptual basis of each, and analyzing their sensitivity to required input data. It contains sample designs and discusses how to "calibrate" an overlay design procedure for local use.

The third volume contains a discussion of the evaluation procedure needed for determining if an overlay is required, the basic requirements of an overlay design procedure, reflection crack concerns, preoverlay repair recommendations, selection of the proper overlay type, and timing of overlay construction.

Objective

Overlays or resurfacings are used by agencies more often than any other type of rehabilitation technique. This three volume set was developed to provide a ready reference on overlay design for use by highway agency engineers. It was designed to provide assistance in determining what overlay design procedures are available for adoption, implementation and use by an agency. It was also designed to provide guidance on how to use an overlay design procedure.

Scope

A thorough review was made of all known highway overlay design procedures which are in use or recently developed and available for use. The Federal Highway Administration completed a survey of State agencies to determine which overlay design procedures were in use in conjunction with this report. Eight states were contacted to gather more thorough information. In addition, some of these agencies provided sample data for use in the analysis of the overlay design procedures.

A set of data was prepared which was used to compare the overlay thickness results of each procedure. This provided overlay thicknesses from each procedure for a series of different pavements. A sensitivity analysis was then conducted to determine how the main input variables affect the overlay design thicknesses.

A guide was developed which addresses the important requirements of an overlay design procedure and all of the factors which need to be considered when designing an overlay or determining if an overlay should be used.

CHAPTER II

SUMMARY OF RESPONSES TO QUESTIONNAIRE

This chapter presents the summary of replies to a questionnaire prepared by the FHWA in conjunction with ERES Consultants, Inc. and sent to the FHWA Division Engineers in each of the fifty states, the District of Columbia, and Puerto Rico. The questionnaire was completed in cooperation with each of the respective highway agencies. A copy of the questionnaire is presented as Appendix A. A table of responses is presented as Appendix B. The purpose of the questionnaire was to determine which overlay design procedures are being used by the State agencies. In addition, the questionnaire addressed the data collected and equipment used to collect deflection data. Also, a separate, more detailed questionnaire was sent to eight selected State agencies. It provided more detailed information on improvements projected for overlay design procedures within the next few years.

In some cases an agency listed "occasionally" as their response. When this occurred, all affected data items were counted as positive replies in the summarized responses in Appendix A. They were marked in the summary listing of responses in Appendix B. This, along with a tendency by the agencies to list more than one response (and quite often more than two) make simple analysis of the data difficult. Readers are encouraged to look to the summary listing of all data before reaching firm conclusions. The analysis was conducted by comparing the "raw data" in the summary listing. Other data problems included vague, missing, and occasionally, erroneous data, as in the case where an agency had listed breaking and seating of existing asphalt pavements before overlaying as one of their possible treatments. Fortunately, these problems were relatively rare. All who participated are to be commended on their effort in this data gathering endeavor. It should be noted that in some cases when responses were received from more than one department of a State agency, conflicts were noted. This was particularly evident when duplicate answers were received from the States which also participated in the more detailed survey. It often indicated a difference in opinion among the design and research personnel of the agency.

A short discussion of each question and the responses received is presented in the following pages. The number of responses is given in parentheses during the discussion. The complete responses are presented in both Appendices A and B.

Data Collected

The items most commonly collected for thickness design are : subgrade properties (20), deflection (19), and pavement material properties (18). It is interesting to note that these are also three of the items most likely to not be collected at all as demonstrated by the negative responses of seventeen, sixteen, and twenty agencies respectively. The responses suggest that most agencies are routinely collecting data on : traffic (52), existing design (47), existing surface distress (47), skid resistance (41), and roughness (39).

Overlay Design Procedure (AC Overlays)

Most agencies answered the question of which procedure they use with more than one design procedure (thirty-eight agencies for flexible overlays of flexible pavements and twenty-four for flexible overlays of rigid pavements). The total number of flexible overlays of flexible pavements responses was one hundred twenty-two and for flexible overlays of rigid pavements eighty-eight. By far the most common method used is engineering judgment (flexible overlays of flexible pavements - 34, flexible overlays of rigid pavements - 29), although some agencies commented that engineering judgment was actually involved in all types of overlay design.

For flexible overlays of flexible pavements the next most popular procedure was an analytical procedure based on estimating material coefficients with twenty-eight agencies responding. This was just ahead of an analytical procedure based on deflection (27). Twelve agencies have a standard thickness policy for flexible overlays of flexible pavements with an average thickness of approximately 2.25 in and a range of 1 to 4 in. Ten agencies indicated that they used distress and seven indicated that they use mechanistic models.

For flexible overlays of rigid pavements the use of estimated material coefficients (19) was slightly preferred over the standard thickness policy (17) with an average thickness of approximately 3.0 in and a range of 1.25 to 6 in. Nine agencies indicated that they are using deflection, seven are using distress, and four are using mechanistic models.

The number of responses indicating no set procedure (engineering judgment plus standard thickness) was forty-six of the possible one hundred twenty-two for flexible overlays of flexible pavements and forty-six of the possible eighty-eight for flexible overlays of rigid pavements, suggesting that there is still a high degree of subjectivity in the design of overlays.

Overlay Design Procedure (PCC Overlays)

The most common response to this question was that none had been designed as of yet (rigid/flex - 28, rigid overlays of rigid pavements - 27) with experimental only running a distant second (13). An analytical material coefficient procedure was the most common in use with seven agencies responding for flexible overlays of rigid pavements and eight for rigid overlays of rigid pavements. Deflection was the next most common response with five responses for rigid/flex and three for rigid overlays of rigid pavements. Engineering judgment (7) and standard thickness (0) do not seem to be the overwhelming favorites in rigid overlays as they did in flexible (asphalt) overlays, but with such a large number of null responses (27) (i.e., none designed to date), accurate conclusions are difficult to draw. It is interesting to note that some agencies (11) are using analytical procedures, and a few agencies (2) are using mechanistic models.

Level in Agency at Which Overlays are Designed

The most likely place for an overlay to be designed in a state DOT is at the Central Office (32) or a combination of the Central Office and the District Office (18). A total of fifty-six of the fifty-eight responses indicated that the overlay would be designed at one or both of these locations.

Design Check

Many agencies either don't have an overlay design procedure, or have never checked it against actual performance. Approximately fifteen agencies have checked or are just beginning to check their designs against actual performance and were able to respond to the questionnaire. The average number of sections checked by the responding agencies was thirty-three. The number of sections that the nine responding agencies listed varied greatly from a minimum of four sections to a maximum of eighty sections. These sections were evaluated approximately two times in an average span of five years. The original pavement age was approximately fifteen years old (there was very little scatter in this reply, with the maximum age of twenty-five years and a minimum age of ten years), and the overlay age was approximately seven years with a range of 0 to 16 years.

The type of data collected was consistent among agencies with almost all contacted agencies collecting distress (9), roughness (8), deflection (8), skid resistance (5), and traffic (12). It is of interest to note that these are very similar to the items most often collected by the agencies (traffic, existing design, existing distress, and skid resistance, from earlier in the chapter) and that other agencies may now wish to start evaluating their overlay methods since they are already collecting this information on a fairly routine basis anyway.

Of the fifteen agencies responding positively to a design check, the most common overlay design types for flexible overlays of flexible pavements were : deflection based (7), analytical procedure based on material coefficients (5), and engineering judgment (5); for flexible overlays of rigid pavements : standard thickness (7), analytical procedure based on material coefficients (3), and engineering judgment (3). For rigid overlays of flexible pavement : analytical procedure based on material coefficients (4) was the most often used.

Automation

The micro computer revolution has not yet conquered overlay designs. Of the sixty-nine responses for flexible overlays, only fourteen involved any type of computer. The other fifty-five were composed of charts and nomographs (35) and design equations (20). A similar conclusion can be drawn for the rigid overlays where twenty-two of the forty-five responses were for charts and nomographs and eighteen were for design equations. Only three agencies responded that they used some type of computer for designing rigid overlays.

One reason for this low level of automation is that the methods used for overlay design do not require automation. Some of the most frequently used methods (engineering judgment and standard thickness) obviously do not require automation, and an analytically based material coefficient design can be done on a hand calculator. Only the mechanistic, and possibly the deflection approach, need a computer. Possibly, as more agencies begin to check their overlay design methods and build data bases, they will move to a computer aided design.

Deflection Equipment

The Benkelman Beam continues to be a very popular piece of equipment with nineteen agencies having used it as their original procedure, ten presently using it, and thirteen planning to use it in the future. Another very popular type of deflection device is the Dynaflect. Seven agencies used it for their original procedure, twenty are presently using it, and eighteen plan on using it in the future. The other type of deflection device which is becoming common is the Falling Weight Deflectometer. Between the KUAB and Dynatest, there are three agencies presently using it and sixteen planning on using an FWD in the future.

The Falling Weight Deflectometer devices appear to exhibit a large increase in percentage of users for the future. Ten agencies indicated that they do not presently use NDT devices and have no plans to do so.

Effectiveness of Methods to Control Reflection Cracking in Flexible Overlays of Flexible Pavements

It appears that the method with the best success is still increased overlay thickness. Of the forty-two responses on this subject, only three indicated poor results, sixteen were marginal, and twenty-three were good, which was far ahead of any other method. Of the three agencies that responded "poor", engineering judgment was used in two cases, material coefficients once, and deflection once to design the overlay. Of the twenty-three agencies that responded "good", fifteen used engineering judgment, fourteen used material coefficients, and also fourteen used deflection to design the overlay. This appears to follow a pattern set in an earlier question regarding design methods indicating that thirty-four agencies used engineering judgment, to twenty-eight using material coefficients and twenty-seven for deflection.

All other methods showed some positive results with good performance ratings being more prevalent than the poor ratings. The crack arresting interlayer received good ratings, but with only seven agencies responding (1 poor, 2 marginal, 4 good) it is less well tested than engineering fabrics (9 poor, 18 marginal, 12 good), stress absorbing membrane (SAMI) (6 poor, 11 marginal, 8 good), or heater scarification (6 poor, 11 marginal, 7 good). Other methods used to control reflection cracking with good performance indicated were : recycling (3 good) and crack sealing prior to overlay (2 good, 1 moderate to good).

Effectiveness of Methods to Control Reflection Cracking in Flexible Overlays of Rigid Pavements

For flexible overlays of rigid pavements, increased thickness seems to perform better than other methods with six poor, seventeen marginal, and twelve good. Of the six poor, four were designed using engineering judgment while the other methods (standard thickness, material coefficients, deflection, and distress ID related to specific thickness) had only one vote each. In addition, these states′ ratings for crack control by any means were : eleven poor, three marginal, and two good. For the twelve rated good, nine were designed by engineering judgment, six using standard thickness, and six using material coefficients. As with flexible overlays of flexible pavements , all other methods, stress absorbing membrane (3 poor, 5 marginal, 5 good), crack arresting interlayer (2 poor, 5 marginal, 6 good), and breaking and seating (3 poor, 5 marginal, 7 good), showed more positive feedback than negative feedback. Sawing joints in the flexible pavement above the joints in the existing pavement was also a method which worked well for the few agencies that tried it (0 poor, 2 marginal, 8 good). The one method that did not perform well was the use of engineering fabrics, with twelve poor, seventeen marginal, and only four good responses.

One other note of interest is that agencies which had checked their overlay design procedures had a higher degree of success with their reflective crack control than states which had not. States which had checked their flexible overlays of flexible pavements had a total of four poor, twelve marginal, and fourteen good responses. The other agencies reported twenty-one poor, forty-six marginal, and forty with good performance. For the flexible overlays of rigid pavements, the States which had checked their overlay design procedures reported they had three poor, six marginal, and eleven good performances with their reflective crack control techniques compared to twenty-three poor, forty-five marginal, and thirty good reported by the States which had not checked their design procedures.

Preoverlay Treatment

The responses to this question were more difficult to evaluate since many states responded that they use all types of repairs depending on the conditions. However, there do appear to be some trends.

Almost all agencies (45 of 50) said that they use tack coats between layers of flexible overlays of flexible pavements, and a leveling course to remove ruts before they overlay (46), and nearly all filled potholes (35) and cold milled (34), although probably not all at the same time. For flexible overlays of rigid pavements, almost all agencies (34 of 42) used tack coats, and many (24) filled potholes and/or added a leveling course (21). The subject of patching was the most difficult to analyze, but basically most agencies use more than a minimum amount of preoverlay patching or joint repair.

Summary of State Responses to the Questionnaire

To summarize this information, one might describe a typical agency. The "typical" agency collects data on traffic, the existing design, surface distress, skid resistance, and roughness. With this data, the central office designs the flexible overlay (since they probably have not designed rigid overlays to date) using engineering judgment and maybe by estimating material coefficients or using a deflection based (Dynaflect, FWD, or Benkelman Beam) procedure. The design is completed using charts, nomographs, and design equations which probably have not been checked against actual field performance data.

Before they overlay (with an increased thickness or engineering fabrics to reduce reflection cracking) a tack coat is applied, potholes are filled and there is a moderate amount of patching completed. A leveling course is added to fill the ruts, or the existing surface is cold milled to remove the ruts.

Summary of Additional Information Supplied by Selected States

The average length of time that selected states (Georgia, Minnesota, Mississippi, Ohio, Texas, and Washington) have been using their overlay design methods was approximately twenty years for flexible overlays, and ten years for rigid overlays (only three states had been using rigid overlays of flexible pavement). The most common type of overlay design employed by these states for flexible overlays of flexible pavements was engineering judgment (5), material coefficients (4), and deflection (4). For flexible overlays of rigid pavements, material coefficients (5), engineering judgment (4), and standard thickness were the methods of choice. The few rigid overlays of flexible pavement were designed using material coefficients (2), deflection (2), mechanistic models (2), and engineering judgment (1 in combination with other methods). For rigid overlays of rigid pavements, material coefficients (3), engineering judgment (2), material coefficients (2), deflection (2), and mechanistic models (2) were used.

They have each designed and built hundreds of flexible overlays but very few rigid overlays.

If new procedures are to be developed, the consensus of the agencies was that they would be using either a deflection based approach (using the FWD or the Dynaflect), or a mechanistic model design. These new procedures would then be made into charts and nomographs.

Summary

The responses reported herein are those of one individual within an agency and may not always reflect the entire department policy or procedure. As a result, the results should not be considered as solid evidence of present or future procedures. A few trends can be found, however.

It appears that there is a trend to move away from total dependence on engineering judgment and toward more analytical procedures. No reasons for these moves were requested or received in the questionnaires. It can only be conjectured that possible reasons include poor performance of overlays previously designed only by engineering judgment, loss of experienced personnel who had the expertise to design with engineering judgment, new materials and designs, availability of computer equipment, and availability of NDT equipment.

APPENDIX A

QUESTIONNAIRE WITH

SUMMARIZED RESPONSES

1. Please check the data which is collected to determine the need for, and/or thickness design of overlays :

	Not Collected	Routinely Collected	For Thickness Design only
a. Existing Design	2	37	10
b. Traffic Loadings	1	40	12
c. Pavement Material Properties (material tests)	20	13	18
d. Subgrade Properties (soil tests)	17	14	20
e. Existing Surface Distress	5	41	6
f. Deflection Data	16	14	19
g. Roughness	13	36	3
h. Skid Resistance	10	39	2
i. Climatic Factors	30	15	7

j. Other (10) Cores (6), Asphalt extraction, Performance history Public hearings, Groundwater level

2. Please check which overlay thickness design procedure your agency uses to design flexible (asphalt) overlays for existing flexible (asphalt) or rigid (concrete) pavements.

	Existing Flexible	Existing Rigid
a. Engineering Judgment	34	29
b. Standard Thickness policy (specified thickness for each functional highway classification: Interstate, Primary, etc.)	12	17
c. If so, what thicknesses have been used on most primary and interstate overlays ?	4,2-2.5,3+ 3+,1.25,1+ 1.25M, 2.5	3,4,2-2.5,4,3 1.25,4M,3-6, 3+,4,1.5M,2.5
d. Analytical Procedure based on Estimating Material Coefficients (AASHTO eq., etc.)	28	19
e. Analytical Procedures based on Deflection testing	27	9
f. Distress Identification related to Specific Thickness	10	7
g. Mechanistic Models (elastic layered theory, stress-strain calculation, etc.)	7	4
h. Other State's own procedures (3), California DOT, PCA, Pennsylvania DOT	4	3
i. None designed to date	0	3

3. Please check which overlay thickness design procedure your agency uses to design rigid (concrete) overlays for existing flexible (asphalt) or rigid (concrete) pavements.

	Existing Flexible	Existing Rigid
a. Engineering Judgment	3	7
b. Standard Thickness policy (specified thickness for each functional highway classification: Interstate, Primary, etc.)	2	0
c. If so, what thicknesses have been used on most primary and interstate overlays ?	8, 9-10	
d. Analytical Procedure based on Estimating Material Coefficients (AASHTO eq., etc.)	7	8
e. Analytical Procedures based on Deflection testing	5	3
f. Distress Identification related to Specific Thickness	0	1
g. Mechanistic Models (elastic layered theory, stress-strain calculation, etc.)	3	2
h. None designed to date	28	27
i. Designed on experimental basis only	13	
j. Other PCA (2), AASHTO, Corps of Engineers	2	6

4. Please check at which level within your agency overlay thicknesses are designed.

a. Central Office 32
b. Disrtict Office 6
c. Central Office and District Office 18
d. Other 2
Committee,Materials Testing and Research Branch

5. If you have an overlay thickness design procedure, was it checked against actual performance over time ?

a. No 35 or Yes 11 (plus four others just beginning or informally done)
b. If yes, how many sections were included in the study ?
   (4,20,22,24,25,34,40,44,80)
c. If yes, how many times were the sections evaluated ?
   (1,1,1,2+,3,3-7,continuously)
d. If yes, how many years did the evaluation period cover ?
   (1-3,2,3,5+,10,10)
e. If yes, what was the range of original pavement ages included ?
   (10-15,12-16,12+,15,15-25)
f. If yes, what was the range of overlay ages included ?
   (0-15,1-3,3-8,5-12,7-16)
g. Check the type of data collected :
   9 1. Distress
   8 2. Roughness
   8 3. Deflections
   5 4. Skid Resistance
   12 5. Traffic
   ___ 6. Other

6. Please check the appropriate description of the level of automation of your overlay thickness design procedure :

	Flexible Overlay	Rigid Overlay
a. Design Equations	20	18
b. Charts and/or nomographs	35	22
c. Batch input to mainframe computer	4	2
d. Interactive computer program on mainframe	5	1
e. Interactive computer program on microcomputer	2	1
f. Other HP 41CV, Fill program by profilometer, Computerized analytical procedure	3	1

7. If deflection equipment is used, please check which equipment was used as the basis of the Original (O) overlay design procedure, which equipment may also be used in the design at the Present (P) time, and which equipment is being evaluated for Future (F) use.

	Original Procedure	Presently Used	In the Near Future
a. Benkelman Beam	19	10	13
b. Curve Meter	0	0	0
c. Plate Bearing	3	0	0
d. Travelling Deflectometer	1	0	0
e. La Croix Deflectograph	0	0	0
f. Dynaflect	7	20	18
g. Road Rater Model 400	1	4	3
h. Road Rater Model 400 B	0	1	4
i. Road Rater Model 510	0	0	0
j. Road Rater Model 2000	0	2	1
k. Road Rater Model 2008	0	1	0
l. Dynatest Falling Weight Deflectometer	0	2	13
m. KUAB Falling Weight Deflectometer	0	1	3

n. Other Cox Device, Dehlen Curve Meter

8a. Please enter the overall effectiveness (P - Poor, M - Marginal, G - Good) for the methods used to reduce reflection cracking in flexible (asphalt) overlays over flexible (asphalt) existing pavements based on usage by your agency :

	Existing Flexible P	M	G
a. Increased overlay thickness.	3	16	23
b. Engineering fabrics.	9	18	12
c. Stress-absorbing membrane (asphålt rubber interlayer SAMI).	6	11	8
d. Crack arresting interlayer (open aggregate layer Arkansas/Tennessee method, etc.).	1	2	4
e. Heater-scarify flexible pavement prior to overlay.	6	11	7

f. Other
P - Asbestos additive
M - Fiberized hot mix, Sheet asphalt, Milling, Surface treatment, Polyester fiber modified
M-G Crack sealing
G - Recycle (3), Crack seal (2), Chip seal - Surface treatment

8b. Please enter the overall effectiveness (P - Poor, M - Marginal, G - Good) for the methods used to reduce reflection cracking in flexible (asphalt) overlays over rigid (concrete) existing pavements based on usage by your agency :

	Existing Rigid P	M	G
a. Increased overlay thickness.	6	17	12
b. Engineering fabrics.	12	17	4
c. Stress-absorbing membrane (asphalt rubber interlayer SAMI).	3	5	5
d. Crack arresting interlayer (open aggregate layer Arkansas/Tennessee method, etc.).	2	5	5
e. Break and seat rigid pavement prior to overlay.	3	5	7
f. Saw joints in overlay above joints in existing pavement and seal	0	2	8

g. Other P - Asbestos additive, Crack seal
M - Fiberized hot mix, Sheet asphalt, Repair joints
G - Recycle

9. Please check the appropriate description of pre-overlay treatment your agency employs for flexible (asphalt) overlays over existing flexible (asphalt) and rigid (concrete) pavements.

	Existing Flexible	Existing Rigid
a. Little or none	3	2
b. Tack coat	45	34
c. Potholes filled	35	24
d. Minimal patching of potholes and severe areas (alligator cracking joint breakup, etc.)	14	12
e. Moderate patching which includes all potholes and moderately deteriorated areas (alligator cracking, joint breakup, etc.)	28	18
f. Major patching which includes all potholes and most deteriorated areas (alligator cracking, joint breakup, etc.)	23	26
g. Leveling course used to fill ruts	46	21
h. Cold milling used to remove ruts	34	7
i. Other	8	4

F - Seal cracks, Mill, and Recycle, Heater scarify (2), Clean, rout, and seal cracks, Rout and clean, skin patch
R - Bond breaker, Clean and reseal joints (2), Underseal

APPENDIX B

DETAILED QUESTIONNAIRE RESPONSES

1. WHAT DATA IS COLLECTED ? N = NOT COLLECTED R = ROUTINELY COLLECTED
T = FOR THICKNESS DESIGN ONLY

AGENCY	A	B	C	D	E	F	G	H	I	J
ALABAMA	R	T	N	T	R	N *	R	R	N	CORES * OCCASIONALLY
ALASKA		R	T	T	R	R	R	N	N	
ARIZONA	R	R	T	T	R	T	R	R	R	
ARKANSAS	R	R	R	N	R*		R	R	N	* OCCASIONALLY
CALIFORNIA	N	R	N	N	R	T	R	R	R	THICK OF AC, TYPE OF BASE
COLORADO	T	R	T	T	R	T	N	R	N	
CONNECTICUT	R	R	N	N	R	N	R	R	R	
DELAWARE	R	R	R	R	R	N	N	R	N	
D OF C	R	N	N	R	R	N	R	R	N	
FLORIDA	R	R	T	T	R	T	R	R	N	SURFACE TEMP, AC EXTRACTION
GEORGIA	R	R	T	R	R	T	R	R	N	
HAWAII	T	RT	N	N	T	N	N	N	T	T PERFORMANCE HISTORY
IDAHO	R	R	R	R	R	R	R	R	R	
ILLINOIS	R	R	R	N	R	N	N	N	N	
INDIANA	R	R	N	N	R	R	R	R	R	
IOWA	R	R	R	R	RT	T	R	R	R	
KANSAS	T	R	T	T	T	RT	RT	R	T	
KENTUCKY	R	R	N	N	R	*	R	R	N	* OCCASIONALLY
LOUISIANA	T	T	N	T	R	T	N	N	N	PUBLIC HEARING
MAINE	R	R	R*	R*	N	R*	N	R	N	* OCCASIONALLY
MARYLAND	T	R	N	T	R	T	R	R	T	CORES
MASSACHUSETTS	R	R	N	R	R	N	R	R	N	
MICHIGAN	R	T	N	N	T		R	R	R	
MINNESSOTA	R	T	T	T	R	T	R	NR	NR	CORES
MISSISSIPPI	R	R	N	R*	N	*T	R	R	N	* OCCASIONALLY
MISSOURI	R	T	T	T	R	*T	R	N	N	* OCCASIONALLY
MONTANA	R	R	N	N	R	N	N	N	R	
NEBRASKA	R	R	R	N	R	R	R	R	N	
NEVADA	T	RT	T	T	R	T	R	R	RT	
NEW HAMPSHIRE	R	R	R	N	R	N	R	R	R	
NEW JERSEY	R	R	R	R	R	N	R	R	N	
NEW MEXICO	R	R	R	R	R	R	R	R	R	
NEW YORK	R	R			R		R	R		
NORTH CAROLINA	R	R	N	N	R	R	N	N	R	
NORTH DAKOTA	R	R	N	*T	N	N	N	N	N	* OCCASIONALLY
OHIO	T	T	T	T	R	T	R	R	N	CORES
OKLAHOMA	R	R	N	R	N	N	N	N	N	
OREGON	T	T	T	T	R	T	T	R	T	ALL DONE OCCASIONALLY
PENNSYLVANIA	R	T	N	T	R	T	N	N	N	
RHODE ISLAND	N	T	T	N	T	N	N	T	T	CORES
SOUTH CAROLINA	T	T	T	T	T	T	T	T	T	
SOUTH DAKOTA	R	R	R	R	R	R	R	R	R	
TENNESSEE	R	R	N *	N	N	N	N	R	N	CORES - OBSERVE STRIPPING
TEXAS		R	T	T	*	R	R	*	*	* OCCASIONALLY
UTAH	R	R	T	T	R	R	R	R	N	
VERMONT	T	R	N	N	R	N	R	R	N	
VIRGINIA	R	R	*T	N	R	*T	R	R	N	* OCCASIONALLY
WASHINGTON		R	T	T	R	T	R	R	N	
WEST VIRGINIA	R	R	R	R	R	R	R	R	R	
WISCONSIN	R	T	N *	N	R	N	R	R	N	* ONLY COLLECTED FOR RECYCLE
WYOMING	R	R	T	T	R	R	R	R	N	
PUERTO RICO	R	R	R	R	R	R	N	R	N	GROUNDWATER LEVEL

A - EXISTING DESIGN
B - TRAFFIC LOADINGS
C - PAVEMENT MATERIAL PROPERTIES
D - SUBGRADE PROPERTIES
E - EXISTING SURFACE DISTRESS
F - DEFLECTION DATA
G - ROUGHNESS
H - SKID RESISTANCE
I - CLIMATIC FACTORS
J - OTHER

2. DESIGN PROCEDURE FOR AC OVERLAYS OF: F = FLEXIBLE R = RIGID PAVEMENTS

AGENCY	A	B	C	D	E	F	G	H	I	J
ALABAMA										
ALASKA	F			F			F		R	* OCCASIONALLY
ARIZONA	F R			F	F			F		CAL DOT, ADOT
ARKANSAS				F R						
CALIFORNIA	R	R	3		F	F				
COLORADO				F	F					
CONNECTICUT	F R	F R								
DELAWARE	F R	F R	4X							1.8BASE,1.2 SURF,1 OGS
D OF C	F R	F R	2-2.5			F R	F R			
FLORIDA		F R			F		F	F		AASHTO ON RECYC
GEORGIA	F	R	4							
HAWAII				F					R	
IDAHO	F R			F		F				
ILLINOIS		R		F R						
INDIANA	F R				F R					
IOWA	F				F R					
KANSAS	F	F R			F			R		PCA
KENTUCKY	F R				F**R	F R	F R			* OCCASIONALLY
LOUISIANA	F R			F R	F R	F R				
MAINE	F	F	1.25	F R						
MARYLAND	F R	R	4M	F R	F	F				
MASSACHUSETTS	R			F						
MICHIGAN	F R					F R				ROAD DES. NOTES
MINNESSOTA	F R	R	3-6	F R	F	R	F			
MISSISSIPPI	F R	F R	3+3+	F R	F**R					* OCCASIONALLY
MISSOURI		F R	1+ 3							
MONTANA	F R	F		F						
NEBRASKA		R	4		F		F			
NEVADA	F	F	1.5M	F R	F	F				
NEW HAMPSHIRE	F			F						
NEW JERSEY	F R			F R		F R				
NEW MEXICO	F R	R		F R						
NEW YORK	F R	F R	2.5			F				
NORTH CAROLINA				F R	F					
NORTH DAKOTA	F R									
OHIO	F R	F R	X X	F R	F R		F R			SEC-.8,PRI-1.5,INT-2.5
OKLAHOMA	F R			R		R				
OREGON	R				F			R		
PENNSYLVANIA				F R	F					
RHODE ISLAND				F R						
SOUTH CAROLINA	F R			F R						
SOUTH DAKOTA					F					
TENNESSEE	F R			F	F					
TEXAS	F R			F R	F**R		R			* OCCASIONALLY
UTAH	F				F				R	
VERMONT	F R									
VIRGINIA	F R									
WASHINGTON				R	F			F		WASH. FLEX PVT. DES
WEST VIRGINIA	F R				F R			F R		CALIF.+PENN. METHOD
WISCONSIN				F R	F**R					* OCCASIONALLY
WYOMING				F	F					
PUERTO RICO	F R	R	3	F	F					

A - ENGINEERING JUDGMENT
B - STANDARD THICKNESS
C - THICKNESS USED (in)
D - ANALYTICAL PROCEDURE BASED ON MATERIAL COEFFICIENTS
E - ANALYTICAL PROCEDURE BASED ON DEFLECTION
F - DISTRESS ID RELATED TO SPECIFIC THICK
G - MECHANISTIC MODELS
H - OTHER
I - NONE DESIGNED TO DATE
J - PUBLISHED PROCEDURE

3. DESIGN PROCEDURE FOR PCC OVERLAYS OF: F = FLEXIBLE R = RIGID PAVEMENTS

AGENCY	A	B	C	D	E	F	G	H	I	J
ALABAMA								F R		
ALASKA								F R		
ARIZONA								F R		
ARKANSAS				R				F		
CALIFORNIA									*	
COLORADO								F R		
CONNECTICUT								F R		
DELAWARE								F R		
D OF C										
FLORIDA								F R	*	
GEORGIA									*	F R AASHTO ASSIGN "K"
HAWAII				F				R		
IDAHO								F R		
ILLINOIS									*	
INDIANA									*	
IOWA	R				F R					
KANSAS								F	*	R PCA
KENTUCKY								F R		
LOUISIANA									*	
MAINE				R						
MARYLAND									*	
MASSACHUSETTS								F R		
MICHIGAN	R							F	*	
MINNESSOTA	R					R				
MISSISSIPPI				R				F R		
MISSOURI								F R		
MONTANA										
NEBRASKA				F			F	R		
NEVADA	F	F	8	F R	F					
NEW HAMPSHIRE								F R		
NEW JERSEY								F R		
NEW MEXICO	R							F	*	
NEW YORK									*	
NORTH CAROLINA								F		R CORPS OF ENG
NORTH DAKOTA								F R		
OHIO				F R	F R		F R		*	
OKLAHOMA		F	9-10					R		
OREGON					F					F R PCA
PENNSYLVANIA										R CORPS OF ENG
RHODE ISLAND								F R		
SOUTH CAROLINA								F R		
SOUTH DAKOTA								R		
TENNESSEE								F R		
TEXAS	F R				F R		F R			R CORPS OF ENG
UTAH				F				R		
VERMONT								F R		
VIRGINIA								F R		
WASHINGTON				F R						
WEST VIRGINIA								F R		
WISCONSIN	F R			F R						
WYOMING	R			R				F	*	
PUERTO RICO								F R		

A - ENGINEERING JUDGMENT
B - STANDARD THICKNESS
C - THICKNESS USED (in)
D - ANALYTICAL PROCEDURE BASED ON MATERIAL THICKNESSES
E - ANALYTICAL PROCEDURE BASED ON DEFLECTION TESTING
F - DISTRESS ID RELATED TO SPECIFIC THICK
G - MECHANISTIC MODELS
H - NONE DESIGNED TO DATE
I - EXPERIMENTAL ONLY
J - OTHER

4. AT WHICH LEVEL WITHIN YOUR AGENCY ARE OVERLAY THICKNESSES DESIGNED ?

AGENCY	A	B	C	D	
ALABAMA			X		
ALASKA			X		
ARIZONA	X				
ARKANSAS			X		
CALIFORNIA	X				
COLORADO		X			
CONNECTICUT	X				
DELAWARE	X				
D OF C	X				
FLORIDA			X		
GEORGIA	X				
HAWAII	X			X	MATERIAL TESTING AND RESEARCH BRANCH
IDAHO			X		
ILLINOIS		X			
INDIANA	X				
IOWA	X				
KANSAS			X		
KENTUCKY	X				
LOUISIANA	X			X	COMMITTEE
MAINE	X				
MARYLAND			X		
MASSACHUSETTS	X				
MICHIGAN			X		
MINNESSOTA			X		
MISSISSIPPI			X		
MISSOURI	X				
MONTANA	X				
NEBRASKA	X				
NEVADA	X				
NEW HAMPSHIRE	X				
NEW JERSEY			X		
NEW MEXICO	X				
NEW YORK		X			
NORTH CAROLINA	X				
NORTH DAKOTA	X				
OHIO	X				
OKLAHOMA	X				
OREGON	X				
PENNSYLVANIA			X		
RHODE ISLAND	X				
SOUTH CAROLINA	X				
SOUTH DAKOTA	X				
TENNESSEE	X				
TEXAS	X	X	X		VARIES FROM PROJECT TO PROJECT
UTAH			X		
VERMONT	X				
VIRGINIA		X			
WASHINGTON			X		
WEST VIRGINIA			X		
WISCONSIN		X	X		
WYOMING	X		X		
PUERTO RICO	X				

A - CENTRAL OFFICE
B - DISTRICT OFFICE
C - CENTRAL AND DISTRICT OFFICE
D - OTHER

5. IF YOU HAVE AN OVERLAY DESIGN PROCEDURE, WAS IT CHECKED OVER TIME ?

AGENCY	A	B	C	D	E	F	G	H	I	J	K	L	
ALABAMA													
ALASKA	N												
ARIZONA	Y	24	3-7	10		3-8	X	X	X		X		
ARKANSAS	N												
CALIFORNIA	Y	40	1			7-16	X	X		X	X		
COLORADO	N												
CONNECTICUT	N												
DELAWARE	N												
D OF C	N												
FLORIDA	N												
GEORGIA	Y	20		5+	15		X	X	X	X	X		
HAWAII	Y		1				X				X		
IDAHO	N												
ILLINOIS	Y	80				0-15	X	X			X		
INDIANA													
IOWA	N												
KANSAS	Y	25	1	3	10-15								
KENTUCKY	N												
LOUISIANA	N												
MAINE	Y	34		1-3	15-25		X	X	X		X		
MARYLAND	N												
MASSACHUSETTS	N												
MICHIGAN													
MINNESSOTA	N												BEGINNING
MISSISSIPPI	Y	44	2+	2	12-16	1-3			X		X		
MISSOURI	N												
MONTANA	N												
NEBRASKA	Y	4	3	10	12+	5-12	X	X	X	X	X		
NEVADA	N												
NEW HAMPSHIRE	N												
NEW JERSEY	N												
NEW MEXICO	N						X	X	X	X	X		INFORMALLY
NEW YORK	N												
NORTH CAROLINA													
NORTH DAKOTA													
OHIO	N												
OKLAHOMA													
OREGON	Y								X		X		INFORMALLY
PENNSYLVANIA	N												
RHODE ISLAND	N												
SOUTH CAROLINA	N												
SOUTH DAKOTA	Y	22	*						X		X		* CONT. UPDATED
TENNESSEE	N												
TEXAS	N												
UTAH	N												
VERMONT	N												
VIRGINIA	N												
WASHINGTON	N						X	X		X	X		BEGINNING
WEST VIRGINIA	N												BEGINNING
WISCONSIN	N												
WYOMING	N												
PUERTO RICO	N												

A - YES OR NO
B - HOW MANY SECTIONS
C - HOW MANY TIMES WERE SECTIONS EVALUATED
D - HOW MANY YEARS DID EVALUATION COVER
E - RANGE OF ORIGINAL PAVEMENT AGES
F - RANGE OF OVERLAY AGES
G - DISTRESS
H - ROUGHNESS
I - DEFLECTIONS
J - SKID
K - TRAFFIC
L - OTHER

6. CHECK THE APPROPRIATE DESCRIPTION OF THE LEVEL OF AUTOMATION OF YOUR OVERLAY THICKNESS DESIGN PROCEDURE.

AGENCY	A	B	C	D	E	F
ALABAMA						
ALASKA		F				
ARIZONA			F	F		
ARKANSAS		F R				
CALIFORNIA		F				
COLORADO				F		
CONNECTICUT						NONE
DELAWARE						
D OF C	F R	F R				
FLORIDA		F				
GEORGIA						NONE
HAWAII		F R				
IDAHO		F				
ILLINOIS	F R	F R				
INDIANA						
IOWA	F R	F R				
KANSAS	F R	F R				
KENTUCKY	F R	F R	F			
LOUISIANA	F	F				
MAINE	F R					
MARYLAND	R	F				
MASSACHUSETTS		F				
MICHIGAN		F R				
MINNESSOTA	F R	F		F*	F*R	* FUTURE
MISSISSIPPI	F R	F R		F*		* OCCASIONALLY
MISSOURI						F R BASED ON PAVEMENT TYPE
MONTANA	F R	F R				
NEBRASKA				F R		
NEVADA	F R	F R	F R			
NEW HAMPSHIRE	F	F				
NEW JERSEY	F R	F R				
NEW MEXICO	F	F				NONE FOR RIGID
NEW YORK						
NORTH CAROLINA	F R					
NORTH DAKOTA						NONE
OHIO	F R	F R				F R AASHTO DESIGN EQ. ON HP 41CV
OKLAHOMA		F R				
OREGON	F R	F R				
PENNSYLVANIA	F R	F R				
RHODE ISLAND		F R				
SOUTH CAROLINA		F R				
SOUTH DAKOTA		F				
TENNESSEE						F R EXPERIENCE AND JUDGMENT
TEXAS	R	F R	F R			
UTAH		F				
VERMONT		F				
VIRGINIA						NONE
WASHINGTON		F R				
WEST VIRGINIA	F				F	F FILL PROGRAM BY PROFILOMETER
WISCONSIN		F R				
WYOMING	F R	F R				F COMPUTERIZED ANALYTICAL PROCEDURE
PUERTO RICO						

A - DESIGN EQUATIONS
B - CHARTS AND NOMOGRAPHS
C - BATCH INPUT TO MAINFRAME
D - INTERACTIVE COMPUTER PROGRAM ON MAINFRAME
E - INTERACTIVE COMPUTER PROGRAM ON A MICRO
F - OTHER

7. IF DEFLECTION EQUIPMENT IS USED,CHECK WHICH TYPE OF DEVICE WAS USED AS A BASIS FOR THE ORIG. (O) OVERLAY DESIGN PROCEDURE, PRES. (P), AND FUT.(F)

AGENCY	A	B	C	D	E	F	G	H	I	J	K	L	M	N
ALABAMA	P											F		
ALASKA	O												PF	
ARIZONA						OPF						F		
ARKANSAS	O					PF								
CALIFORNIA	O			O		P	P							P COX,DEHLEN
COLORADO						OPF								
CONNECTICUT														NONE
DELAWARE														
D OF C	P					F								
FLORIDA	O		O			OPF						F		
GEORGIA	OP					OP								
HAWAII														NONE
IDAHO						PF								
ILLINOIS											P			
INDIANA						F								
IOWA	O		O				PF							
KANSAS						PF								
KENTUCKY	OPF						PF							
LOUISIANA														
MAINE	OP							F						
MARYLAND							O	PF						
MASSACHUSETTS								F						
MICHIGAN														
MINNESSOTA	OP		O							PF		PF		
MISSISSIPPI						PF								
MISSOURI														
MONTANA	O							F						
NEBRASKA	O					PF								
NEVADA	O					PF						F		
NEW HAMPSHIRE														NOT YET
NEW JERSEY														
NEW MEXICO	O									P				
NEW YORK												F		
NORTH CAROLINA	P					F						F		
NORTH DAKOTA												F		
OHIO						PF								
OKLAHOMA														
OREGON	OPF					PF								
PENNSYLVANIA						P	F							
RHODE ISLAND	O													
SOUTH CAROLINA						F								
SOUTH DAKOTA						OPF								
TENNESSEE							P					F		
TEXAS						P						F	F	
UTAH	O					PF								
VERMONT														NOT USED
VIRGINIA	O					PF								
WASHINGTON	O											PF		
WEST VIRGINIA						OP						F OR F		
WISCONSIN	OPF													
WYOMING						OP						F		
PUERTO RICO	P													

A - BENKLEMAN BEAM
B - CURVE METER
C - PLATE BEARING
D - TRAVELLING DEFLECOMETER
E - LACROIX DEFLECTOMETER
F - DYNAFLECT
G - ROAD RATER 400
H - ROAD RATER 400D
I - ROAD RATER 510
J - ROAD RATER 2000
K - ROAD RATER 2008
L - DYNATEST FWD
M - KUAB FWD
N - OTHERS

8A. EFFECTIVENESS (P - POOR M - MARGINAL G - GOOD) FOR THE METHODS USED TO REDUCE REFLECTION CRACKING IN AC OVERLAYS OF EXISTING AC PAVEMENTS.

AGENCY	A	B	C	D	E	F
ALABAMA						
ALASKA	M	M				
ARIZONA	M	P	G		M	
ARKANSAS	G	M	M	G	G	
CALIFORNIA	G		G		MG	
COLORADO	G	M	M		M	
CONNECTICUT	G	G			G	
DELAWARE	G		G			M (EXPERIMENTAL) FIBERIZED HOT MIX
D OF C						P ASBESTOS ADDITIVE M SHEET ASPHALT
FLORIDA	M	M		M	M	G RECYCLE
GEORGIA	M					
HAWAII		G				G CRACK SEAL G COLD PLANE OR SCARIFY
IDAHO	M	M	G		P	
ILLINOIS						
INDIANA	P	P		P		
IOWA	MG	MG			MG	
KANSAS	M	M	M		M	
KENTUCKY	G					M MILLING
LOUISIANA	M					
MAINE	G	P	P			
MARYLAND	G					
MASSACHUSETTS	G	P	P	M	M	
MICHIGAN	M	P	M		P	
MINNESSOTA	G	M	G		P	
MISSISSIPPI		G	G		M	M SURFACE TREATMENT
MISSOURI	M					
MONTANA						
NEBRASKA	G	G			P	G RECYCLED
NEVADA		MG	M		G	
NEW HAMPSHIRE	M	G	P		G	
NEW JERSEY	G			G		
NEW MEXICO	G	PM	M	G	M	M-G CRACK SEALING
NEW YORK	M	PM				
NORTH CAROLINA	G	M	M			
NORTH DAKOTA	P	M				
OHIO	G	M	M			
OKLAHOMA	M	G	M			
OREGON	G		M			
PENNSYLVANIA	G	G	G			
RHODE ISLAND	P	G				
SOUTH CAROLINA	G	M				G CHIP SEAL-SURFACE TREATMENT
SOUTH DAKOTA		M				
TENNESSEE	G					
TEXAS	G				PM	
UTAH	G		P		G	
VERMONT	M	P	P			M POLYESTER FIBER MODIFIED OVERLAY
VIRGINIA	G	G				
WASHINGTON	M	M	P	G	P	
WEST VIRGINIA		M	G			
WISCONSIN	M	P			M	G HOT RECYCLE FULL DEPTH
WYOMING		G	M			
PUERTO RICO						REMOVE AND REPLACE FAILED SECTIONS

A - INCREASED OVERLAY THICKNESS
B - ENGINEERING FABRICS
C - STRESS-ABSORBING MEMBRANE INTERLAYER
D - CRACK-ARRESTING INTERLAYER
E - HEATER-SCARIFY AC PAVEMENT PRIOR TO OVERLAY
F - OTHER

8B. EFFECTIVENESS (P - POOR M - MARGINAL G - GOOD) FOR THE METHODS USED TO REDUCE REFLECTION CRACKING IN AC OVERLAYS OF EXISTING PCC PAVEMENTS.

AGENCY	A	B	C	D	E	F	
ALABAMA							
ALASKA							
ARIZONA			G		G	G	
ARKANSAS	M	M	M	M			
CALIFORNIA					G		
COLORADO	G	M	M		P		
CONNECTICUT	G	G				G	
DELAWARE	G	P	G				M FIBERIZED HOT MIX
D OF C							P ASBESTOS ADDITIVE M SHEET ASPHALT
FLORIDA	M	M		M	M		G RECYCLE
GEORGIA	M	M	G	G			
HAWAII							
IDAHO							
ILLINOIS	M	M					
INDIANA	P	P		P			
IOWA	M	MG					
KANSAS	P	P					
KENTUCKY	G				G		
LOUISIANA	M				M	M	
MAINE					G	G	
MARYLAND	M						
MASSACHUSETTS	M	P	P	M		G	
MICHIGAN	P	P			M	M	M REPAIR JOINTS
MINNESSOTA	G	P	M	P	G		
MISSISSIPPI					P*		* FAILED
MISSOURI	M						
MONTANA							
NEBRASKA	G	M		G			
NEVADA							
NEW HAMPSHIRE							NONE
NEW JERSEY	M	P				G	
NEW MEXICO	G	PM		G			P CRACK SEAL
NEW YORK	M	PM			M		
NORTH CAROLINA	G	M					
NORTH DAKOTA	P		P				
OHIO	G	P				G	
OKLAHOMA	M				M		
OREGON	G						
PENNSYLVANIA	M	G	G			G	
RHODE ISLAND	P	G				G	
SOUTH CAROLINA	G	M					
SOUTH DAKOTA		M					
TENNESSEE	M	M	MG				
TEXAS	G	PM		M			
UTAH							
VERMONT	P						
VIRGINIA	M	M					
WASHINGTON	M	M	P	G	P*		* NOT DONE EFFECTIVELY
WEST VIRGINIA		M	M	G			
WISCONSIN	M	P		M	G		
WYOMING							
PUERTO RICO					G		

A - INCREASED OVERLAY THICKNESS
B - ENGINEERING FABRICS
C - STRESS-ABSORBING MEMBRANE INTERLAYER
D - CRACK-ARRESTING INTERLAYER
E - BREAK AND SEAT RIGID PAVEMENT PRIOR TO OVERLAY
F - SAW JOINTS IN OVERLAY ABOVE JOINTS IN EXIST. PVT. AND SEAL
G - OTHER

9. APPROPRIATE DESCRIPTION OF PRE-OVERLAY TREATMENT YOUR AGENCY EMPLOYS FOR FLEXIBLE OVERLAYS OF EXISTING FLEXIBLE (F) AND RIGID (R) PAVEMENTS.

AGENCY	A	B	C	D	E	F	G	H	I	
ALABAMA		F R	F R			F	F R	F		
ALASKA		F	F				F			
ARIZONA		F	F	F	F	F	F	F	F	SEAL CRACKS
ARKANSAS		F			F	R	F		R	BOND BREAKER
CALIFORNIA										
COLORADO		F R	F R	F		R	F R			
CONNECTICUT		F R	F R		F R		F R			
DELAWARE		F R			F R	F R		F R		
D OF C		F R	F R	F R	F R	F R	F R	F R		
FLORIDA		F R	F R	F R	F R	F R	F R			ALL USED AND RECYCLING
GEORGIA		F R	F R	F R	F R	F R	F R	F R	F	MILL UP TO 4" AND RECYCLE
HAWAII		F			F		F			
IDAHO		F	F			F	F	F		
ILLINOIS		R	R	R	R		R			
INDIANA		F R	F R		F	R	F			
IOWA		F R	F			F R	F R	F		
KANSAS					F R		F R			
KENTUCKY		F	F R		F R		F	F		
LOUISIANA		F R	F R			F R	F R	F		
MAINE			F R	F R	F R	F R	F			
MARYLAND		F R	F R			F R	F R	F	R	CLEAN AND RESEAL JOINTS
MASSACHUSETTS		F R		F R			F R			
MICHIGAN	F*R	F R	F R		F*R	F*R	F	F*		* OCCASIONALLY
MINNESSOTA		F R	F R	F R	F R	F R	F R	F		
MISSISSIPPI		F R	F R		F	R	F	F		
MISSOURI		F R		F R			F R	F		
MONTANA		F	F		F		F	F		
NEBRASKA		F R	F R			F R	F	F		
NEVADA		F R	F	F	F	F	F	F	R	FABRIC OVER JOINTS
NEW HAMPSHIRE						F	F	F		
NEW JERSEY		F R			F R		F R	F		
NEW MEXICO		F R				F R	F	F R		
NEW YORK		F R	F	R	F R		F			
NORTH CAROLINA					F	R				
NORTH DAKOTA		F R		F R						
OHIO		F R			F	R	F R	F R	F	HEATER SCARIFY
OKLAHOMA						R		F		
OREGON		F R	F R	F R	F R	F R	F	F		ALL USED DEPENDING ON PVT COND
PENNSYLVANIA		F R	F R		F	R	F R	F		
RHODE ISLAND		F R	F R				F		F R	CLEAN,ROUT,SEAL ALL CRACKS,JTS
SOUTH CAROLINA		F	F R			F R	F	F		
SOUTH DAKOTA		F	F			F	F	F	F	ROUT AND CLEAN JOINTS
TENNESSEE		F R	F			R	F	F		CHIP SEAL,UNDERSEAL +DRAINS
TEXAS		F R	F		F R		F R	F		
UTAH	F	F	F	F			F		F	HEATER SCARIFY
VERMONT		F			F		F	F		
VIRGINIA		F R	F R		F R		F	F	F	SKIN PATCH R UNDERSEAL
WASHINGTON		F R	F R			F R	F R	F R		
WEST VIRGINIA		F R	F R		F R		F R	F R		
WISCONSIN	F R	F	F R	F R	F R	F R	F R			AS NEEDED
WYOMING		F R				R	F	F	F	CRACK OR SLURRY SEAL,MUD JACK
PUERTO RICO		F R	F			F	F	F		

A - LITTLE OR NONE
B - TACK COAT
C - POTHOLES FILLED
D - MINIMAL PATCHING OF POTHOLES AND SEVERE AREAS
E - MODERATE PATCHING - ALL POTHOLES AND MODERATELY DETERIORATED AREAS
F - MAJOR PATCH - ALL POTHOLES AND MOST DETERIORATED AREAS
G - LEVELING COURSE TO FILL RUTS
H - COLD-MILLING TO REMOVE RUTS
I - OTHER

10.HOW MANY YEARS HAS YOUR AGENCY BEEN USING THESE OVERLAY DESIGN PROCEDURES

AGENCY	A	B	C	D
GEORGIA	15 a	5 b	- h	10 h
				AASHTO ASSIGN K
MINNESSOTA	20+ a,d,e,g	20+ a,b,d,f	0	8+ a,f
MISSISSIPPI	15+ a,b,d,e	15+ a,b.d,e	0	12 d
OHIO	40+ a,b,d,g	40+ a,b,d,g	*10+ d,e,g	*10+ d,e,g
		RIGID OVERLAYS STOPPED IN 1940,BEGUN 1983		
TEXAS	MANY a,d,e	MANY a,d,e,g	10- a,e,g	MANY a,e,g
WASHINGTON	8 e,h	8 d	8 d	8 d
	WASH FLEX PVT.			

A - FLEXIBLE/FLEXIBLE C - RIGID/FLEXIBLE
B - FLEXIBLE/RIGID D - RIGID/RIGID

a - ENGINEERING JUDGMENT
b - STANDARD THICKNESS
c - THICKNESS USED (in)
d - ANALYTICAL PROCEDURE BASED ON MATERIAL COEFFICIENTS
e - ANALYTICAL PROCEDURE BASED ON DEFLECTION
f - DISTRESS ID RELATED TO SPECIFIC THICK
g - MECHANISTIC MODELS
h - OTHER
i - NONE DESIGNED TO DATE
j - PUBLISHED PROCEDURE

11. APPROXIMATELY HOW MANY PROJECTS HAS YOUR AGENCY DESIGNED AND CONSTRUCTED USING THESE OVERLAY DESIGN PROCEDURES ?

AGENCY	A	B	C	D
GEORGIA	50+	12	0	1
MINNESSOTA	MANY	MANY	2	2
MISSISSIPPI	100+	100+	0	2
OHIO	MANY	MANY	5-10	10-20 PRE 1940
			PRE 1940	4 SINCE 1983
TEXAS	MANY	MANY	10-	10-
WASHINGTON	500-800	20-30	0	5-10
				NONE BUILT

A - FLEXIBLE/FLEXIBLE C - RIGID/FLEXIBLE
B - FLEXIBLE/RIGID D - RIGID/RIGID

12. IF A NEW OVERLAY THICKNESS DESIGN PROCEDURE WAS BEING DEVELOPED OR TESTED, WHAT APPROACH IS BEING USED AND FOR WHAT TYPES OF OVERLAYS ?
FF - FLEXIBLE/FLEXIBLE　　RR - RIGID/RIGID
FR - FLEXIBLE/RIGID　　RF - RIGID/FLEXIBLE

AGENCY	A	B	C	D	E	F	G
GEORGIA				FR RR			
MINNESOTA		FF	FWD		FF		
MISSISSIPPI							
OHIO	FF FR RR RF	FF FR RR RF	DYNAFLECT			AASHTO GUIDE	
TEXAS		FR RR	DYNAFLECT OR FWD FWD				
WASHINGTON		FF	FWD		FF		

A - AASHTO INTERIM GUIDE STRUCTURAL DEFICIENCY
B - DEFLECTION BASED
C - IF DEFLECTION EQUIPMENT IS TO BE USED WHAT TYPE
D - DISTRESS
E - MECHANISTIC
F - OTHER
G - REFERENCE

13. IF A NEW PROCEDURE IS TO BE DEVELOPED, WHAT LEVEL OF AUTOMATION WILL IT HAVE FOR F - FLEXIBLE R - RIGID OVERLAY.

AGENCY	A	B	C	D	E	F
GEORGIA		F R				
MINNESOTA				F		
MISSISSIPPI						
OHIO	F R	F R				AASHTO ON HP 41CV
TEXAS						NOT SURE YET
WASHINGTON		F			F	

A - DESIGN EQUATIONS
B - CHARTS AND/OR NOMOGRAPHS
C - BATH INPUT TO MAINFRAME
D - INTERACTIVE WITH MAINFRAME
E - INTERACTIVE ON MICROCOMPUTER
F - OTHER

APPENDIX C

SENSITIVITY FIGURES

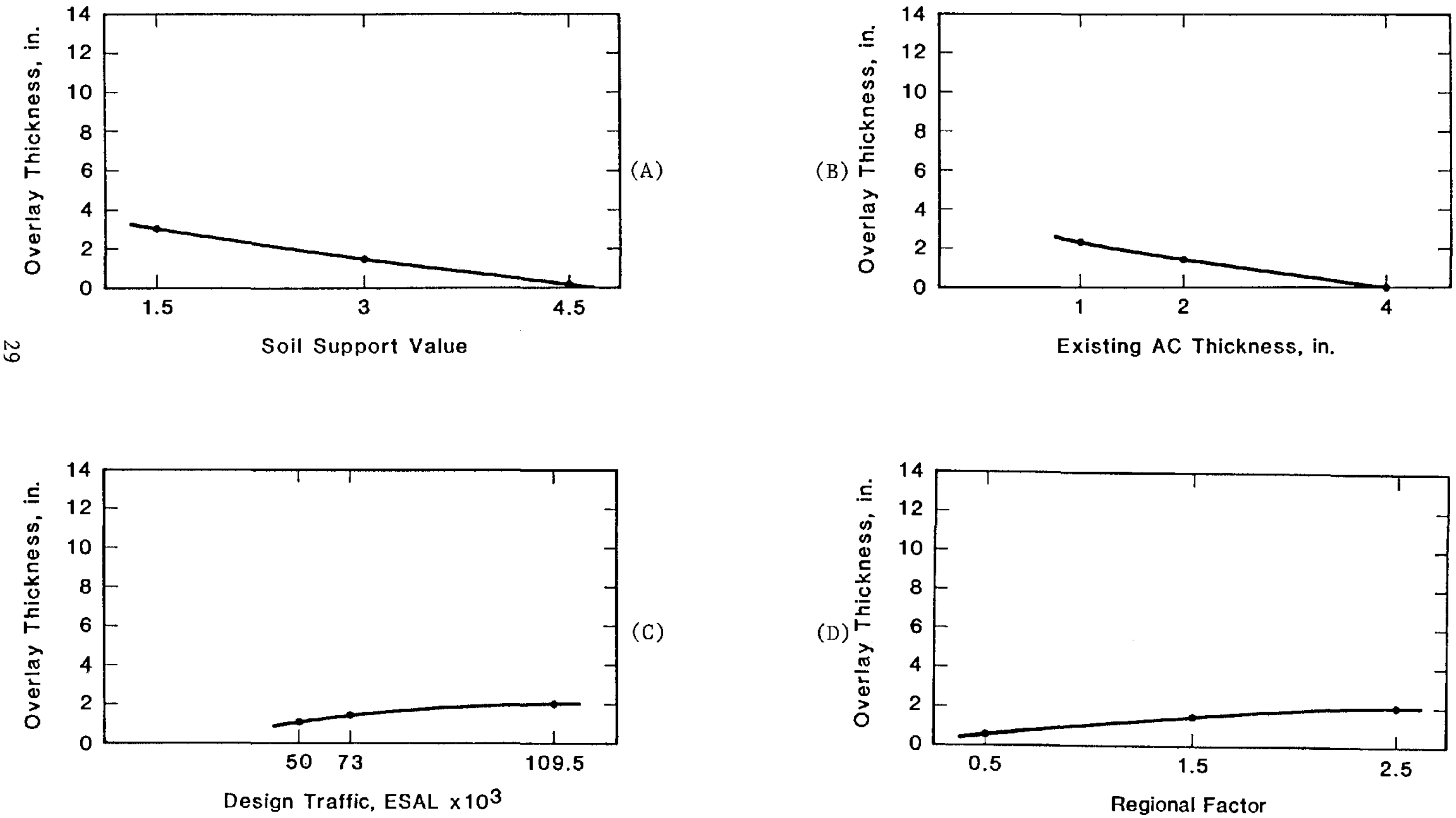


Figure 1. Sensitivity of AASHTO Flexible Overlay Design of Flexible Pavements to: (A) Soil Support Value, (B) Existing AC Thickness, (C) Design Traffic, and (D) Regional Factor (1 in = 25 mm).

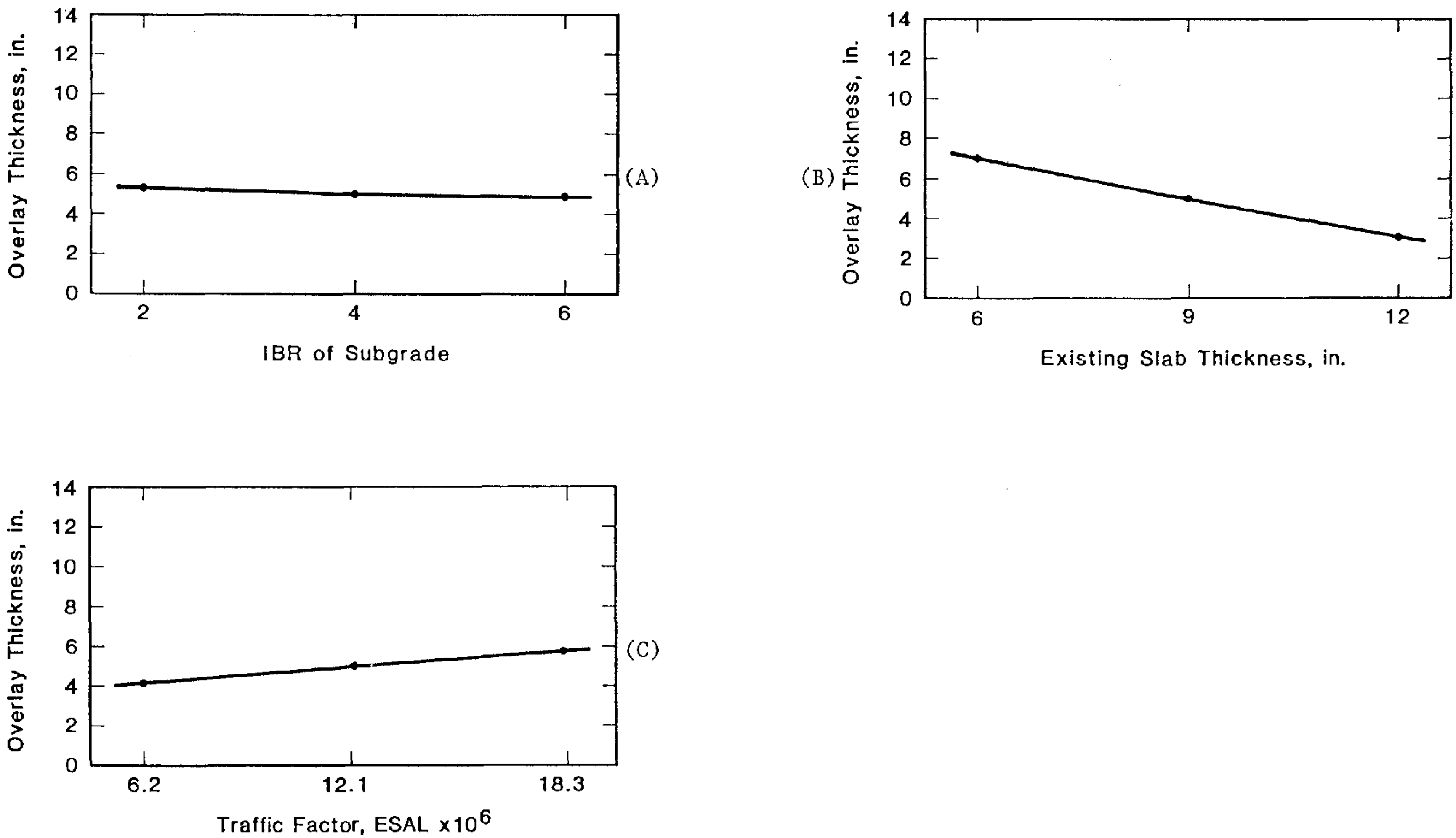


Figure 2. Sensitivity of Illinois Department of Transportation Flexible Overlay Design of Rigid Pavements to: (A) IBR of Subgrade, (B) Existing Slab Thickness, and (C) Traffic (IBR is similar to CBR, 1 in = 25 mm).

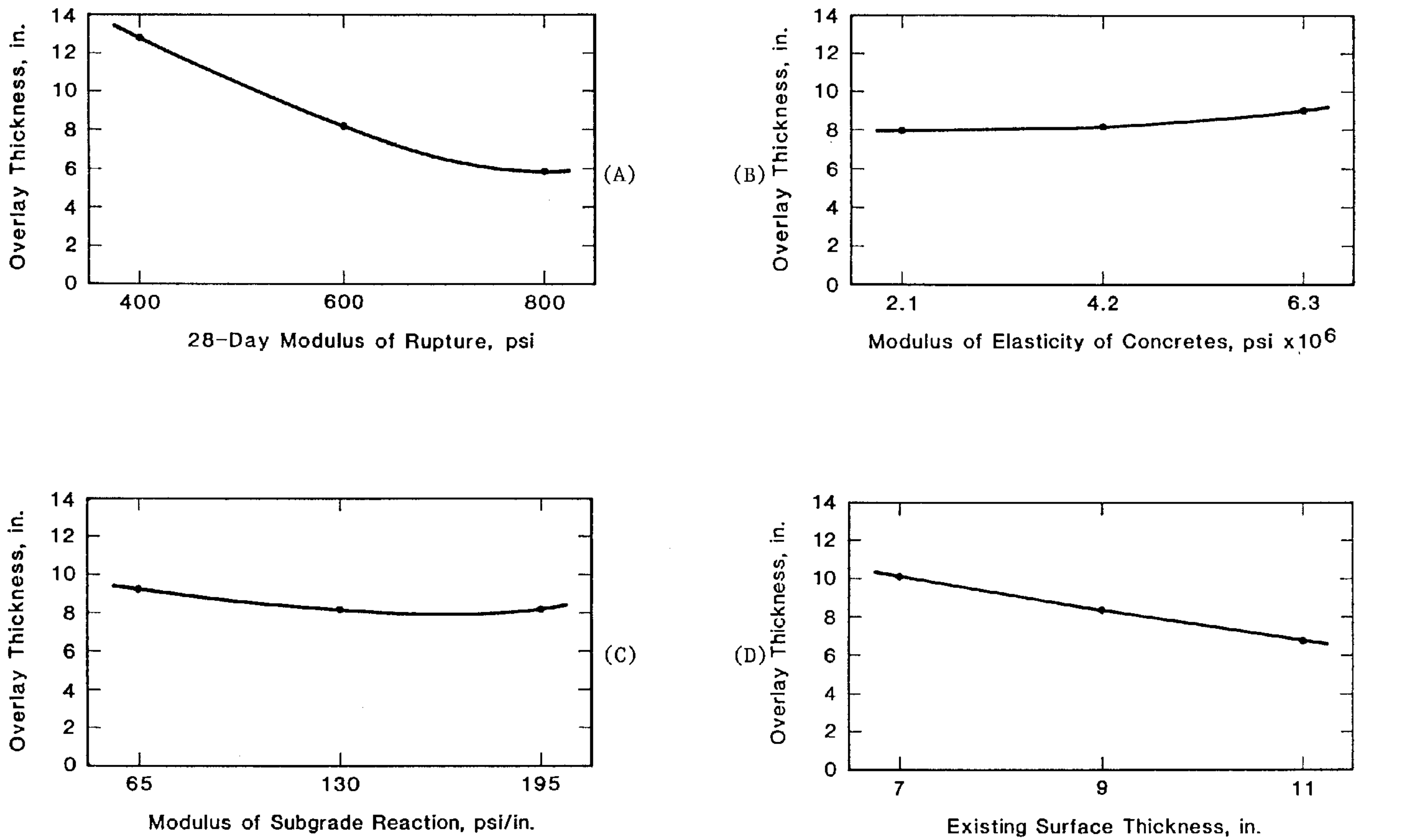


Figure 3. Sensitivity of AASHTO/COE Rigid Overlay Design for Rigid Pavements to: (A) Modulus of Rupture, (B) Modulus of Elasticity, (C) Modulus of Subgrade Reaction, (D) Surface Thickness (E) Traffic, (F) Condition, and (G) Bond (1 in = 25 mm, 1 psi = 6.9 kN/m^2).

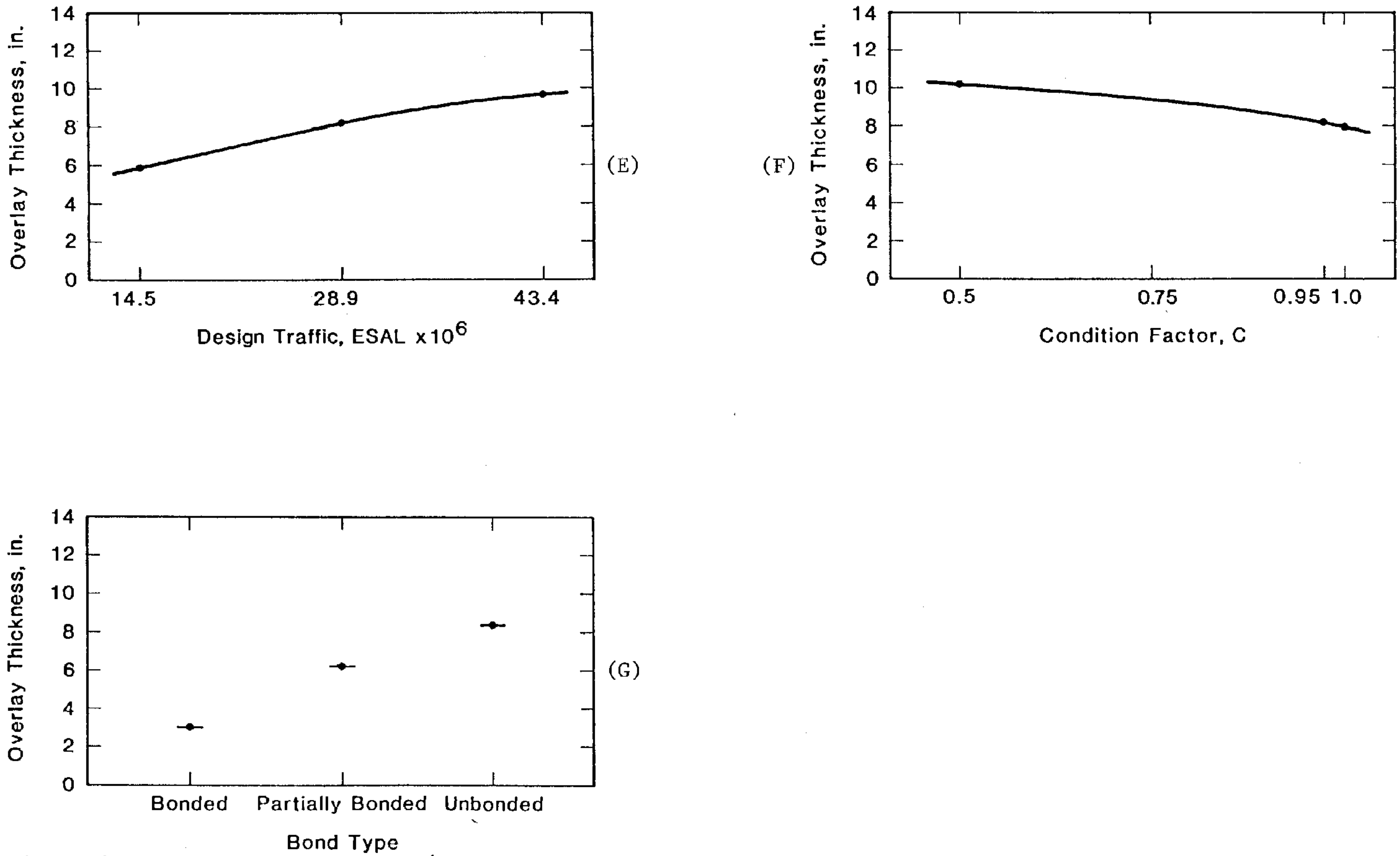


Figure 3. Sensitivity of AASHTO/COE Rigid Overlay Design for Rigid Pavements to: (A) Modulus of Rupture, (B) Modulus of Elasticity, (C) Modulus of Subgrade Reaction, (D) Surface Thickness (E) Traffic, (F) Condition, and (G) Bond (1 in = 25 mm, 1 psi = 6.9 kN/m^2). (Continued)

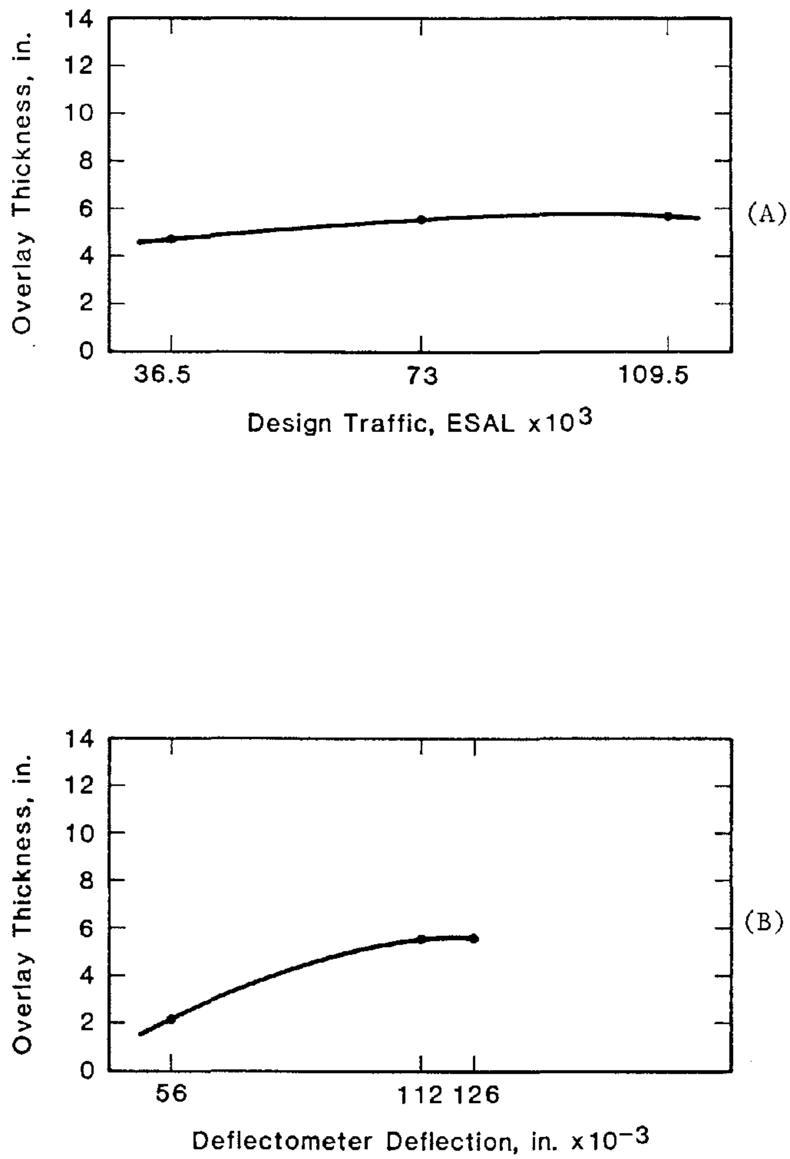


Figure 4. Sensitivity of CALTRANS Flexible Overlay Design for Flexible Pavements to: (A) Traffic and (B) Deflection (1 in = 25 mm).

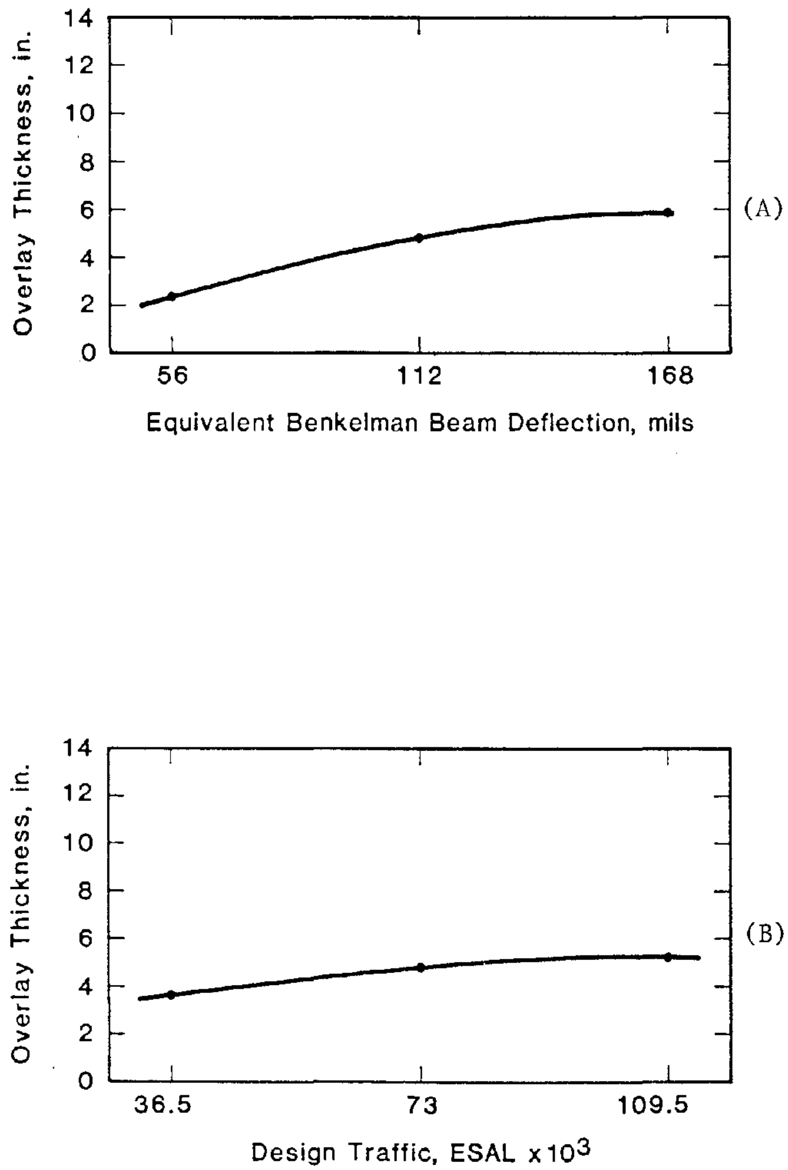


Figure 5. Sensitivity of Louisiana Flexible Overlay Design for Flexible Pavements to: (A) Deflection and (B) Traffic (1 in = 25 mm, 1 mil = 2.5 x 10^{-2} mm).

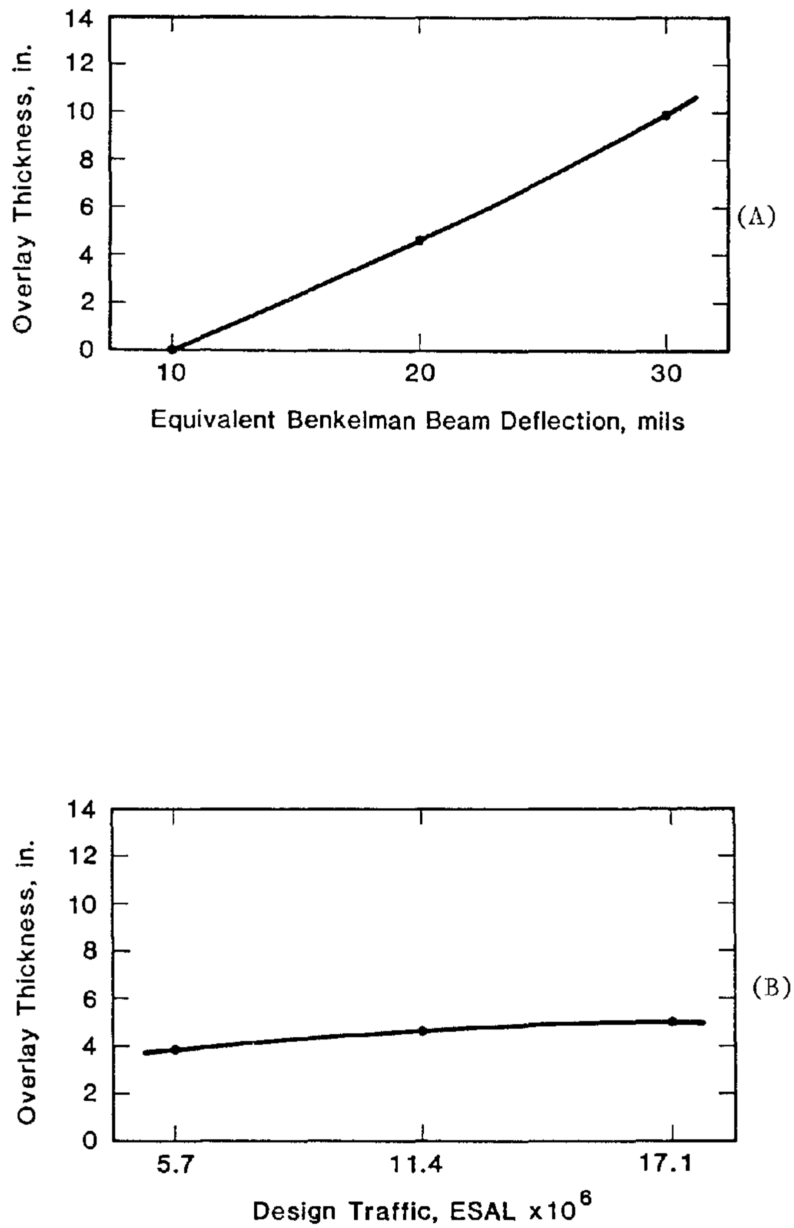


Figure 6. Sensitivity of Louisiana Flexible Overlay Design for Rigid Pavements to: (A) Deflection and (B) Traffic (1 in = 25 mm, 1 mil = 25 x 10^{-2} mm).

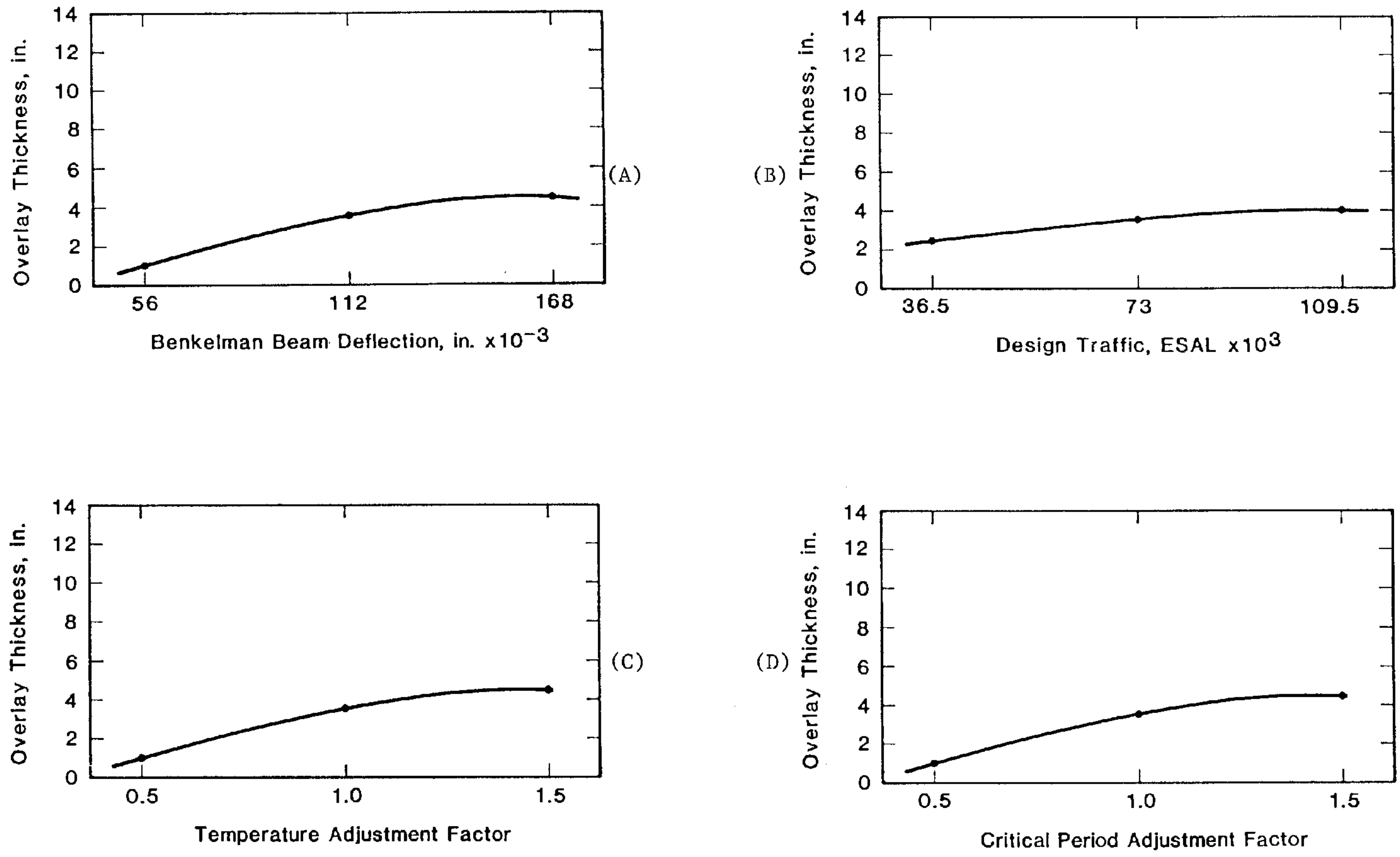
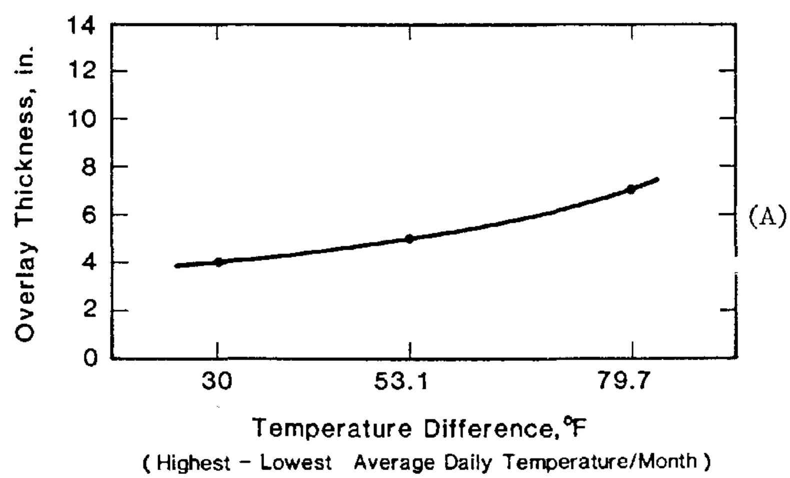


Figure 7. Sensitivity of Asphalt Institute Flexible Overlay Design Procedures for Flexible Pavements to: (A) Deflection, (B) Traffic, (C) Temperature Adjustment, and (D) Critical Period Adjustment (1 in = 25 mm).



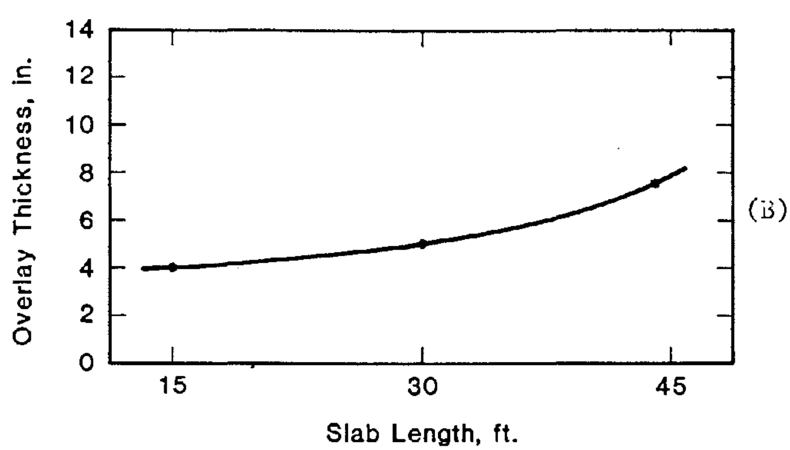


Figure 8. Sensitivity of Asphalt Institute Flexible Overlay Design for Rigid Pavements to (A) Temperature Difference and (B) Slab Length (1 in = 25 mm, 1 ft = 305 mm).

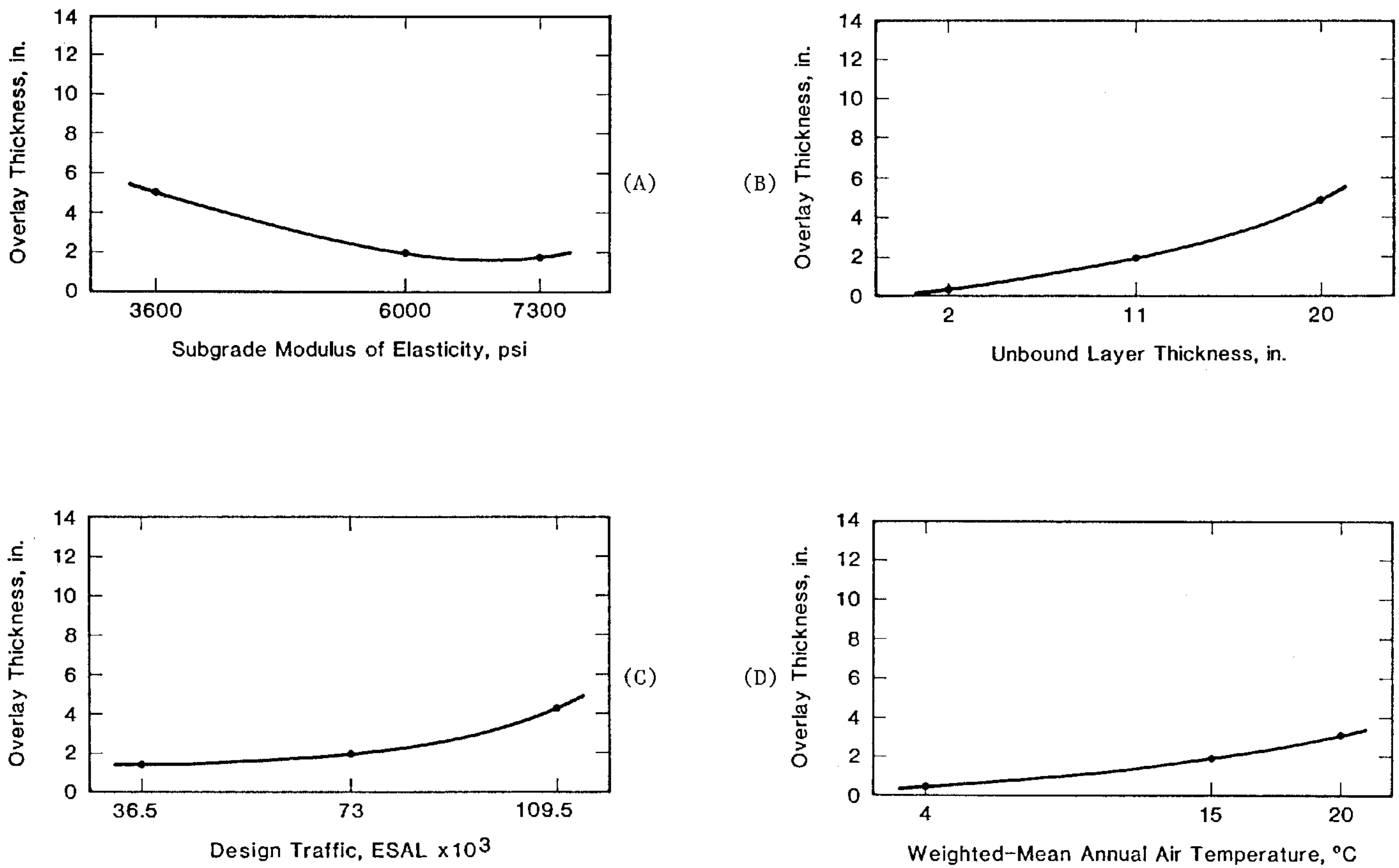


Figure 9. Sensitivity of Shell Flexible Overlay Design for Flexible Pavements to: (A) Subgrade Modulus, (B) Base Thickness, (C) Traffic, and (D) Weighted-Mean Annual Air Temperature (1 in = 25 mm and 1 psi = 6.9 kN/m^2).

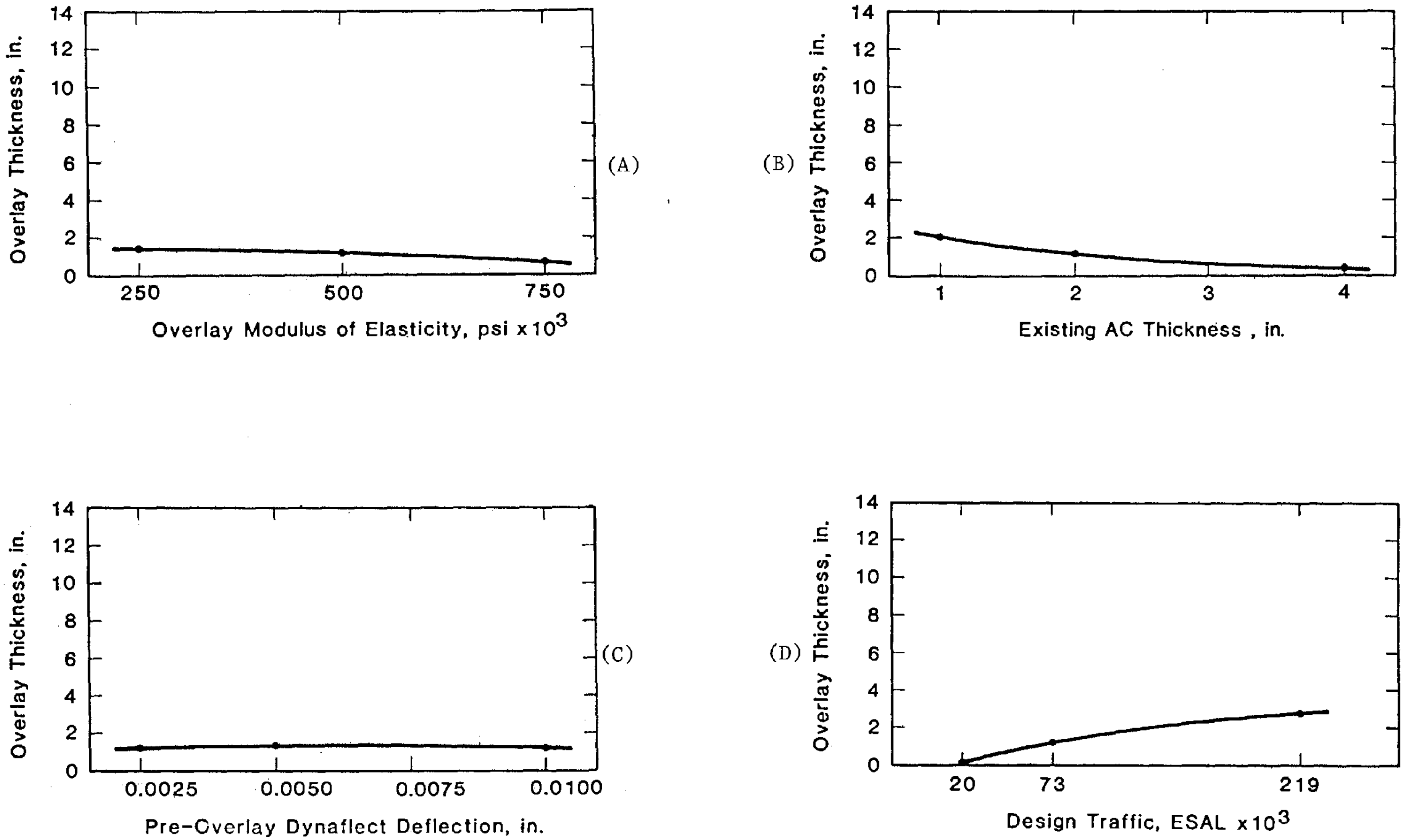


Figure 10. Sensitivity of POD Flexible Overlay Design for Flexible Pavements to: (A) Overlay Modulus, (B) Existing Thickness, (C) Deflection, and (D) Traffic (1 in = 25 mm and 1 psi = 6.9 kN/m^2).

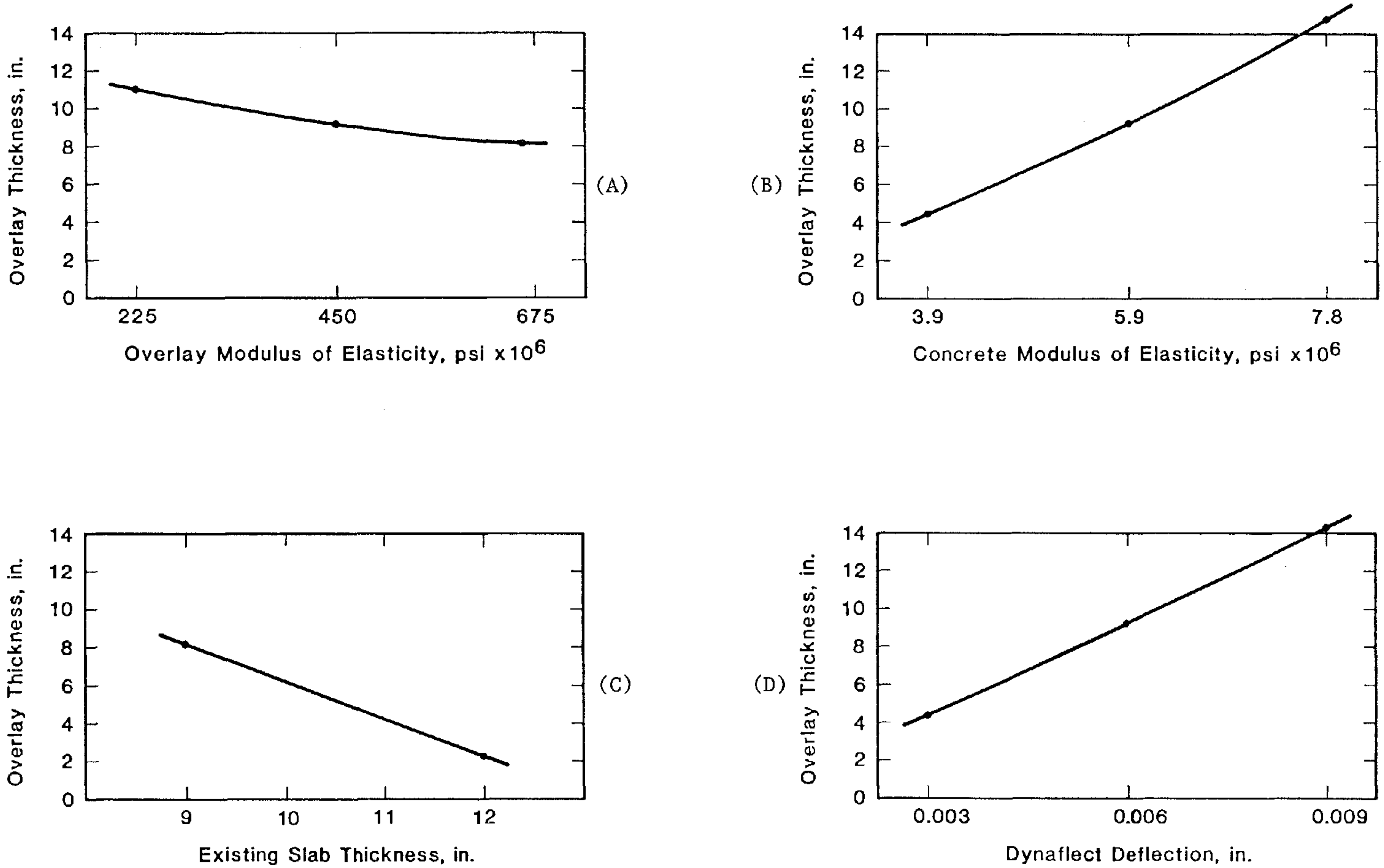


Figure 11. Sensitivity of POD Flexible Overlay Design for Rigid Pavements to: (A) Overlay Modulus, (B) Existing Modulus, (C) Existing Thickness, (D) Deflection, (E) Design Traffic, (F) Projected Traffic, and (G) Crack Type (1 in = 25 mm, 1 psi = 6.9 kN/m^2).

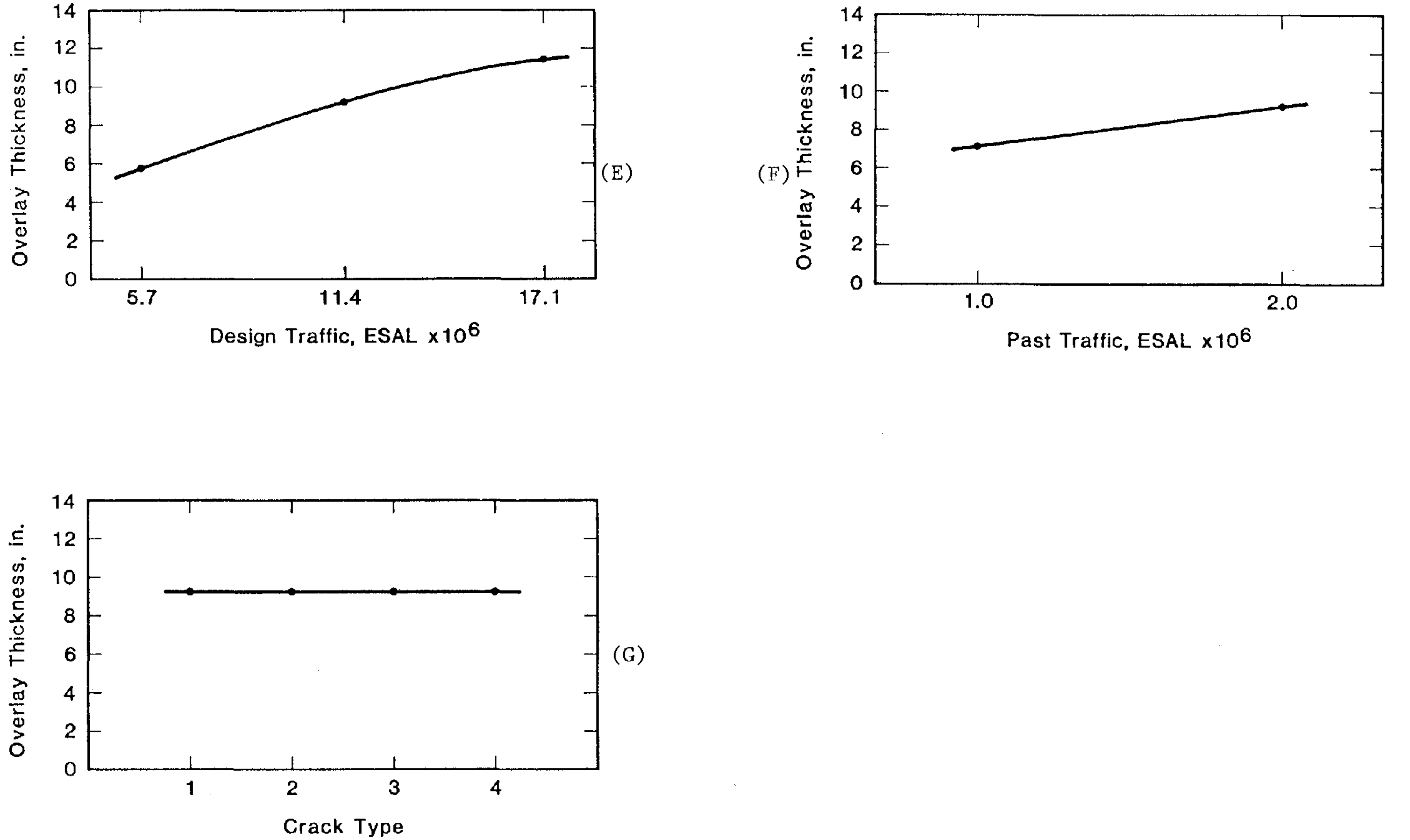


Figure 11. Sensitivity of POD Flexible Overlay Design for Rigid Pavements to: (A) Overlay Modulus, (B) Existing Modulus, (C) Existing Thickness, (D) Deflection, (E) Design Traffic, (F) Projected Traffic, and (G) Crack Type (1 in = 25 mm, 1 psi = 6.9 kN/m^2). (Continued)

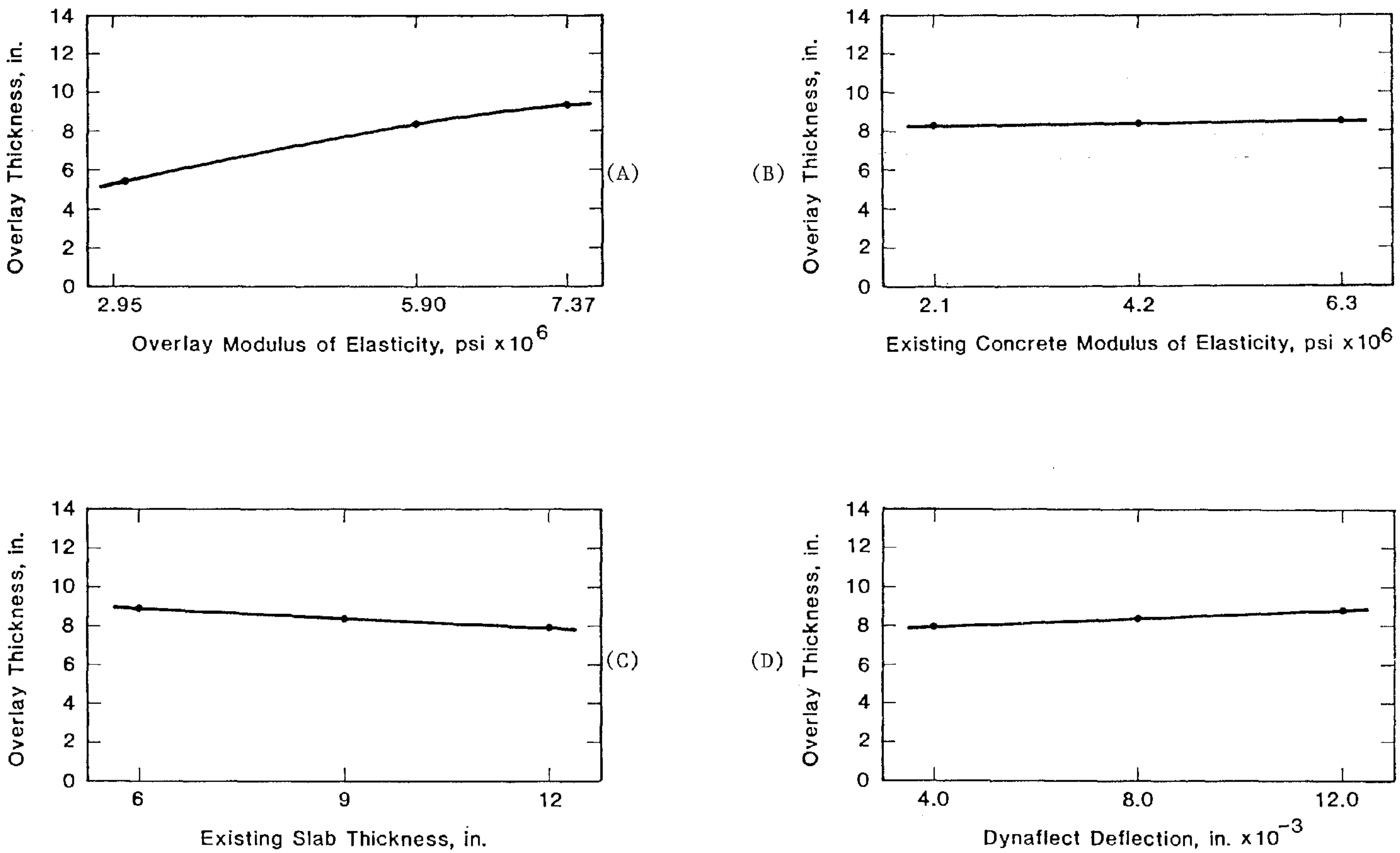


Figure 12. Sensitivity of POD Rigid Overlay Design for Rigid Pavements to: (A) Overlay Modulus, (B) Existing Modulus, (C) Existing Slab Thickness, (D) Deflection, (E) Design Traffic (F) Past Traffic, and (G) Bond (1 in = 25 mm, 1 psi = 6.9 kN/m^2).

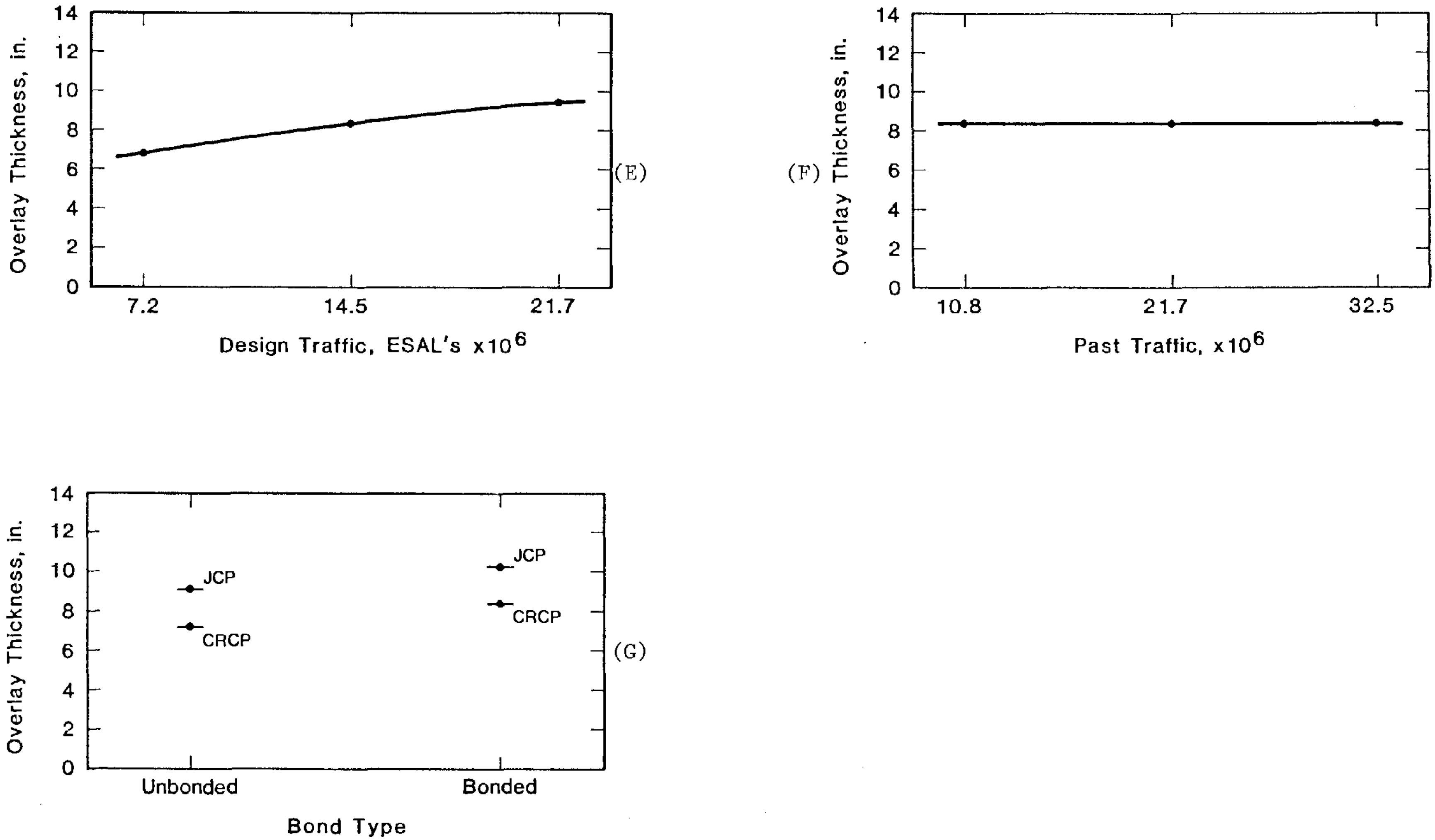


Figure 12. Sensitivity of POD Rigid Overlay Design for Rigid Pavements to: (A) Overlay Modulus, (B) Existing Modulus, (C) Existing Slab Thickness, (D) Deflection, (E) Design Traffic, (F) Past Traffic, and (G) Bond (1 in = 25 mm, 1 psi = 6.9 kN/m^2). (Continued)

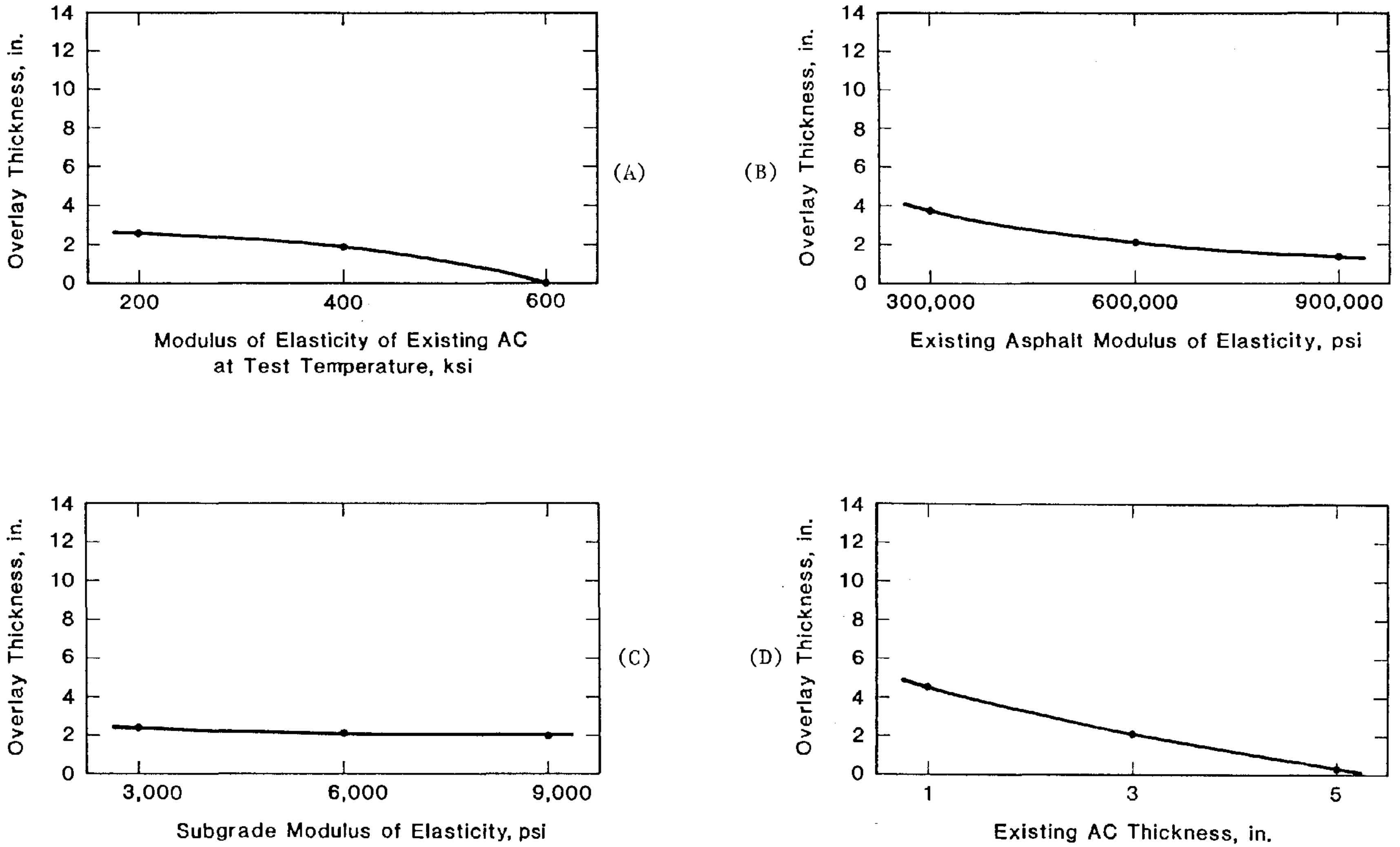
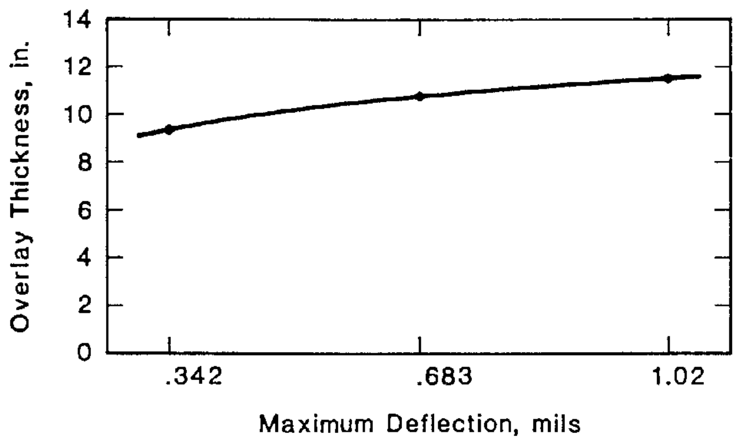
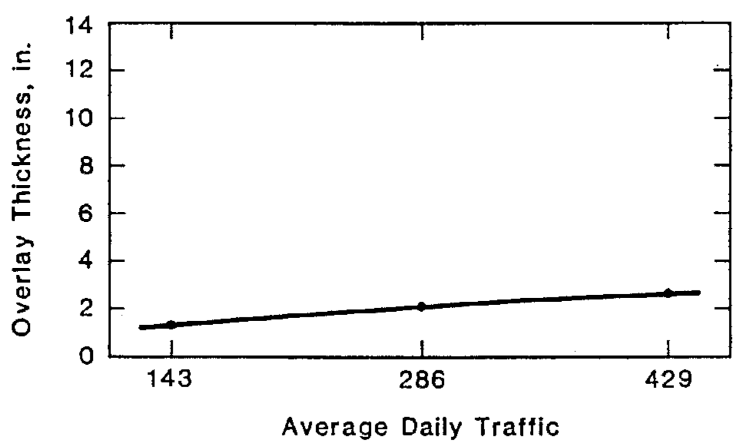


Figure 13. Sensitivity of OAF Flexible Overlay Design for Flexible Pavements to: (A) Surface Modulus, (B) Existing Modulus, (C) Subgrade Modulus, (D) Existing Thickness, (E) Deflection, and (F) Traffic (1 in = 25 mm, 1 psi = 6.9 kN/m^2, 1 ksi = 6.9 x 10^3 kN/m^2, 1 mil = 2.5 x 10^{-2} mm).



(E)



(F)

Figure 13. Sensitivity of OAF Flexible Overlay Design for Flexible Pavements to: (A) Surface Modulus, (B) Existing Modulus, (C) Subgrade Modulus, (D) Existing Thickness, (E) Deflection, and (F) Traffic (1 in = 25 mm, 1 psi = 6.9 kN/m^2, 1 ksi = 6.9 x 10^3 kN/m^2, 1 mil = 2.5 x 10^{-2} mm). (Continued)

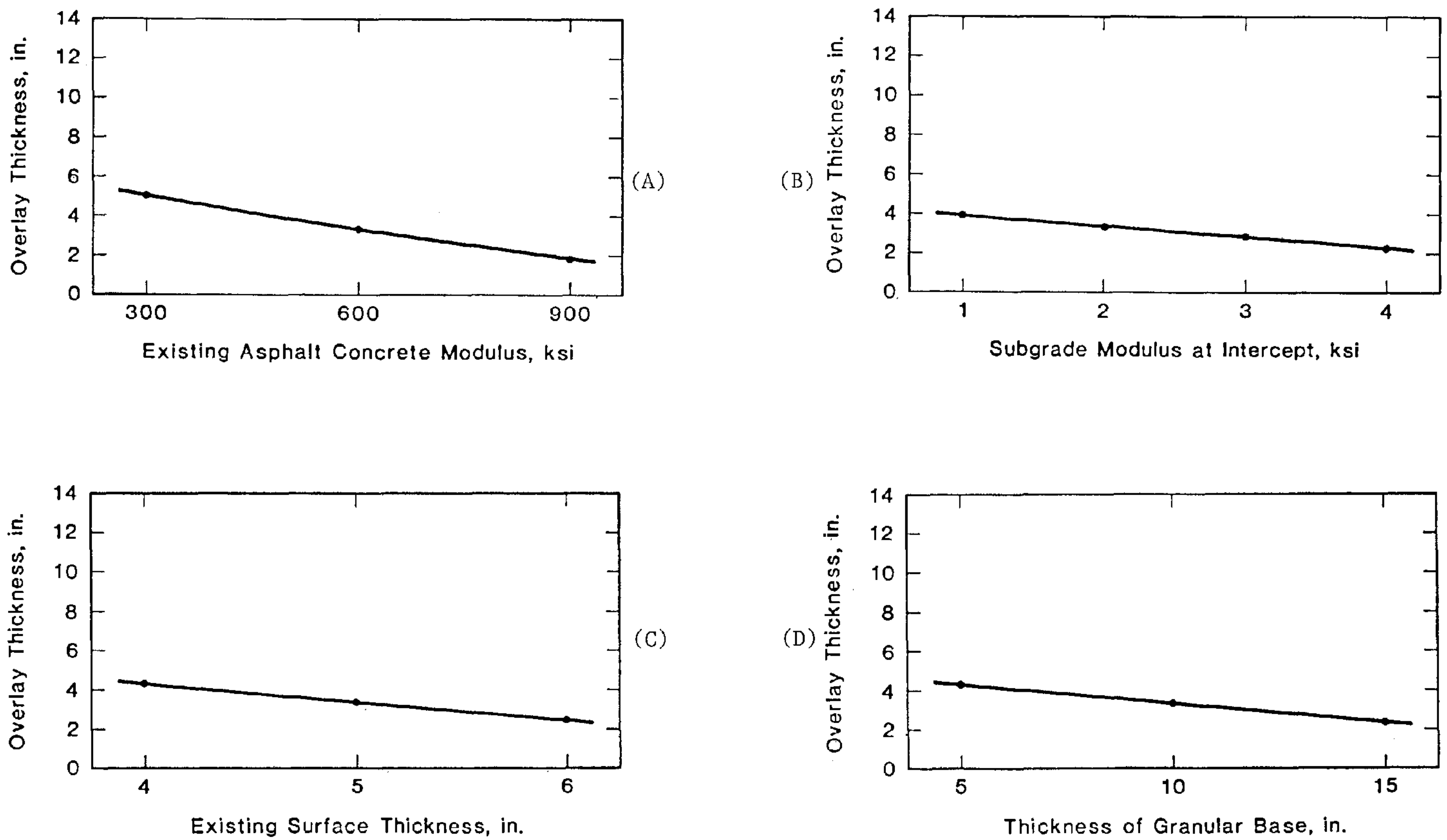
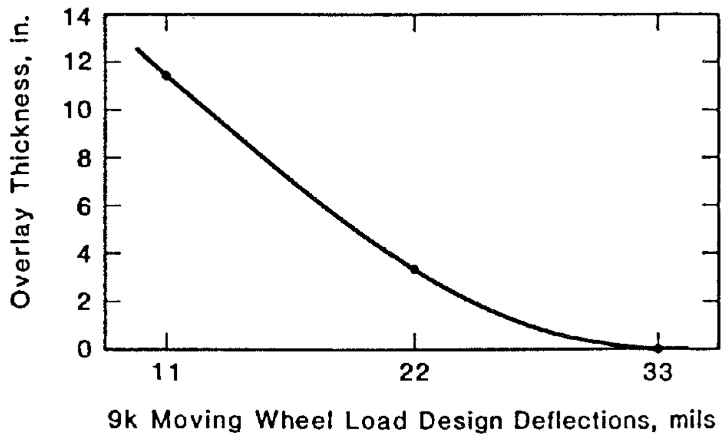
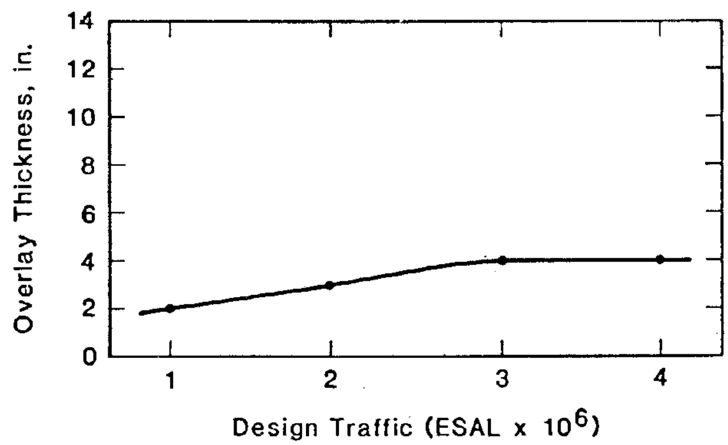


Figure 14. Sensitivity of University of Illinois Flexible Overlay Design for Flexible Pavements to: (A) Existing Modulus, (B) Subgrade Modulus, (C) Surface Thickness, (D) Base Thickness, (E) Deflection, and (F) Traffic (1 in = 25 mm, 1 ksi = 6.9×10^3 kN/m^2, 1 mil = 2.5×10^{-2} mm).



(E)



(F)

Figure 14. Sensitivity of University of Illinois Flexible Overlay Design for Flexible Pavements to: (A) Existing Modulus, (B) Subgrade Modulus, (C) Surface Thickness, (D) Base Thickness, (E) Deflection, and (F) Traffic (1 in = 25 mm, 1 ksi = 6.9×10^3 kN/m^2, 1 mil = 2.5×10^{-2} mm). (Continued)

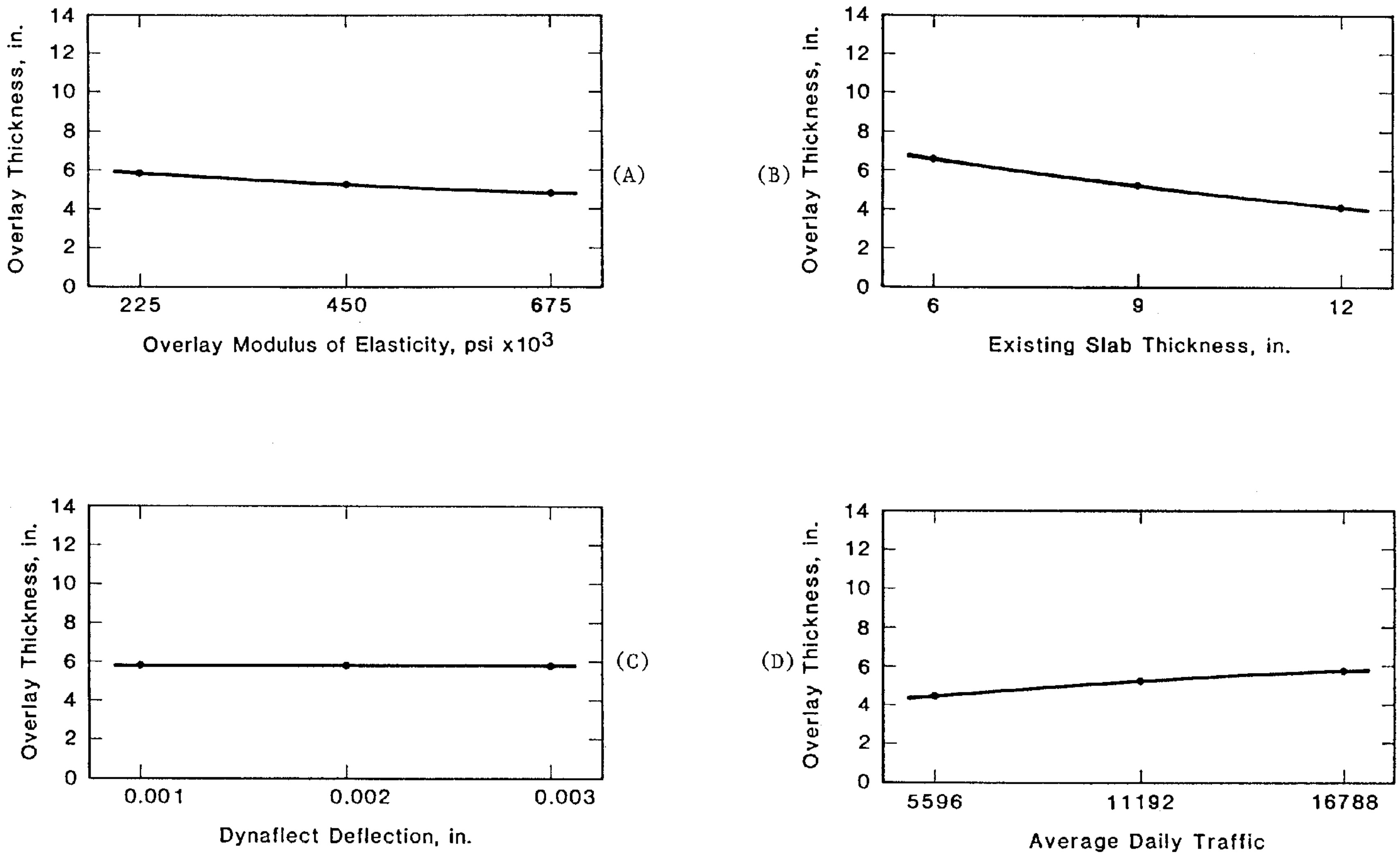


Figure 15. Sensitivity of OAR Flexible Overlay Design for Rigid Pavements to: (A) Overlay Modulus, (B) Existing Thickness, (C) Deflection, (D) Traffic, (E) Regional Factor, (F) Direction Factor, and (G) Lane Distribution (1 in = 25 mm, 1 psi = 6.9 kN/m^2).

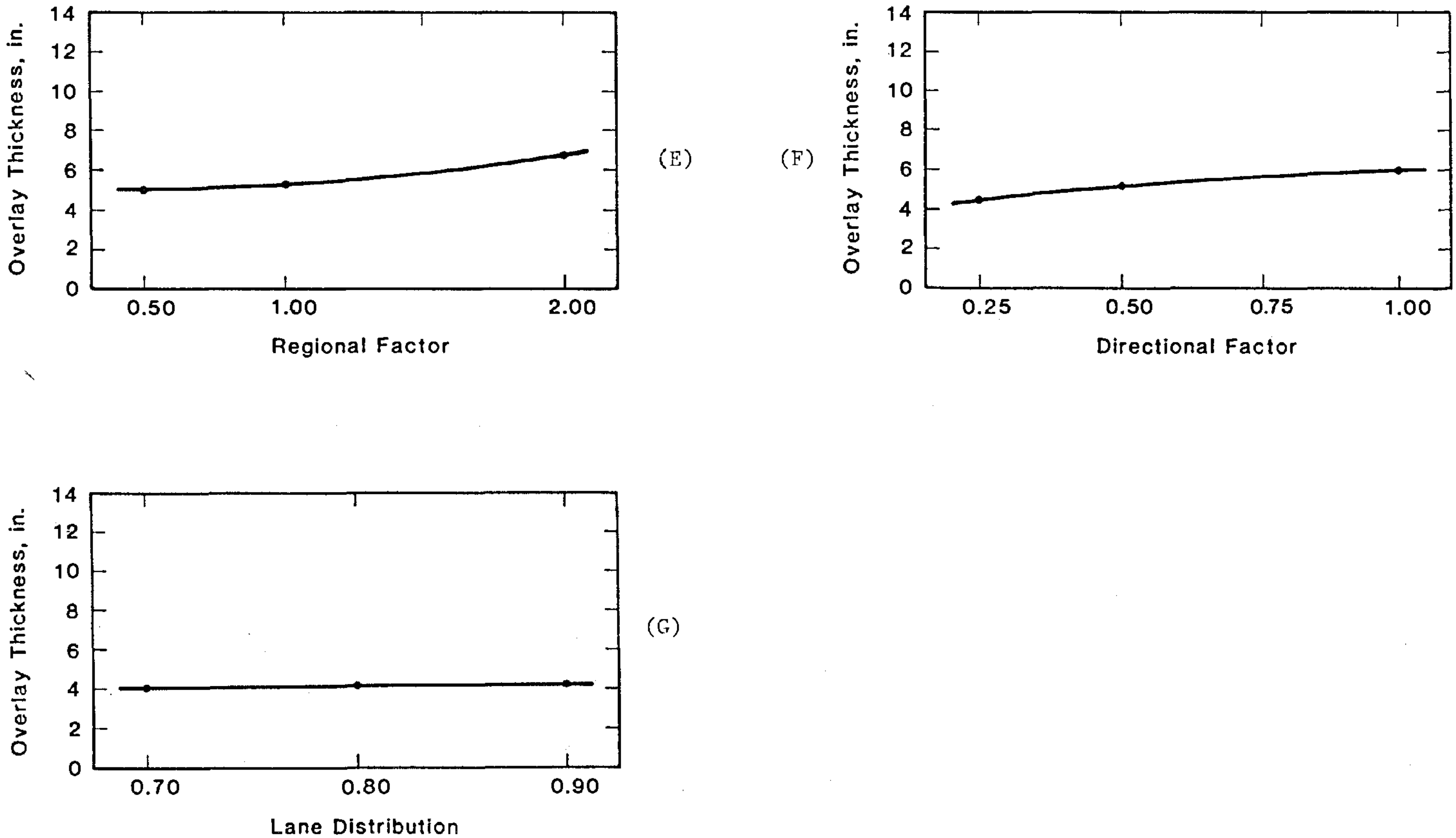


Figure 15. Sensitivity of OAR Flexible Overlay Design for Rigid Pavements to: (A) Overlay Modulus, (B) Existing Thickness, (C) Deflection, (D) Traffic, (E) Regional Factor, (F) Direction Factor, and (G) Lane Distribution (1 in = 25 mm, 1 psi = 6.9 kN/m^2). (Continued)

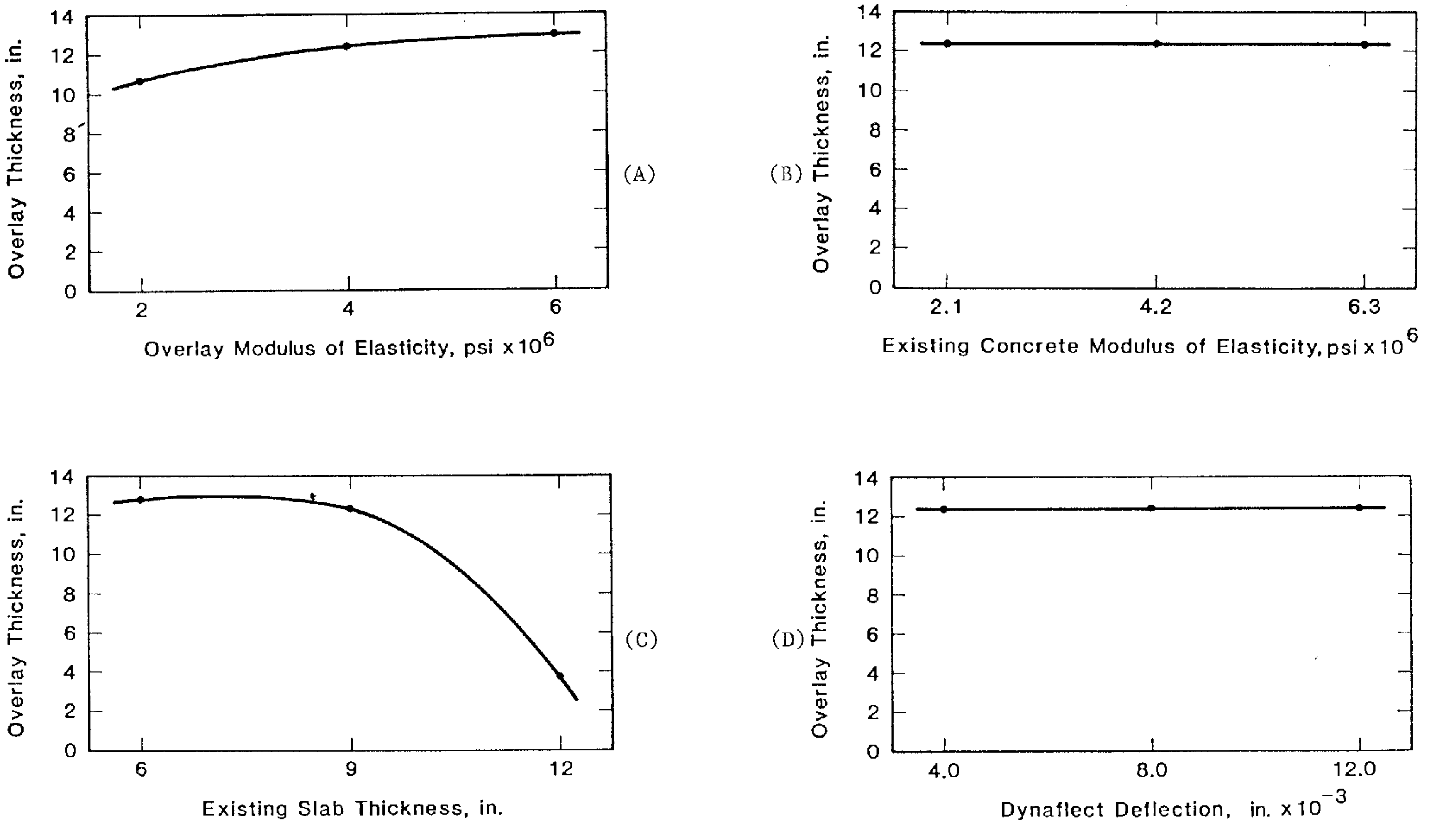


Figure 16. Sensitivity of OAR Rigid Overlay Design for Rigid Pavement to: (A) Overlay Modulus, (B) Existing Modulus, (C) Existing Thickness, (D) Deflection, (E) Traffic, (F) Load Transfer, (G) Traffic Growth, (H) Lane Distribution, (I) Bond, and (J) Directional Distribution (1 in = 25 mm, 1 psi = 6.9 kN/m^2).

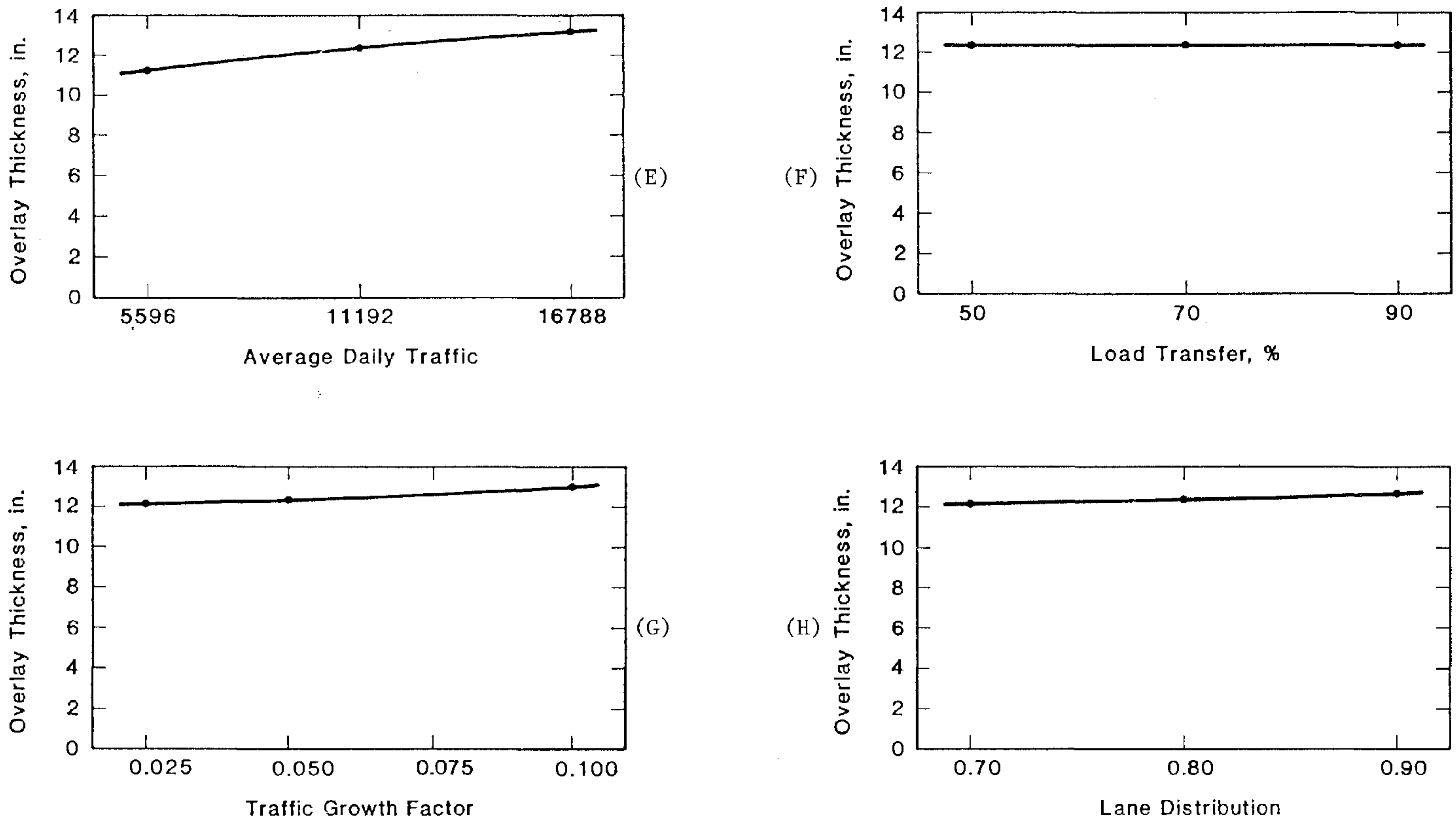
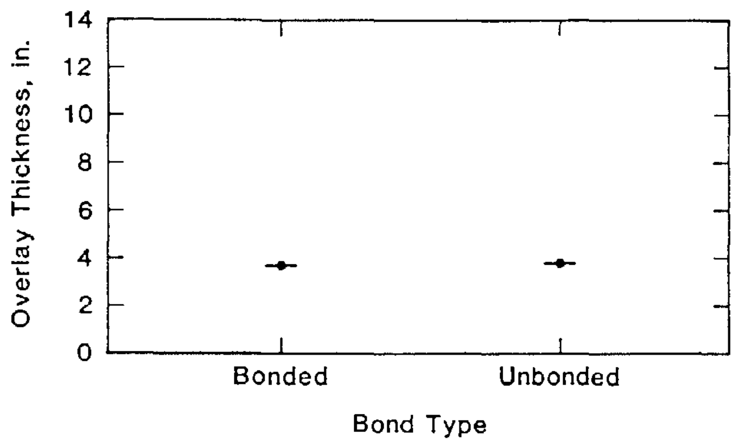
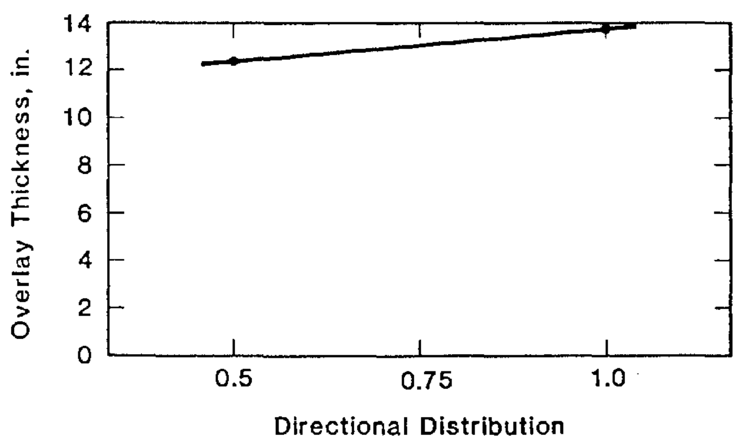


Figure 16. Sensitivity of OAR Rigid Overlay Design for Rigid Pavement to: (A) Overlay Modulus, (B) Existing Modulus, (C) Existing Thickness, (D) Deflection, (E) Traffic, (F) Load Transfer, (G) Traffic Growth, (H) Lane Distribution, (I) Bond, and (J) Directional Distribution (1 in = 25 mm, 1 psi = 6.9 kN/m^2). (Continued)



(I)



(J)

Figure 16. Sensitivity of OAR Rigid Overlay Design for Rigid Pavement to: (A) Overlay Modulus, (B) Existing Modulus, (C) Existing Thickness, (D) Deflection, (E) Traffic, (F) Load Transfer, (G) Traffic Growth, (H) Lane Distribution, (I) Bond, and (J) Directional Distribution (1 in = 25 mm, 1 psi = 6.9 kN/m^2). (Continued)

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FEDERALLY COORDINATED PROGRAM (FCP) OF HIGHWAY RESEARCH, DEVELOPMENT, AND TECHNOLOGY

The Offices of Research, Development, and Technology (RD&T) of the Federal Highway Administration (FHWA) are responsible for a broad research, development, and technology transfer program. This program is accomplished using numerous methods of funding and management. The efforts include work done in-house by RD&T staff, contracts using administrative funds, and a Federal-aid program conducted by or through State highway or transportation agencies, which include the Highway Planning and Research (HP&R) program, the National Cooperative Highway Research Program (NCHRP) managed by the Transportation Research Board, and the one-half of one percent training program conducted by the National Highway Institute.

The FCP is a carefully selected group of projects, separated into broad categories, formulated to use research, development, and technology transfer resources to obtain solutions to urgent national highway problems.

The diagonal double stripe on the cover of this report represents a highway. It is color-coded to identify the FCP category to which the report's subject pertains. A red stripe indicates category 1, dark blue for category 2, light blue for category 3, brown for category 4, gray for category 5, and green for category 9.

FCP Category Descriptions

1. **Highway Design and Operation for Safety**
   Safety RD&T addresses problems associated with the responsibilities of the FHWA under the Highway Safety Act. It includes investigation of appropriate design standards, roadside hardware, traffic control devices, and collection or analysis of physical and scientific data for the formulation of improved safety regulations to better protect all motorists, bicycles, and pedestrians.

2. **Traffic Control and Management**
   Traffic RD&T is concerned with increasing the operational efficiency of existing highways by advancing technology and balancing the demand-capacity relationship through traffic management techniques such as bus and carpool preferential treatment, coordinated signal timing, motorist information, and rerouting of traffic.

3. **Highway Operations**
   This category addresses preserving the Nation's highways, natural resources, and community attributes. It includes activities in physical maintenance, traffic services for maintenance zoning, management of human resources and equipment, and identification of highway elements that affect the quality of the human environment. The goals of projects within this category are to maximize operational efficiency and safety to the traveling public while conserving resources and reducing adverse highway and traffic impacts through protections and enhancement of environmental features.

4. **Pavement Design, Construction, and Management**
   Pavement RD&T is concerned with pavement design and rehabilititation methods and procedures, construction technology, recycled highway materials, improved pavement binders, and improved pavement management. The goals will emphasize improvements to highway performance over the network's life cycle, thus extending maintenance-free operation and maximizing benefits. Specific areas of effort will include material characterizations, pavement damage predictions, methods to minimize local pavement defects, quality control specifications, long-term pavement monitoring, and life cycle cost analyses.

5. **Structural Design and Hydraulics**
   Structural RD&T is concerned with furthering the latest technological advances in structural and hydraulic designs, fabrication processes, and construction techniques to provide safe, efficient highway structures at reasonable costs. This category deals with bridge superstructures, earth structures, foundations, culverts, river mechanics, and hydraulics. In addition, it includes material aspects of structures (metal and concrete) along with their protection from corrosive or degrading environments.

9. **RD&T Management and Coordination**
   Activities in this category include fundamental work for new concepts and system characterization before the investigation reaches a point where it is incorporated within other categories of the FCP. Concepts on the feasibility of new technology for highway safety are included in this category. RD&T reports not within other FCP projects will be published as Category 9 projects.