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DESIGN OF OVERLAYS BASED ON PAVEMENT CONDITION, ROUGHNESS, AND DEFLECTIONS

Part 1

Tentative Method For Overlay Design Based On Visual Pavement Distress

by

Dr. N. K. Vaswani
Senior Research Scientist

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

Data collected on 111 interstate highway projects in Virginia were analyzed by multiregression analysis and the rating coefficient for each type of distress determined. By this means, the total pavement distress and, hence, the maintenance rating of each pavement was obtained. The types of distress that were found to influence the maintenance rating were longitudinal cracking, alligator cracking, rutting, pushing, ravelling, and patching. Then, a method for designing the required thickness of an overlay was developed based on taking the thickness equivalency of an asphaltic concrete overlay in Virginia as equal to 0.5 (the thickness equivalency of an asphaltic concrete for new construction is 1.0) and the overlay thickness as a function of the ratio of the traffic, in terms of 18-kip (8,160 kg) equivalents, carried by the pavement before the overlay to the traffic it would carry after the overlay, depending on the durability of the asphaltic mix. This design method does not require the use of a deflection measuring device.

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INTRODUCTION

Conventionally in Virginia the decision to provide overlays over flexible pavements is based on visual inspections without reference to any defined criteria for pavement evaluation. With the Federal Highway Administration 3R Program has come a need for procedures whereby the necessity for an overlay and its required thickness could be validated so as to obtain federal participating funds.

Virginia and some other states have developed mechanistic methods for determining the required thicknesses for overlays, but all of these methods are based on deflection data,[1,2] so their use in each district would require that all districts have deflection equipment such as the dynaflect available, along with a technician, for the collection of data. Likewise, the methods for quantifying the total pavement distress based on rating systems would include some techniques of measuring distress by mechanical means. Consequently, there is a need for establishing a relationship between total pavement distress, traffic, and the structural strength of the pavement that could be used to design overlays without the necessity for pavement deflection measuring devices or, sometimes, the necessity for any other measuring devices.

OBJECTIVE AND SCOPE

The objective of the investigation reported here was to develop a method of designing the thickness of overlays for flexible pavements based on maintenance ratings of the pavements accomplished through visual observations and sound engineering judgement. The overlays would be designed for the sole purpose of improving the structural strength of the pavement. Consideration would not be given to improving defects in the pavement surface having no influence on the strength of the pavement.

As outlined in the working plan(3) the study would accomplish the following tasks.

1. Develop a pavement maintenance rating system based on the total observed pavement distress.

2. Develop a relationship between the maintenance rating, traffic in terms of 18-kip (8,160 kg) equivalents, and the structural strength of the pavement in terms of the thickness index of the pavement. This would enable evaluations of the performance of the pavements before and after the overlay.

3. Determine the thickness equivalency of the overlay.

4. Develop a method for determing the required thickness of the overlay.

The activities carried out in accomplishing these tasks are discussed under the four succeeding major headings. These are followed by a section on conclusions.

PAVEMENT MAINTENANCE RATING SYSTEM

The pavement maintenance rating technique developed in this investigation is based on the same principle as the serviceability index included in the AASHTO Road Test Results. The initial serviceability index of the new pavement at the AASHTO Road Tests varied from 3.9 to 4.5, with an average value of 4.2. For the design of overlays in Virginia it is proposed that a maintenance rating factor (MR) of 100 for a new pavement be adopted. Thus an AASHTO Serviceability Index (SI) of 4.2 would equal an MR of 100, and an SI of 0 would equal an MR of 0. As distress increases, factors assigned to various types and degrees of distress are deducted such that the MR decreases. The MR value for a new pavement would reduce from 100 with an increase in accumulated traffic, and hence an increase in distress.

While over the first few years that a road is open to traffic the pavement distress is so small that it is not discernible to the naked eye, it can be measured by a dynaflect or a roughometer. However, measurement of this indiscernible distress is not needed for the design of overlays. In the rating system developed, an SI of 3.9 or an MR of 93 ($\frac{3.9}{4.2} \times 100 = 93$) is considered as the maximum value of incipient visual distress for the following three reasons.

1. The minimum value of the AASHTO SI for a new pavement was 3.9, which is equal to an MR of 93.

2. The rate of decrease in MR with an increase in traffic is constant up to an MR of approximately 93, and below that value the rate of reduction accelerates. Thus it is seen that at an MR of 93 the deterioration of the pavement starts to accelerate.

3. Statistical analysis gives higher values of correlation coefficients when pavements with no visual distress are given an MR of 93. In this investigation all pavements with no visible distress were assigned an MR value of 93, irrespective of their age because pavements with MR values of 93 or above are never considered for overlays.

The types of distress that contribute to pavement deterioration are given in Table 1. For these types it is recommended that the ratings given in Table 2 be adopted.

Table 1

Distress That Contributes to Pavement Deterioration

Type	Notation
Longitudinal Cracking	LC
Alligator Cracking	AC
Rutting	Ru
Pushing	Pu
Ravelling	Ra
Patching	Pa

Table 2

Distress Rating By Amount and Severity

Amount of Distress	Rating		
	Not Severe	Severe	Very Severe
No distress observed	0	0	0
Distress rarely observed	1	2	3
Distress occasionally observed	2	4	6
Distress frequently observed	3	6	9

On interstate highways overlays are applied while the distress is not severe, while on low traffic primary roads the distress on some sections is rated severe or very severe before overlays are placed. The amount and severity of distress will need to be spelled out clearly before the rating systems can be used by the districts.

McGhee, in 1974-75, carried out a survey on 111 projects (521 miles, or 886 km) on flexible pavements on the interstate highway system.(4) The present author performed multiregression analysis of the data collected by McGhee in which it was assumed that none of the distress recorded was rated as being severe. Table 3 presents a sample of the rating on I-81 for three counties. The model equation used in the analysis is

$$MR = a_0 + a_1 \text{ (Rating for LC)} + a_2 \text{ (Rating for AC)} + a_3\text{(Rating for Ru)} + a_4 \text{ (Rating for Pu)} + a_5 \text{ (Rating for Ra)} + a_6 \text{ (Rating for Pa)}.$$

As a result of the multiregression analysis, the following equation was developed:

$$MR = 92.6 - 2.4 \text{ (LC)} - 2.3 \text{ (AC)} - 1.0 \text{ (Ru)} - 1.0 \text{ (Pu)} - 0.9 \text{ (Ra)}.$$

(This equation had a cor. coeff. of $R = 0.96$ and an S.E. = 0.39.)

Table 3

A Sample of Interstate Flexible Pavement Distress and Overlay Data

Serial No.	Route No.	Project	Pavement Distress Rating 1974 - 75						Year Const.	First Overlay		Va. D
			LC	AC	Ru	Pu	Ra	MR		Year	EAL-18	
1	0081	095-013-P1	2	1	0	1	0	88	1961	1971	1.55	12.3
2	0081	095-037-	1	3	1	1	0	78	1960	1971	2.00	12.3
3	0081	095-014-P401	3	2	2	0	0	83	1963	1977	2.72	14.0
4	0081	095-014-P402	3	2	2	0	1	83	1963	1975	2.24	13.8
5	0081	095-038-P1	1	0	0	0	0	93	1962	1975	2.43	13.8
6	0081	095-038-P402	3	3	0	0	3	78	1963	1976	2.44	13.8
7	0081	095-009-C502	0	0	0	0	0	93	1963	1974	2.02	13.6
8	0081	095-009-C503	2	0	0	0	0	93	1963	1974	1.97	13.6
9	0081	086-003-P401	2	0	0	0	0	93	1963	1969	1.09	13.8
10	0081	086-003-C501	1	0	0	0	2	91	1963	1969	1.16	13.8
11	0081	086-003-P403	1	0	0	0	2	91	1963	1970	1.27	13.8
12	0081	086-003-P405	3	3	3	0	0	78	1963	1976	2.27	13.8
13	0081	086-004-P402	0	0	0	0	0	93	1964	1974	1.77	13.8
14	0081	098-001-P401	0	0	0	0	0	93	1964	1973	1.57	13.8
15	0081	098-001-P402	0	0	0	0	0	93	1964	1973	1.55	13.8
16	0081	098-101-P403	0	0	0	2	0	91	1964	1972	1.42	13.8
17	0081	098-002-P401	3	3	3	0	0	78	1965	1975	1.61	13.8
18	0081	098-101-C503	1	0	0	0	0	93	1968	—	—	15.2
19	0081	098-008-P1	1	0	0	0	0	93	1961	1969	1.36	13.4
20	0081	098-008-P402	0	0	0	0	0	93	1962	1970	1.39	13.4

Since none of the projects on the interstate highways considered had any patched areas, no coefficient for patching was included in equation 2. Patching is usually provided to cover a severe or very severe distress, generally in the form of alligator cracking. If patching is considered in equation 2, the coefficient for it would be 2.3, the same as that for alligator cracking. However, patching is here classified as "not severe" and is rated only by the amount observed.

The data in Table 4, taken from Route I-81, project 095-014-P402 in Table 3, can be used to illustrate the method for determining the MR of a pavement.

Table 4

Illustrative Data from Route I-81

Type of Distress	Amount	Severity	Rating
Longitudinal Cracking (LC)	Frequent	Not Severe	3
Alligator Cracking (AC)	Occasional	Not Severe	2
Rutting (Ru)	Occasional	Not Severe	2
Pushing (Pu)	None	—	0
Ravelling (Ra)	Rare	Not Severe	1
Patching (Pa)	None	—	0

Using these data and equation 2,

$$MR = 92.6 - 2.4 \times 3 - 2.3 \times 2 - 1.0 \times 2 - 1.0 \times 0 - 0.9 \times 1 - 2.3 \times 0 = 77.9$$

Of the MR ratings of the 111 interstate projects cited above, none were below 78. The average rating for each district is shown in Table 5. The fact that these averages range from 88 to 93 indicates that interstate pavements in all districts are maintained at a very high service level.

The MR of the 111 projects was determined in June 1975. Pavements with values between 78 and 83 were overlaid in either 1975 or 1976, except for a few that were overlaid in 1977. Thus, there is an indication that the rating system determined in this investigation is in line with field practice. However, it is felt that the establishment of priorities based on the system can lead to improvements in the utilization of funds. For example, reference to Table 3 shows that (a) one project with an MR of 83 in 1975 was overlaid in 1977; (b) two projects with values of 78 in 1975 were overlaid in 1976, and (c) three projects with values of 78, 83, and 93, respectively, were overlaid in 1975. If priorities had been established by the rating system, the pavements with the lower MR values would have been overlaid first.

Table 5

Average MR Values for Interstate Highways (1975)

District	No. of Projects	MR
Bristol	22	89
Salem	24	89
Lynchburg	1	88
Richmond	12	91
Suffolk	5	93
Culpeper	11	91
Staunton	33	89

The SI limits recommended by the AASHTO Committee[5] for use in decisions as to when overlays should be applied have been correlated in this investigation to the MR system as shown in Table 6. Thus the interstate highway pavements in Virginia with MR values of 83 or less are justified for overlays. Pennsylvania has utilized the same approach to pavement maintenance rating.[6]

Table 6

Rating for Overlays

Road Classification	AASHTO SI	Va. MR
Interstate Highways	3.5 or less	83 or less
Arterial Roads	3.0 or less	71 or less
Primary Roads	2.5 or less	60 or less
Low Primary or Secondary Roads	1.5 or less	36 or less

RELATION OF MAINTENANCE RATING, TRAFFIC, AND STRUCTURAL STRENGTH

The rate and amount of pavement deterioration is a function of the pavement strength and accumulated traffic in terms of 18-kip (8,160 kg) equivalents. The author has determined that the following model equation could be used to correlate these three variables.(7)

$$\text{Log 18-kip} = A + B \text{ (thickness index)}, \qquad (3)$$

where

A = f (MR), a function of the maintenance rating and a constant for a given MR value, and B = a constant for any given MR value.

The 18-kip (8,160 kg) equivalent can be determined from a traffic count by means of the chart given in Figure 1, which was developed by the author.(8) The yearly traffic counts are prepared by the Traffic and Safety Division of the Virginia Department of Highways and Transportation.(9)

The thickness index is a number which shows the strength of the pavement without the subgrade support. It is a non-dimensional quantity and is obtained by the model equation

$$D = a_1 h_1 + a_2 h_2 + a_3 h_3 + \ldots \qquad (4)$$

In this equation h_1, h_2, and h_3 are the thicknesses of the asphaltic concrete surface layer, the base layer, and the sub-base layer, respectively. The terms a_1, a_2, and a_3 are the thickness equivalencies for the respective layers h_1, h_2, and h_3, The values of a_1, a_2, a_3,...are given in Table 7.

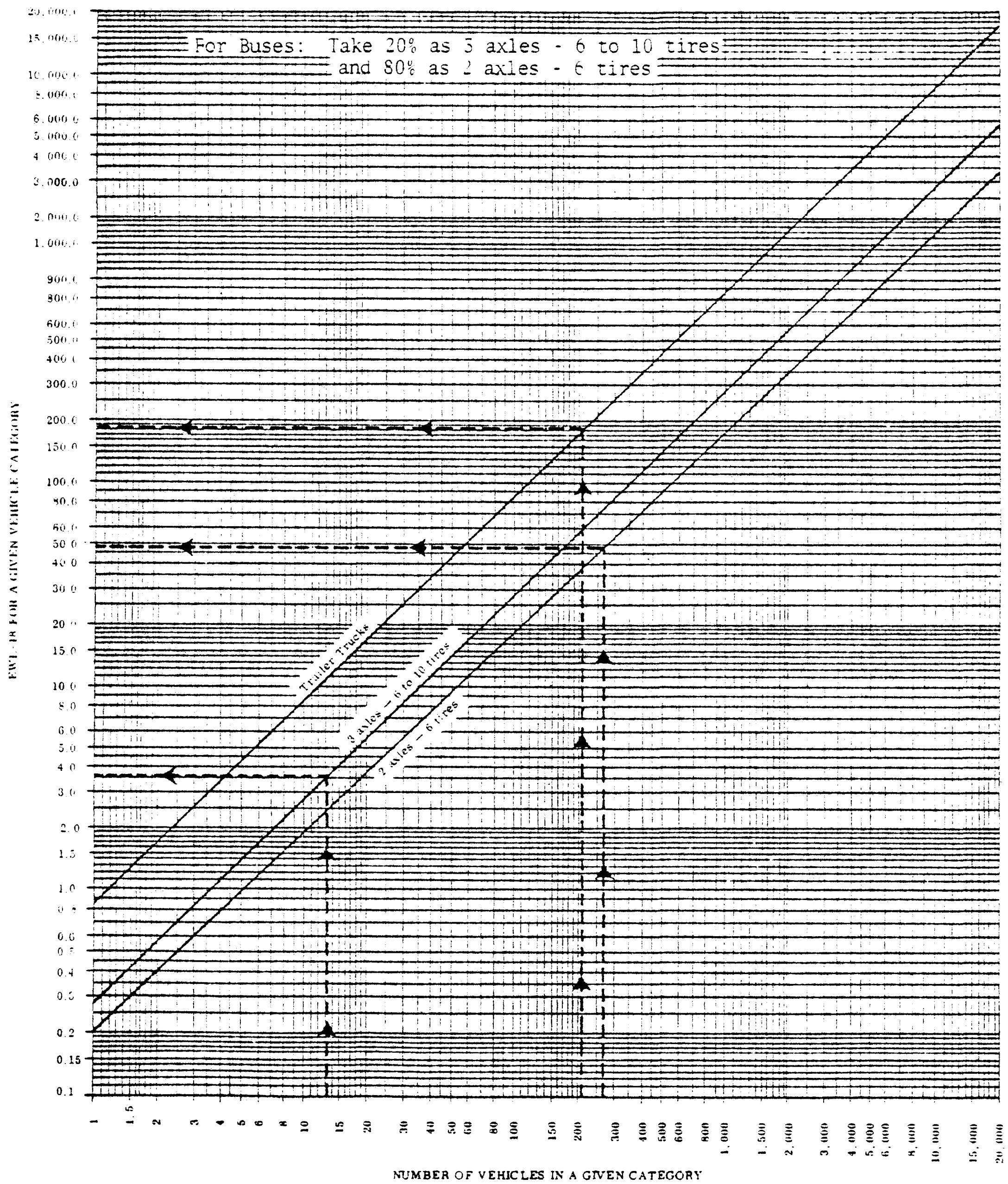

Figure 1. Determination of 18-kip equivalent from traffic count. (Conversion unit: 18-kip = 8,160 kg)

Table 7

Thickness Equivalencies of Materials in Virginia For Interstate, Arterial, and Primary Roads

Location	Material	Notation	Thickness Equiv.
Surface	Asphalt concrete.	AC	1.0
Base	(a) Asphaltic Concrete.	AC	1.0
	(b) Cement treated aggregate base material over untreated aggregate base or soil cement or soil lime and under AC mat.	CTA	1.0
	(c) Untreated aggregate base material crushed or uncrushed. Spec. No. 20, 21, and 22.	Agg.	0.35
	(d) Select material I directly under AC mat and over a subbase of a good quality (a < 0.2).	Agg.	0.35
Subbase	(a) Select material types I, II, & III.	Sel.Mat.	
	1. In Piedmont area.		0.0
	2. In Valley and Ridge area and Coastal Plain.		0.2
	(b) Soil cement or soil lime.	SC	0.4
	(c) Cement treated aggregate base directly over subgrade.	CTA	0.6

Because no maintenance rating data for pavements in Virginia were available for evaluation, raw data from AASHTO road test pavements were used by the author in this investigation. The AASHTO road test results give raw data on 270 projects comprising different pavement cross sections. On each of the 270 projects, traffic in terms of 18-kip (8,160 kg) equivalents is given by them for MR values of 83, 71, 60, 48, and 36 (SI values of 3.5, 3.0, 2.5, 2.0, and 1.5, respectively). The thickness index on each project was obtained by use of the thickness equivalency values given in Table 7 as

$$D = (1.0 \times h_1 + 0.35\ h_2 + 0.2\ h_3) \qquad (5)$$

Equations based on model equation (3)* were developed for MR values of 83, 71, 60, 48, and 36. These are as follows

For MR = 83 (270 data points)

$$\text{Log (18-kip)} = 1.14 + 0.511\ D \qquad (6)$$
(Cor. Coeff. = 0.87)

For MR = 71 (258 data points)

$$\text{Log (18-kip)} = 1.70 + 0.480\ D \qquad (7)$$
(Cor. Coeff. R = 0.92)

For MR = 60 (239 data points)

$$\text{Log (18-kip)} = 1.82 + 0.488\ D \qquad (8)$$
(Cor. Coeff. = 0.94)

For MR = 48 (230 data points)

$$\text{Log (18-kip)} = 1.83 + 0.499\ D \qquad (9)$$
(Cor. Coeff. = 0.94)

For MR = 36 (216 data points)

$$\text{Log (18-kip)} = 1.85 + 0.50\ D \qquad (10)$$
(Cor. Coeff. = 0.94)

As can be seen, the values of B in model equation(3)for the five maintenance ratings as shown by equations 6 through 10 are almost identical. The maximum value is 0.511, the minimum is 0.480, and the average is 0.50. The value of the constant B was, therefore, taken as 0.5 and the value of A was redetermined. The

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* Log 18-kip = A + B (thickness index).

equation so determined and the values of A so obtained are

$$\text{Log 18-kip} = A + 0.5\ (\text{thickness index}) \qquad (11)$$

and

$$A = 1.213 \text{ for } MR = 83\ (R = 0.87;\ S.E. = 0.71)$$

$$A = 1.582 \text{ for } MR = 71\ (R = 0.92;\ S.E. = 0.49)$$

$$A = 1.742 \text{ for } MR = 60\ (R = 0.94;\ S.E. = 0.41)$$

$$A = 1.823 \text{ for } MR = 48\ (R = 0.94;\ S.E. = 0.39)$$

$$A = 1.871 \text{ for } MR = 36\ (R = 0.94;\ S.E. = 0.39)$$

The correlation coefficient values and the standard error for the MR values are also given. The correlation coefficient values show that an excellent relationship exists for MR, traffic, and structural strength.

Based on equation (11), Figures 2 and 3 have been drawn to show relationships between MR, 18-kip (8,160 kg), and D throughout the life of a flexible pavement. The graphs in these figures were extrapolated to an MR of 100 by plotting the five values of A against the five MR values 83 through 36 as given above in equation (11), and extrapolated as shown in Figure 4. By means of these graphs the values of A could be obtained for any MR value.

A study of the AASHTO pavements tested before and after the application of an overlay showed that they all behaved in the manner shown by the solid line in Figure 5. This figure shows a pavement deteriorated to an MR value of 40 prior to the overlay. Since the overlay covered all the observed types of distress, the MR values increased without a change in traffic. After an overlaid pavement is open to traffic, the rate of decrease in the MR value with an increase in traffic is constant. The duration of this trend depends upon the thickness of the overlay. After some time, the reduction in MR accelerates in the same manner as for a new pavement, and the curve of MR versus traffic follows the general trend shown for new pavements before the overlay. This behavior of the overlaid pavement is shown in Figure 5. By this means the MR value and the traffic carrying capacity of the overlaid pavement could be determined.

To design an overlay thickness one needs to know its thickness equivalency. The determination of this value is discussed in the succeeding section.

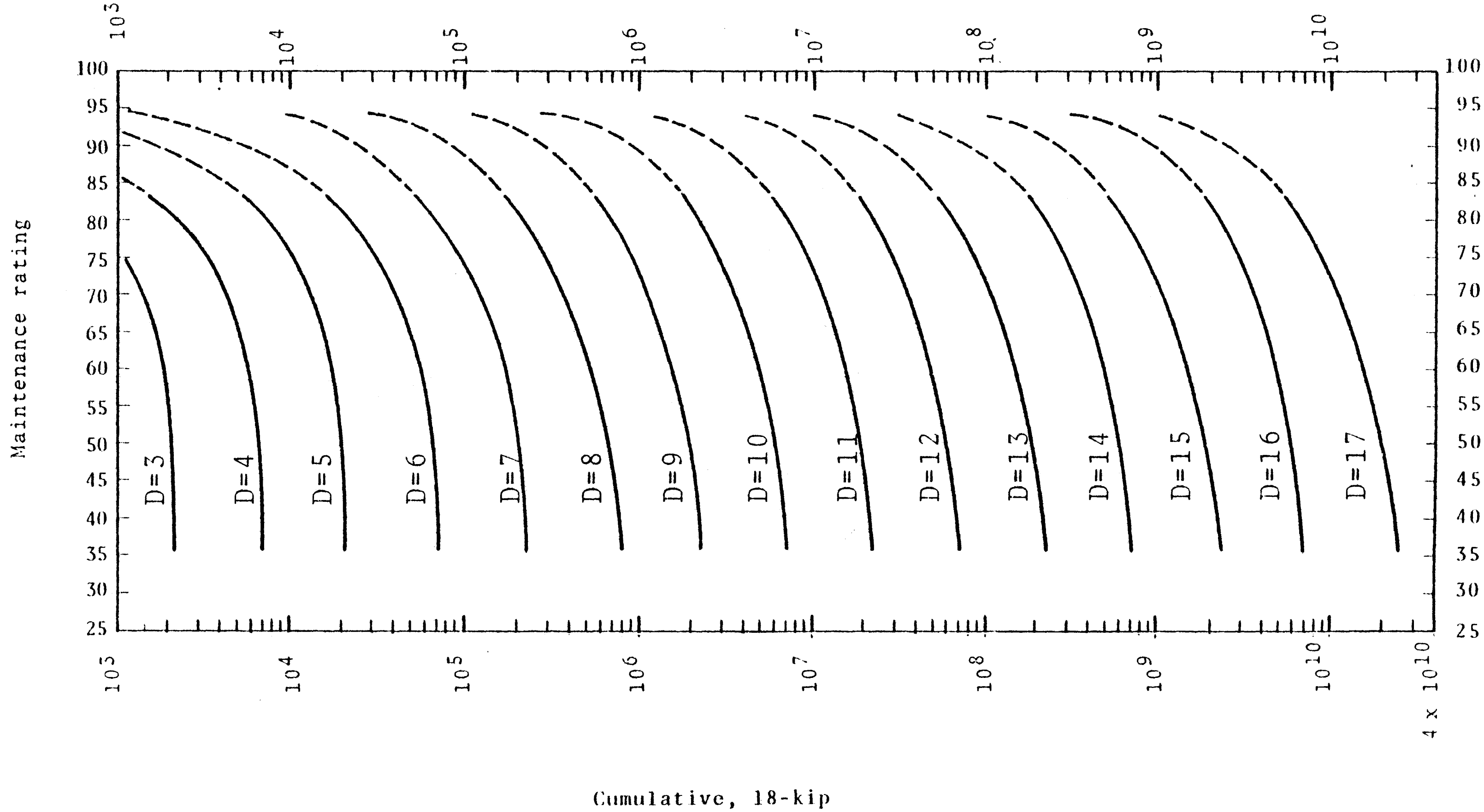

Figure 2. Cumulative traffic in 18-kip equivalents between accumulated traffic and pavement maintenance rating. (Conversion unit: 18-kip = 8,160 kg)

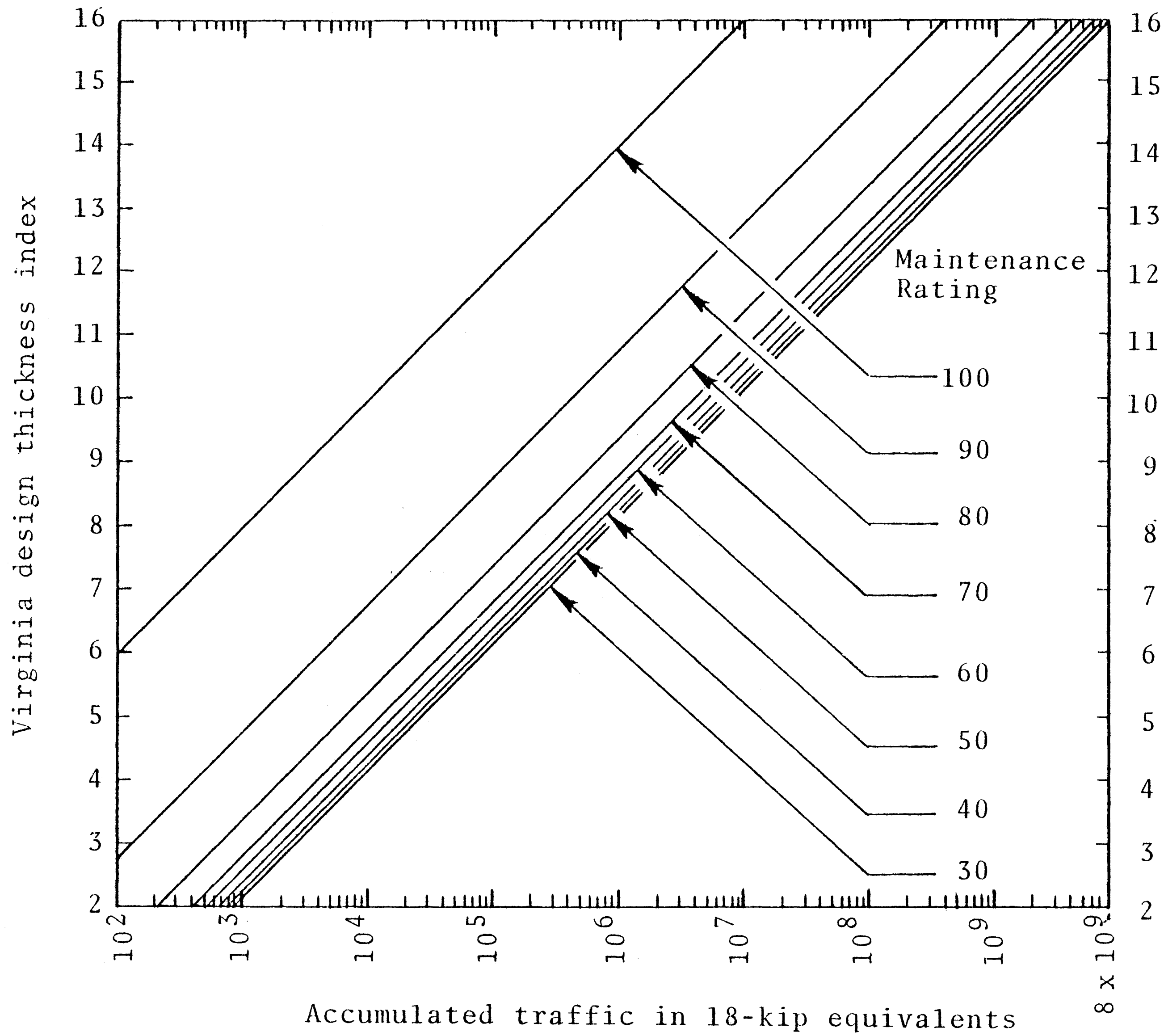

Figure 3. Relationships of design thickness, traffic, and maintenance rating.

(Conversion unit: 18-kip = 8,160 kg)

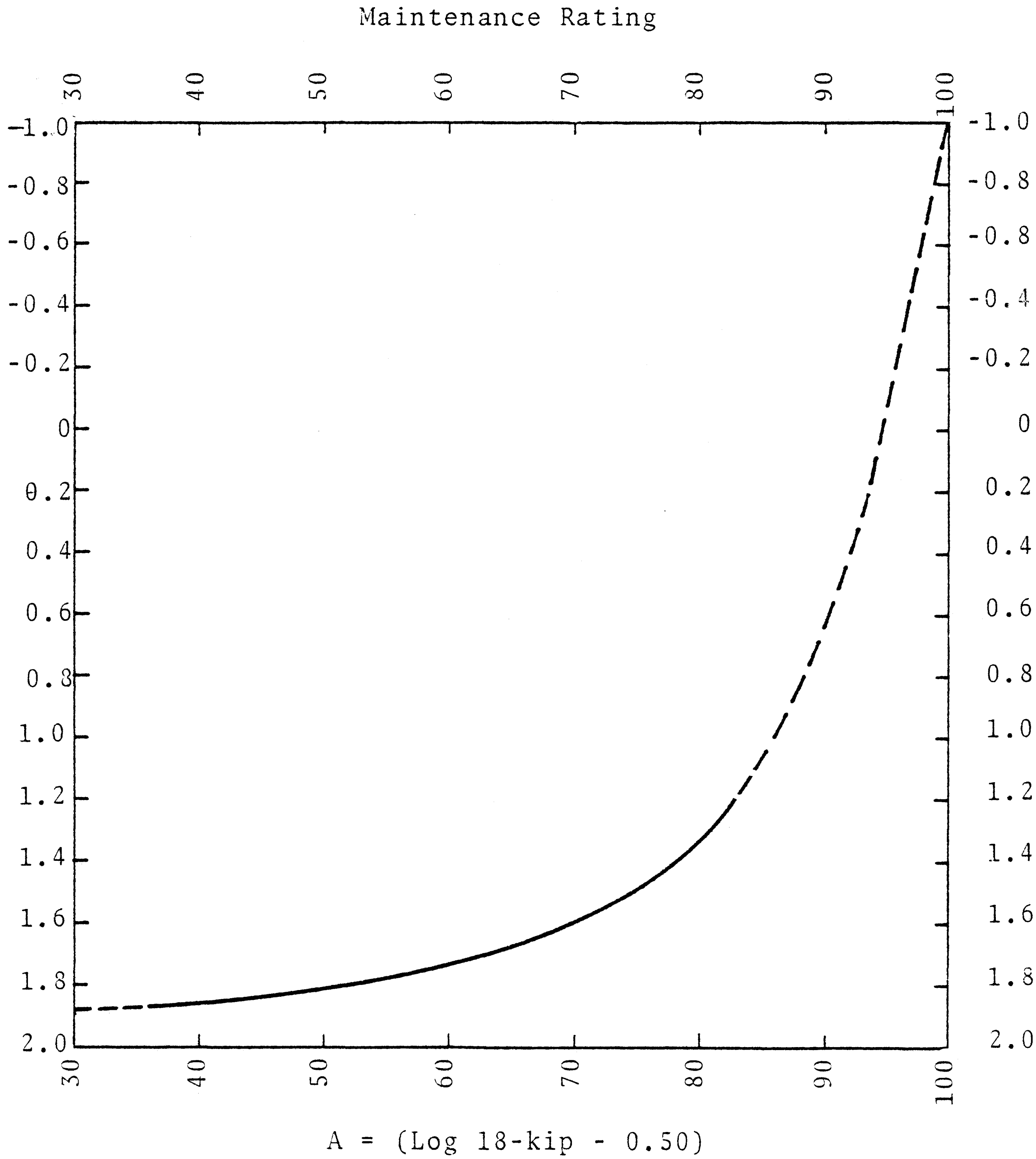

Figure 4. A versus maintenance rating.
(Conversion unit: 18-kip = 8,160 kg)

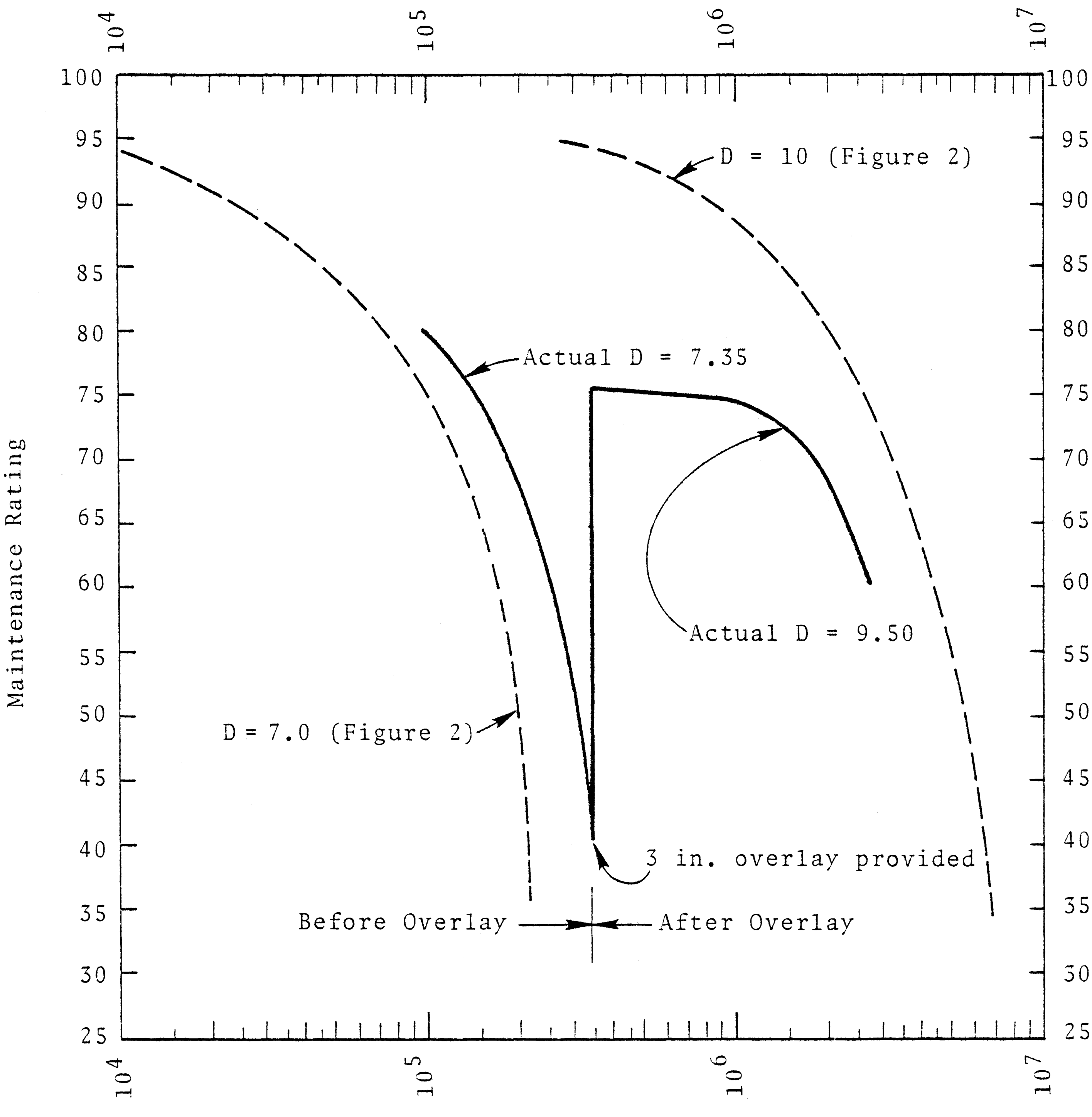

Figure 5. An example of the relationship between traffic and maintenance rating of a pavement, before and after the overlay.

THICKNESS EQUIVALENCY

No maintenance rating data are available for overlaid pavements in Virginia; however, the AASHTO Road Test gives basic data on 99 overlaid projects. These AASHTO data have been evaluated by the author and the results presented in a separate report.(7) The results of the evaluation showed that the thickness equivalency of an overlay should be taken as one-half that of asphaltic concrete for new construction. In Virginia the thickness equivalency of asphaltic concrete for new construction is equal to 1 as shown in Table 7. The thickness equivalency of asphaltic concrete for an overlay in Virginia is therefore equal to 0.5.

Of the 111 projects analyzed in this investigation, eight were overlaid in 1975. The average MR value of these eight projects was 83 and the average traffic on them before the overlay was about 2 million 18-kip (8,160 kg) equivalents. The average thickness of an overlay on these eight projects is equal to 1 inch (2.5 cm). One inch (2.5 cm) overlays on new pavements in Virginia are usually found to last as long as the pavement before the overlay. Hence, it is assumed that these eight pavements will carry an additional 2 million 18-kip (8,160 kg) equivalents before a second overlay is needed. The MR versus traffic history of the average of these eight pavements was plotted in Figure 1 and the same is shown on an exaggerated scale in Figure 6. This figure shows that the average thickness indexes of these eight pavements before and after the overlays are 10.1 and 10.6, respectively. Thus a 1-inch (2.5 cm) overlay gives a thickness equivalency of 10.6 - 10.1 = 0.5. Hence, it appears that the conclusion reached in the evaluation of the overlay thickness equivalency for AASHTO road projects could also be applied to overlays in Virginia.

Taking the thickness equivalency of an asphaltic concrete overlay as half the value for new construction can be justified as follows. With age and traffic the pavement becomes fatigued and weak. When an underlying layer becomes weaker than the overlying one, the thickness equivalency of the overlying layer decreases. This is illustrated by the practice in Virginia of taking the thickness equivalency of cement treated aggregate as 0.6 when it is placed directly over a raw subgrade, but as 1.0 when it is over a strong subbase course.

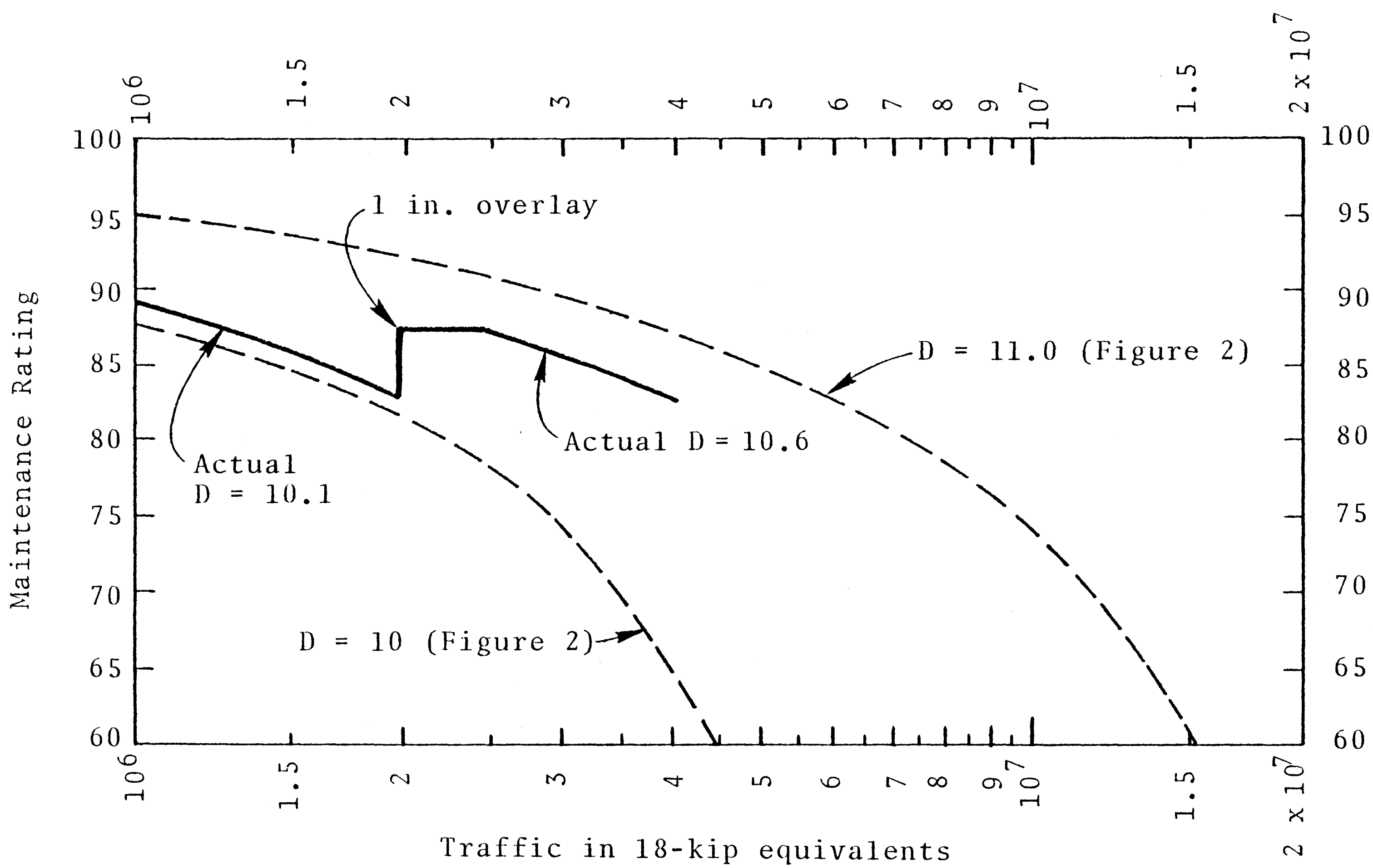

Figure 6. Relationship between traffic and maintenance rating of an interstate pavement in Virginia before and after the overlay. (Conversion unit: 18-kip = 8,160 kg)

THICKNESS OF AN OVERLAY

Based on equation (11) the traffic carried by an overlaid pavement could be obtained as

$$\text{Traffic} = \text{Antilog}\ (Aa + 0.5\ Da) - \text{Antilog}\ (Ab + 0.5\ Db) \qquad (12)$$

where Ab and Aa are the constants for the maintenance rating before the overlay and at the end of the overlay service and Da and Db are the thickness indexes of the pavement before and after the overlay.

As stated above, for a given highway type the MR values before the overlay and at the end of the overlay service are the same; that is, Aa = Ab. In such a case equation (12) reduces to

$$\text{Traffic after the overlay} = \text{Traffic before the overlay} \times [\text{Antilog}\ (0.5 \times \text{overlay thickness} \times \text{thickness equivalency of overlay}) - 1], \text{ or} \qquad (13)$$

$$\frac{\text{Traffic after the overlay}}{\text{Traffic before the overlay}} = [\text{Antilog}\ (0.25 \times \text{overlay thickness}) - 1], \text{ or} \qquad (14)$$

$$\text{Percentage increase in traffic after the overlay} = [\text{Antilog}\ (0.25 \times \text{overlay thickness}) - 1] \times 100 \qquad (15)$$

Based on equation (15), Figure 7 has been drawn. It shows the percentage increase in the 18-kip equivalent versus the overlay thickness and can be used in determining the required thickness of an overlay. This figure shows that the traffic capacities for overlay thicknesses of 1, 2, and 3 inches (2.5, 5.1, and 7.6 cm) are respectively 78%, 217%, and 464% of the traffic before the overlay.

If these percentage increases in traffic are examined carefully, it is seen that the percentage increase in traffic would be the same if the overlay were applied in several thin layers rather than in one thick layer. Thus, one thick layer of, say, 3 inches (7.6 cm) would carry the same traffic as three layers of 1-inch (2.5 cm) as shown in Table 8.

Deflection studies in Virginia carried out before and after the application of asphaltic concrete overlays have shown that overlay thicknesses of 1-inch (2.5 cm) and above do contribute to an increase in the structural strength of the pavement. It is, therefore, recommended that overlays provided for increasing the structural strength of the pavements be limited to a minimum of 1-inch (2.5 cm). The method described in the next section is recommended for the design of overlay thickness.

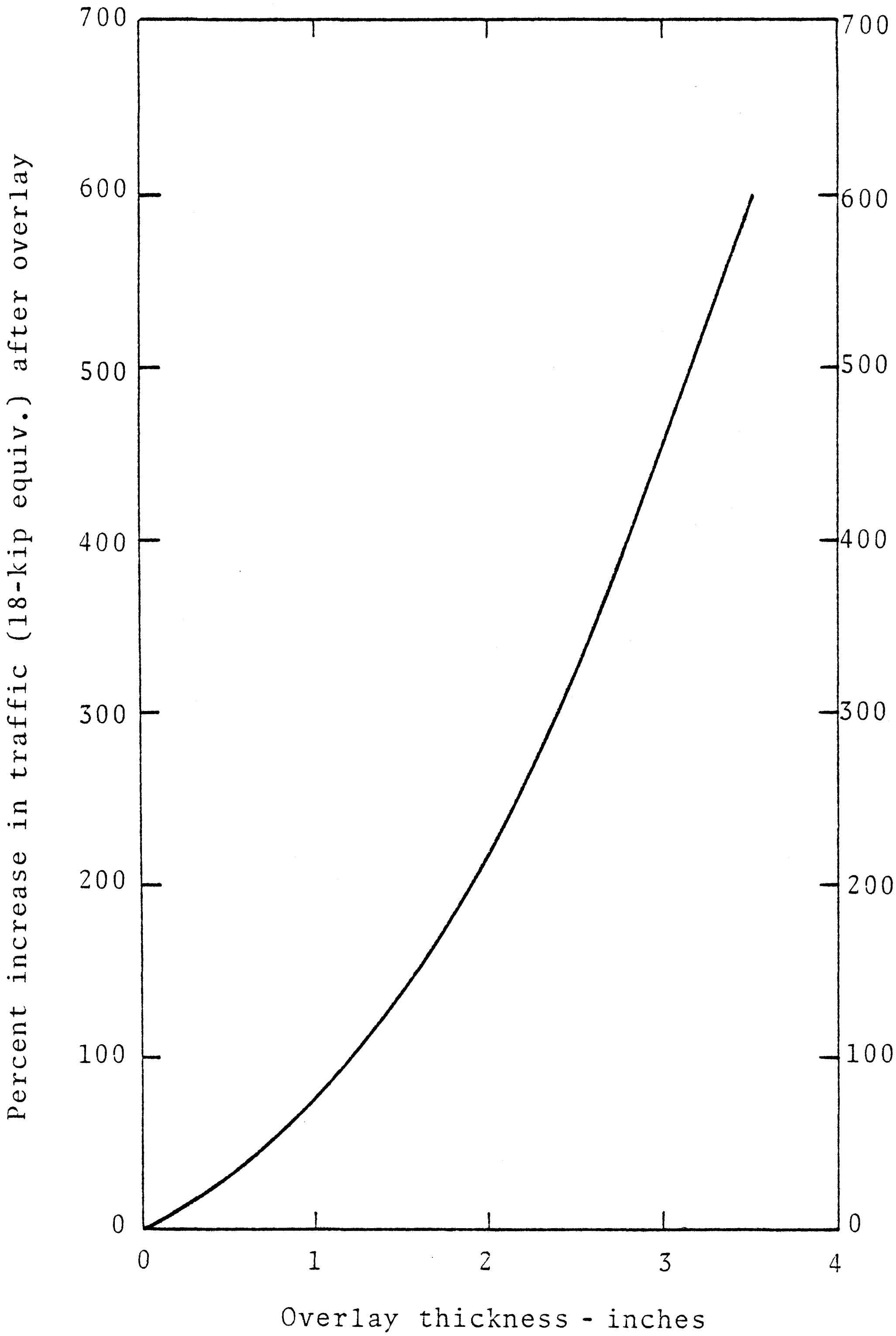

Figure 7. Overlay thickness versus traffic carrying capacity. Conversion units: 18-kip = 8,160 kg
1 inch = 2.5 cm

Table 8

Example of Overlay Thickness Versus Traffic

Pavement section	Total traffic before overlay	Traffic due to the overlay	Total traffic due to overlays only
No overlay	-	0	0
First 1 inch overlay	1	78%	0 + 78 = 78%
Second 1 inch overlay	1 + 0.78 = 1.78	1.78 x 78 = 139%	78 + 139 = 217%
Third 1 inch overlay	1 + 2.17 = 3.17	3.17 x 78 = 247%	217 + 247 = 464%

Design of Overlay Thickness

The design of the overlay thickness is dependent upon the durability of the asphaltic concrete mix as influenced by the age, hardening, and stripping of asphalt, etc. An overlay made from a well-designed mix properly placed could perform satisfactorily for 10 to 15 years without surface rejuvenation. For determining the thickness of an overlay, the use of a 12-year service life for the mix is recommended. The procedure for determining the overlay thickness is as follows.

1. Determine the accumulated traffic in terms of the 18-kip (8,160 kg) equivalents that the pavement has carried from the date of construction to the date of the proposed overlay, irrespective of any previous overlays. If needed, use Figure 2 to convert the traffic count into 18-kip (8,160 kg) equivalents.

2. Determine the accumulated traffic in terms of the 18-kip (8,160 kg) equivalents the pavement will carry in the 12 years following the overlay.

3. From Figure 7, determine the thickness of the overlay from a given percentage increase in traffic after the overlay, taking the percentage increase as

$$\frac{\text{18-kip (8,160 kg) after the overlay}}{\text{18-kip (8,160 kg) before the overlay}} \times 100$$

For example, an interstate highway pavement that was built in 1967 and had an MR of 76.5 in 1977, an overlay would be justified.

The accumulated traffic up to 1977 was 0.45 million 18-kip (8,160 kg) equivalents. The ADT in 1977 was 140 18-kip (8,160 kg) equivalents. Assuming a yearly increase in traffic of 5%, the accumulated traffic at the end of 12 years would be

$$140 \times 365\ [1 + (1 + .05) + (1 + .05)^2 + \ldots (1 + .05)11]$$

$$= 51100 \times 15.92$$

$$= 0.81 \text{ million 18-kip(8160 kg) equivalents.}$$

The percentage increase in traffic after the overlay would be

$$\frac{0.81}{0.45} \times 100,$$

or 180%. From Figure 7 the designed thickness of the overlay is determined to be 1.75 inch (4.5 cm).

CONCLUSIONS

1. A simplified method based on visual inspections could provide uniformity in decisions regarding the stages at which pavements would be overlaid in an economical manner.
2. The thickness equivalency value for an asphaltic concrete overlay is 0.5 for Virginia.
3. A method for designing the thickness of overlays has been developed.

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