Overlays for Flexible Pavements for the 1968 Interstate Estimates

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Interstate funds for additional state construction were made available under the provision of IM 21-1-67 issued by the Bureau of Public Roads in January 1967. However, certain criteria were required to be met before a project could become qualified. Primarily these criteria were the project must have been authorized for construction prior to October 24, 1963; the condition of the pavement must exhibit visual evidence of physical stress; and a complete structural analysis of the pavement design must establish a need for additional thickness. These considerations are to provide a serviceability index of 2.0, 20 years after the date of authorization of the initial pavement construction project.

This paper explains the methods of determining conditions, determining structural adequacy, design analysis, and determining the thickness of overlay required for flexible pavements included in the 104(b)5 report for the 1968 Estimate of the Cost of Completing the Interstate System in Oklahoma.

A method is included to predict if a project will meet the criteria prior to 1972 even though the present condition does not qualify for immediate overlay.

Although this method of analysis was used for Interstate pavements, it is one which may be adopted (and has been used prior to this time) on any system.

•ALTHOUGH the design of pavements has been studied for hundreds of years, the design of overlays for pavements, until recently, has been a "seat of the pants" operation.

When the Bureau of Public Roads issued IM 21-1-67 in January 1967, Interstate funds were made available for additional stage construction. However definite criteria were required to be met in order that a particular project could qualify for these funds. Primarily these criteria were (a) the project must have been authorized for construction prior to October 24, 1963; (b) the condition of the pavement must exhibit visual evidence of physical stress; and (c) a complete structural analysis of the pavement design must establish a need for additional thickness. These considerations are to provide a service ability index of 2.0, 20 years after the date of authorization of the initial pavement construction project. It is evident these requirements reduce the latitude of guesswork in arriving at the thickness of overlay required.

Using these criteria, the sections of Interstate highways qualifying for immediate overlays can be defined. However another problem was presented to the several highway departments when the Bureau of Public Roads asked that an estimate of the cost of overlays through 1972 be included in the 104(b)5 report for the 1968 Estimate of the Cost of Completing the Interstate System. In essence, the department engineers needed a method of predicting which sections would meet the criteria within the next five years.

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TABLE 1

VISUAL CONDITION SURVEY—TERMS

Terms	Percent of Area
Few, slight	<5
Some	5 to 15
Considerable	15 to 30
Extensive	>30

SURVEYS OF PAVEMENTS

Two types of surveys were made on each section of Interstate pavement authorized prior to October 24, 1963:

1. A visual condition survey (1, 2) to determine the rate of deterioration. The visual survey was conducted using the outline in Tables 1 and 2.

If maintenance has been performed, the maintained area will be rated in one of the preceding classifications as to its effectiveness. A note will be made in the remarks column of the condition survey form regarding the type of maintenance that has been formed. Other remarks included the general condition of the pavement structure.

Condition surveys of projects which had been recently resurfaced could not be expected to reflect the true rate of deterioration; therefore, particular cognizance was taken of undulation of shoulders and curb lines as indicators of distress and special Benkelman beam deflection testing was accomplished.

2. On all projects except those with soil-cement base courses, Benkelman beam tests (3) were run at 500-ft intervals. All Benkelman beam tests were conducted with a 9000-lb wheel load. In areas having a condition rating less than 90, the deflections were run at 250-ft intervals. Projects that had been resurfaced were tested at 1000-ft intervals, except where the deflections were greater than 0.022 in. These areas were isolated by testing in both directions at 250-ft intervals until the deflections returned to the 0.022-in. level.

In selection of a design wheel load for a given pavement, the volume and character of traffic, including some form of load repetition, is a major consideration. Earlier work in Oklahoma (4) had established an allowable deflection of 0.037 in. for a 9000-lb wheel load design using a 20-yr design life. Later testing established the relationship between 9000-lb wheel load and 15,000-lb wheel load deflections (Fig. 1). Using the assumption that the permissible deflection for a 20-yr design is 0.037 in. for the designed wheel load and considering the 15,000-lb wheel load design used for Interstate

TABLE 2

VISUAL CONDITION SURVEY—CLASSES AND RATING

Classes	Rating (%)	Remarks
Excellent	98-100	No apparent major or minor defects. No maintenance performed.
Superior	90-97	No base failures or other major defects and no structural maintenance has been necessary. Any one or all of the following characteristics may be present within a 0.2-mi extent: slight surface roughness, cracking, riding quality impaired but very slightly.
Good	80-89	No base failures. Any one or all of the following characteristics may be present within a 0.2-mi extent: some surface roughness, or cracking, slight raveling, or distortion.
Average	65-79	Few localized base failures, considerable surface roughness, or cracking, some raveling (especially in the outer wheel lanes and along the edges), some distortion.
Poor	50-64	Considerable base failures, extensive surface roughness, or cracking, surface raveled extensively throughout its width, or considerable distortion.
Failure	<50	Numerous and extensive base failures, extensive distortion, extensive traffic hazards due to failures and distortion, or routine and special maintenance repairs have not been effective.

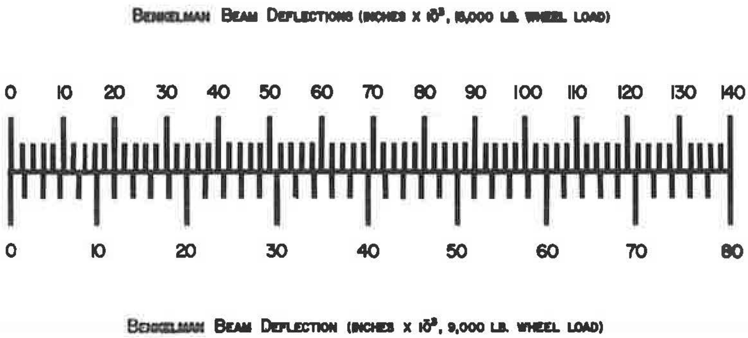


Figure 1. 9000-lb wheel load deflection vs 15,000-lb wheel load deflection.

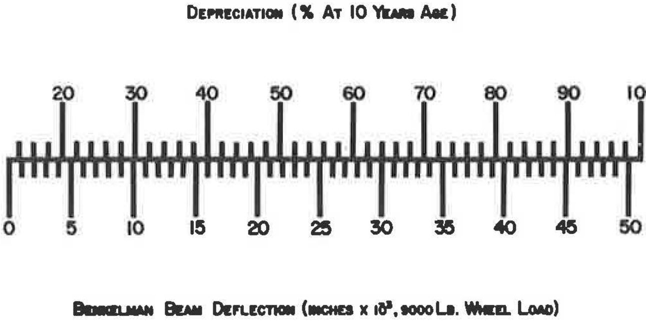


Figure 2. 9000-lb wheel load deflection vs depreciation for Interstate pavements (flexible).

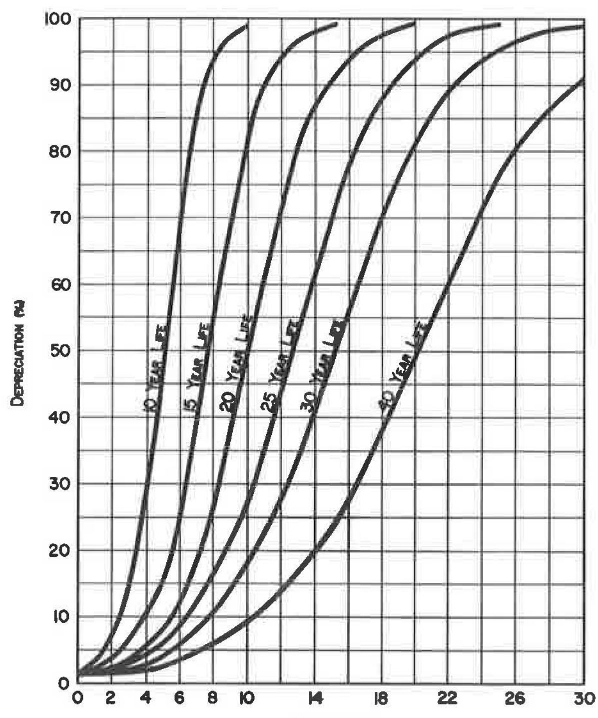
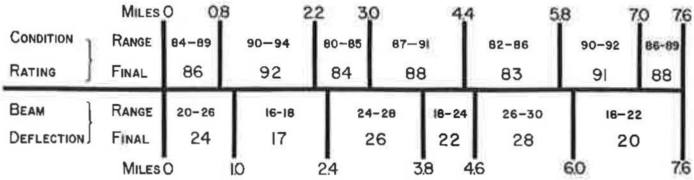


Figure 3. Life curves for flexible pavements.



Design Analysis Equivalent Base Thickness Increase 5 Inches

Extent Miles	Condition Rating	Condition Overlay	B. Beam Defl. (10^{-3})	B. Beam Overlay	Design Overlay	Recommended Overlay
0.0-0.8	86	1	24	3	3.3	3
0.8-1.0	92	0	24	3	3.3	3
1.0-2.2	92	0	17	0	3.3	0
2.2-2.4	84	5	17	0	3.3	4
2.4-3.0	84	5	26	3	3.3	4
3.0-3.8	88	0	26	3	3.3	3
3.8-4.4	88	0	22	0	3.3	0
4.4-4.6	83	6	22	0	3.3	5
4.6-5.8	83	6	28	5	3.3	5
5.8-6.0	91	0	28	5	3.3	5
6.0-7.0	91	0	20	0	3.3	0
7.0-7.6	88	0	20	0	3.3	0

Figure 4.

designs in Oklahoma, the allowable 9000-lb wheel load deflection should be 0.022 in. Extropolation of these values in conjunction with the results of the earlier research establish the relationship of the rate of depreciation to measured deflection for this system (Fig. 2).

Projects constructed with a soil-cement base were rated using the present serviceability index (5) rather than the Benkelman beam.

ANALYSIS OF CONDITION SURVEYS

Using the pavement life curves (4) in Figure 3, the age of the pavement and the depreciation (100 - condition) the expected life of the roadway (with normal maintenance) can be projected. As an example: A pavement five years old exhibiting a condition rating of 85 would have an expected life of 15 years. In addition, the depreciation of the pavement at the end of 10 years would be approximately 82 percent. For projects which have been resurfaced, the date of overlay rather than date constructed is used to determine age. Referring to Figure 2, this project could be expected to experience a deflection level of about 0.040 in. when subjected to a 9000-lb wheel load. Further analysis of this information will be discussed in the section of this paper dealing with analysis of deflections.

For purposes of analysis, the condition rating for each portion of a project was recorded on a line chart (Fig. 4) using a suitable scale, generally 1 in. = 1 mile. Further, the conditions were grouped in appropriate ranges (i.e., a 4-5 percent spread) and a representative value selected, not necessarily the average, to use for determining the overlay required.

ANALYSIS OF BENKELMAN BEAM DEFLECTIONS

The beam deflections as taken in the field must be adjusted in accordance with the curve in Figure 5 to adjust for seasonal effects of temperature and general moisture conditions. This adjustment has been determined as a result of deflection studies during a 10-yr period. These corrections are added to the measured deflections. Deflections determined from condition do not require adjustment.

Further studies indicate that the deflection for a particular pavement will remain rather constant until the structure is overstressed and begins to fail. Because of this, deflection may be related to depreciation (Fig. 2). The results of the deflection tests (as adjusted) are recorded in the same manner as the condition on the line chart (Fig. 4).

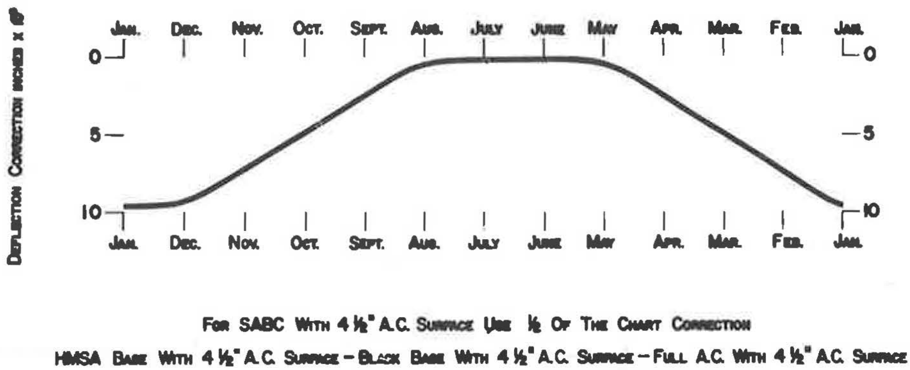


Figure 5. Benkelman beam—seasonal effects.

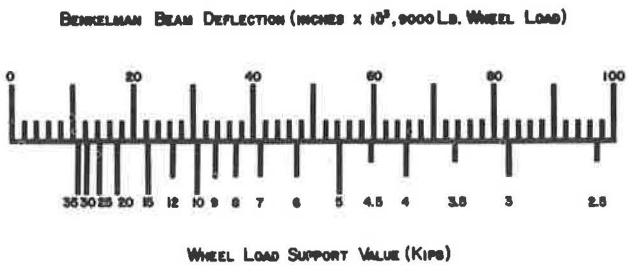


Figure 6. Relationship of Benkelman beam deflections to wheel load support value of flexible pavements.

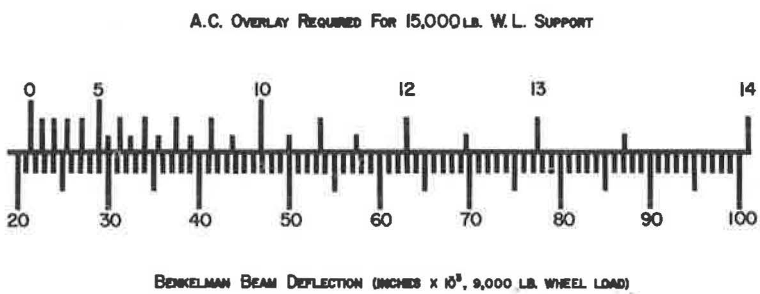


Figure 7. Asphaltic-concrete overlay requirement based on Benkelman beam deflections.

Deflections have been related to the allowable wheel load for a pavement (Fig. 6) and the ability of the overlay material to import additional strength to the structure has been established (4). From these relationships, the excess deflection may be used to establish the amount of overlay required to give adequate performance (Fig. 7).

DESIGN ANALYSIS

Using Oklahoma's Procedure for Pavement Design (6), the thickness required for 20-yr design life was developed and compared to the in-place thickness of the pavement, including the thickness of overlays if the overlay thickness was 1½ in. or greater.

Questions may arise relative to the exclusion of overlay thickness less than 1½ in. This thickness, by past experience, has been accepted in Oklahoma as the least amount of overlay attributing additional strength to the initial structure (see Fig. 8). Some of

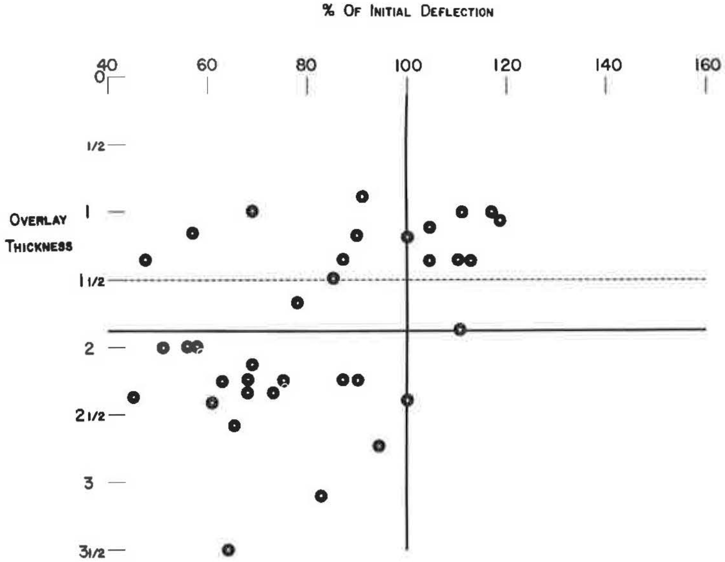


Figure 8. Overlay thickness vs deflection reduction (percent).

the scatter in this figure is accounted for by the inability to retake deflections in the same locations after the overlay had been placed, the variation in moisture conditions attributed to installation of additional underdrains, and the range of level of the initial deflections. In the areas of low initial deflection (0.020-0.025 in.) the decrease in deflection was not as noticeable as in the areas of higher initial deflection (0.040-0.050 in.).

The present design equation used by Oklahoma (4, 6) provides for increases in pavement thickness to account for traffic and climate. Because the design traffic was restricted to the year 1975 for projects authorized prior to October 1963 and the present procedure and authorization allows these designs to be updated to a 20-yr design, the increase in current pavement thickness over the in-place thickness is generally accounted for by the increase in traffic subsequent to 1975. Because the traffic effect is independent of soil type and because climate remains the same, it suffices to examine any point within the project for increase in design base thickness. The increase, if any, is recorded below the line chart in Figure 4.

Prior studies (4) indicate that asphaltic concrete has approximately $1\frac{1}{2}$ times the equivalency of the base material used as a standard in Oklahoma. For this reason, the equivalent base thickness is divided by $1\frac{1}{2}$ to establish the required thickness of overlay. This figure is recorded as the design overlay.

RECOMMENDED OVERLAY

After each extent of the project has been analyzed (as illustrated by the chart and table in Fig. 4), three of the parameters must be evaluated in combination to recommend the overlay thickness.

Although all projects receiving a recommendation for overlay do not qualify for immediate overlay based on present condition, the rate of deterioration can be examined and a determination made whether the "visual" condition of a particular project could be expected to meet the criteria for overlay by 1972. If it is determined that the project may qualify by 1972, it was included in the estimate of cost for completion of the Interstate System.

PRESENT SERVICEABILITY INDEX ANALYSIS

Sufficient data for determination of the serviceability-age relationship were not available to make a rational evaluation of the soil-cement base projects. Therefore, an arbitrary index level of 3.5 at this point in time was chosen as possibly qualifying the project for an overlay.

As further data become available, this portion of the procedure will be revised.

CONCLUSION

This procedure has been used for design of overlays in Oklahoma for several years and may be adjusted for various classes of highways and wheel loads. Methods similar to this have been used by others (7) with success. Each agency can, with modifications to adapt the information to its experience, use these parameters for such designs.

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