Assessment of Stripped Asphalt Pavement

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Many miles of pavement that are stripped need to be restored to a serviceable condition, but there is no accepted procedure to determine whether the pavement should be removed during the rehabilitation process. This paper describes an attempt to develop a methodology that employs a quantitative test to evaluate pavement layers. The indirect tensile test was used under various testing conditions to develop a deterioration curve for stripped pavement layers based on data from three field projects. The procedure will be valuable because it will make possible the evaluation of individual layers of asphalt; for in situ strength tests, however, such as those provided by deflection devices, that employ dynamic field measurements, the asphalt layers are evaluated as a whole. Criteria defining minimum strengths necessitating removal are suggested. It is realized that these criteria may have to be changed as experience with the evaluation procedure is gained.

Stripping of asphalt pavement, which is the loss of cohesive and/or adhesive strength in the presence of moisture, has been recognized as a major cause of pavement distress (*1*). Prior to rehabilitation, several questions arise. Should the stripped asphalt concrete be removed before an overlay is applied? Will it continue to deteriorate in the future? These questions should be answered to ensure that the new pavement will attain its anticipated life.

Considerable research has been directed toward prediction and prevention of stripping, but little has been done in the evaluation of stripped pavement. Because of its simplicity, the most common method of evaluation is visual inspection of pavement samples; however, the reproducibility of the results of this method is very poor. Quantitative measurements such as tensile strength and tensile strength ratios have been used with limited success to determine the degree of damage, and more thought needs to be directed toward their use and interpretation. Because there are many stripped pavements that need to be rehabilitated, there is a definite need for a reliable method of evaluation.

PURPOSE

The purpose of this investigation was to develop a method to evaluate stripped pavement. The investigation involved field testing pavements that were damaged by stripping, testing cores from these pavements, and developing an evaluation methodology.

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APPROACH

The results of a visual assessment of pavement samples lack satisfactory reproducibility; although this method will not alone suffice, it may supplement other methods. Indirect tensile strength is the quantitative measure that is used most often to evaluate new asphalt mixtures, and it is a suitable choice for the evaluation of pavements in the present study; however, the interpretation of tensile strength measurements is even more critical in the case of rehabilitation, and it needs to be refined.

The relationship between strength and age needs to be understood before a methodology can be developed. As pavement ages, it stiffens, primarily because of asphalt hardening; and its strength increases (Curve 1 in Figure 1). Lottman (*2*) found that pavements that strip tend to strengthen for a short period of time and then to weaken because of the stripping (Curve 2). To measure the degree of damage, it is necessary to measure the present strength of the stripped asphalt concrete and the strength of the material that has been restored to an unstripped state, and it is desirable to predict the minimum strength that will be reached in the future. The present and future strengths and the ratio of present or future strength to the unstripped strength (TSR) should give the investigator an indication of the adequacy of the pavement.

It is not a problem to remove cores and test them immediately to determine the present strength; however, it is more difficult to determine the unstripped strength of the asphalt. An attempt was made to duplicate the unstripped strength by drying cores, reheating them, and remolding them into fresh specimens (see Figure 2a). The future strength was predicted

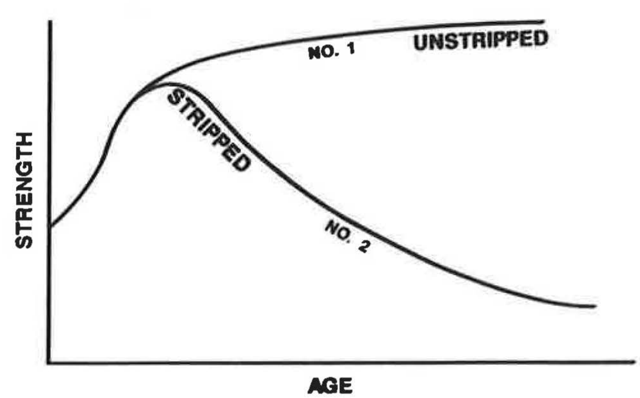

FIGURE 1 Strength versus age of pavement.

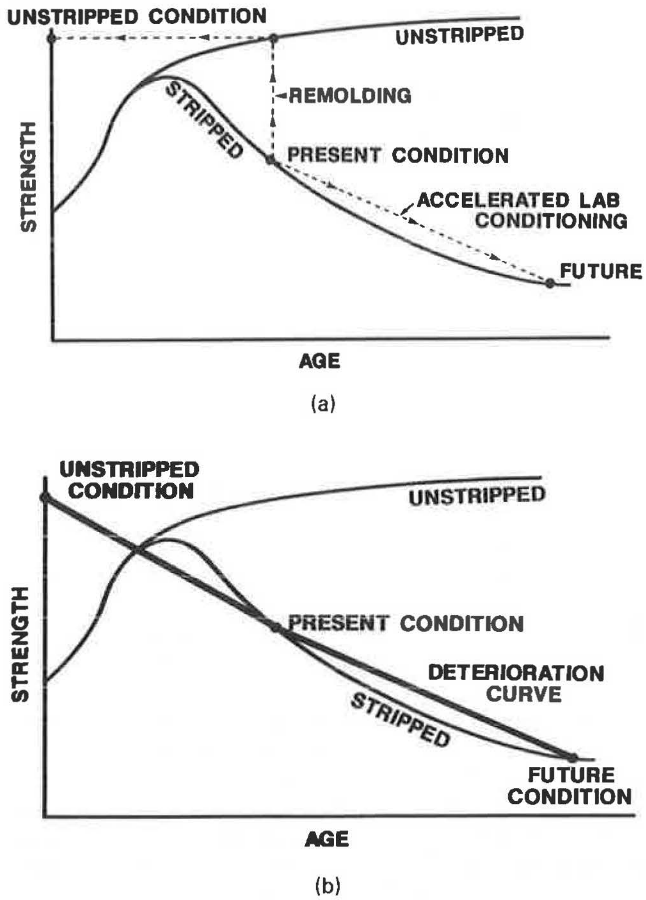

FIGURE 2 (a) Development of deterioration curve. (b) Deterioration curve.

by testing a set of cores that were conditioned to simulate future deterioration. Plotting the estimated deterioration curve using the measured strength values was done to visualize the existing and potential damage to a pavement layer (see Figure 2b).

The strength parameters were compared with general observations of the pavement condition, previous test results, and strength measurements computed from pavement deflections to assess the potential usefulness of the procedure.

FIELD PROJECTS

The three field projects were on I-81 (Rockbridge County), I-64 (Goochland County), and Greenwood Drive (Portsmouth).

I-81 (Rockbridge County)

The pavement was composed of 9 in. of select material, 6 in. of crushed stone base, 7.5 in. of asphalt base mix, 1.2 in. of intermediate mix, 0.9 in. of surface mix, and an overlay of 0.75 in. of porous friction course (Table 1). The original pavement was completed in 1967, and the porous friction course was placed in 1974. The pavement, which had experienced random cracking and potholes, had an estimated present serviceability index (PSI) of 2.5.

General deterioration necessitated that some type of rehabilitation be undertaken. Approximately 4.5 in. was milled, and then Dynaflect tests were performed under the direction of K. H. McGhee of the Virginia Transportation Research Council to determine if additional material needed to be removed and replaced to achieve the necessary structural

TABLE 1 MIX DESIGN GRADATIONS (PERCENT PASSING)

	Mix Type			
Sieve	Surface	Intermediate	Base	Porous Friction Course
1 1/2			100	
1		100		
3/4			73-85	
1/2	100			100
3/8		63-77		85-100
4	53-67	43-57	38-48	15-32
8			28-35	0-7
30	19-27			
50		6-14		
200	4-8	2-6	2-6	0-0.5

strength. It was an excellent project for the subject investigation because the structural strength of the asphalt concrete obtained from Dynaflect tests could be compared with the strength obtained from the indirect tensile tests.

I-64 (Goochland County)

The structural cross section was composed of 6 in. of soil cement, 8 in. of stone base, 7.5 in. of asphalt base, 1.2 in. of intermediate mix, and 0.9 in. of surface mix, which was completed in 1970. A slurry seal was applied in 1978, and various combinations of fabric and overlays ranging from 160 to 250 lb/sq yd were added in 1980 and 1981.

The pavement distress was attributed to raveling of open-texture overlays and some cracking, possibly caused by weakness of the underlying layers. The estimated PSIs of the eastbound and westbound lanes, which were 3.4 and 3.1, respectively, had dropped suddenly over the previous year.

A similar study had been performed on this section of pavement in 1978 prior to overlaying (*3*); therefore, previous strength data from indirect tensile tests and Dynaflect data were useful for the present investigation.

Greenwood Drive (Portsmouth)

This 1,000-ft project was a former test section used in NCHRP Project 4-8(3) to evaluate a stripping test developed by Lottman (*4*); therefore, a great deal of useful test information was available. The structural cross section was composed of 6 in. of cement-stabilized subgrade, 6 in. of crushed stone, 5.5 in. of intermediate mix, and 1.5 in. of surface mix, which was constructed in 1976.

TESTING

Approximately 50 to 60 cores (4 in.) were removed from each project by wet-drilling; they were grouped as follows and tested:

1. Present (as soon after removal as practical),
2. Dried (dried until moisture loss ceased),
3. Conditioned (Root-Tunnicliff procedure) (*5*) and,
4. Remolded.

Approximately 10 cores were selected randomly for each group. The present cores were wrapped in plastic to prevent the escape of moisture, transported to the lab, and tested as soon as practical. Although the cores were removed using water as a coolant, it is the author's opinion that the present strength was not influenced substantially. The dry cores were dried in the lab until the moisture weight loss ceased, and then they were tested; however, it was evident from visual observation that enough moisture remained in the interior of some cores to affect the healing of the stripped surfaces. The conditioned cores were conditioned according to the procedure recommended in *NCHRP Report 274*, which consists of vacuum saturating to a specified level and then soaking in a 140°F water bath for 24 hr (*5*). The cores that were remolded were heated to 275°F, remixed, and compacted with a Marshall hammer using a compactive effort to duplicate the void content (VTM) of the pavement cores. It was not possible to remold the base mixes into 4-in. specimens because of the large aggregate contained in these mixes.

All cores were tested at a temperature of 77°F and a loading deformation rate of 2 in./min.

The Dynaflect device, which applies dynamic loading to pavement, was used to determine the relative strength (strength equivalency) of the combined thickness of the asphalt layers. It was assumed that undamaged asphalt has a strength equivalency of 1.0. If the strength equivalency of a 4-in. layer of damaged asphalt was determined to be 0.5, the strength had been reduced 50 percent, and the 4-in. layer was equivalent to only a 2-in. layer of undamaged asphalt. Dynaflect tests were performed approximately every 100 linear ft and averaged for each section.

RESULTS

I-81 (Rockbridge County)

The four layers of asphalt analyzed were (a) surface, (b) base, and (c and d) two distinct layers of intermediate mix, one containing limestone aggregate and the other containing quartzite aggregate.

Figures 3 and 4 illustrate the estimated deterioration of the various layers. In all cases the remolded strength was higher than the dry strength, as anticipated. Past experience indicates that it is difficult to heal the stripping damage completely by a simple drying process. Although the remolding process produces a higher strength, one disadvantage of the remolding process is the increase in the fracturing of aggregate by the compaction process.

The layers of surface and intermediate mix had similar estimates of deterioration. Although the unstripped strength of the surface mix was slightly higher than the unstripped strengths of either intermediate mix layer, the present and future strengths were not significantly different. It is also evident that expected deterioration will not progress significantly in the future for these layers. The present strengths were higher than 80 psi, which is usually considered adequate. The Georgia Depart-

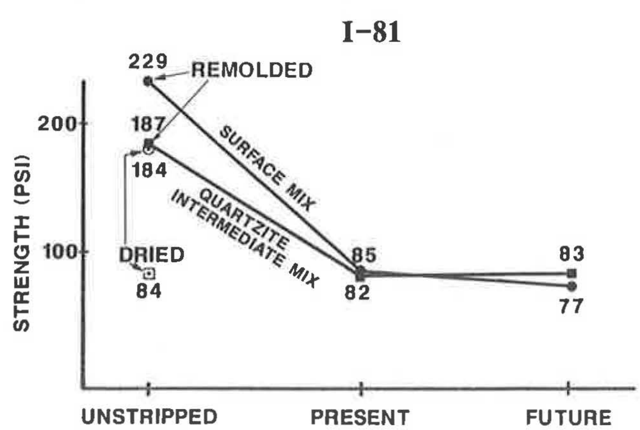

FIGURE 3 Deterioration curves for I-81.

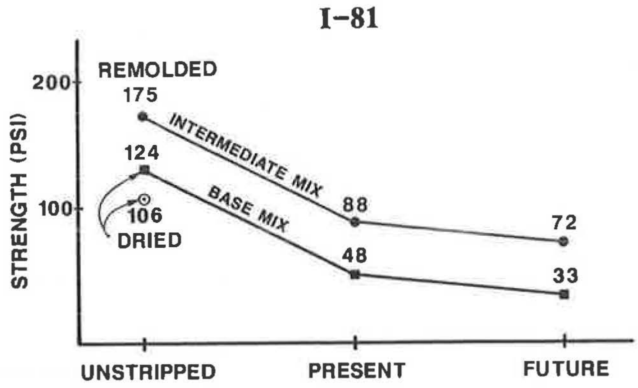

FIGURE 4 Deterioration curves for I-81.

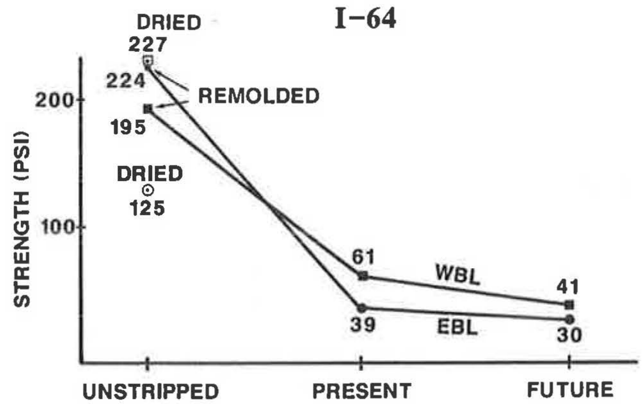

FIGURE 5 Deterioration curves for intermediate mix on I-64.

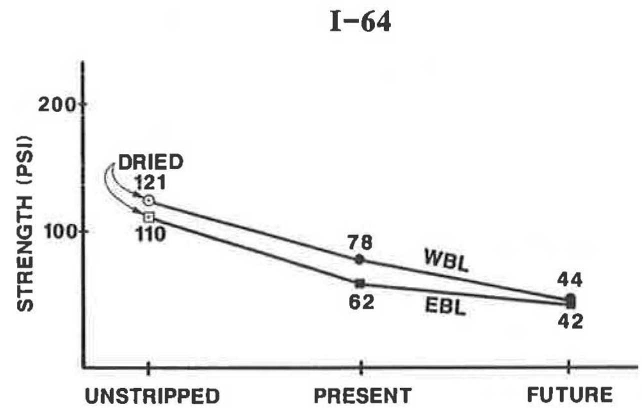

FIGURE 6 Deterioration curves for base mix on I-64.

ment of Transportation (DOT) considers pavements with strengths less than 40 psi to warrant consideration for removal (telephone conversation with Ronald Collins on July 28, 1987, unpublished data). Although the minimum value is not based on a systematic comparison of satisfactory and unsatisfactory pavements, it is based on experience. The present strength of the surface mix was 37 percent of its unstripped strength (i.e., TSR = 0.37), which does indicate a considerable loss of its original strength. The past experience of the author indicates that removal of pavement with a TSR less than 0.30 should be considered.

The present strength of the base mix was weaker than that of the other layers, and the future predicted strength was only 27 psi, which was considerably below the suggested 40 psi minimum.

Dynaflect measurements indicated a strength equivalency of 0.29 for the combined layers of asphalt; that is, the asphalt is contributing only 29 percent of the strength of undamaged asphalt. The computed weighted average present tensile strength ratio of the asphalt layers was 0.44, which was higher, but compared rather favorably with the Dynaflect strength equivalency.

An independent decision by McGhee based on Dynaflect data and current traffic loads was to remove at least 6.5 in. of asphalt, which included approximately 2.0 in. of the base mix. Although tensile strength data indicated that the entire base mix was weak, removal and replacement of only 2.0 in. of the base mix strengthened the pavement sufficiently for the designed traffic load. The indirect tensile strength data did confirm that it was advisable to remove some of the weak base mix and replace it rather than pave on top of it.

I-64 (Goochland County)

The intermediate mix layer and base layer were tested on this project in both the eastbound traffic lane (EBL) and the westbound traffic lane (WBL).

The estimated deterioration, illustrated in Figures 5 and 6, indicates that the strength of the EBL was less than the strength of the WBL; and similar measurements performed in 1978 demonstrated the same trend. It is shown subsequently that the Dynaflect measurements substantiated the same trend. The present strength of the intermediate mix from the EBL was only 17 percent of its original strength, and the present and future strengths were less than the suggested 40 psi; therefore, it should be removed in the rehabilitation. Although the strength of the intermediate mix layer in the WBL may be questionable, it appears that neither it nor any of the other mixes will drop below the suggested 40 psi level.

Dynaflect measurements indicated that the strength equivalencies of the combined layers of asphalt in the EBL and WBL were 0.30 and 0.46, respectively. There were no strength data for the surface mix and intermediate mix overlay; therefore, a weighted TSR could not be computed for the total asphalt thickness. When reasonable values are estimated by visual assessment for the surface and intermediate mixes, however, it appears that the TSR of the present strength would be slightly higher than the comparable value calculated from Dynaflect measurements. This trend is similar to that observed on the I-81 project.

The deterioration curves not only point out that the EBL was weaker than the WBL but also indicate that the weakest layer was the intermediate layer. The Dynaflect device also determined that the EBL was weaker than the WBL, but it could not identify the specific layers that were weak.

Greenwood Drive (Portsmouth)

The bottom half of the 5-in. layer of intermediate mix was tested because the same layer was tested in the previous NCHRP study.

The estimated deterioration curve is shown in Figure 7. The present and future strengths are greater than the 40 psi minimum value suggested by the Georgia DOT.

The predicted TSR of the cores shortly after construction was 0.51, which compares favorably with the ratio of the present strength to the unstripped (remolded) strength, which was 0.55 (Figure 8). The future TSR is predicted to decrease to 0.39; however, this decrease may not materialize in the pavement because the traffic volume is low.

The pavement is performing satisfactorily, which substantiates the reasonably high strength and TSR values that were obtained.

No Dynaflect tests were performed because the author felt that poor and variable soil support would make the results of strength calculations of the asphalt layer dubious.

Visual Assessment

There was no correlation between the amount of visible stripping on the coarse and fine aggregate and TSR in any of the projects. A correlation may have been apparent if a wider range of values had been available; it is also possible that cohesion failures, which are not visible, had a significant effect on the TSR values.

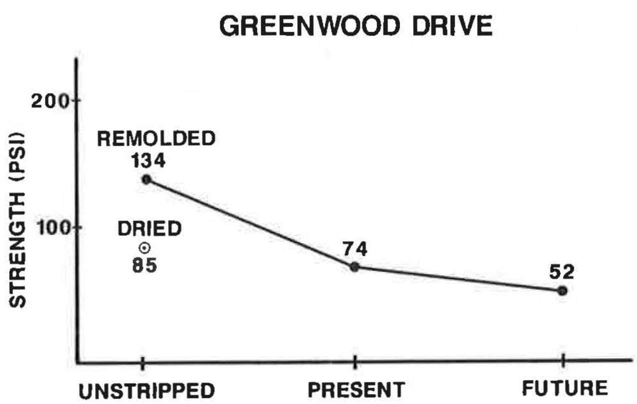

FIGURE 7 Deterioration curve for Greenwood Drive.

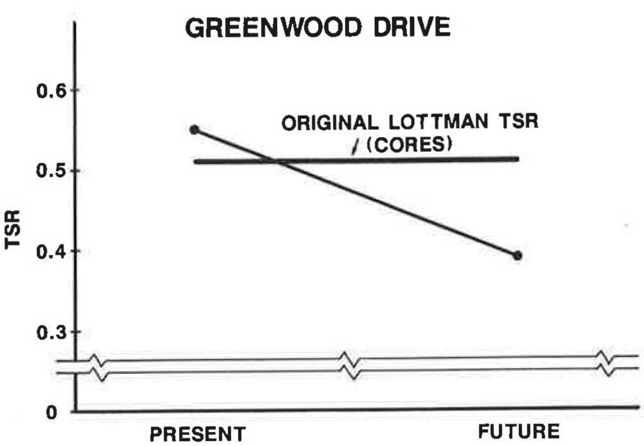

FIGURE 8 Tensile strength ratio, Greenwood Drive.

CONCLUSIONS AND RECOMMENDATIONS

The use of a deterioration curve, minimum values of strength, and TSR appears to be a logical means of evaluating stripped pavement. TSR should provide a reasonable estimate of the strength equivalency as measured by the Dynaflect device; however, a structural evaluation with the Dynaflect device is still desirable. Strength and TSR results can be used to analyze each layer of asphalt, whereas the Dynaflect results indicate the overall strength of the combined layers of asphalt. It appears that minimum values of 40 psi for strength and 0.3 for TSR are reasonable for initial use of the procedure. Visual evaluation can be used to supplement other data, but it should not be the sole technique used to determine stripping damage.

The following recommendations are offered:

1. Use remolded cores to determine the original strength because dried cores seldom, if ever, completely heal. Dried cores may be used only where large aggregate makes remolding impractical.
2. Use 40 psi as the minimum allowable value for present and future strengths on the deterioration curve.
3. The TSRs based on the ratios of present and future strength to the original (remolded) strength should be higher than 0.3.

As experience is gained through testing and observing the effectiveness of rehabilitation, the recommended criteria may have to be modified.

The author believes that the method of stripping evaluation that has been described will provide the engineer with a tool to make sound, defensible decisions regarding pavement rehabilitation.

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