Application of the Indirect Tensile Test To Stabilized Materials

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The importance of the tensile characteristics of the subbase of rigid pavements can be demonstrated both from theoretical considerations and from field observations. Information on the tensile behavior and properties of treated and untreated subbase material is limited primarily because of the lack of a satisfactory tensile test. On the basis of a literature review concerned with tensile testing, it was concluded that of the currently available tensile tests the indirect tensile test has the greatest potential for the evaluation of the tensile properties of highway materials.

This paper discusses tensile testing, theory of the indirect tensile test, and factors affecting the test. In addition, the results of a limited testing program to evaluate the effect of such factors as composition and width of loading strip, testing temperature, and loading rate on the indirect tensile test parameters of strength, vertical failure deformation, and a load-vertical failure deformation modulus for asphalt-stabilized and cement-treated materials are included. On the basis of the literature review and experimental investigation, it is recommended that the indirect tensile test be used for evaluating the tensile properties of stabilized materials and that the test be conducted utilizing a 1.0-in. wide stainless steel loading strip, a loading rate of 2 in./min, and a testing temperature of 77 F.

•THE importance of the tensile characteristics of the subbase of a rigid pavement can be demonstrated from both theoretical considerations and field observations, yet little is known about behavior and design of subbase materials.

From available evidence it is logical to assume that the cohesive or tensile characteristics of the subbase significantly affect pavement performance. Unfortunately, little information is available on the tensile behavior and properties of treated and untreated subbase material primarily because of the lack of a satisfactory tensile test. The purpose of this paper is to evaluate tensile testing and to tentatively recommend a tensile test and a testing procedure (1).

TYPES OF TENSILE TESTS FOR HIGHWAY MATERIALS

Various tests and modifications have been developed and used for evaluating the tensile characteristics of highway materials. These tests can be classified as (a) direct tensile tests, (b) bending tests, or (c) indirect tensile tests.

Direct Tensile Test and Bending Test

The direct tensile test, which consists of applying an axial tensile force directly to a specimen and measuring the stress-strain characteristics of the material, is simple

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in theory and principle. However, serious difficulties have been encountered in practical applications. Major problems have included the addition of bending stresses due to eccentricity or misalignment of the load and the addition of stress concentrations at the loading grips. Another problem concerns the evaluation of test results; it is assumed that the stress is distributed uniformly across the cross section, but it has been reported that the maximum stress on the central cross section of a figure-eight briquette is about 1.75 times the average stress.

The bending test involves the application of a bending load to a beam specimen. It is considerably simpler to conduct than the direct tensile test, requires less care in the preparation of the specimens, and is favored by many engineers because the loading conditions are similar to the field loading conditions of pavement materials. Basically, this test involves two types of loading conditions: the common flexure test is conducted by applying a load to a simply supported beam, and the cohesiometer test involves the application of a bending moment to a specimen through a cantilever arm.

The results of the common flexure test are normally expressed as the modulus of rupture or by relating the modulus of rupture to the tensile strength. The modulus of rupture, however, is calculated by the standard flexure formula which assumes a linear stress-strain relationship. Such a relationship does not exist for most material, and even in the more elastic materials this assumption is seriously in error at failure conditions. The net effect usually produces a modulus of rupture which is much higher

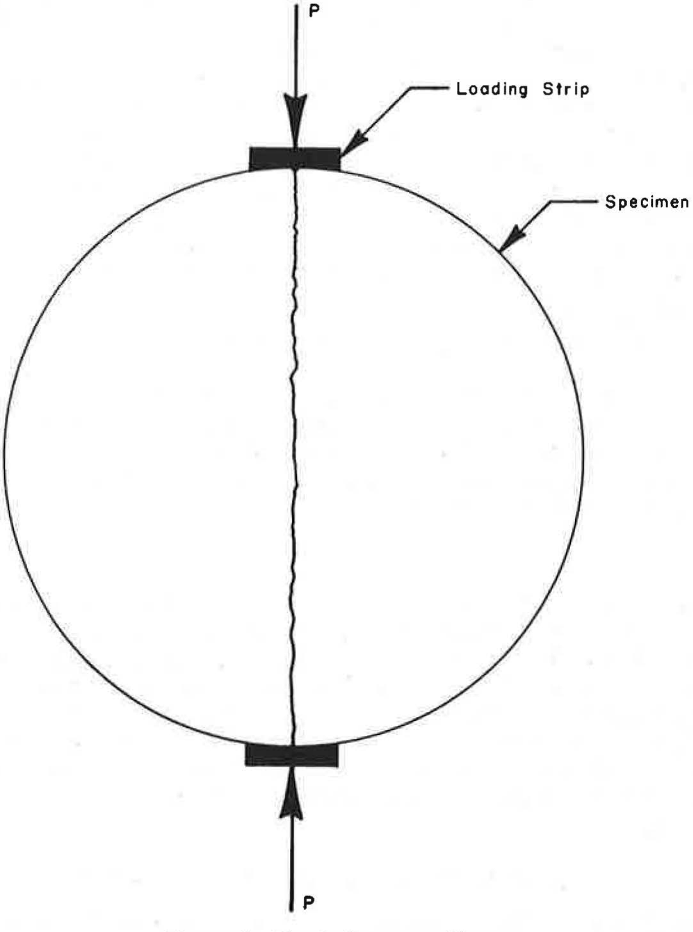

Figure 1. The indirect tensile test.

than the actual failure stress. For concrete, it has been estimated that the modulus of rupture is equal to or greater than two times the tensile strength.

One method of utilizing the modulus of rupture is to consider it to be an index of tensile strength. A second method is to establish a relationship between the modulus of rupture and the tensile strength, but this approach has not been too satisfactory since the relationship has generally been assumed to be linear when in reality it appears to be curvilinear.

The cohesiometer test consists of clamping a sample in the testing device directly over a hinge. One end of the specimen is held fixed and the other is loaded through a cantilever arm, producing failure. The load required to cause failure is used to calculate the cohesiometer value (grams per inch of width corrected to a 3-in. height). This value is empirical and has no theoretical counterpart.

The major criticisms of both types of bending tests concern the nonuniform and undefined stress distribution which exists across the specimen and the fact that the maximum tensile stress occurs at the outer surface. This latter condition accentuates the effect of surface irregularities and may result in low indicated values of tensile strength.

Indirect Tensile Test

The indirect tensile test was developed simultaneously but independently in Brazil and in Japan. The test involves loading a cylindrical specimen with compressive loads distributed along two opposite generators (Fig. 1). This condition results in a relatively uniform tensile stress perpendicular to and along the diametral plane containing the applied load. The failure usually occurs by splitting along this loaded plane.

Previous use of this test has generally been on concrete or mortar specimens; however, Thompson (2) found the test to be satisfactory for the evaluation of the tensile characteristics of lime-soil mixtures while Messina (3) and Breen and Stephens (4, 5) used the test for the study of asphaltic concrete. In addition, Livneh and Shklarsky (6) used the test in the evaluation of anisotropic cohesion of asphaltic concrete. From a review of the literature concerned with the evaluation and use of the indirect tensile test, a number of advantages and two disadvantages were found. The main disadvantage is that the test loading conditions do not resemble those in the field; the second is that the theory is more complex than the theory of the direct tension test and the bending test. The six major advantages attributed to the test are the following:

1. It is relatively simple;
2. The type of specimen and equipment are the same as that used for compression testing;
3. Failure is not seriously affected by surface conditions;
4. Failure is initiated in a region of relatively uniform tensile stress;
5. The coefficient of variation of the test results is low; and
6. Mohr's theory is a satisfactory means of expressing failure conditions for brittle crystalline materials such as concrete.

Choice of Test

On the basis of the review of literature, it was concluded that of the currently available tensile tests the indirect tensile test has the greatest potential for the evaluation of the tensile properties of highway materials. The main disadvantage attributed to the test concerns its failure to duplicate field loading conditions. Although such conditions may be desirable, the lack is not decisive and is more than offset by the many apparent advantages of the test, as is the secondary disadvantage, that the theory is more complex than for the direct tensile and bending tests. Thus, the indirect tensile test has been given priority for use as a method for evaluating the tensile properties of stabilized highway materials.

THEORY OF INDIRECT TENSILE TEST

According to the literature, the theory for the stress distribution for the indirect tensile test was first developed by H. Hertz. Later A. Foppl and L. Foppl, S. Timoshenko and J. N. Goodier, M. M. Frocht, and R. Peltier considered the theory.

Theoretical Development

Usually the theory of the indirect tensile test is developed from Frocht's equations for stresses at a point. The distributions of stresses calculated from these equations are shown in Figure 2 for the horizontal diameter and Figure 3 for the vertical diameter. The vertical stress σ_y along the horizontal diameter is compressive and the magnitude varies from a maximum of $\frac{6P}{\pi t d}$ at the center to zero at the circumference. The horizontal stress σ_x along the vertical diameter is a constant tensile stress of magnitude $\frac{2P}{\pi t d}$; the vertical stress σ_y is compressive and varies from a minimum of $\frac{6P}{\pi t d}$ at the center to a maximum of infinity at the circumference beneath the loads.

Under conditions of a line load, the specimen would be expected to fail near the load points due to compressive stresses and not in the center portion of the specimen due to tensile stress. It has been shown, however, that these compressive stresses are greatly reduced by distributing the load through a loading strip. In addition, the horizontal tensile stress along the vertical diameter changes from tension to compression near the points of load application.

Deviation of Test From Ideal Conditions

The preceding development is an exact solution for the idealized case considered. In reality the actual test deviates from the assumed ideal condition. The following deviations should be considered.

Heterogeneous Nature of Material Tested—The theory on which this test is based assumes a homogeneous material. Stabilized materials are normally heterogeneous not homogeneous; nevertheless, the greatest application of the test has been with concrete,

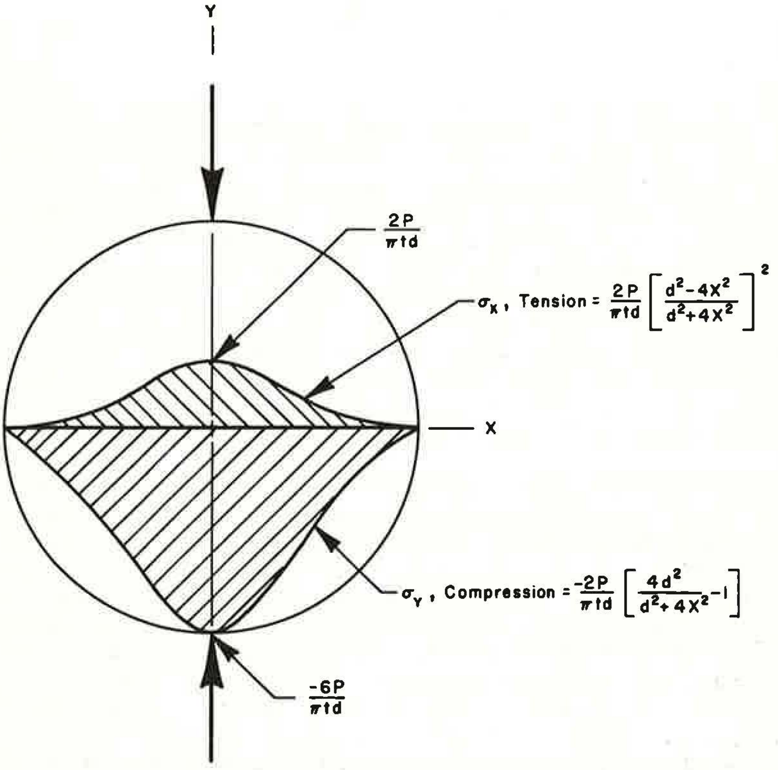

Figure 2. Stress distributions on x-axis.

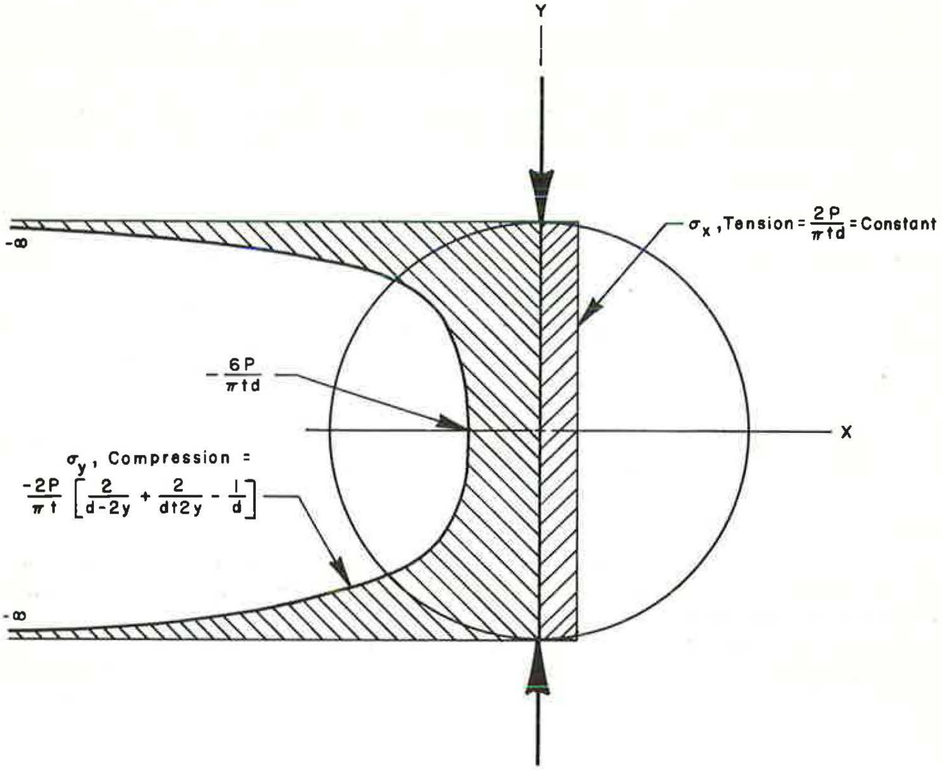

Figure 3. Stress distributions on y-axis.

which is also very heterogeneous. In addition, the test has been used for the evaluation of asphaltic concrete (3, 6), a nonhomogeneous material, and lime-soil mixtures (2). In all of these cases, the test was found to be satisfactory although undoubtedly errors were introduced by the heterogeneous nature of the tested materials. With regard to this problem, it has been concluded that although the effect on the general stress distribution cannot be determined it is probably small enough to permit the use of the test.

Distribution of Applied Load—The theory of the test assumes a point load on a thin disk which corresponds to line loading along a generator of the cylinder. Actually the load is distributed over an area with an appreciable width because of the practice of applying the load through a loading strip. Studies concerning the effects of a load strip on stress distribution have shown that the magnitude of the vertical compressive stresses is significantly reduced and that the magnitude of the horizontal stress is virtually unaffected near the center of the specimen but is changed to compression near the edges (Fig. 4).

A number of investigations have indicated that a semisoft material is desirable as a loading strip. It has been recommended that the loading strip should be soft enough to allow distribution of the load over a reasonable area and yet narrow enough to prevent the contact area from becoming excessive. The basic requirement for selection of the loading strip is that it produce tensile rather than compressive or shear failures.

Deviation from Hooke's Law—It is assumed in the theoretical considerations of the test that strain is proportional to stress. This does not hold in the case of concrete, asphaltic concrete, and stabilized materials. Probably the worst case occurs with bituminous materials. In all of these materials, the modulus of elasticity or deformation tends to decrease with increased stress. A nonlinear stress-strain relationship such as this tends to relieve the more highly stressed parts of the specimen. This condition, however, would tend to increase the load required to cause failure in the specimen and

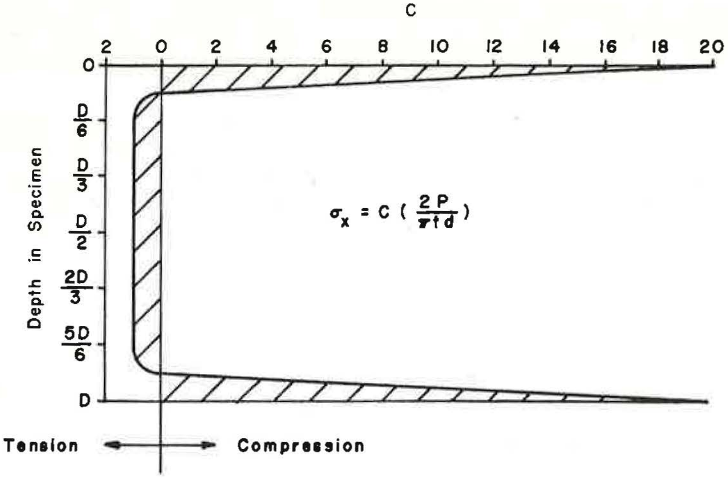

Figure 4. Horizontal stress distributions on the y-axis for loading strip width equal to d/12.

to give higher strength values. Nevertheless, there is no apparent reason to question seriously the results obtained from indirect tensile testing of nonlinear stress-strain materials provided the specimen fails in tension.

It is also reasonable to conclude that the test is more applicable to brittle materials and that some consideration and test evaluation would be desirable for materials such as asphaltic concrete and bituminous stabilized materials before the test can confidently be used for the evaluation of these materials.

EXPERIMENTAL EVALUATION AND DEVELOPMENT OF THE INDIRECT TENSILE TEST

Some of the characteristics of the indirect tensile test and the materials tested which may affect the test results are the following:

1. Load-deformation characteristics of the material tested;
2. Size and dimensions of the specimen;
3. Composition and dimensions of the loading strip;
4. Rate of loading; and
5. Testing temperature.

More important than the change in strength associated with increased loading rates and decreased temperature is the change in the character of the stress-strain relationship exhibited by the material. Both a decreased testing temperature and an increased loading rate tend to produce more brittle behavior and a more linear stress-strain relationship which is advantageous according to test theory.

Previous evaluation, both theoretical and experimental, has established the influence of some of these factors. It has been shown that the length-to-diameter ratio of the specimen tested has little effect on the resulting strength parameter, and it has been shown that an increase in the overall specimen size results in more uniform strength data, but slightly reduced average strength values.

It has also been established that the composition and dimensions of the loading strips affect strength results and type of failure. However, previous tests do not indicate the best type of material and dimensions of the loading strips. In addition, there is little information on the effects of testing temperature and loading rate.

Unfortunately, most of the experimental evaluation of the indirect tensile test has been conducted on concrete and has not included deformation measurements. This fact, along with the lack of conclusive evidence concerning the most desirable composition and width of the loading strips and the lack of temperature and loading rate information, makes it important to evaluate the indirect tensile test using materials other than concrete and to include deformation measurements. The findings of such an evaluation along with previously reported findings will aid in establishing standard test procedures for future studies.

The objectives of this initial phase of investigation were to develop equipment and a technique for conducting the indirect tensile test and, as a part of this development, to evaluate the effect of (a) composition of loading strip, (b) width of loading strip, (c) testing temperature, and (d) loading rate on several test parameters including the indirect tensile strength, vertical failure deformation, and a load-vertical deformation modulus.

Experimental Program

The primary objective of the experimental program was to evaluate the effects produced by the composition of the loading strip, width of loading strip, testing temperature, and loading rate. The primary statistical parameters for the evaluation were the standard deviation or variance and the coefficient of variation used as measures of dispersion.

The three test series which were conducted included samples of asphaltic concrete and cement-treated gravel. The asphaltic concrete consisted of crushed limestone and 5.3 percent AC-10; the cement-treated gravel was a rounded gravel treated with 6 percent type I portland cement. All specimens were 4.0 in. in diameter with a nominal height of 2.0 in. and were compacted using the Texas automotive gyratory shear compactor. Details concerned with the equipment, mix design, sample preparation, and curing of the asphaltic concrete and cement-treated gravel are given elsewhere (1).

In these preliminary tests, the following parameters were defined and evaluated:

1. Indirect Tensile Strength—

$$S_T = \frac{2P_{max}}{\pi t d},$$

where

P_{max} = maximum total load, lb;
t = average height of specimen, in.; and
d = nominal diameter of specimen, in.

2. Vertical Failure Deformation—vertical deformation of the specimen in inches at maximum load including the deformation in the loading strip (corrections were made for deformations occurring in the neoprene load strip in some parts of the analysis). This deformation was assumed to be equal to the movement of the upper platen from the point of initial load application to the point of maximum load as measured by a DCDT and recorded on the load-vertical deformation plot.

3. Tangent Modulus of Vertical Deformation—slope of the load-vertical deformation relationship prior to failure as defined by a regression analysis. Approximately 10 points between the points of initial load and maximum load were obtained from the load-vertical deformation relationship and analyzed by the method of least squares to obtain the slope of a line through the points.

Because of space limitations only the test results associated with strength are included in this paper. The findings associated with the vertical failure deformation and tangent modulus of vertical deformation are included and discussed elsewhere (1).

Evaluation of Composition and Width of Loading Strip—The first phase of testing was concerned with the evaluation of the type of material used for the loading strip and the width of the loading strip. Initially, plywood loading strips were considered and were used in testing because of previous recommendations. These previous studies, however, did not involve deformation measurements. Since the measured vertical deformation included the deformation of the loading strip and since plywood strips deform appreciably, it was necessary to subtract the loading-strip deformation from the deformation measured in order to obtain an estimate of the vertical deformation of the specimen.

TABLE 1

SUMMARY OF DATA AND ANALYSIS OF VARIANCE OF EFFECT OF STRIP TYPE AND WIDTH ON LOG VARIANCE FOR ASPHALTIC CONCRETE

Type of Loading Strip		Neoprene		Stainless Steel		Platens (no strips)
Strip width, in.		0.5	1.0	0.5	1.0	∞
Number of specimens		8	8	8	8	8
Indirect Tensile Strength	Average, psi	105	108	106	103	111
	Standard deviation, psi	7.0	2.0	8.1	4.2	9.8
	Coefficient of variation, %	6.7	1.9	7.6	4.1	8.8

Source of Variation		Degrees of Freedom	Mean Squares	F	Significance[a] Level (%)
Indirect Tensile Strength	Strip type	1	0.418	4.49	None
	Strip width	1	1.541	16.6	5
	Interaction	1	0.280	3.01	None
	Error	4	0.093		
	Total	8			

[a] If significance level is greater than 10 percent, it is called "none."

Such corrections were difficult and probably erroneous due to the fact that (a) wood is heterogeneous and variable, (b) wood deforms appreciably at higher stresses, and (c) wood does not exhibit a linear stress-strain relationship. For these reasons wood was discarded as a possible loading-strip material.

Other strip materials investigated were stainless steel and neoprene. These two materials were chosen because they were readily available, easily specified, and represent,

TABLE 2

SUMMARY OF DATA AND ANALYSIS OF VARIANCE OF EFFECT OF STRIP TYPE AND WIDTH ON MEAN FOR CEMENT-TREATED GRAVEL

Type of Loading Strip		Neoprene		Stainless Steel		Platens (no strips)
Strip width, in.		0.5	1.0	0.5	1.0	∞
Number of specimens		5	5	5	5	5
Indirect Tensile Strength	Average, psi	146	178	166	177	167
	Standard deviation, psi	12.0	16.5	30.8	15.4	21.1
	Coefficient of variation, %	8.3	9.3	18.6	8.7	12.6

Source of Variation		Degrees of Freedom	Mean Squares	F	Significance[a] Level (%)
Indirect Tensile Strength	Strip type	1	476	1.19	None
	Strip width	1	1835	4.58	5
	Interaction	1	1038	2.59	None
	Error	16	401		
	Total	19			

[a] If significance level is greater than 10 percent, it is called "none."

to a certain degree, extremes with regard to rigidity. Strip widths of 0.5 and 1.0 in. were used. An additional variable involved the application of load directly through the platens with no loading strips. All specimens were tested at 75 F at a loading rate of 0.5 in./min. This phase of the testing was divided into two parts. The first part involved the testing of asphaltic concrete, which was considered a questionable material since it exhibits plastic characteristics rather than purely elastic characteristics as assumed by theory and because there was lack of information concerning the use of the indirect tensile test for testing asphaltic materials. The second part of the testing involved cement-treated gravel, a more brittle material, which more closely approximates the behavior of an elastic material.

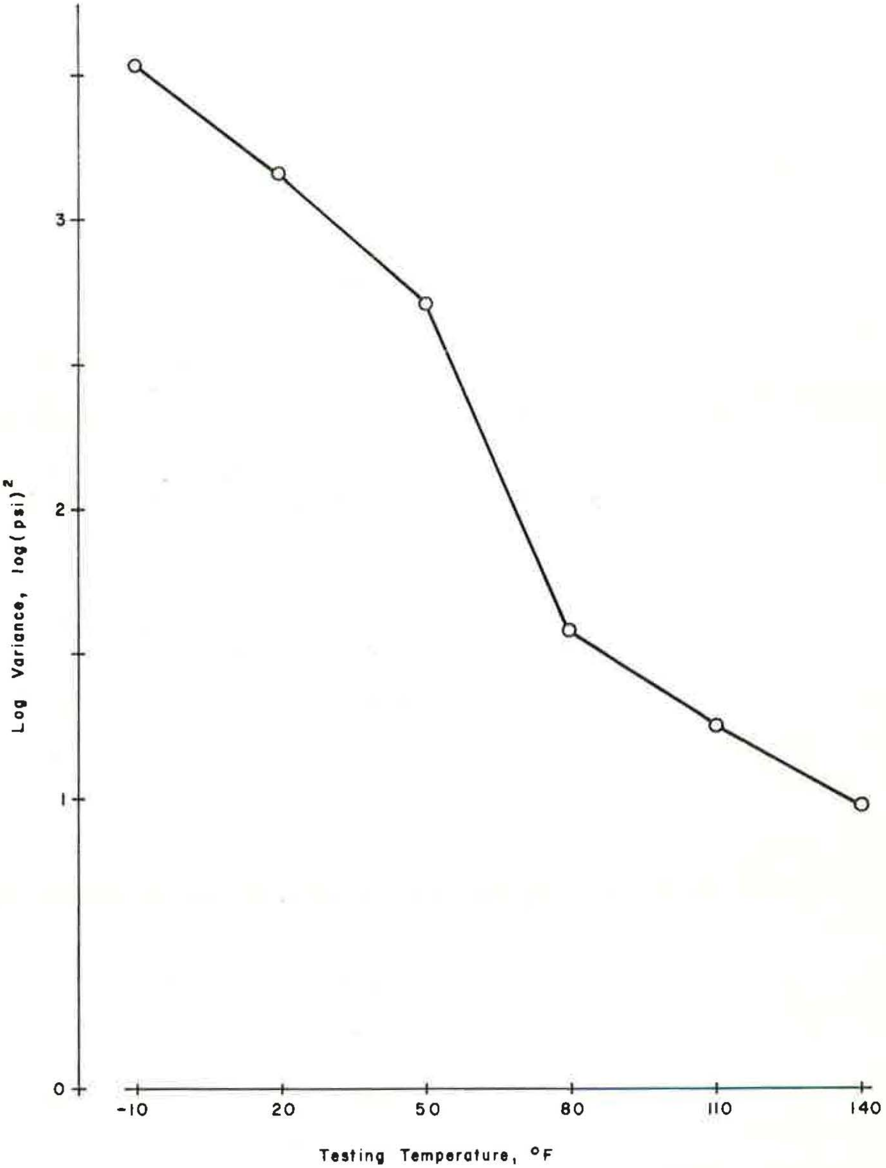

Figure 5. Effect of testing temperature on the log-variance of indirect tensile strength of asphaltic concrete.

The experimental designs for these two series of tests were full-factorial, randomized designs involving two types of strips and two strip widths. Analyses of variance of the log-variances and some of the means were conducted for these variables. No statistical analysis was conducted for the variable involving the direct application of load with no loading strip, although subjective comparisons were made.

Findings Using Asphaltic Concrete—The initial test series in the evaluation of the effect of composition and width of loading strip was conducted on asphaltic concrete specimens. Basic statistical parameters and results of the analysis of variance of the log-variances are summarized in Table 1. Similar information for the parameters of vertical failure and tangent modulus of vertical deformation is summarized and discussed elsewhere (1).

The analysis of variance of the log-variances indicated that the type and width of material used as a loading strip had no significant effect on the standard deviations of the vertical failure deformations and the tangent moduli of vertical deformation. In the case of the strengths, the type of material was found to have no significant effect; however, the width of strip did produce a significant effect ($\alpha = 0.05$).

There is apparently a definite advantage to using the 1.0-in. wide strip because of the reduced dispersion for both steel and neoprene. The standard deviations for the specimens tested with steel strips are slightly higher than those for specimens tested with neoprene; however, the difference is small and is not statistically significant in this experiment. The very high dispersion values associated with the use of the platens alone precludes the possibility of eliminating the loading strip.

On the basis of this analysis, it could be recommended that future testing be conducted using a 1.0-in. wide neoprene loading strip. Nevertheless, in view of the practical advantages of using steel and the small and insignificant differences between the dispersion of the data obtained from the steel and neoprene, it is felt that a 1.0-in. wide steel loading strip is more desirable. Results published with regard to concrete and mortar, however, have generally recommended a softer, more flexible loading strip material. In addition, it has been reported that the width of the loading strip has an effect on the type of failure. On the basis of the above recommendation and the lack of significant advantage of one material over the other, it was desirable to investigate the effects of both type and width of loading strip on a more brittle material.

Findings Using Cement-Treated Gravel—The second test series in the evaluation of the effect of composition and width of loading strip was conducted on cement-treated gravel specimens. The data and the analysis of variance of the means of the strength parameter are summarized in Table 2. Similar information for the other parameters are given elsewhere (1).

The analysis of variance of the log-variances indicated that the type and width of the load strip had no significant effect on the variances of the test parameters. Hence, the analysis of variance of the means in this case is justified and showed a significant effect ($\alpha = 0.05$) due to strip width with the 1.0-in. strips resulting in higher average strengths.

Although not statistically significant ($\alpha = 0.05$), the 1.0-in. wide strips in this experiment produced less scatter of the strength values than the 0.5-in. strips. Considering only the data for the steel strips, the 1.0-in. strips resulted in a lower standard than the 0.5-in. strips; however, the reverse was true for the neoprene loading strips. The minimum value for dispersion occurred with 0.5-in. neoprene and the highest value occurred with the 0.5-in. steel. The standard deviations for the 1.0-in. strips for both steel and neoprene were essentially equal.

The best strip appears to be neoprene, as it did in the case of the test series on asphaltic concrete. Nevertheless, this slight advantage of neoprene over steel is not statistically significant; therefore, it is felt that the use of steel loading strips is justifiable because of the many practical advantages of using steel strips. Analyzing the findings for only steel loading strips indicates that the 1.0-in. steel strips are better.

Recommendation Concerning the Composition and Width of Loading Strip—It is recommended tentatively that future testing utilize a loading strip composed of stainless steel which is 1.0 in. in width. This recommendation is based primarily on the many practical advantages of using steel rather than the softer, more flexible neoprene.

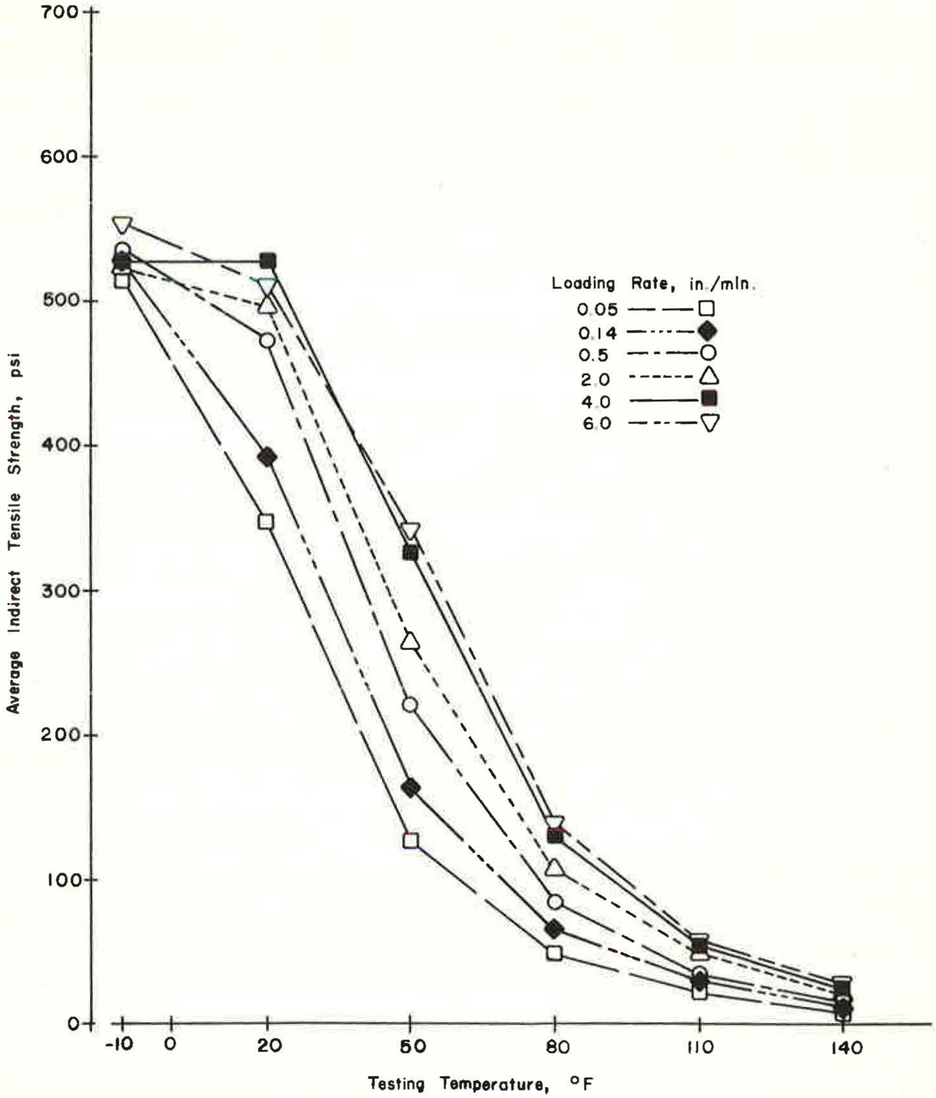

Figure 6. Effect of testing temperature on indirect tensile strength of asphaltic concrete.

Evaluation of the Effects of Testing Temperature and Loading Rate—The second phase of testing was concerned with the evaluation of the effects of testing temperature and loading rate. The evaluation was conducted on asphaltic concrete because of its temperature susceptibility. Testing temperature ranged from -10 F to 140 F ± 2 F; loading rates ranged from 0.05 to 6.0 in./min. A split plot type experiment design with three blocks or replications was used in this phase of the testing.

The analysis of variance of the log-variance of strengths indicates that temperature has a significant effect ($\alpha = 0.01$) on the standard deviation of strength, but that there is no significant effect associated with loading rate. The reduction in variance in the range between 50 F and 80 F observed in Figure 5 is statistically significant ($\alpha = 0.05$). In Figure 6, a substantial change also occurs in the slope of the strength-temperature relationship at or slightly less than a temperature of 80 F, indicating that the effects of temperature are much more pronounced in the lower temperature range. At the lower temperatures, the relationships become slightly erratic.

Figure 6 indicates that the effect of load rate is not as great as the temperature effect. A possible exception can be seen for the strength averages obtained at very low loading rates. There would appear to be a substantial increase in the mean value as the loading rate is increased at these low rates, especially at low testing temperatures.

It is recommended that future testing be conducted at room temperature (77 F) and at a loading rate of 2.0 in./min. This temperature was chosen because (a) it approximates the lower temperature range in which the strength and tangent-modulus parameters were relatively uniform and non-temperature susceptible, (b) it approximates the lower limit of the temperature range exhibiting reasonably low dispersion, (c) it has previously been used as a standard testing temperature, and (d) it is fairly close to the normal temperature of air conditioned laboratories and, thus, does not require special equipment or facilities for substantially raising or lowering the temperature. The loading rate of 2.0 in./min. was chosen primarily as a compromise. At slow loading rates the magnitudes of the test parameters were more susceptible to loading-rate changes than at higher rates. In addition, the theory assumes a linear-stress-strain or brittle characteristic for the material being tested, and a more rapid loading rate tends to produce a more brittle behavior. At the very rapid loading rates, however, the test is more difficult to conduct. At 2.0 in./per min. the indirect tensile test was easy to conduct, and this loading rate is above the range in which the test parameters appeared to be very susceptible to changes in loading rate.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Review of existing information indicates that the indirect tensile test is the best test currently available for determining the tensile properties of highway materials.
2. From this information and the results of a limited testing program, the indirect tensile test appears to be a feasible method for evaluating the tensile characteristics of stabilized subbase materials although previous use of this test has generally been with concrete.
3. Primary characteristics of the indirect tensile test and the materials tested which may affect the test results are (a) load-deformation characteristics of the material tested, (b) size and dimensions of the specimen, (c) composition and dimensions of the loading strip, (d) rate of loading, and (e) testing temperature.
4. Characteristics and properties of the material being tested are not considered in the theoretical development of the test, except as a limiting tensile strength. The materials are assumed to have linear-elastic stress-strain characteristics. Although many deviations from the assumed conditions exist and although the use of the simple formula $S_T = (2 P_{max})/(\pi t d)$ introduces small errors in the results, there does not appear to be any evidence that the error is significant as long as the specimen ultimately fails in tension.
5. The indirect tensile strength has been shown both theoretically and experimentally to be independent of the length-diameter ratio. It has been assumed that other indirect tensile parameters such as failure deformations and load-deformation characteristics are also independent of this ratio.
6. The indirect tensile strength is reduced slightly by an increase in the overall size of the specimen, and the dispersion of the data is reduced.
7. On the basis of the literature review, it is concluded that the composition and width of the loading strip have a definite effect on the stress distribution in the specimen, the test results, and the mode of failure.
8. Wood which has often been recommended as a loading strip was eliminated from future use by this project because of practical difficulties associated with measuring deformations in the specimen.
9. It is recommended that steel be used as a loading strip because of its significant practical advantages even though experimental results presented in this report indicate that neoprene is a slightly better loading strip material than steel.
10. A 1.0-in. wide strip is recommended over a ½-in. width because of the reduced data dispersion.

11. Under the conditions of the tests performed in this study, temperature had a highly significant effect on the average test results. The parameters of strength and load-deformation modulus were less temperature susceptible and more uniform at testing temperatures of 80 F and above.
12. Under the conditions of these tests, loading rate had a significant effect on the average test results. The effect, however, was not as great as that produced by testing temperature.

Recommendations

Based on the preceding conclusions, certain decisions concerning parameters in the indirect tensile test have been made. These parameters will be fixed tentatively for evaluation tests to be conducted in the project in the near future.

1. The specimen will be as large as is practical in order to obtain more uniform test results and a better measure of the average of the test results. It is planned that ultimately samples will be 6 in. in diameter with heights in the range of 8 to 12 in.
2. The loading strip will be stainless steel with a width of 1 in.
3. The loading rate will be 2.0 in./min.
4. The testing temperature will be room temperature in the range of 75 to 77 F.

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