ESTIMATIONS OF INDIRECT TENSILE STRENGTHS FOR CEMENT-TREATED MATERIALS

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•THE IMPORTANCE of the tensile characteristics of subbases can be demonstrated from both theoretical considerations and field observations. Nevertheless, until recently, little attention was given to the tensile characteristics of stabilized materials; thus, little information was available. Therefore, the Center for Highway Research at the University of Texas at Austin began a study to evaluate the tensile properties of stabilized subbase materials for use in pavement design, utilizing the indirect tensile or split-cylinder test (1). As a part of this study, a design procedure based on layered theory was developed.

To evaluate this pavement design procedure, performance data must be obtained from in-service pavements. Fortunately, various test sections exist in Texas for which performance data are available; however, there is no information concerning the tensile characteristics of the various materials used in their construction. Therefore, an attempt was made to develop correlations between indirect tensile strength and the results of both the cohesiometer test and the unconfined compression test, which are and have been used by the Texas Highway Department to evaluate cement-treated materials. The primary purpose for these correlations was to provide a means of estimating the tensile strengths of cement-treated subbases used in rigid pavements currently in service in order that the performance data collected during the life of the pavement can be used in the development of the subbase design procedure without the neccessity to wait for test sections to be designed, approved, funded, and constructed.

EXPERIMENT PROCEDURES

Two different correlation experiments were conducted. The first experiment was general in nature, and the second involved fixed curing and compaction conditions as specified by the Texas Highway Department. Thirty specimens were tested for each of these 2 correlations: 10 specimens in indirect tension, 10 specimens in the cohesiometer, and 10 specimens in unconfined compression.

The indirect tensile test specimens had a diameter of 6 in. and a height of 2 in. and were tested at 75 F at a loading rate of 2 in./min (1, 2, 3). The unconfined compression and cohesiometer tests were conducted according to the Texas Highway Department procedures (4). The unconfined compression test specimens had a diameter of 6 in. and a height of 8 in.; the cohesiometer specimens had a diameter of 6 in. and a height of 2 in.

Five factors were allowed to vary in the 2 correlation analyses. Three factors and their levels were the same for both correlations, and 2 factors were constant for a given correlation but were different for the 2 separate correlations. The 3 factors that were the same for both correlations and their levels were as follows:

Factor	Low	Medium	High
Molding water content, percent by weight	4	6.5	9
Cement content, percent by weight	2	6	10
Aggregate type	Gravel	–	Crushed limestone

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The constant factors were as follows:

Factor	General	Texas Highway Department
Aggregate gradation	Medium	Medium (well graded)
Curing temperature, deg F	100	75
Compactive effort	175 psi	25 blows/layer

Two different aggregates that are used extensively in central Texas were included in both correlation experiments. The first was a rounded gravel obtained near Seguin, Texas, which was relatively nonporous, and the second was a crushed limestone exhibiting high porosity. These 2 aggregates were separated and recombined to produce a well-graded mixture with a maximum aggregate size of ⅞ in. and approximately 10 percent passing a No. 200 sieve. In addition to the 2 aggregate types, molding water content and cement content were allowed to vary at 3 levels.

The 2 remaining factors, which were associated with compaction and curing conditions, differed for each correlation. In the general correlation, all specimens were compacted by the Texas Gyratory shear compactor (3) at a compactive effort specified in terms of a compaction procedure and were then cured for 7 days at 100 F while wrapped in a PVC film. The specimens in the second correlation were compacted and cured according to procedures specified by the Texas Highway Department for cohesiometer and unconfined compressive test specimens. The specimens were compacted by using a Rainhart impact compactor, striking 25 blows per layer with a 10-lb hammer dropping 18 in. The specimens were then cured 7 days at 75 F in an environment of 100 percent relative humidity.

DISCUSSION OF RESULTS

Two correlation relationships relating the indirect tensile strength with the unconfined compressive strengths and the cohesiometer values were obtained for both the general conditions and for the conditions involving the Texas Highway Department curing and compaction procedures. In addition, a combined correlation analysis was conducted for all specimens. These 6 correlations, given in Table 1, were judged to be acceptable for the purposes outlined earlier. The combined correlation results are shown graphically in Figures 1 and 2.

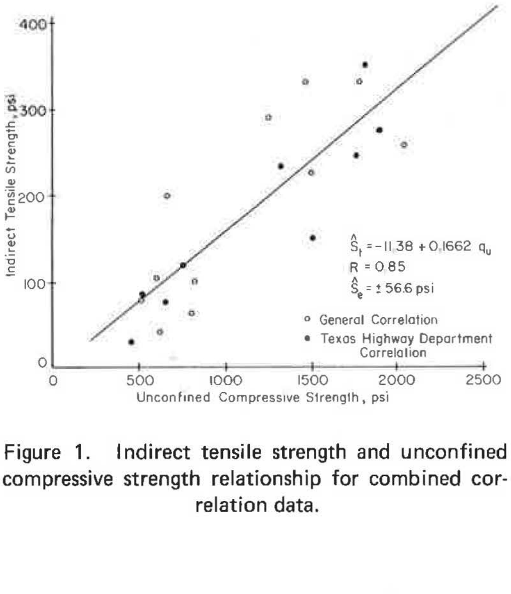

Figure 1. Indirect tensile strength and unconfined compressive strength relationship for combined correlation data.

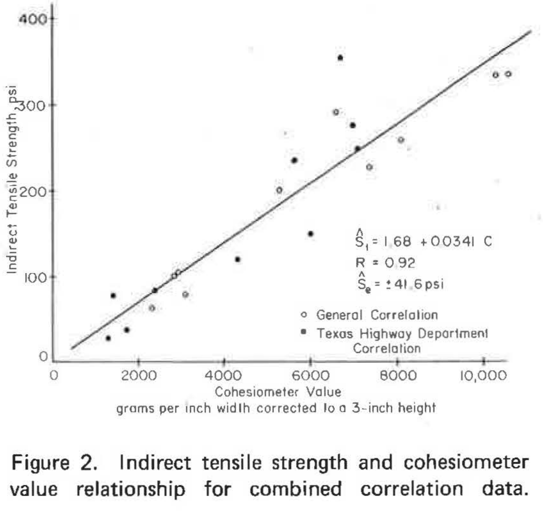

Figure 2. Indirect tensile strength and cohesiometer value relationship for combined correlation data.

TABLE 1

SUMMARY OF CORRELATION RESULTS

Correlation Variable	Equation[a]	Multiple Correlation Coefficient	Standard Error of Estimate (psi)	Coefficient of Variation (percent)
Indirect tensile strength versus unconfined compressive strength				
General	$S_t = 18.45 + 0.1548q_u$	0.80	67.2	34.3
Texas Highway Department	$S_t = -38.34 + 0.1752q_u$	0.93	43.8	27.3
Combined	$S_t = -11.38 + 0.1662q_u$	0.85	56.6	31.8
Indirect tensile strength versus cohesiometer value				
General	$S_t = 4.85 + 0.03200C$	0.96	30.4	14.5
Texas Highway Department	$S_t = -16.14 + 0.0403C$	0.91	49.3	30.8
Combined	$S_t = 1.68 + 0.0341C$	0.92	41.6	23.4

[a] S_t = predicted value of indirect tensile strength, psi; q_u = measured value of unconfined compressive strength, psi; and C = measured cohesiometer value, grams/in. of width corrected to a 3-in. height.

SUMMARY AND CONCLUSIONS

This paper presents a set of correlations from which indirect tensile strengths may be estimated from unconfined compressive strengths and from cohesiometer values (Table 1). It was found that correlations exist for these tests and that tensile strengths may be estimated from cohesiometer and unconfined compressive strength data. Nevertheless, these correlation relationships exhibited relatively high standard errors and coefficients of variation. Therefore, anyone attempting to use these relationship must judge their acceptability in terms of the needed accuracy and permissible error.

ACKNOWLEDGMENTS

This investigation was conducted at the Center for Highway Research at the University of Texas at Austin. The authors wish to thank the sponsors, the Texas Highway Department and the U.S. Department of Transportation, Federal Highway Administration. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Federal Highway Administration.

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