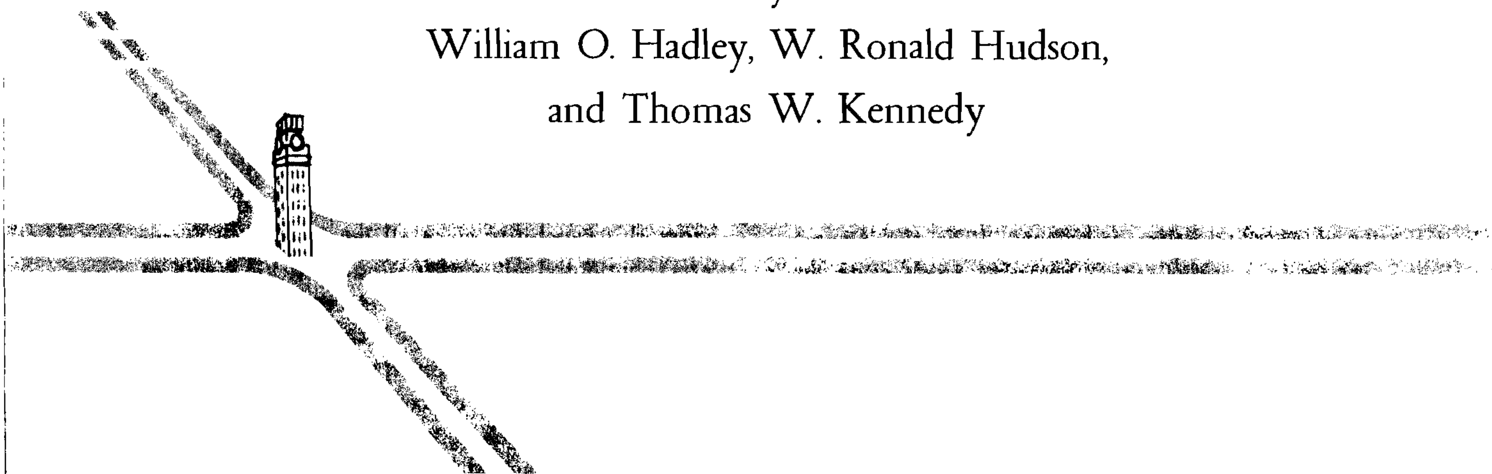
AN EVALUATION OF FACTORS AFFECTING THE TENSILE PROPERTIES OF ASPHALT-TREATED MATERIALS

By

William O. Hadley, W. Ronald Hudson,

and Thomas W. Kennedy



SUMMARY REPORT 98-2 (S)

SUMMARY OF

RESEARCH REPORT 98-2

PROJECT 3-8-66-98

COOPERATIVE HIGHWAY RESEARCH PROGRAM
WITH TEXAS HIGHWAY DEPARTMENT
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Foreword

Research Report No. 98-2 discusses some of the factors affecting the properties of asphalt-treated materials and describes the experimental program and statistical technique used to evaluate the effects of the important factors. It is the second report in a series which describes work done on Project 3-8-66-98, "Evaluation of Tensile Properties of Subbases for Use in New Rigid Pavement Design," and is the first which deals primarily with asphalt-treated materials.

Introduction

Current pavement design or evaluation techniques involving layered systems or slab-on-foundation analyses recognize that tensile stresses are created in the individual layers of the roadway. In addition, field observations indicate the importance of tensile strength to the behavior of the materials comprising the various layers of the roadway. Unfortunately, information on the tensile characteristics of roadway materials is lacking, primarily because of the lack of a satisfactory tensile test. In an attempt to alleviate this condition, the indirect tensile test was adopted at The University of Texas at Austin for the study of the tensile characteristics of stabilized materials (Refs 1 and 2).

Report 98-2 summarizes the findings of one phase of an investigation which involves the evaluation of the factors affecting the tensile characteristics of asphalt-treated materials subjected to static tensile stresses. The purpose of the experiment was to evaluate the factors and interactions between them which significantly affect the tensile characteristics of asphalt-treated materials and to develop a preliminary regression model which could be used to predict the tensile properties of asphalt-treated materials.

Experimental Program

An investigation of a large number of factors requires a design which allows the results to be applicable over the ranges of factors considered. A completely randomized factorial experiment provides this capability since all levels of each factor are represented in combination with all levels of every other factor. When the complete factorial experiment requires a large number of test specimens, it is often desirable to select only a fraction of the total number of combinations for testing. This concept, which is known as fractional factorial analysis, was used in this study to establish the factors and interactions which significantly affect the tensile properties of asphalt-treated materials by investigating eight different factors at two levels. The factors and levels are given below.

FACTOR	LEVEL	
	LOW	HIGH
Aggregate type	Crushed limestone	Rounded gravel
Aggregate graduation	Fine	Coarse
Asphalt viscosity (specification)	AC-5	AC-20
Asphalt content, %	3.5	7.0
Compaction type	Marshall impact	Texas gyratory shear
Mixing temperature, °F	250	350
Compaction temperature, °F	200	300
Curing temperature, °F	40	110

Using these factors and levels, an experiment involving 68 test specimens was conducted. Each specimen was tested in indirect tension as described in Refs 1 and 2. The tensile strength and horizontal failure deformation values were recorded and are analyzed in the report.

Conclusions

Based on the results of the study, the following conclusions were drawn:

(1) There were six main effects, twelve 2-way interactions, and three 3-way interactions which had highly significant effects on the tensile strength of asphalt-treated materials and were considered to be of practical significance to the engineer.

(2) There were five main effects, one 2-way interaction, and two 3-way interactions which had highly significant effects ($\alpha = .01$) on the horizontal deformation of asphalt-treated materials.

(3) The existence of such a large number of highly significant main effects and interactions illustrates the complexity of the relationship between tensile properties of asphalt-treated materials and a number of independent factors.

(4) Since there are a number of interactions between factors which are important in establishing the tensile properties, it is not adequate to infer to a specific combination of factors based only on main effects because consideration must be given also to any interaction effect in predicting the value of the particular property.

(5) In general it was found that tensile strength was increased by

(a) increasing the asphalt content from 3.5 to 7.0 percent,

(b) increasing the compaction temperature from 200°F to 300°F,

(c) using impact rather than gyratory shear compaction,

(d) increasing the mixing temperature from 250°F to 350°F,

(e) using an AC-20 rather than AC-5 asphalt cement, and

(f) using crushed limestone rather than rounded gravel aggregate.

(6) In general it was found that horizontal failure deformation was increased by

(a) increasing the asphalt content from 3.5 to 7.0 percent,

(b) decreasing the mixing temperature from 350°F to 250°F,

(c) using crushed limestone rather than rounded gravel aggregate,

(d) decreasing the compaction temperature from 300°F to 200°F, and

(e) using a coarse gradation rather than a fine gradation.

(7) Within the confines of this study asphalt content appears to have the greatest effect on the tensile strength of asphalt-treated highway materials. This is evidenced by the fact that the main effect of asphalt content, all 2-way interactions involving asphalt content (seven), and two 3-way interactions involving asphalt content had highly significant effects on tensile strength.

Recommendations

The work reported in Research Report No. 98-2 points out some significant needs for reaching the ultimate goal of developing adequate design procedures for stabilized subbases. These include the following:

(1) A theoretical development relating the elastic properties of materials, i.e., Poisson's ratio and modulus of elasticity, to the applied load and corresponding total vertical and horizontal strains obtained in the indirect tensile test would be very beneficial in the evaluation of the factors affecting the tensile properties of asphalt-treated materials.

(2) A detailed look at the effect of several different asphalt contents on the tensile properties of stabilized mixtures could provide sufficient information to develop adequate predictive equations for each dependent variable. At the same time intermediate values of the other quantitative independent variables, e.g., compaction temperatures and mixing temperature, could be entered into the study. Optimization techniques could then be utilized on the data obtained from such an expanded study to estimate the value of each independent variable, which should be specified to obtain the optimum value for the

dependent variable, i.e., tensile strength, modulus of elasticity, or Poisson's ratio.

(3) An investigation of the effect of the significant factors on the tensile properties of asphalt-treated materials in repeated loading should be undertaken in future testing.

(4) Consideration should be given in future experiments to an evaluation of the possible effect of phasing, i.e., mixing, compaction, and curing, on the experimental error. The results from such a study would determine the type of statistical analysis required for that particular experiment and might cause a change in the order and significance of the factors and their interactions.

Application of Research Findings

The research work summarized herein was not performed for direct application in the field. It is one part of a comprehensive effort to develop better design procedures for stabilized pavement layers and to better determine the relationship between the various methods of stabilization. Nevertheless, the results reported herein can be helpful in pointing out to practicing engineers and other researchers the complexities involved in the investigation and design of asphaltic materials and can lead to a better understanding of tensile strength.

References

1. Hudson, W. Ronald, and Thomas W. Kennedy, "An Indirect Tensile Test for Stabilized Materials," Research Report No. 98-1, Center for Highway Research, The University of Texas at Austin, January 1968.
2. Kennedy, Thomas W., and W. Ronald Hudson, "Application of the Indirect Tensile Test to Stabilized Materials," *Highway Research Record*, No. 235, 1968, pp 36-48.