PROJECT SUMMARY

0-6949: Establishing Best Practices for Construction and Design of Cement Treated Materials

Background

TxDOT has extensive experience with the use of cement to improve the orthogonal load bearing capacity and enhance the durability of base layers and subgrade soils for the design of new pavements and the rehabilitation of existing roads. However, the absence of a rapid turnaround and harmonized laboratory mixture design protocol that accounts for compressive strength, tensile strength, and long-term durability due to moisture intrusion have resulted in an ongoing challenge for Districts across Texas. In Project 0-6949 our research team developed a new protocol for mixture design of cement-treated materials and calibrated field performance models for stabilized virgin aggregates and reclaimed materials.

What the Researchers Did

This project's goal was to update the existing mixture design specification to account for diverse soils and aggregates, blend ratios of reclaimed and virgin materials, and environmental factors. The secondary focus was to develop and calibrate a fatigue performance model to estimate service life of pavements with cement-treated base and subbase layers.

To that end, the research team developed and distributed a survey questionnaire among TxDOT Districts to compile their experiences using cement treatment techniques based on the regional nature of aggregates, soils, and climate. Based on the survey's responses, eight different aggregate base materials—limestone sourced from El Paso and Houston, full depth reclamation materials sourced from Atlanta, siliceous gravel from Pharr, recycled asphalt pavement materials from Atlanta and El Paso, and recycled concrete aggregate (RCA) sourced from Houston and El Paso—were incorporated in the project. Also used were seven different subgrade soils: sandy soils sourced from Corpus Christi, Atlanta, and El Paso; and clay soils sourced from Sierra Blanca, Houston, Bryan, and El Paso. All permutations of the experiment design were prepared at different levels of stabilizer content, from light stabilization to heavily stabilized systems.

Different quantities of calcium-based treatment agents, such as cement, lime, and fly ash, in combination with polypropylene fibers, were also incorporated in the experimental design to investigate the effectiveness of fiber reinforcement along with chemical additives on the strength properties and volumetric stability of expansive plastic soils with high sulfate contents.

More than 3,000 specimens, considering replicates, were fabricated and subjected to the laboratory tests indicated in Table 1 to provide the basis for the update to the mixture design specification.

The research team developed and calibrated a new fatigue performance model for flexible pavements with cement-treated pavement foundations. The new model accounts for the shrinkage cracking potential due to excessive cement content in the mix, as well as a modified indirect diametrical tensile (IDT) strength in lieu of modulus of rupture for the cement-treated materials. The new model can be potentially incorporated in the TxME pavement design system.

A comprehensive catalogue of pavement features based on non-destructive field testing (such as field distress measurements, falling weight deflectometer, and ground penetrating radar), in combination with available databases from previous TxDOT projects, was developed for calibration of the fatigue performance model. The performance equation was calibrated for 62 pavement sections across Texas with diverse material properties and climatic conditions to improve model generalization.

Research Performed by:
University of Texas at El Paso's Center for Transportation Infrastructure Systems (CTIS)

Research Supervisor:
Reza S. Ashtiani, Ph.D., P.E.

Researcher:
Mohammad Rashidi, MSCE
Edgar Rodriguez, MSCE
Margarita Ordaz, BSCE
Hector Cruz Lopez, BSCE
German Garay, BSCE
Sergio Rocha, BSEE
Jose Garibay, MSCE

Project Completed:
08-31-2020

Table 1: Laboratory Tests for Cement-Treated Materials.

Purpose	Tests
General properties	Sieve analysis, Atterberg limits, moisture-density tests, and sulfate content using the colorimetric method
Activity and plasticity of clay soils	Methylene Blue Test
Moisture susceptibility	Tube suction test, submergence, and backpressure saturation tests
Influence of method of compaction	Texas Gyratory Compactor (TGC), impact hammer, vibratory hammer, and Superpave gyratory compactor
Micro-structural analysis	X-ray computed tomography (CT) imaging technique
Compressive and tensile strength	Unconfined compressive strength (UCS) test and modified IDT strength test with outside strain measurements
Resilient properties and permanent deformation potential	Submaximal modulus tests at different strength ratios
Aggregate geometry	Aggregate Image Measurement Systems (AIMS)
Volumetric stability and expansion characteristics	One dimensional swell and swell pressure tests
Shrinkage characteristics	Coefficient of thermal expansion (COTE) test

What They Found

Several systematic shortcomings were identified associated with the characterization of the moisture susceptibility of granular bases using the traditional methods in this project. Alternative moisture susceptibility protocols were developed in conjunction with routine mechanical tests to underscore the significance of including moisture susceptibility tests in the mixture design process.

This study also focused on providing updates to sample fabrication in the laboratory to ensure the uniformity of compaction and distribution of the treatment agent in the mixture.

Further, the research team investigated the efficiency of dual stabilization techniques to improve the volumetric stability of the plastic soils with excessive sulfate contents. The results showed the superiority of dual-stabilization techniques to mitigate the volumetric expansion of laboratory-prepared specimens.

The laboratory testing, numerical simulations, and field-testing efforts were synthesized to draft an update to the existing design specification Tex-120-E. The traditional UCS value is necessary but not sufficient to identify the optimum cement content in the mix, particularly for reclaimed materials with high blend ratios. Therefore, the updated protocol incorporates the modified IDT strength, two alternative moisture susceptibility tests, and the retained strength concept to provide an all-inclusive view of the influence of cement to improve the orthogonal strength properties and reduce the moisture susceptibility of treated systems. Other noteworthy departures from existing mixture design protocols pertain to the use of Superpave gyratory compactor to replace the traditional impact hammer. In addition, the upodated specification uses slurry mixing to alleviate the concern about distribution uniformity in lightly treated lab specimens.

What This Means

This project yielded an update to the current mixture design specification based on comprehensive laboratory testing. The modified specification considers new trends in using reclaimed materials, and provisions to consider the loss of orthogonal strength properties due to moisture intrusion in extreme weather events. The newly developed strain-based fatigue performance model with considerations of shrinkage cracking in the cement-treated layer, can potentially mitigate reflective cracking issues in flexible pavements with cement-treated layers.

For More Information

Project Manager:
Joanne Steele, RTI (512) 416-4657

Research Supervisor:
Amir Hessami, TAMUK (361) 593-4117

Technical reports when published are available at
http://library.ctr.utexas.edu.

Research and Technology Implementation Office
Texas Department of Transportation
125 E. 11th Street
Austin, TX 78701-2483

www.txdot.gov
Keyword: Research