SOUTHERN PLAINS TRANSPORTATION CENTER

HIGHLIGHTER

VALIDATING FIELD EMPLOYED X-RAY FLUORESCENCE (XRF) ON STABILIZED SUBGRADE PROJECTS

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PROJECT TITLE
VALIDATING FIELD EMPLOYED X-RAY FLUORESCENCE (XRF) ON STABILIZED SUBGRADE PROJECTS

FINAL REPORT
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INVESTIGATORS
Amy B. Cerato, Ph.D., P.E.,
Gerald A. Miller, Ph.D., P.E.,
Nathan Ferraro, M.Sc.,
Rodney Collins, Ph.D.
The University of Oklahoma

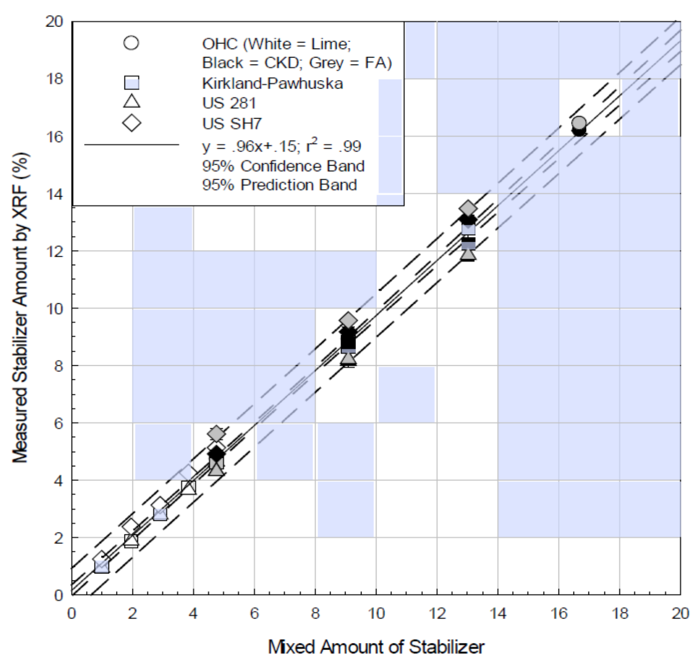
MORE INFORMATION
sptc@ou.edu

Southern Plains
Transportation Center (SPTC)
OU Gallogly College of Engineering
201 Stephenson Parkway,
Suite 4200
Norman, Oklahoma 73019

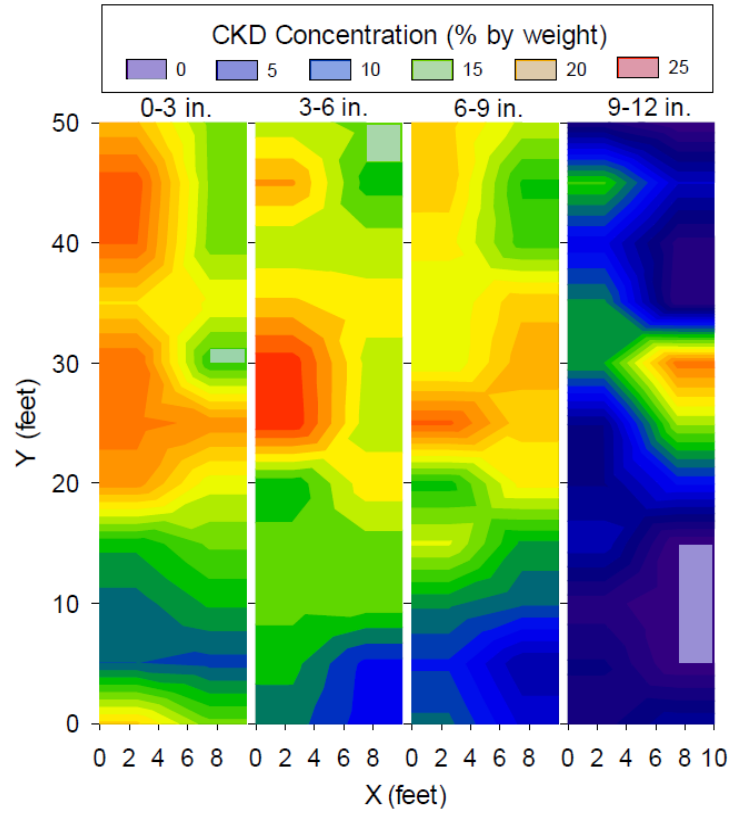
OVERVIEW Transportation corridor construction projects use lime and other calcium-based stabilizers to reduce soil plasticity, increase soil shear strength, reduce soil compressibility, and reduce soil's tendency to undergo volume change when subjected to variations in water content. Recommendations for how much stabilizer to add to a specific soil to achieve appropriate and long-term soil parameter changes is based upon soil classification and type of stabilizer. These recommendations are based on laboratory tests that are performed under certain moisture conditions and do not account for precipitation events in the field. Additionally, the actual amount and distribution of stabilizer in the subgrade soil, which significantly impacts the long-term behavior of the roadway, if often variable and unknown. Currently, there is no reliable way to determine if the field stabilization amount is consistent with the laboratory design amount specified, nor how well the stabilizer is distributed, both spatially and throughout the required design depth. The goal of this project is to assist the state in improving stabilized subgrade behavior by providing a fast, easy-to-implement method of testing stabilizer content and distribution during construction, prior to pavement placement.

RESULTS This project provides a simple and accurate method for making discrete measurements of field additive contents using the portable field employed x-ray fluorescence (PHXRF) tool. Given proper sampling and testing protocols, the methodology can provide an excellent assessment of the spatial distribution of a soil additive.

The project validated PHXRF on stabilized subgrade projects to facilitate construction quality control and geotechnical forensic investigations. This was achieved through two comprehensive rounds of experiments: laboratory testing and field testing (graph, shown right). Laboratory testing sought to assess the effects of scan duration, scan technique, sample particle size, and sample type on the precision and accuracy of the stabilizer content (SC) measurements of the PHXRF devices.



Field testing sought to assess how the sampling and testing protocol [e.g., *in situ* (no soil preparation) and *ex situ* (some sample preparation)] affected the accuracy of the SC measurements as well as to assess relative spatial and depth SC homogeneity of the tested sites. The figure (shown right) graphically depicts the spatial and depth distribution of stabilizer content of an actual field site as measured by the PHXRF tool. The subgrade was designed to contain 15% additive using cement kiln dust (CKD) and the figure shows that for the full 8" stabilization depth, the average stabilizer content stayed above the design value of 15%.



The key findings of this research are as follows:

- Longer scan durations neither improve nor hinder PHXRF precision and accuracy and are therefore considered negligible.
- Significant benefits in terms of PHXRF accuracy are observed when particle sizes are reduced from passing No. 4 to passing No. 40, yet the benefits are less significant when particle sizes are reduced further.
- The relationships between sample type (pressed pellet versus powder) and the precision and accuracy of the PHXRF devices are inconclusive due to conflicting results between OHC and SGB samples.
- Either a standard scanning technique, where a sample is scanned at the same location three times, or a quartering scanning technique, where a sample is rotated 90° after each scan, may be appropriate for PHXRF SC measurements.
- When used in the field, the PHXRF device performs poorly in situ (e.g., no sample preparation) during direct measurement on the surface of the treated subgrade.
- However, when samples are removed and tested, the PHXRF device performs well ex situ (e.g., sampling and processing soil over a #40 sieve).
- The linear relationship between ex situ measurements and commercial XRF SC measurements has an r^2 value of 0.925, which suggests that PHXRF measurements can be mathematically corrected to obtain a truer SC value.
- PHXRF is a convenient way of gathering data needed to assess the spatial and depth heterogeneity of stabilized subgrade sites.

Using X-ray fluorescence (XRF) can accurately detect the amount of stabilizer in a subgrade at any given point, which can help inspection officials make timely corrections if necessary and provide a tool for forensic investigations if a roadway is not behaving as expected. In terms of cases where the stabilized subgrade loses strength due to extreme precipitation events (possibly due to leaching of the stabilizer), the XRF can be used to determine how much additional stabilizer is necessary to bring the roadway into compliance with design standards.

POTENTIAL BENEFITS This XRF technique of measuring and monitoring the stabilizer content of a stabilized subbase has the potential to revolutionize construction inspection practice, as well as geotechnical forensic investigations. This research is an important step to implementing XRF in construction protocol and demonstrates how XRF technology can help transportation officials achieve a more uniform and better behaving pavement system.