



TECHSUMMARY February 2024

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Using the Portable XRF to Identify/Verify Field Material Properties

INTRODUCTION

Materials such as cement, concrete, limestone, thermoplastic, steels, glass beads, and bridge coatings must be sent into the central laboratory for testing of properties, such as chloride content of bridge deck cores, silica content of aggregates, chemical composition of cement, and lead content of existing bridge coatings. However, these laboratory tests are time consuming, expensive, or need destructive sampling. The second Strategic Highway Research Program (SHRP₂) Ro6B identified the portable X-ray Fluorescence (XRF) unit as a potential solution to quickly determine some of these properties in the field on in-place materials without sampling delays. Hence, in collaboration with the spark spectrometer and the benchtop XRF at DOTD materials lab, this report investigates the feasibility of using an Olympus Vanta C series handheld XRF as a nondestructive means to test the composition of some common construction materials.



Figure 1. Olympus Vanta C Series

OBJECTIVE

Portable spectroscopy technologies such as X-Ray Fluorescence (XRF) are proposed for a rapid identification of chemical compounds or detection of certain additives or contaminants in some commonly used construction materials in Portland cement concrete, structural coatings, or pavement markings. The ability to provide fast verification in the field of material properties at the source or on the job site prior to incorporation can enhance quality assurance, and therefore alleviate potential issues after the project is complete. Hence, it has been set as the objective of this study to evaluate the efficiency of the portable devices to characterize relevant materials for acceptance and develop a methodology for applications in Louisiana.

SCOPE

To meet the objectives of this study, a portable XRF was employed to test steel, portland cement, fly ash, and aggregates that were available at DOTD material's laboratory.

METHODOLOGY

To investigate the feasibility of using portable XRF to characterize the compositions of commonly used construction materials, the selected materials were tested with the traditional device (spark spectrometer for metal samples, and benchtop XRF device for non-metal samples) at DOTD materials laboratory and the portable Olympus Vanta C series handheld XRF device at LTRC. A comparison study between the testing results was followed to evaluate the efficiency of using portable XRF to characterize the compositions of commonly used construction materials. Replicate specimens were prepared for testing.

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CONCLUSIONS

By comparing the testing results of portable XRF (Olympus Vanta C series) and DOTD materials laboratory, it is concluded that:

- For A955 grade 60 stainless steel, portable XRF works fairly well for the testing of manganese, copper, nickel, chromium, and molybdenum. The portable XRF device used in this study was able to detect phosphorus, sulfur, and silicon, but cannot produce reliable results for their contents.
- For ASTM F1554 Grade 55 and 105 anchor bolts, the portable XRF device used in this study was not able to detect phosphorus and sulfur that have a content value less than 0.04%. There is a linear relationship between the portable XRF testing results and DOTD materials laboratory testing results for the testing results of element copper.
- For ASTM A194 Grade 2H steel nuts, the portable XRF used in this study was not able to detect phosphorus, and sulfur that have a content value less than 0.5%. For element manganese, there is linear relationship between the portable XRF testing results and DOTD materials laboratory testing results.
- For ASTM F436 type I steel washers, the portable XRF was not able to detect phosphorus and sulfur that have a content value less than 0.03%.
- For portland cement Type I/II, the portable XRF was not able to detect magnesium oxide, which might be due to the fact that magnesium is at the edge of the detection capability of Olympus Vanta C series. Portable XRF works fairly well to detect silicon dioxide, calcium oxide, and ferric oxide though different correlation/calibrations would be needed for all of them. However, the testing results of aluminum oxide from portable XRF are more dispersive, which could be due to the lower atomic weight of aluminum and its low content in the samples.
- For portland cement Type III, a linear relationship with R₂ value of approximately 0.7 could be established between the portable XRF testing results and DOTD materials laboratory testing results for silicon oxide, calcium oxide, and ferric oxide. However, the R₂ value drastically reduced to 0.1206 for aluminum oxide. This confirms that the portable XRF was not able to detect light weight element reliably.
- For Class F fly ash, the detected content of ferric oxide from portable XRF was close to the results from the DOTD materials laboratory, but with a lower standard deviation. However, the portable XRF underestimated silicon dioxide and aluminum oxide to a higher degree.
- For crushed sand aggregate, the portable XRF generally underestimated the contents, except for aluminum oxide in two samples (3.3% vs 2.31%, and 1.73% vs 1.19%).
- For crushed gravel aggregate, portable XRF underestimated the contents of silicon oxide and ferric oxide.
- For crushed stone aggregate, a linear relationship with R₂ value of above 0.85 could be established between the portable XRF testing results and DOTD materials laboratory testing results for silicon oxide, aluminum oxide, ferric oxide, and calcium oxide.

RECOMMENDATIONS

Portable XRF could be used to detect heavy-atomic-weight elements, provided the device has been calibrated with the results from benchtop XRF.