AHTD TRC TRANSPORTATION RESEARCH COMMITTEE

TRC1301

Use of Non-Nuclear Devices for Quality Assurance

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Final Report

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Arkansas State Highway & Transportation Department

Transportation Research Committee

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Introduction

When constructing new transportation infrastructure or maintaining current infrastructure systems, achieving sufficient soil strength is critical to a successful construction effort. Currently, soil design specifications are given in terms of a minimum soil density and a specified range of soil moisture content. Quality control is achieved by monitoring the soil density and moisture content throughout the construction process. The Nuclear Density Gauge (NDG) is the most commonly employed device to determine soil density and moisture content due to its ease of use, speed of readings, and reliability of results. However, due to potential safety hazards and rigorous user certification requirements, many agencies are seeking to replace the NDG.

Work Plan

The primary objective of this research project was to determine if the use of non-nuclear devices could replace the use of nuclear devices for quality control. The work plan was divided into five phases. Phase one included conducting a literary review on the use of non-nuclear devices for quality control. Phase two was the study of available non-nuclear devices. Phase three consisted of laboratory testing. Phase four is to evaluate, analyze, and compare data. Phase five is the implementation of non-nuclear devices if deemed necessary.

Literature Review

A thorough review of relevant literature was conducted. The major emphasis of the literature review was conducted in the first part of the project. The literature review

also continued throughout the project. A search of all relevant journal articles, books, and technical reports was conducted. The review found two reports to focus on. These reports are TRB NCHRP Synthesis 456 and TRB NCHRP Report 626.

TRB NCHRP Synthesis 456 “Non-Nuclear Methods for Compaction Control of Unbound Materials” suggest that most Transportation Departments have an interest in replacing the NDG with a Non-Nuclear Gauge. Many Transportation Departments have evaluated the Non-Nuclear Gauge. Most of them were very unsatisfied with the results and will not recommend the non-nuclear gauge. At the time of this study all available non-nuclear gauges require longer testing time and more difficult to operate than the NDG. The Moisture indicator also has limitations when testing a certain type of soil such as high-plasticity clay and stiff soils.

TRB NCHRP Report 626 “NDT Technology for Quality Assurance of HMA Pavement Construction” evaluates several Non-Destructive Testing (NDT) methods on hot-mix asphalt. Out of all the pieces of equipment evaluated the main two used for density are the Electrical Density Gauge (EDG) and the PaveTracker. For testing unbound layers and materials with NDT devices the EDG had unacceptable rates below 50% for identifying areas with anomalies. The EDG had a standard deviation in density measurements of less than 1pcf. For testing HMA mixtures and layers with NDT devices the seismic and non-nuclear gauges were the only devices that were consistent. They were both able to identify the areas with and without segregation. It was determined that as long as the EDG is calibrated properly that it is suggested for use on HMA layers.

Study of Available Devices

There are multiple non-nuclear devices available to determine sub grade properties. After reviewing the units it was determined that the Humboldt Electrical Density Gauge (EDG) and the Trans Tech Soil Density Gauge (SDG) would be purchased. The Research Section of Arkansas State Highway and Transportation Department (AHTD) received training on both of the units. After training, the nuclear and non-nuclear devices were tested alongside each other to determine the repeatability and reliability of the non-nuclear devices.

The Humboldt EDG uses high radio frequency waves to measure the density and moisture content of soils. The EDG is equipped with four tapered 6-inch long spike probes, a hammer, a soil sensor and cables, template, temperature probe, a battery charger, and a hard case. The four probes are driven into the ground and the device transmits high radio frequency waves through the probes; four measurements are obtained. After the probes are driven into the ground four measurements are obtained. The EDG then analyzes the transmitted radio frequency to determine the electrical properties of the tested soil. The electrical properties are then converted into dry density and moisture content measurements using a soil-specific calibration model.

The Trans Tech SDG is a self-contained unit that uses electromagnetic impedance spectroscopy to measure the density and moisture content of various unbound material. The SDG has a non-contacting sensor that consists of a central ring and an outer ring. The central ring generates and transmits radio frequency into the soil. The response of the radio frequency is received by the outer ring and is used to measure the dielectric properties of the tested soil matrix. A calculation of the dielectric properties is then performed to determine the density and moisture content.


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Laboratory Testing

The laboratory testing was completed using the non-nuclear and nuclear devices. Field soil samples were brought in to check for actual moisture content. The results were then compared to the readings on the devices. This was done to expose any issues with the devices in order to check the difficulty of calibrating the devices. There were no issues exposed during the laboratory testing.

Site Locations and Comparative Information

There were comparative field test completed with the nuclear and non-nuclear gauges. There were several construction sites chosen around the state, all with different materials to test the gauges. The different materials were chosen so we could see how each unit would work with the different materials. There were a total of six

different construction sites chosen. The sites had job numbers of 080395, 061244, 061094, 040569, 040605, and 070291.

Job 080395 was located in Faulkner County and it had two test sites. The first test site consisted of sandy material. The second site for 080395 consisted of dark gray shale. For the sand the EDG and the SDG gave readings that were not close to the nuclear gauge readings. For the dark gray shale in job 080395 the EDG and SDG also gave readings that were not comparable to the nuclear density gauge.

Job number 061244 was located in Pulaski County at the I-430/I-630 interchange. This job only had one test site. This construction site consisted of white and tan fine sand. The EDG and SDG gave readings that were not comparable to the nuclear density gauge on this material. On test number eight the nuclear gauge gave a reading of 11.0% for moisture. The EDG gave a reading of 18.0% for moisture and the SDG gave a reading of 6.0% for moisture. These are not comparable readings.

Job number 061094 was located in Pulaski County at Baseline Road and Scott Hamilton Drive. The material consisted of dark gray shale. The SDG and the nuclear gauge are the only two devices that could be tested at this site. They did not give any comparable readings. The EDG could not be tested because the material was too hard. Driving the probes into this material was too difficult. The probe was attempted to be driven in several different locations and was unsuccessful. During the process of driving the probes every one of them bent.

Job number 040569 was located in Washington County on Highway 16 Section 3. The material sampled on this job consisted of red clay. The readings of the SDG and EDG were comparable, but not with the nuclear gauge. The reading of the SDG

had a moisture reading of 1.9%. The EDG had a moisture reading of 1.7%. The nuclear gauge had a moisture reading of 5.4%.

Job number 040605 was located in Washington County on Interstate 540 Section 4. The material sampled at this job site consisted of red clay. The SDG was having issues and was not able to be tested at this site. The EDG and nuclear gauge were compared for this site. The EDG had a reading of 112.4% wet density and the nuclear gauge had a reading of 105.9% wet density. These readings are not close enough to each other to give consideration.

Job number 070291 was located in Cleveland and Dallas Counties on Highway 167 Sections 8 and 9. The tests were performed on red dirt at this job site. The SDG was not able to be tested at this site also. The nuclear gauge and the EDG readings were not comparable at all. The EDG had a 3.2% moisture reading. The nuclear gauge had an 8.3% moisture reading. These readings are also not close enough to be comparable.

Conclusions and Recommendations

Many locations throughout the jobs listed above were tested. At each location the readings of the SDG and EDG were not comparable to the readings of the nuclear density gauge. On average, there was at least a five number difference on moisture percentage, a ten number difference on dry density, and a twelve number difference on wet density. At this time it is not recommended for AHTD to do away with the nuclear density gauge and implement the non-nuclear density gauges. Companies are still

developing newer non-nuclear density gauges and it will be beneficial if AHTD is able to look at these in the near future.