A SUMMARY OF OPERATIONAL DIFFERENCES BETWEEN NUCLEAR AND NON-NUCLEAR DENSITY MEASURING INSTRUMENTS

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STUDY

The purpose of this evaluation was to compare the accuracy and reproducibility between a non-nuclear and nuclear measuring device used to determine the in-place density of compacted asphalt concrete pavements. FAA and regulator Agencies are placing more emphasis on compaction; thus it is imperative that the paving industry be able to accurately measure compaction in the finished pavement.

BACKGROUND

There has always been a need for a quick, accurate and non-destructive instrument for measuring in-place density in the paving industry. In the late fifties and early sixties, several manufacturers began experimenting with the use of low level radiation as a source of energy for measuring the in-place density of soil, aggregates and asphalt concrete. Over the ensuing years the paving industry has realized the importance of timely compaction results.

The first generation of nuclear gages were quite awkward, heavy and required a scaler attached by a long umbilical cord to the density device. The nuclear source shielding for operator protection was not yet refined and required the operator to read the results from a scaler at some distance from the gage. Over the years nuclear gage manufacturers have refined instrument accuracy and operator safety. However, owning and operating nuclear gages still requires a State Radioactive Materials license, a Radiation Safety Officer, dosimeter badges for the operators, and the operators must attend a radiation safety and operation training class. There are also certain restrictions for transporting gages onto Federal and Military properties. The license requires that nuclear gages must be properly stored and transported. Maintaining the nuclear licenses is in itself a cumbersome ordeal.

While nuclear density gages have served our paving industry well, the need for an instrument without the difficulties of a radioactive materials license, special handling and a more operator friendly device is needed.

Recently a company has developed a lightweight, non-nuclear in-place density measuring device. This report presents comparative information between present day conventional nuclear density gage and the non-nuclear gage.

INSTRUMENTS

The nuclear testing instrument used was a Troxler 3440, manufactured by Troxler Electronic Laboratories, Inc. of North Carolina and a non-nuclear PQI Model 300 instrument manufactured by TransTech Systems, Inc. of Schenectady, New York.

PROJECT

Camarillo Airport, Parallel Taxiway construction, consisting of 2-inch lifts of P401, ¾ inch, maximum asphalt concrete placed over prepared aggregate base.

FIELD TESTING PROCEDURES

The Troxler 3440 gages use Cesium 137 and Americium 241 as the source of energy for measuring material density, while the Pavement Quality Indicator, Model 300 (PQI) uses electrical waves to measure the dielectric constant of the material being tested.

A test strip was placed on the first day of paving from which gage biases were developed for each testing unit based on the cores taken from the test strip. The test strip was placed per typical FAA requirements with three cores cut from the finished mat and three cores cut from the longitudinal joint.

Both gages were used to monitor compaction during placement. Placement test sites were delineated to facilitate repeated testing to assist in evaluating gage reproducibility. Both the mat and joints were tested. The standard operating procedures recommended by each manufacturer were followed during field-testing.

The Troxler was used in the backscatter mode and rotated 180 degrees after each 1-minute test with the average of the two tests being reported. The TransTech PQI instrument instructions recommend that five 5-second measurements be taken at each site. After the first PQI test was taken, a circle was outlined around the base. Then the additional four tests were conducted at the 2, 4, 8 and 10 o'clock position with the center of the PQI along the outlined circumference. The results of the five readings were averaged by the devise and reported as a single value.

Periodically, throughout the placement, test sites were revisited and re-testing was performed. This was intended to give us density values for evaluating the reproducibility of each of the units. Over the course of three days of paving, the gage biases were confirmed from cores cut through the mat and joints representing each paving day. To minimize variables due to underlying materials, results of our findings are based on testing conducted on top or final lift of asphalt concrete.

FINDINGS

The conclusions reached from this limited field comparison may vary from project to project or mix to mix.

1. Ease of Handling: The Troxler 3440 weighs 30.5 pounds. While the PQI weighs 15.4 pounds. This is a significant weight difference when you consider taking hundreds of tests per day.

2. Warm Up Time: The Troxler requires a warm up period and a standard count, which requires about 15 minutes. The PQI is good to go from the moment the power is turned on.

FINDINGS (continued)

3. Test Time: While the Troxler can take 15 second readings, the one minute count is by far more accurate and repeatable and is recommended. The PQI readings take 5 seconds each. To complete a test at a given site the Troxler requires 2 minutes, while the PQI requires 20 seconds.

4. Ease of Screen Reading: The PQI screen was easier to read in direct sunlight and provided the operator with averaged test values, while Troxler values averages had to be calculated by the technician.

5. Key Boards and Functions: Both boards allow data input with ease, however, the PQI keyboard had additional functions and was more direct and user friendly. The PQI keyboard pads are extremely sensitive and duplicated instructions happen often if the technician is not careful when in putting.

6. Re-Testing: To evaluate repeatability/reproducibility, selected test sites were retested. The PQI gage reproduced the same results as it din in the original measurement, while the Troxler results showed a large variability in repeating original results, as much as 2pcf to 5pcf difference. We experienced similar differences in Troxler density values by just rotating the gage 180 degrees during both the original and re-testing. The Troxler re-test results were typically lower than the original density.

7. Gage Bias: There was a large difference between the two gage biases. The Troxler's bias was in 2pcf to 4pcf range while that of the PQI was on the order of 10pcf to 12pcf. Both gages without the bias would read lower than the core densities.

8. Standard Deviation: The standard deviation for PQI density values over three days testing were: 0.95 and 0.79 for mat densities and 0.84 for joint densities. The standard deviation for the Troxler values were: 1.51, 2.12 for the mat and 0.90 for joint test.

9. Surface Texture Affect: The results of the Troxler gage, while in the backscatter mode, show a wide range in values, as much as ± 5pcf. It is evident that the surface texture has a significant affect on the performance of this gage. The PQI shoed no measurable affect from the pavement surface texture.

10. Use Without a Bias: Due to the large bias needed for the PQI, to utilize this instrument without a bias would introduce very erroneous density information. On the other hand, the Troxler would provide you with realistic but low-density values.

CONCLUSIONS

Based on this limited study, and with a correct gage/core bias, it is our opinion that TransTech's Pavement Quality Indicator Model 300 is a reliable and accurate instrument to measure in-place density of compacted asphalt concrete.

Instrument costs are comparable to present day nuclear gage prices, approximately $6,000. The PQI is very user friendly and being lighter causes less strain on the back of the technicians. It can be stored and transported anywhere and can be purchased without a Radioactive Materials license. It is fast and has good repeatability as well as having a low standard deviation between tests. Unlike the nuclear gages, it does not require extensive and periodic calibrations either by the manufacturer or State agency. While biases based on core is a proven method the use of rolling patterns "v" density can also be used. However, this procedure will not provide you with the correct in-place unit weight. Instead it will give you percent of improvement established by the rolling pattern.

Our plans are to continue to evaluate the PQI on different projects using different mixes over the next few months. Should the results of this testing warrant, an additional report will be issued.