NoNuke™ Application Brief

InstroTek® Inc.

Introduction

Road building is a major industry, with an average of 6,500 miles of new roads constructed each year. This does not count for the number of overlays and repairs to the existing roads. Part of the process of building good roads is an efficient quality control and quality assurance program. Contractors and state agencies are serious about and employ methods to produce quality roads, as a large sum of money is spent to ensure safety and driving comfort for the public.

In order to assure long lasting roads are built, quality control and quality assurance programs utilize different tools and instruments. These tools include careful design of the material being used, subjecting the designed material to a range of tests predictive of performance, and testing of the physical properties of the road.

Precise knowledge of the physical properties of the materials are indicative of the performance and durability of the roads. In the process of construction, it is important to assess properties of the road to assure that what is constructed in the field matches what has been designed in the laboratory. This application brief focusses on two parameters used to assess the quality of the road, these are the density of the finished paved product and the percent compaction. Measuring the density of the finished pavement could generally fall under the heading of quality assurance and measuring the density or percent compaction during construction would be quality control.

There are various tools used to assess the density and percent compaction of a road. Drilling and extracting a core sample from the road and measuring the density in the lab is one method. However, this is time consuming, costly and by the time accurate results are obtained hundreds of thousands of dollars of road would have been constructed.

In the mid-1950s radioisotope gauges (normally referred to as nuclear gauges) were developed for field density measurements.

These gauges are used to obtain quicker results as the road is being constructed. Nuclear gauges require licensing by federal and state agencies, with stringent adherence to safety regulations during use and transportation. In the early to mid-2000s, non-nuclear density gauges based on the dielectric constant of the material were utilized and have been used, as an alternative to nuclear gauges.

NoNuke™

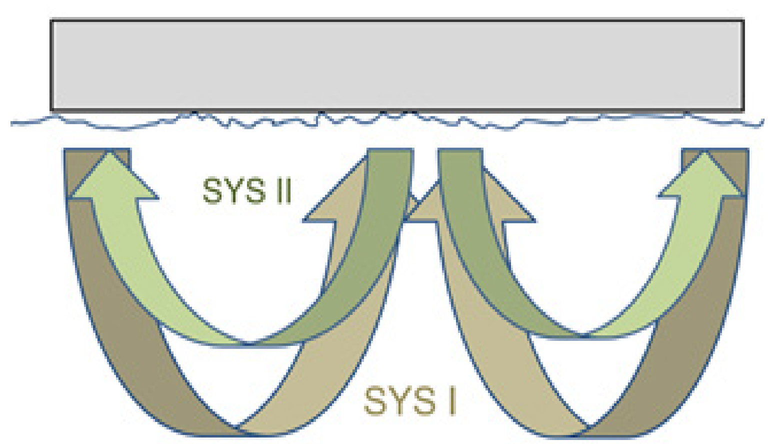
InstroTek, Inc. introduced the NoNuke™, a non-nuclear based density gauge in January 2020. InstroTek has spent a significant amount of time researching and developing a capacitance-based gauge that measures the density of material based on the dielectric constant. The dielectric constant is related to the density of the material using advanced models developed by InstroTek Scientists and Engineers. The NoNuke™ gauge utilizes dual sensor technology as shown in the figure below.

The gauge comes with several enhancements, with the capability to distinguish between the surface density and the deep density of the material thereby reducing the effect due to surface roughness. The gauge also incorporates temperature correction routines for the measurement of more accurate density results. The other important feature of this gauge is poor contact and excessive surface moisture indicator. Poor contact or moisture can have a significant impact on the results, if not properly taken into account during measurements.

The NoNuke™ has been extensively tested in the laboratory and field with great results. Since nuclear gauges are primarly used for quality control and also have to be corrected using core desnity values for accurate density indication. This application brief is only focusing on comparsions of nuclear gauge to the NoNuke™ gauge. The NoNuke™ gauge was compared to the nuclear gauge on several different pavement projects.

Any instrument is as good as its calibration. InstroTek has several patents and over 100 years of combined experience in development and utilization of advanced calibration methods for variety of field and laboratory instruments. We have dedicated many hours in identifying and constructing calibration standards, technology, and methodology to ensure the most accurate, precise, and stable measurement of density by the NoNuke™ for asphalt pavement materials.

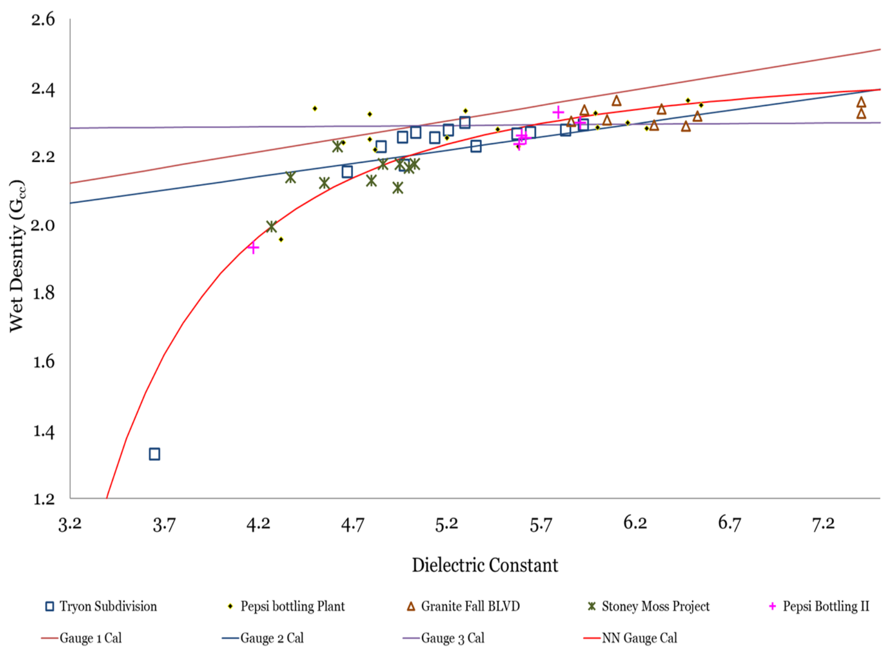
NoNuke™ with Case



Rendering of System I and II Theory

Results

The NoNuke™ has been designed and calibrated against materials whose dielectric constant is known. To delineate the difference between the NoNuke™ and the electrical density gauges in the market, consider the diagram below. Gauge 1, Gauge 2, and Gauge 3 are all electrical density gauges from different manufacturers. The important aspect to note is that the NoNuke™ non-linear calibration more closely follows the behavior of asphalt as the compaction level decreases as shown in the figure below.



Linear calibrations cover a small range of density measurements and can result erroneous readings when densities fall slightly outside the expected range.

Field testing was carried out in several locations to compare the NoNuke™ readings to the nuclear gauge readings. The tables below show the average density result over different locations and the standard deviation of the measurements.

The standard deviation is a measurement of the fluctuations in the density of the pavement, as such if both gauges are responding to density change then the fluctuations as measured by the standard deviation should be close to each other. Both the nuclear and the NoNuke™ gauge density measurements utilized their factory calibrations and there was no offset applied to the readings taken on the asphalt pavement. Even if gauges do not measure the same absolute density, it is expected that the variation in measurements would be close and that when the reading goes low according to one gauge, the same behavior is observed in the measurement of the other gauge. The F test confirms that the standard deviations from two data sets, nuclear gauge and NoNuke™, are not significantly different.

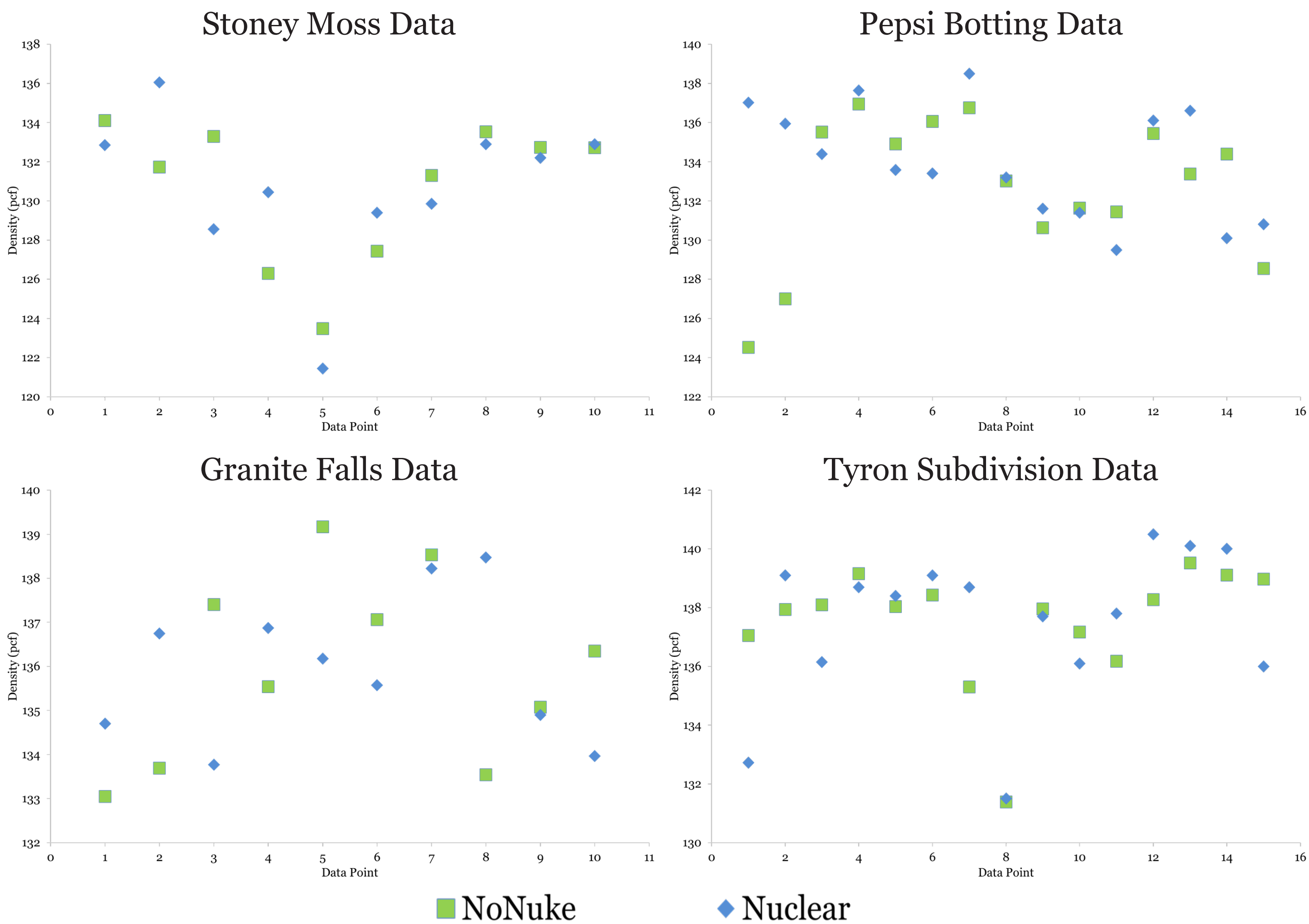
Location	Device	# Data	Avg (pcf)	SD (pcf)	F-Test
Stoney Moss	NoNuke™	10	136.5	3.6	82%
	Nuclear	10	130.7	3.9	
Granite Falls	NoNuke™	10	146.5	2.1	56%
	Nuclear	10	135.9	1.7	
Pepsi Bottling	NoNuke™	15	142.8	5.5	79%
	Nuclear	15	132.7	5.9	
Tyron Sub	NoNuke™	15	141.6	2	37%
	Nuclear	15	138.9	2.6	

The comparisons of the average are direct comparisons with gauges that have not been offset to the asphalt measured, density values are

Results (cont.)

based on the factory calibrations. It is easy to see that an offset will bring the gauges in line. The graphs below show the correlation of the NoNuke™ with the Nuclear gauge.

These graphs show that the trend in NoNuke™ density measurements follows the nuclear density measurements. Also, the magnitude of the changes from test to test are the same. This confirms the NoNuke™ measuring asphalt density is similar to the nuclear gauge.



Conclusion

The NoNuke™ gauge response to density change was found to be similar as compared to the nuclear gauge density values, with essentially the same resolution. The standard deviation of the nuclear gauge and NoNuke™ at different locations were found to be within an acceptable statistical range as examined using the F test. The F-Test results showed there is no statistical difference in the standard deviation of the two gauges. Furthermore, the trend between density readings of the nuclear and the NoNuke™ gauge indicate that while some individual data points may be different, the general trend between these two different type gauges is the same, confirming that the NoNuke™ gauge produces density results that are as reliable as the nuclear gauge and that both gauges can be adjusted by an offset to produce similar density values.