Measuring In-Place Density of Asphalt and the Benefits of using a Non-Nuclear Density Gauge

TransTech Systems, Inc.

Presented by
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Presented By: John Lamond

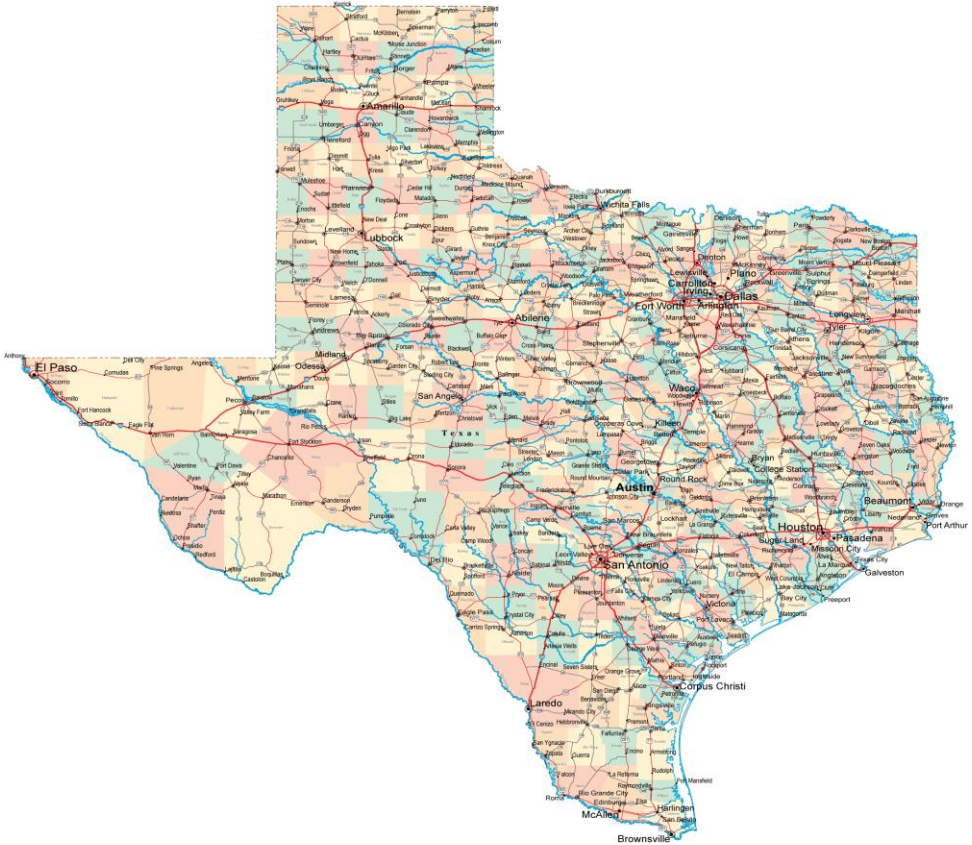
- John is an experienced construction materials testing professional with over 40 years' involvement in the use, specification, training and selling of testing equipment to the construction industry.

- He has had several international technical sales roles, working with a variety of construction materials testing equipment manufacturing companies and is now Sales Manager for TransTech Systems.

Overview

- **General Overview:** Local road network
- **Quality issues:** Pavement - QA procedures
- **Resources:** Funding challenges - possible solutions
- **Compaction:** Its importance - benefits associated
- **Methods of testing:** Options
- **Reasons for testing:** Quality - financial
- **Conclusion:** The way forward to more sustainable, longer lasting asphalt pavements

Overview


Amarillo
Lubbock
Wichita Falls
Abilene
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El Paso
San Angelo
Fort Worth
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Killeen
Austin
Round Rock
College Station
Bryan
Beaumont
Houston
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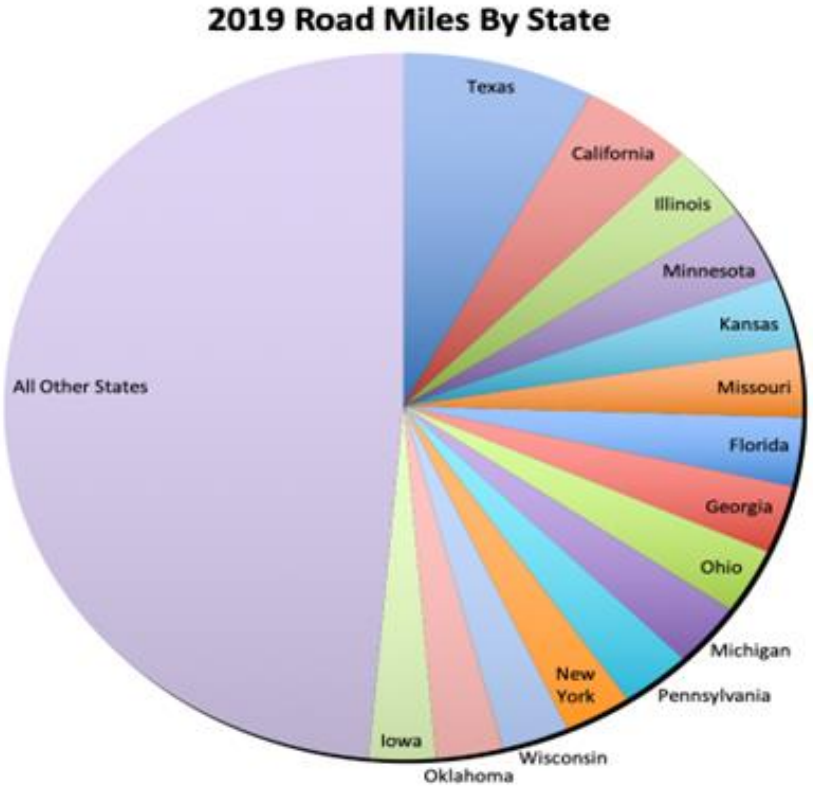
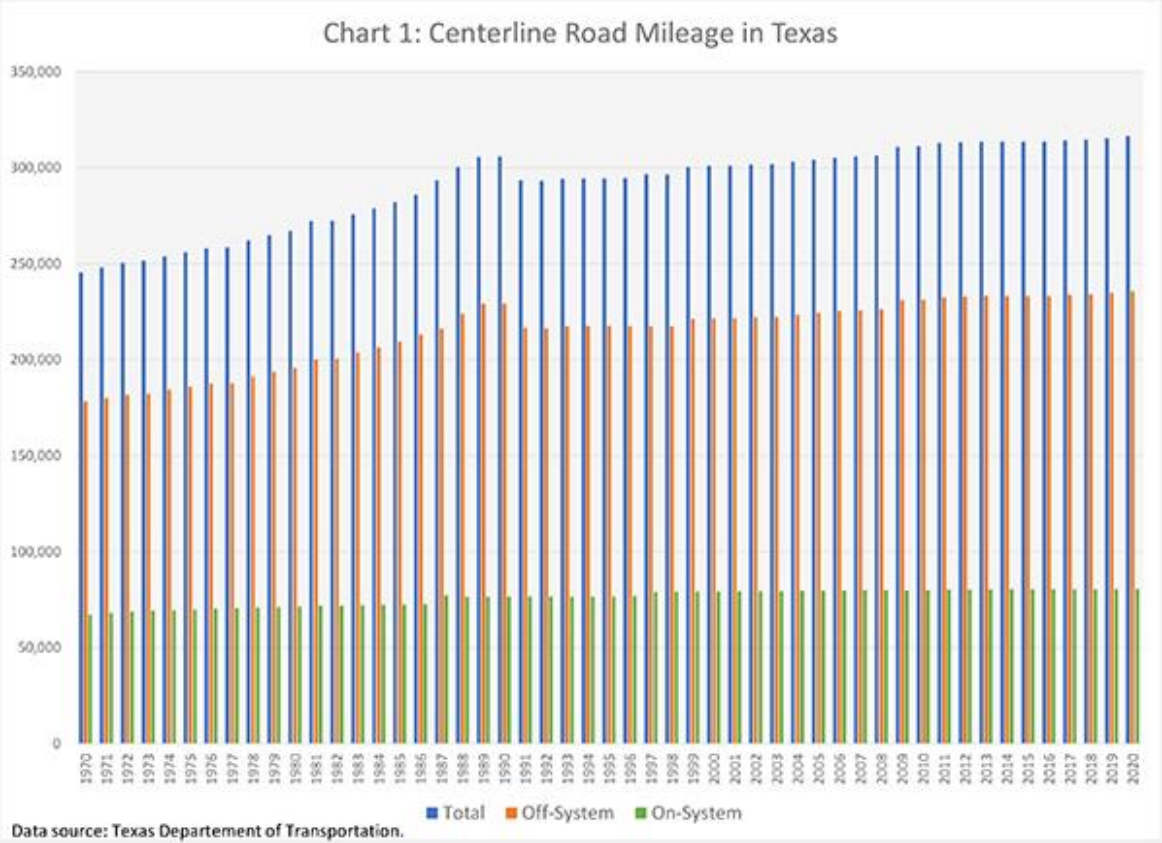
Victoria
Corpus Christi
Laredo
Harlingen
McAllen
Brownsville
Texas

Overview

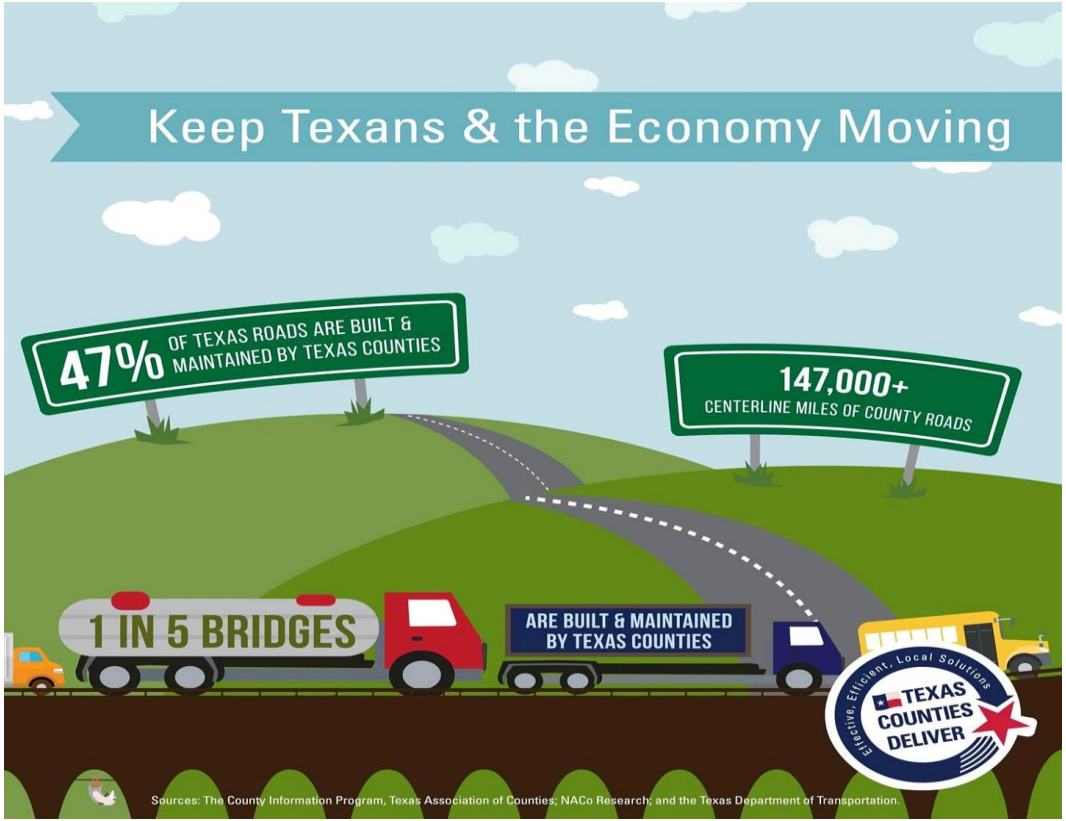


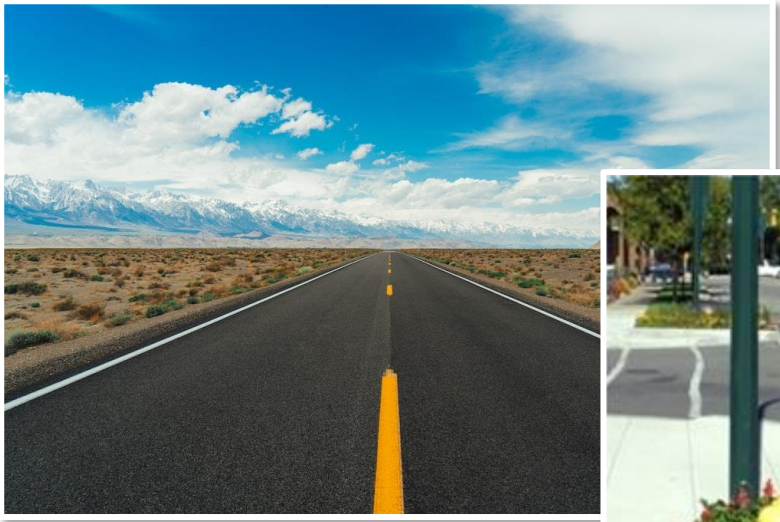
683,533 lane miles of paved roads in Texas as of 2019

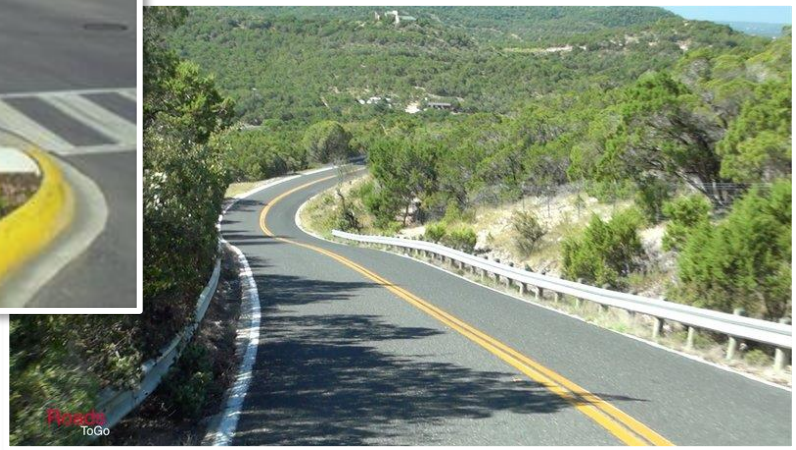
Overview

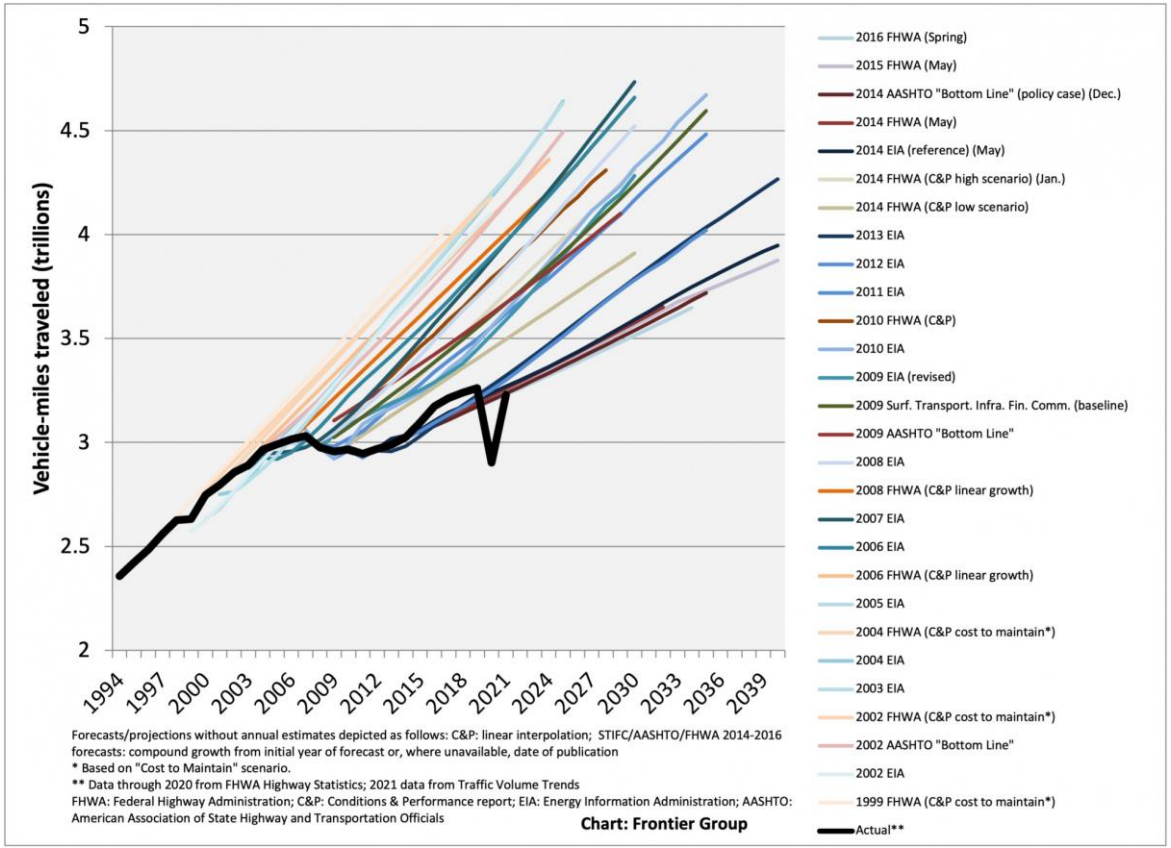


Overview



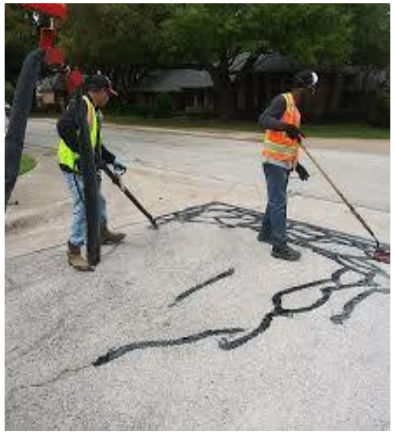






Increased number of axial loads will lead to:

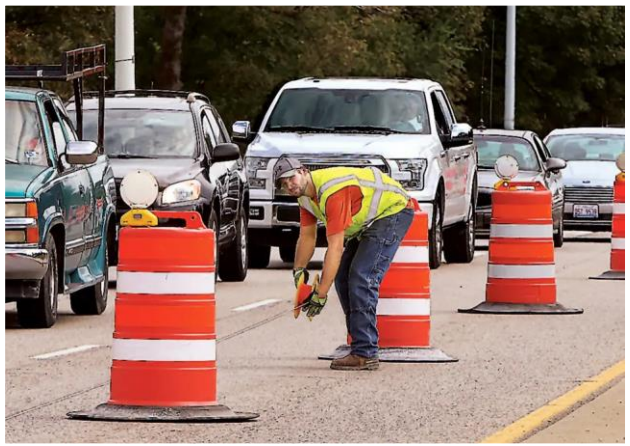
- Increased cracking
- Increased rutting
- Premature failure of pavement

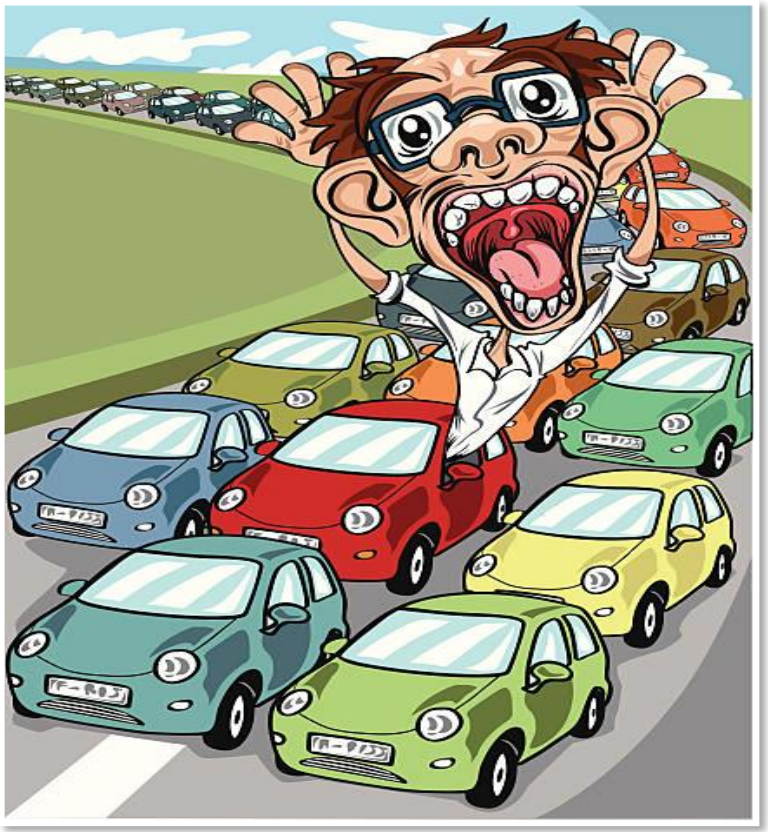


This leads to:

- Increased maintenance
- Increased cost of repair or rehabilitation

$$$$$$$$$





What causes these pavement failures and what can be done to prevent them?

Many factors can play a part on the failure of a pavement

- Insufficient or improperly compacted base below the asphalt
- Over or under compaction of asphalt
- Poor drainage/water intrusion
- Traffic over loading
- Excessive movement due to temperature changes

Over or under compaction of asphalt

- **Environmental -** Ground/air temperature
- **Mix Property -** Aggregate gradation/asphalt binder
- **Construction -** Type of roller/lift thickness/delivery temperature

Can we take any steps to improve these quality processes?

What are the challenges of a QA process for local agencies?

What is a QA System?

- Addresses the overall process of obtaining quality
- Involves continued evaluation
- Includes elements of Quality Control

- QC includes sampling, testing, inspection, and corrective action (where required) to maintain continuous control of a production or placement process.

Local Agencies Vs DOTs

Resources

- Money/funds
- Staff
- Infrastructure

Regulations

- Federal
- State
- County/City

What is Missing & Needed to Assure Quality?

-Testing? - Inspection? - Nothing?

What is Actually Done?

-Testing? - Inspection? - Nothing? - Something?

Local agencies have to balance Risk vs Reward

No QA/QC process or a process that does not specify the in-place measurement of asphalt density as standard

Improving and/or amending the QA/QC process to include in-place measurement of asphalt density as standard

1% Decrease in-place Density = 10% Reduction in Fatigue Life (pavement life)

To illustrate the effect of in-place density on the life cycle cost analysis (LCCA) of asphalt pavements, an LCCA was conducted on two alternatives in which the same asphalt overlay was constructed to 93% and 92% compaction of the maximum theoretical SG (Gmm).

An FHWA LCCA found that the 1% increase in asphalt density could produce an 8.8% net saving on the project

Using the conservative 10% increase in service life described previously, the LCCA results revealed that the client would see a net cost saving of $88,000 on a $1 million paving project. That is an 8.8% saving by increasing the minimum in-place density criteria by 1% of Gmm.

Source: FHWA-HIF-21-020

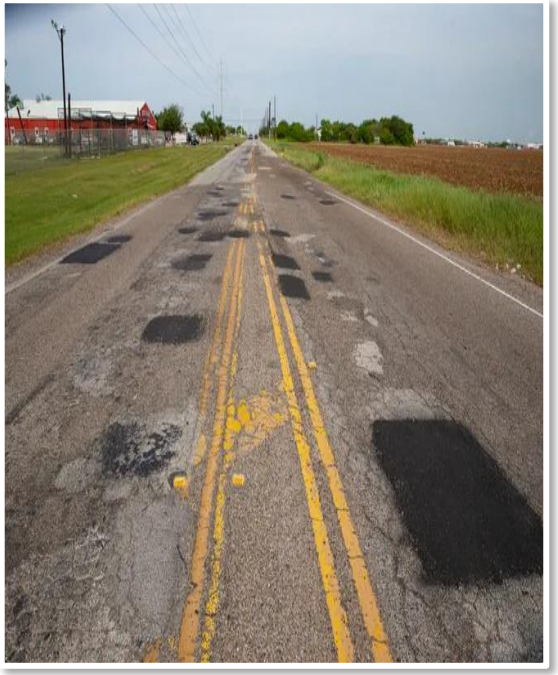
The potential 8.8% saving on EVERY project is money that could be diverted to a QA/QC program to give long term, sustainable improvements to your pavement life expectancy.

Local agencies have to balance Risk vs Reward

- Not achieving density
- Decreasing life expectancy of pavement
- Increased maintenance costs
- Increased traffic disruption and delays

- Increased confidence in achieving density
- Increasing life expectancy of the pavement
- Reducing maintenance costs
- Less disruption and delays

Save Tax Dollars with Every Mile of Asphalt Pavement Laid



When A Proper QA Plan Is In Operation It Will

- *Create confidence in the construction process*
- *Reduce risk of failure and/or future repair and maintenance*
- *Help to give the best use of tax dollars*
- *Provide quality pavements for satisfied road users*

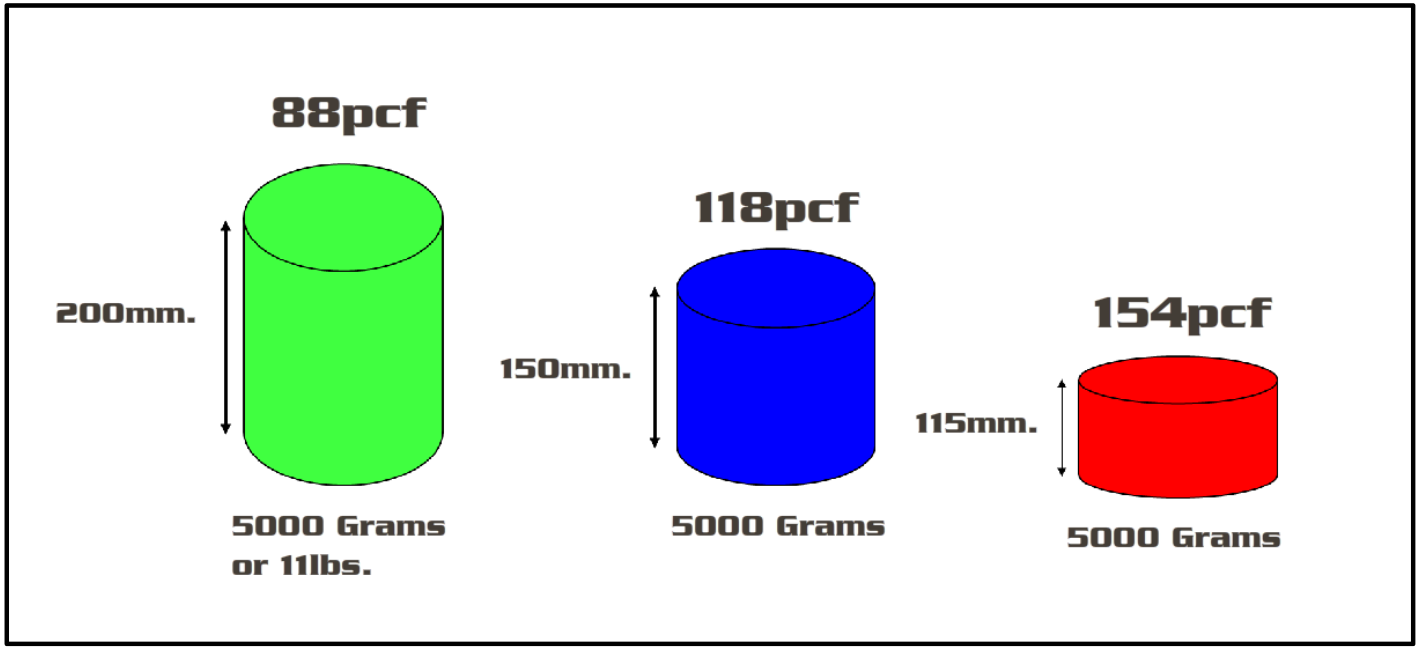
When a proper QA plan is in operation it will help to provide

If you agree that improving your QA is a good idea and that it could offer financial benefits…what steps should we take?

What is compaction and why is it so important ?

Compaction, in its most basic form, is the act of getting the air out of the asphalt mix in order to reach peak performance of the mix

Density is a Calculation of Mass/Volume



Compaction is measured as a relative % of the Maximum Theoretical Density (MTD) of any mix

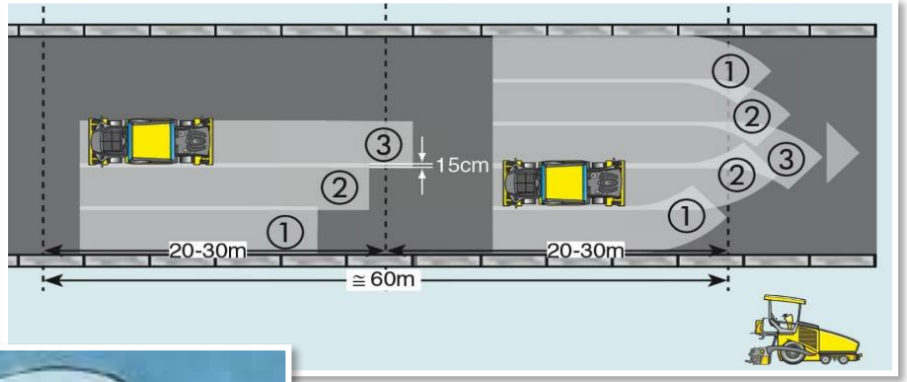
If mix SC70 has an MTD of 150 lbs. cu ft and the target % air voids = 6%.

The target % relative compaction is 94% (of 150 lbs. cu ft) = 141 lbs. cu ft

Generally efforts should be made to control compacted air voids to between 3% to 7%

Compaction Is Required to Help

- Improve mechanical stability
- Improve resistance to rutting
- Reduce moisture penetration
- Improve resistance to cracking



Exceeding specified compaction by even 1% will improve durability and prolong pavement life

“Studies show that a one percent reduction in in-place air voids can extend the asphalt pavement service life by at least 10 percent.”

- Magazine of the Asphalt Institute
Improved durability prolongs pavement life

Recent research suggests the in-place mat density should be greater than 92.0%. The preferred value should be between 9.30% and 94.0%

NCAT Report 19-07 Feb 2020

A 35% reduction in pavement service life can be seen from an in-place density of between 90.0% -92.0% compared to an in-place density of 93.0% -95.0%.

NCAT Report 19-07 Feb 2020

“Improved compaction requires no additional materials, and usually requires no additional equipment usage, but rather careful attention to details and effective management of the factors controlling success.”

- FHWA Tech Brief April 2016 - STRATEGIES FOR IMPROVING SUSTAINABILITY OF ASPHALT PAVEMENTS

How Do You Manage These Controlling Factors?

Monitor and measure in-place density values consistently, efficiently and safely.

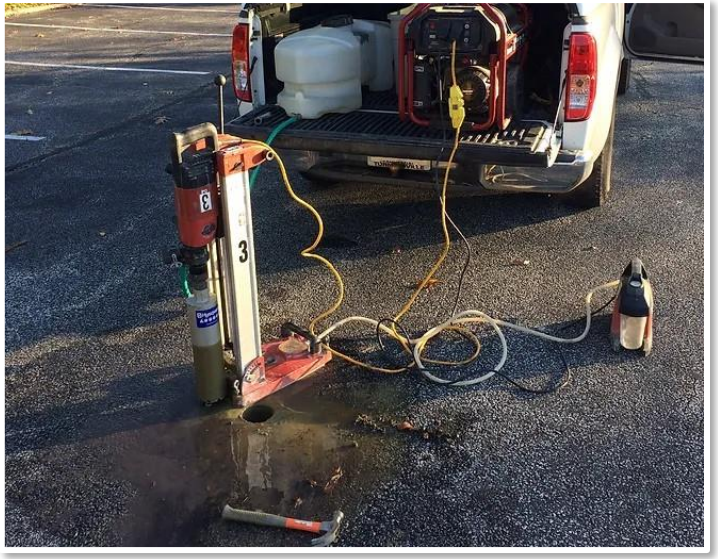
"Compaction is the most critical part of pavement installation. Properly compacted asphalt mats provide many years of reliable service. Proper compaction of the mat will keep moisture out of the pavement and prevent future problems. The plans and specifications should specify how density is tested. The inspector needs to monitor the **specified compaction density with a gauge to ensure that final target densities are achieved."**

- Asphalt Pavement Alliance - Construction Checklist for Asphalt parking lots

If we agree that the in-place asphalt density is important and it should be checked. How can we do it?

How to Test the In-Place Density of An Asphalt Pavement

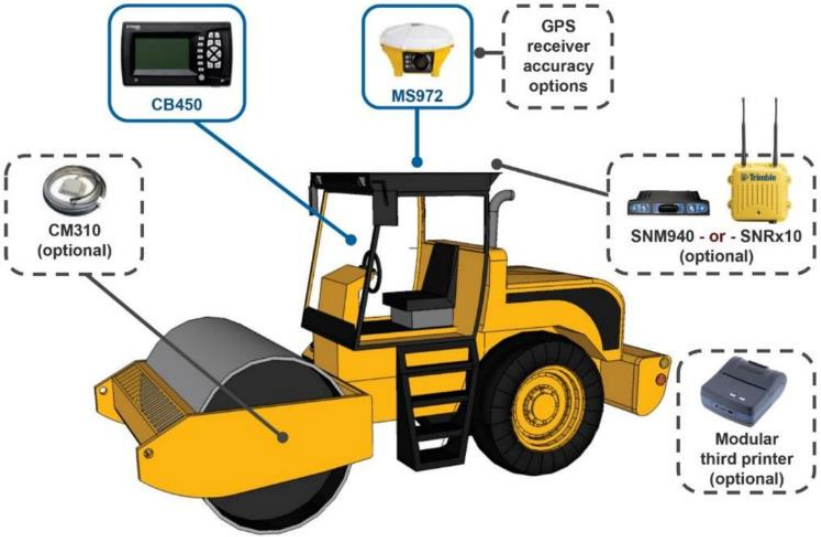
Coring



- Is destructive to the asphalt mat
- Is time consuming and costly
- Requires significant equipment and resources.
- Only gives data from specific locations
- Quality of the core can be affected by the experience of the operator.

How to Test the In-Place Density of An Asphalt Pavement

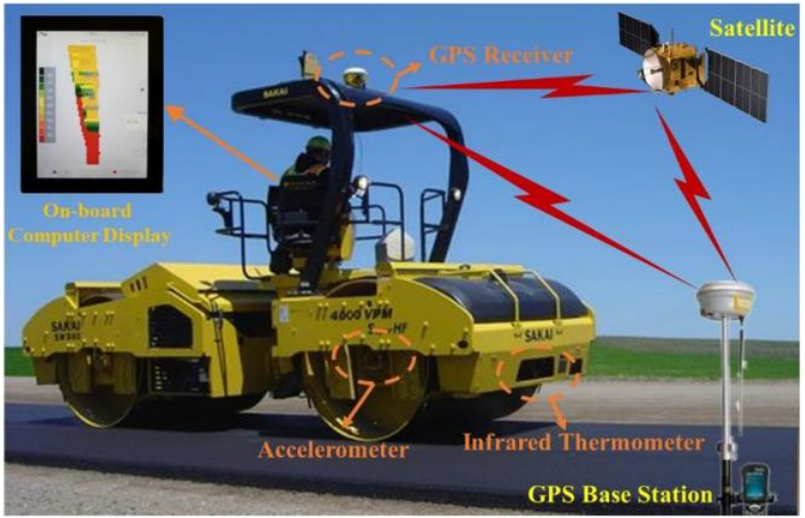
Intelligent Compaction (IC)



- Rollers with IC are costly.
- IC systems vary in design so operator training is essential.
- IC produces a large amount of data but does not report density.
- Site trials are required to correlate density to IC values.

How to Test the In-Place Density of An Asphalt Pavement

Intelligent Compaction (IC)



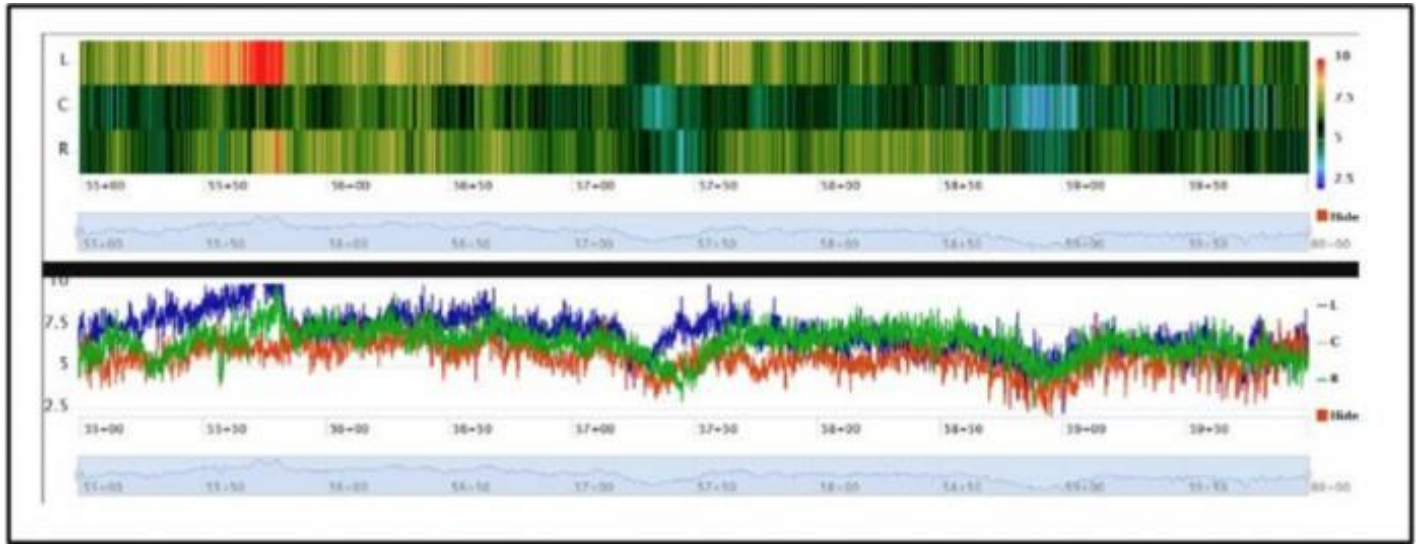
How to Test the In-Place Density of An Asphalt Pavement

Ground Penetrating Radar (GPR)

- Cost of GPR systems are relatively high.
- Is relatively bulky to transport and operate.
- Volume of data produce is huge but needs analysis by a trained operator.
- Readings can be affected by surface water.

How to Test the In-Place Density of An Asphalt Pavement

Ground Penetrating Radar (GPR)



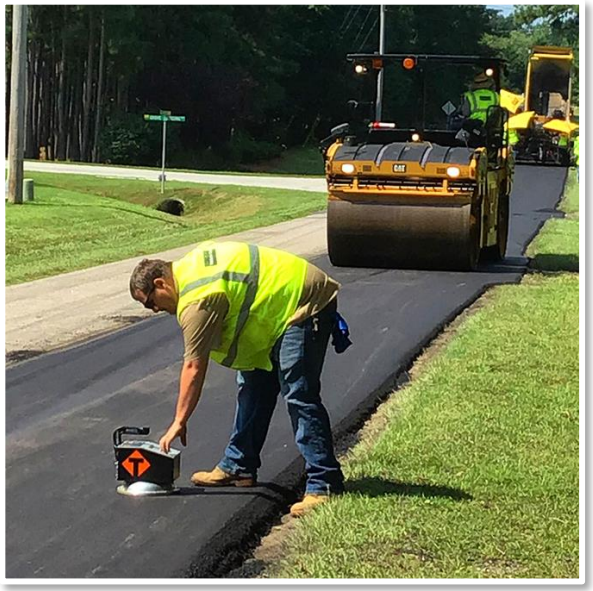
How to Test the In-Place Density of An Asphalt Pavement

Nuclear Density Gauge

- Uses nuclear sources which require restrictive & expensive licensing.
- Requires stringent Safety & Health policy.
- Requires a trained and licensed operator.
- Has high annual operating costs.
- Is not environmentally friendly.

How to Test the In-Place Density of An Asphalt Pavement

Non-Nuclear Density Gauge



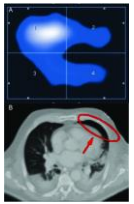
- Is lightweight and easy to use.
- Simple to operate with density readings in less than 3 seconds.
- Has no restrictions on storage, use or transportation.
- Anyone can use it, no need for special licenses.
- In environmentally friendly – no Safety & Health issues.

TransTech Systems PQI 380

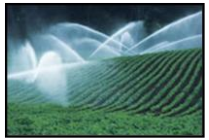
The first non-nuclear asphalt density gauge to use electrical impedance technology

Where Is Electrical Impedance Used?

Widely used in many measurement applications since the 1960s



- **Medical Field**



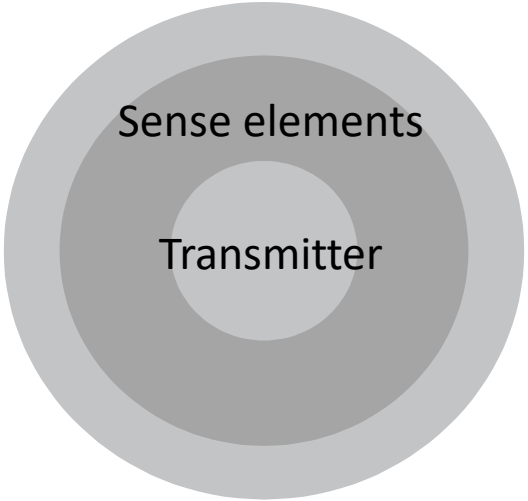
- **Agriculture Industry**

- **Aircraft Maintenance**

What Is Electrical Impedance?

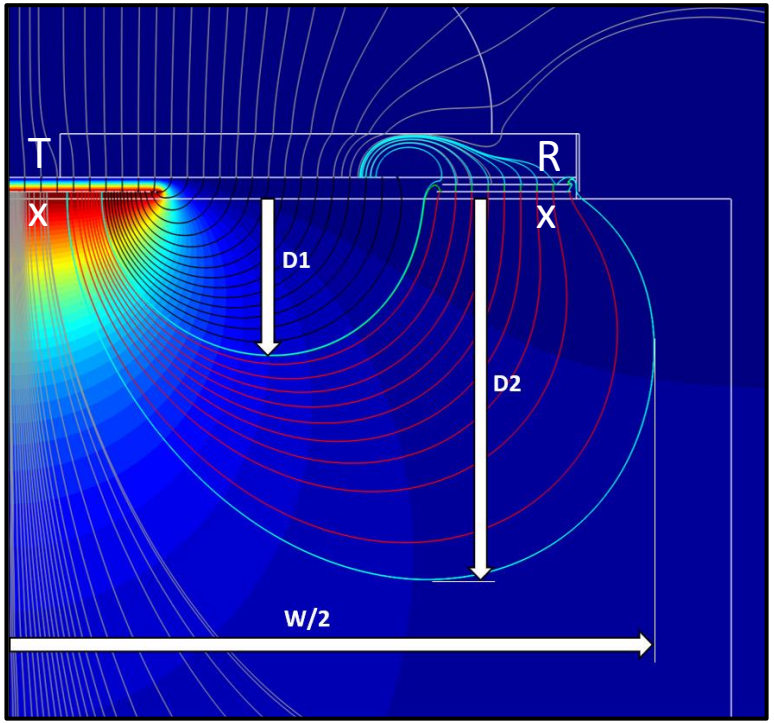
Electrical impedance is a well-established physical concept in which an object's impedance (a calculated measure of electrical conductivity) to an applied alternating current can be measured, in order to assess material composition.

Electrical Impedance Technology for Asphalt Density Measurement



Theory of Operation

Impedance spectroscopy is used to determine material dielectric properties, then correlate to compaction and density



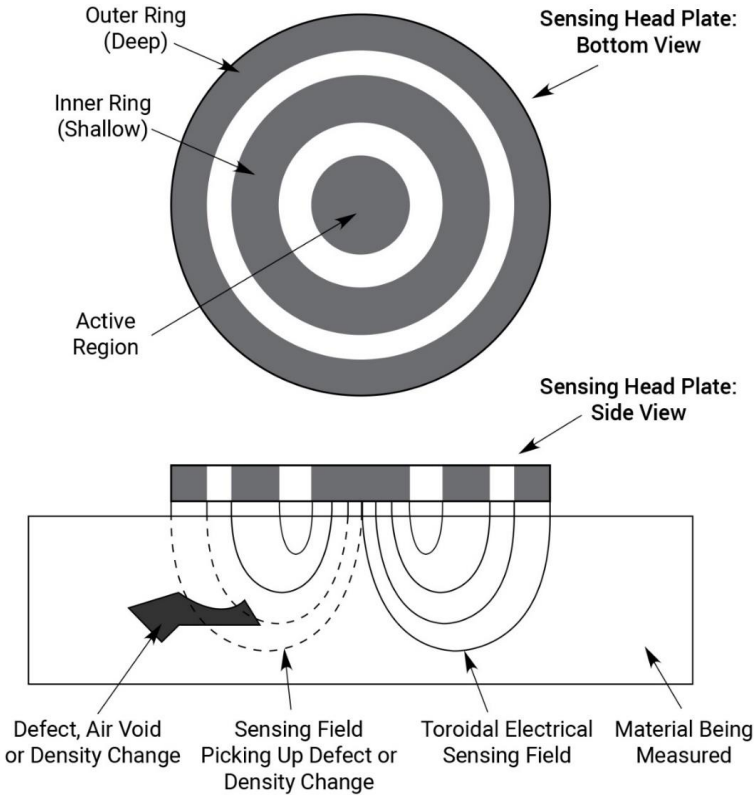
In Asphalt

- Dielectric constant of air 1 range
- Dielectric constant of aggregate and binder 5 to 6 range

High density (compaction) yields less % of air, a higher overall dielectric constant and a lower impedance (resistance to AC electricity flow)

A measurable value that can be recorded and reported as density (lbs.cu ft) or a % relative compaction or a % air voids content.

The importance of this innovation is that relative density measurements can now be taken instantly to allow for necessary changes to the rolling pattern, if required, to help ensure the best possible pavement quality.



Why non-nuclear – what are the benefits to you as a user?

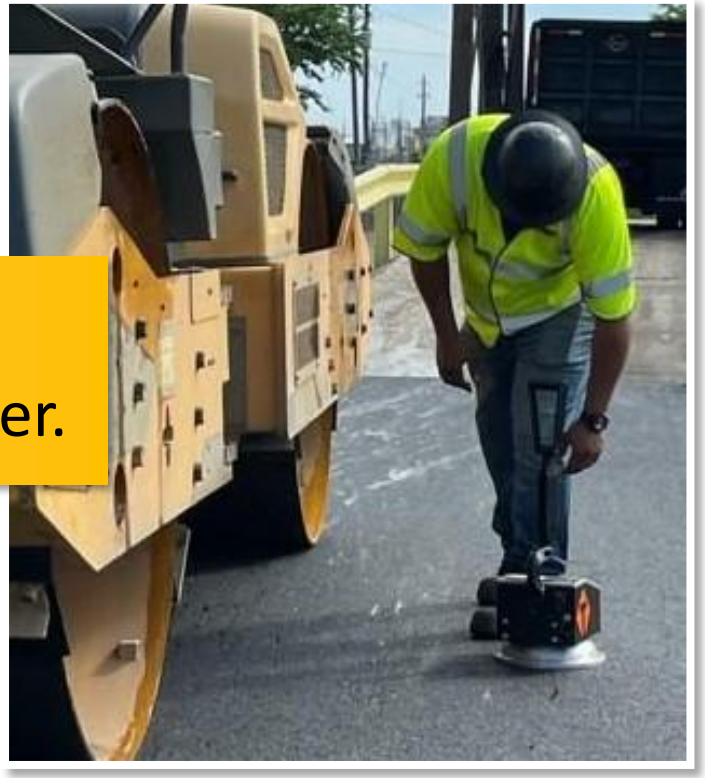
How to Test the In-Place Density of An Asphalt Pavement

Non-Destructive vs Destructive

Non-Destructive
Non-Nuclear
Density Devices

- Uses electrical impedance technology
- Lightweight and easy to use
- Quick to test (under 3 seconds)
- No license required
- No restrictions on use, storage or transportation
- Environmentally preferable
- Anyone can use it

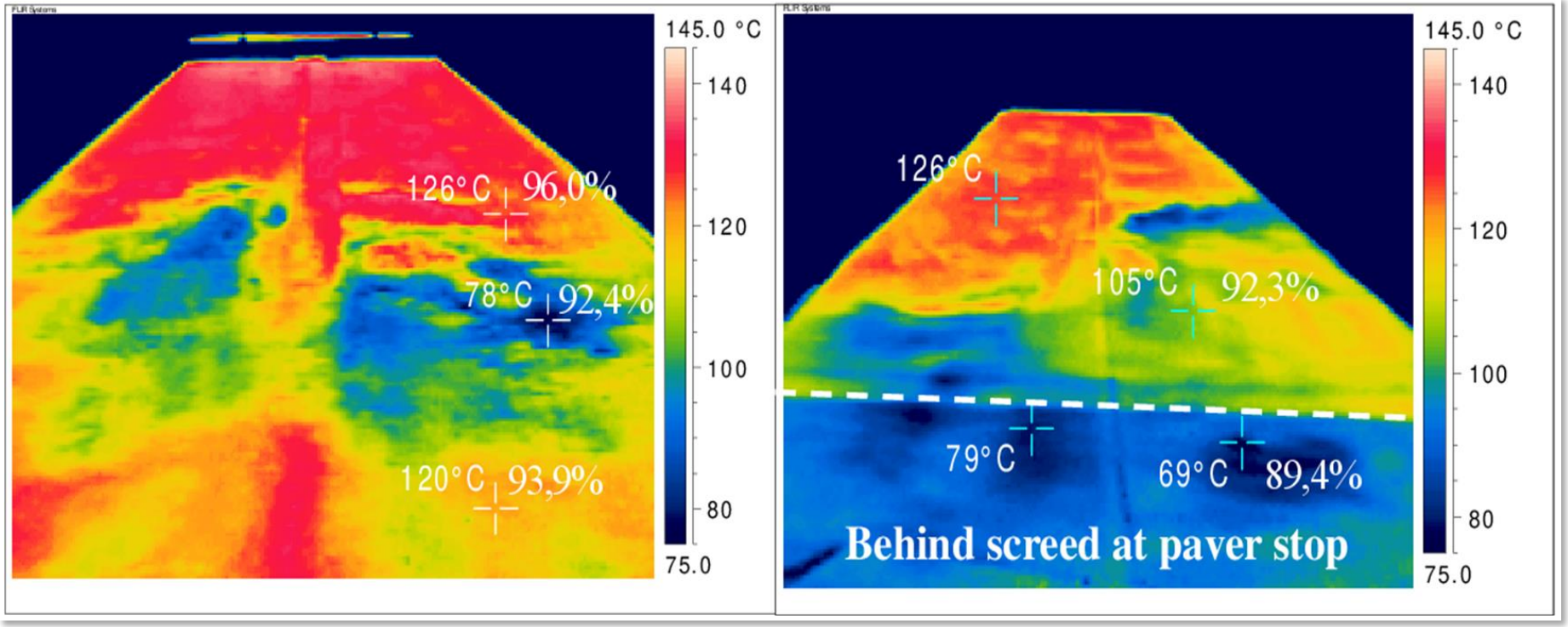
Immediate Compaction Data as the material is being laid behind the roller.

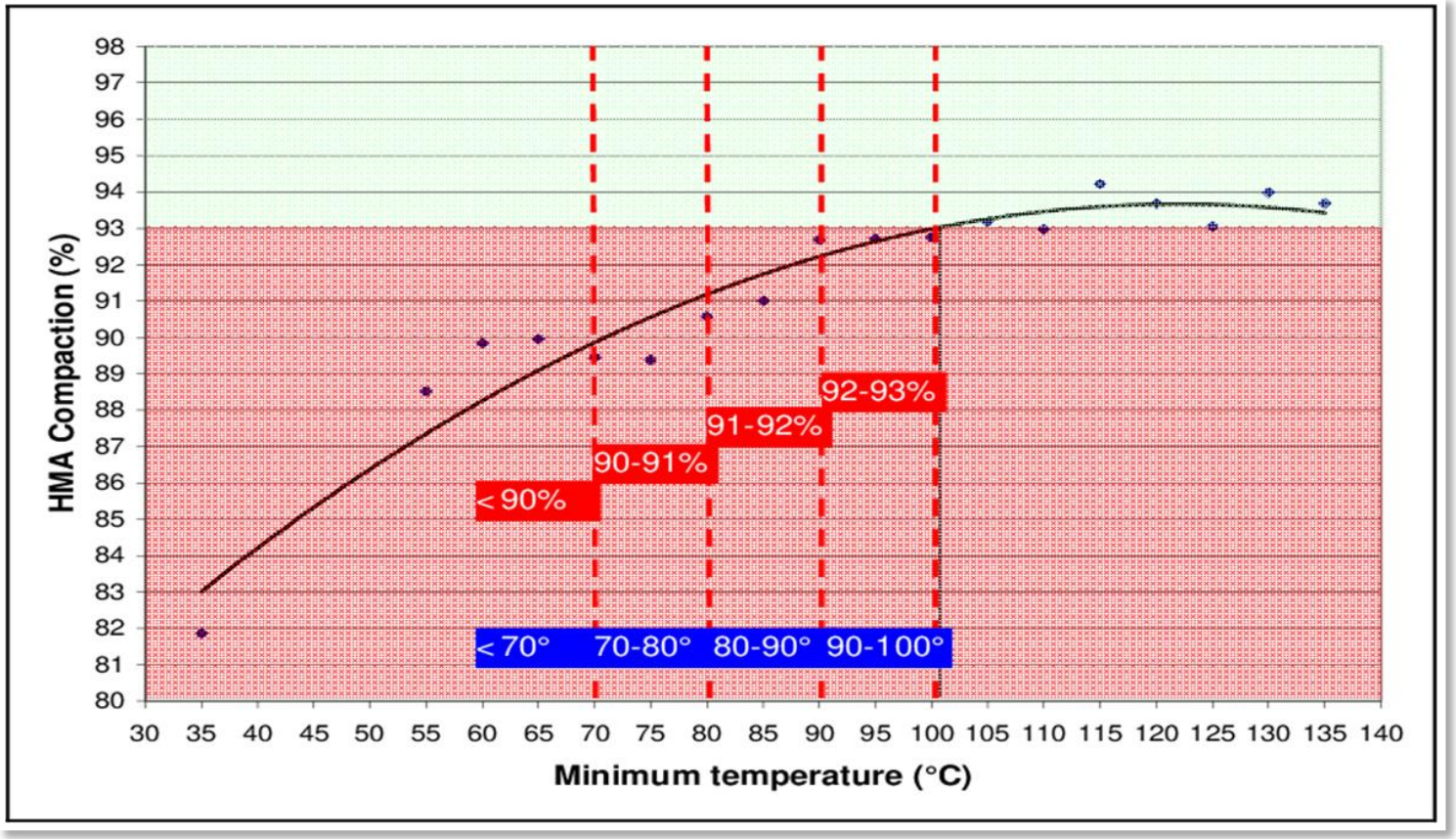


Ability to make on site adjustments to the rolling pattern

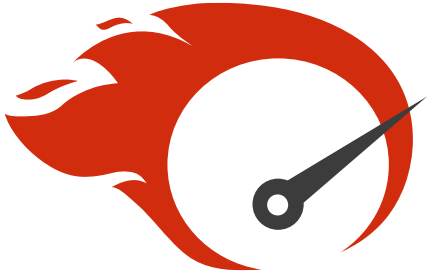
Temperature variation can influence compactive effort required

(The PQI also gives you a surface temperature reading)


145.0 °C
140
120
100
80
75.0
126° C 96,0%
78° C 92,4%
120° C 93,9%
145.0 °C
140
120
100
80
75.0
126° C
105° C 92,3%
79° C
69° C 89,4%
Behind screed at paver stop


HMA Compaction (%)
98
97
96
95
94
93
92
91
90
89
88
87
86
85
84
83
82
81
80
92-93%
91-92%
90-91%
< 90%
< 70°
70-80°
80-90°
90-100°
30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140
Minimum temperature (°C)

Quick and Efficient Test Time



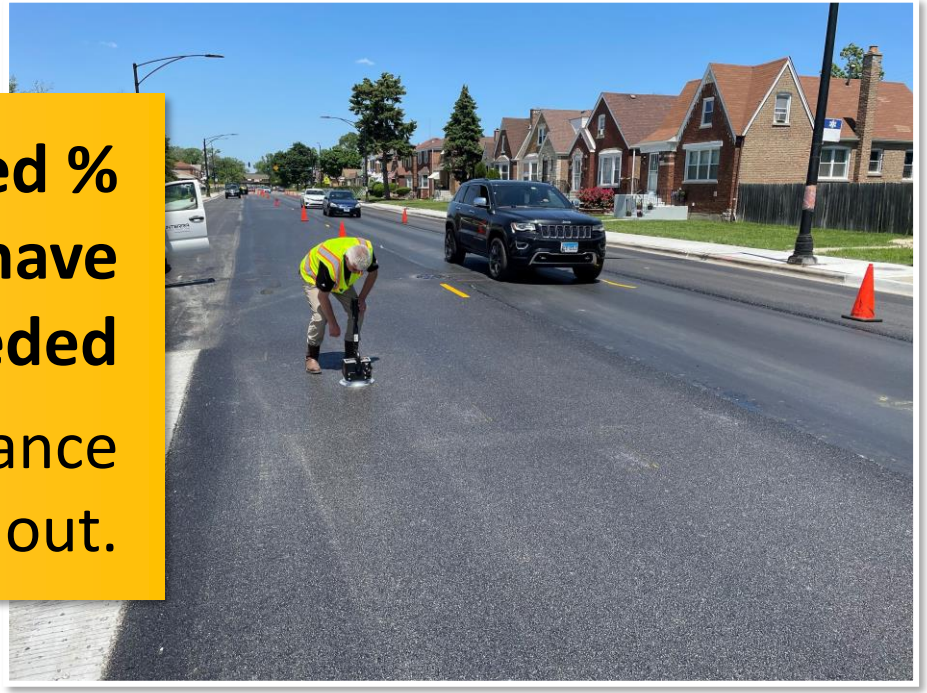
Can produce a large amount of data points

3 seconds per reading OR continuous readings.

- Check the uniformity of compaction
- Identify potential problem areas (while effective decision can still be made to rectify)
- Full coverage across the mat and at joints

Confidence that specified % compaction requirements have been achieved or exceeded

Before compliance testing is carried out.

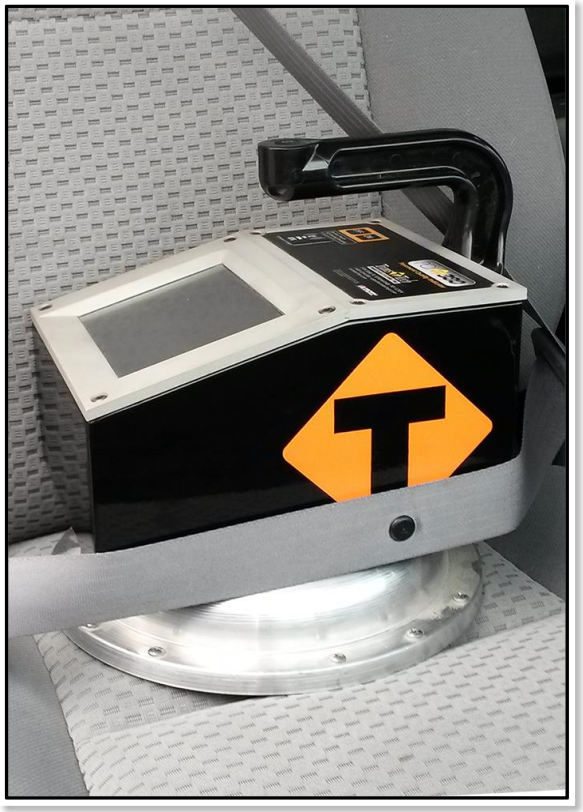


Any site operative can check density.

More effective use of resources.
No delays in getting compaction data.

A PQI can be on site every day.

Improves QC capability over the complete project duration.



A PQI can be transported and stored anywhere.

No wasting time transporting gauges back to a “**safe location**”.

Test data can be downloaded and passed to the QC manager/client the same day.

Increased real time QC visibility.

There are no nuclear sources used in a PQI.

No worries about transporting gauges to and from work sites.

Practical Use of the PQI 380 Asphalt Density Gauge

- **Core correlation –** compare core result to PQI 380 result from same location and apply off-set

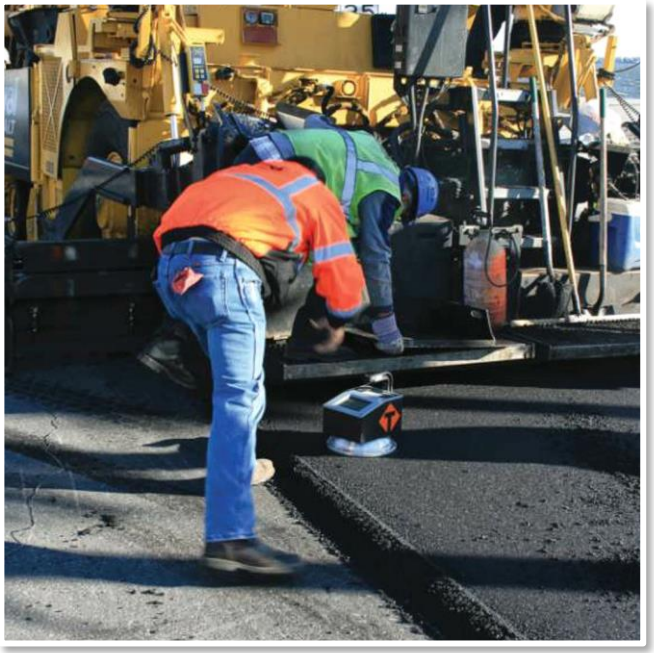
- **Correlation to the uncompacted mat behind the screed –** test the uncompacted mat behind the screed based on 88% of MTD and apply the offset

- **Peaking the mat –** continue rolling until peak density reading is achieved.

Correlation Options – Core Correlation

- On cool mat, mark spots for cores to be taken.
- On each spot take a set of 5 PQI 380 readings.
- Compare the core result to the PQI 380 average value.
- This “offset” is input into the mix details on the PQI 380.
- The PQI 380 is now correlated to this specific mix.

Correlation Options – Correlating to the Mix



- Standard pavers will compact a mix between 84% to 88% of MTD.
- Take several density readings behind the paver of the uncompacted mix.
- Adjust the offset to meet the 88% value.
- The PQI 380 is correlated to check the compacted mix density.

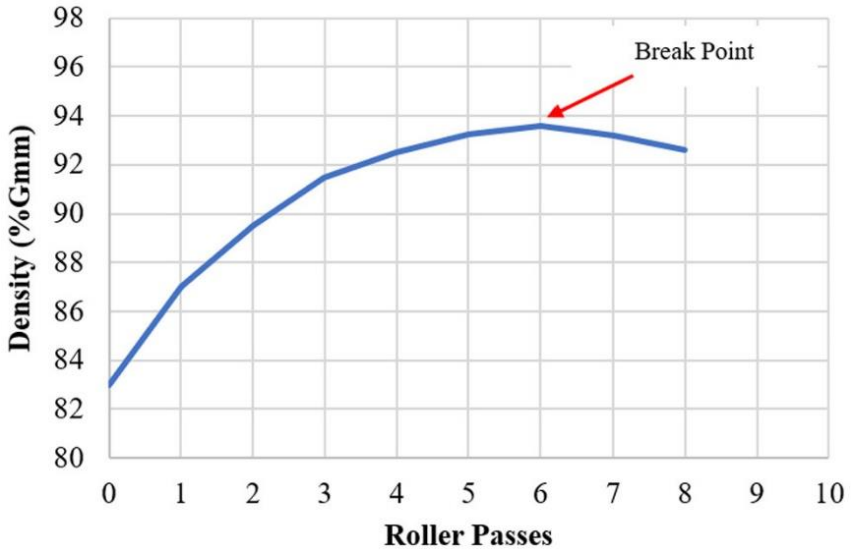
Correlation Options – Correlating to the Mix

EXAMPLE

- MTD of mix = 158.6
- 88% of 158.6 = 139.6
- PQI 380 av of 5 readings = 124.1
- Offset is 139.6-124.1 = 15.5
- 15.5 is the correlation OFFSET you enter into the PQI 380 for that mix.

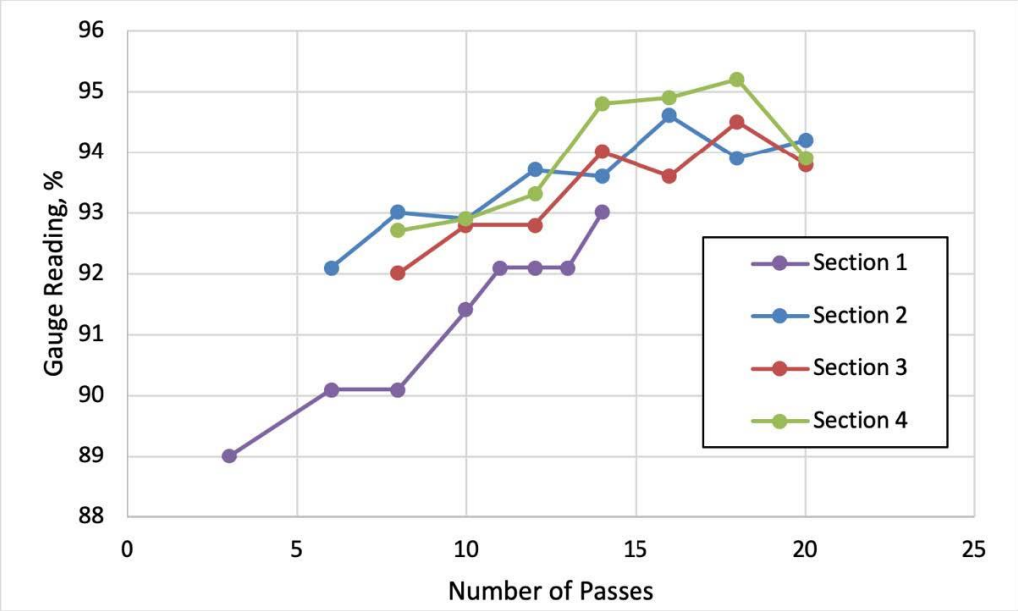
(offset can be positive or negative)

Correlation Options – Peaking the Mat



- Pick a location and measure the density with the PQI 380.
- Roll with 1 or 2 passes and take a reading with the PQI 380.
- Continue with another 2 or 3 passes and take another reading and note the increase in density.
- Continue the rolling and testing process until the density readings do not increase.
- If you see a slight decrease, you are in danger of over compacting the mix.

Data From An Experimental Section Location A.



- **A density of 93% was achieved with about 10 passes.**
- **Extra compactive effort resulted in degradation in the mat.**
- **Average core density was 94.0%.**

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Why Consider Changing Your Current QC Procedures?

- Opportunity to review current QA/QC policy ✓
- Consider the benefits of monitoring in-place density ✓
- Potential for 8.8% savings on every paving project ✓
- Potential to increase service life of pavement ✓
- Reduce maintenance and congestion ✓
- Save tax dollars and support environmentally preferable testing techniques ✓

City of Kerrville, TX – Street Division

Question

Was the decision to buy the PQI 380 a direct choice against a nuclear gauge?

Answer

Yes, because we did not have the ability to create a safe room for the nuclear gauge or able to send an employee to get certified on the gauge.

City of Kerrville, TX – Street Division

Question

How strong were the environmental, safety and health issues a factor in your decision?

Answer

This was a big factor. We are a busy operation here at the City. The last thing we needed to worry about is a nuclear accelerator rolling around in the bed of a truck or leave on the job site.

City of Kerrville, TX – Street Division

Question

How often is the PQI 380 on a asphalt paving project for QC testing?

Answer

90% of the time our PQI 380 is on the job site.

City of Kerrville, TX – Street Division

Question

Do you consider the PQI 380 a cost saving item of equipment and if so, why?

Answer

Yes, it definitely has saved us money. To have an engineering company on standby can get expensive quick. I will still use a company to take cores here and there to make sure we are still at the right offset with the hot mix asphalt. The PQI 380 is on target every time.

City of Kerrville, TX – 2021 TXAPA Award: City Street

Technical Specifications

ASTM D7113/7113M -10 Density of Bituminous Paving Mixtures in Place by the Electromagnetic Surface Contact Methods

AASHTO T 343-12 Density of In-Place Hot Mix Asphalt (HMA) Pavement by Electronic Surface Contact Devices

Technical Specifications

Texas DOT Pavement Manual Rev 2021
Clause 8.2 Compaction Measurement and Reporting

"Contractors can perform quality control of air voids indirectly using a portable density-measuring device such as a nuclear density gauge (see Figure 6-54) or ***electrical impedance measurement gauge*** *(see Figure 6-55). Accurate calibration of these devices is critical."*

Conclusion

The way forward to more sustainable, longer lasting asphalt pavements that will save you tax dollars in the long run……..

- **Review your current QA procedures for the laying of asphalt pavement including the specified value of % air voids.**
- **Consider introducing the testing of the in-place density of the asphalt being laid to confirm % air voids content.**
- **Utilize the safe, clean and efficient non-nuclear technology as seen in the PQI 380 asphalt density gauge.**

Questions & Answers