Field Evaluation of Pavement Quality Indicator as a Replacement for Nuclear Density Meter (Asphalt Paving)

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In situ Non-destructive Density Measurement

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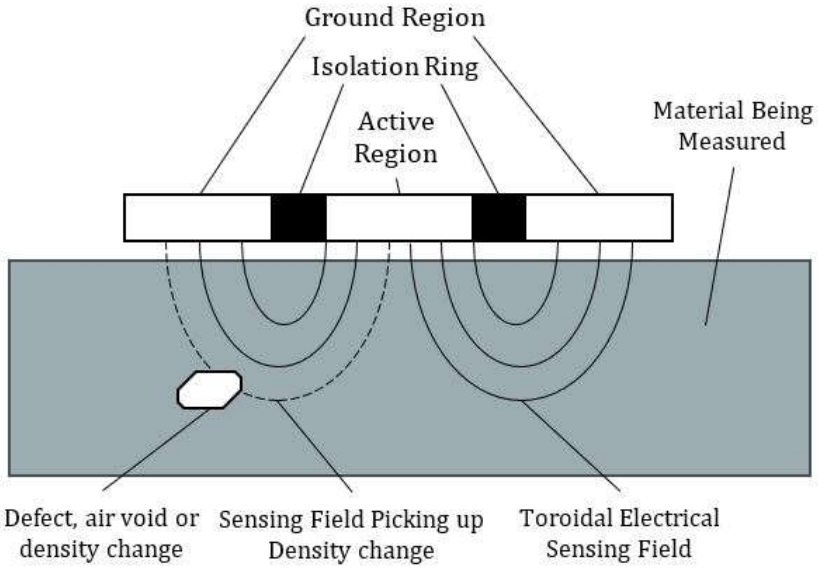
- NDM Problems:
  - Resourcing Constraints
  - Health and Safety (during transit)
  - Operational Ownership
  - Storage Constraints
  - Long term radiation exposure personnel
- NDM Superiority
  - Accuracy and Precision
  - Asphalt and Granular layer applications
  - Non-destructive
- Alternative Density Testing
  - Destructive test – Sand Replacement
  - Non-destructive – Pavement Quality Indicator
- Research Project Asphalt Densities
  - Advancements of PQI since 1990
  - Field trials of **PQI** vs **NDM** vs **Cores (2021/22)**
  - Plateau Field trials of **PQI** vs **NDM (2022/23)**

PQI Principle of Operation

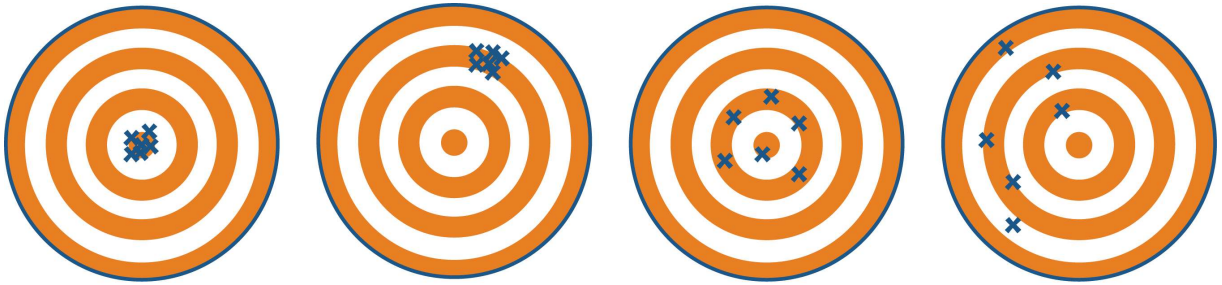
- Main Function explained by a CIVIL ENGINEER
  - Density of material α dielectric constant
  - Emits electro-magnetic field through material
  - Receiver measures the amperage and impedance (resistance) is calculated accordingly.
  - ***Impedance*** ⇒ ***Dielectric constant***
- Dielectric Constant Examples
  - Air – 1.0
  - Water 80
- Dielectric constant function of volume of the particular material type i.e. aggregate, bitumen and air.
- Asphalt layer thicknesses : 20 to 150 mm



PQI Accuracy and Precision

- Surface Moisture
  - Water has the highest dielectric constant of 80 – gives false high compaction rating
  - Roller water is acceptable in overseas standards as long as there is no pooling
  - Will this be a problem when water cart is used to cool down the mat?

- Temperature extremes
  - High temperatures affect dielectric constant of material
  - Changes the reading the PQI gets
  - Will this effect beginning of plateau tests?



PQI Functionality Aspects

- Lightweight and obtains readings in seconds
- Calibrated inside its housing unit
- Input project and mix design to store in the PQI
- Reduced ongoing costs due to no nuclear radiation

Control menu for mix design and project input

Field Trials Auckland -2021/22

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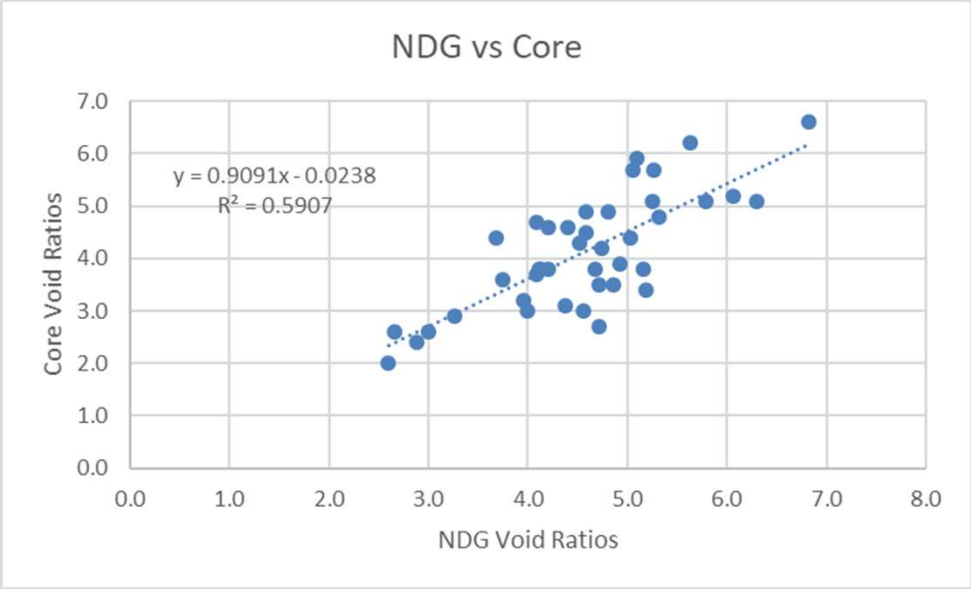
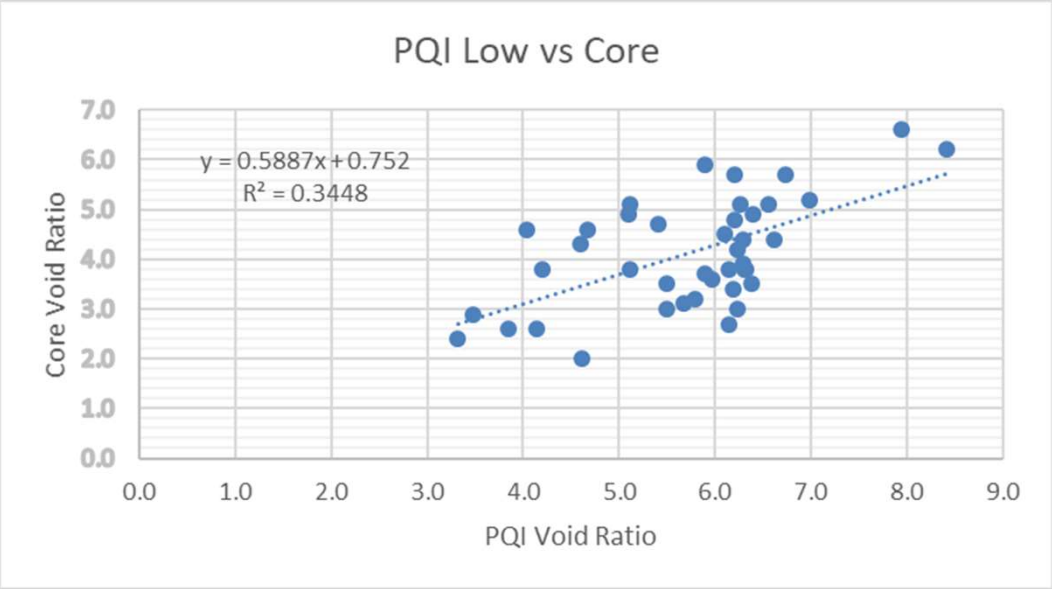
Conducted PQI, NDM readings and extract cores at the some location, using the following procedure:

- Mark test position
- Record pavement & air temperatures, & time of each test
- Recorded calibration details for each device
- Ensured there was no water on or in the asphalt – asphalt surface must be absolutely dry before taking PQI readings
- Minimum of eight (8) test locations within each lot were identified & marked as per the random method in Clause 9.9.1 of NZTA M10: 2020
- For each location, the NDM test consisted of calculated average of two readings taken at 180-degree angles to each other (handle parallel to paving train), rotated about the centre point of the NDM gauge
- For each location, the PQI test consisted of the calculated average of 3 readings taken with the PQI rotated approximately 120 degrees after each reading
- All individual readings recorded
- Cores taken from the centre of the marked footprint
- Core densities determined in laboratory setting
- Plot PQI density versus core density, NDM density versus core density, & PQI density versus NDM density
- Linear regression including R-squared values & estimated regression functions.
- Assessed correlation between results of PQI density & core density, & between nuclear gauge density and core density

Results –Low Temperature (<40°C)





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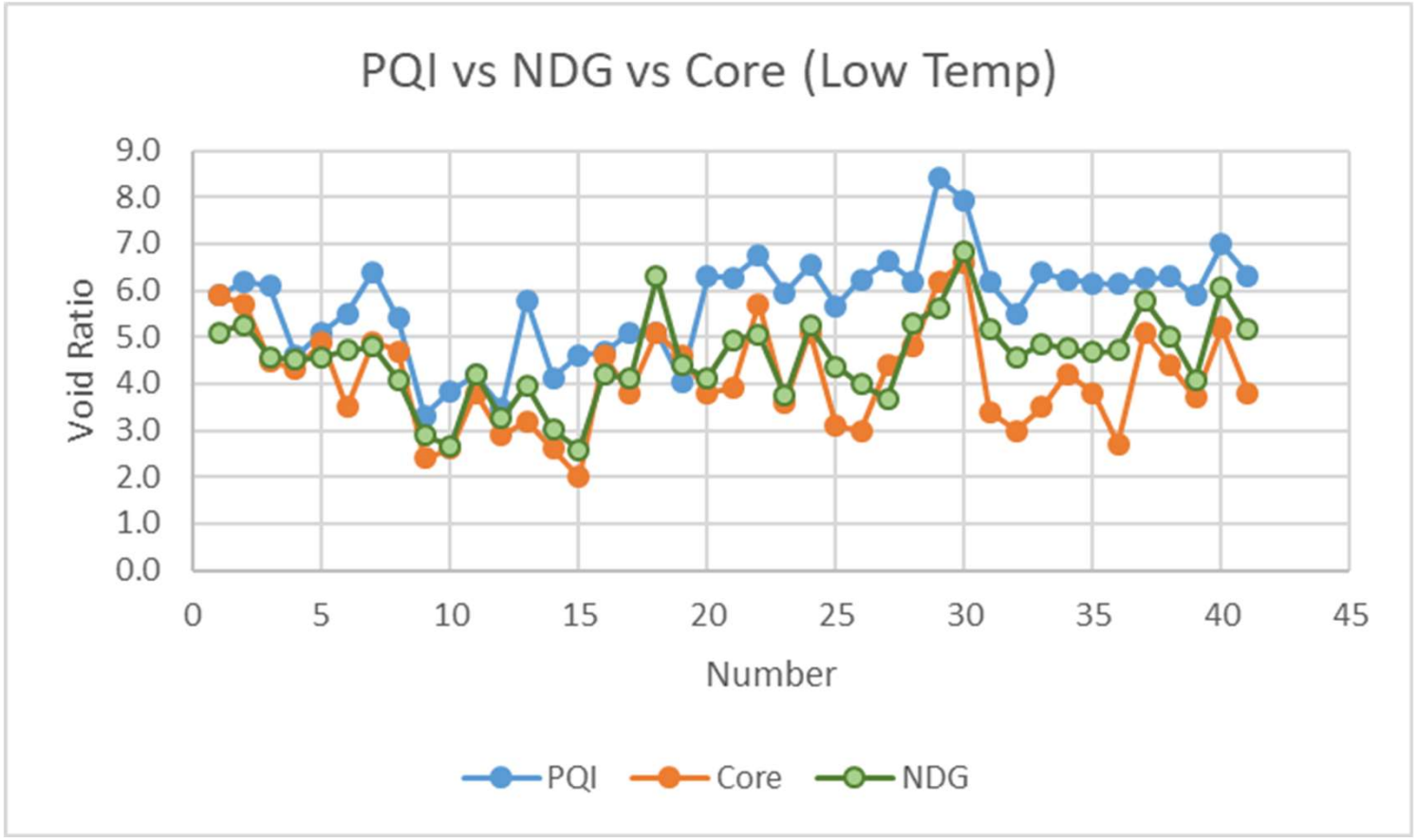
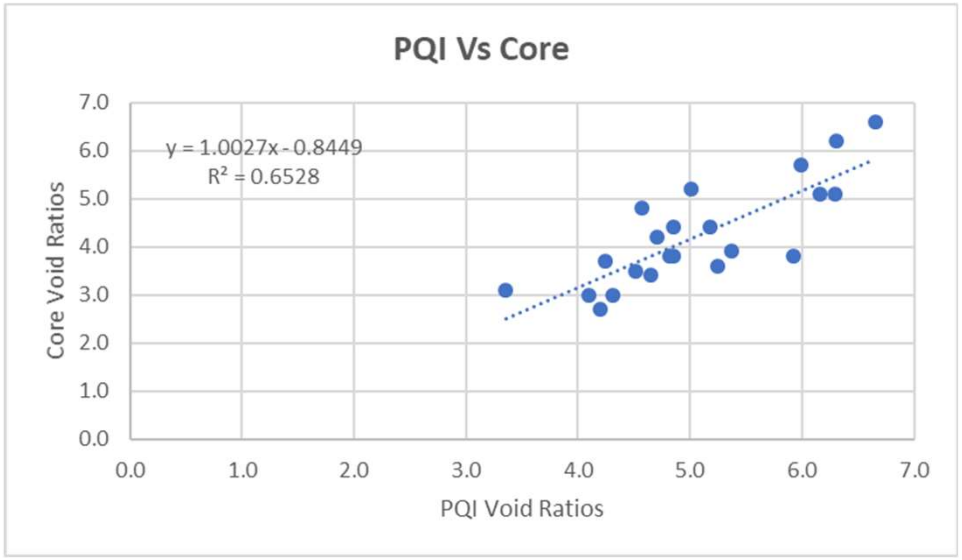
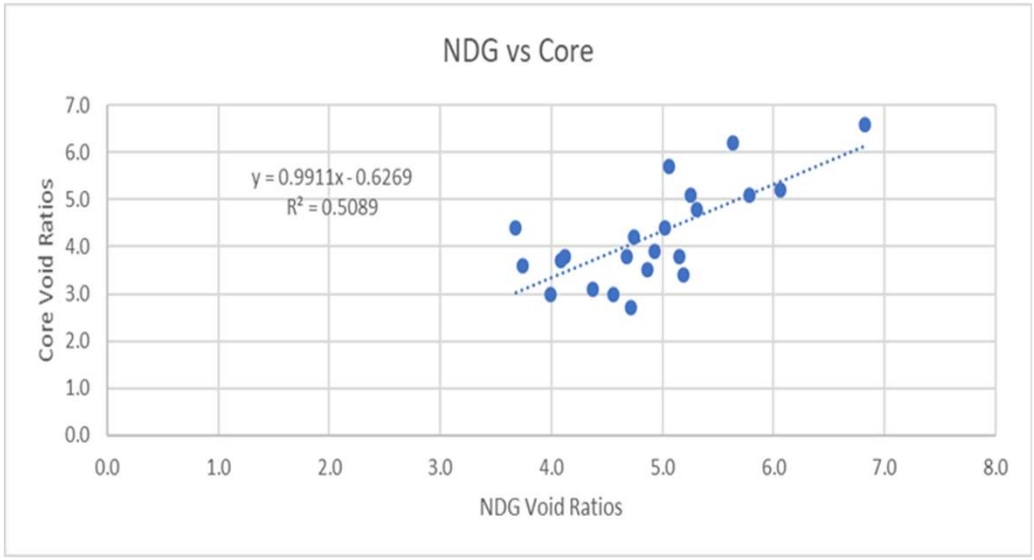


Results –High Temperature (40°C -90°C)





Results –Higher Temp. (40°C-90°C)

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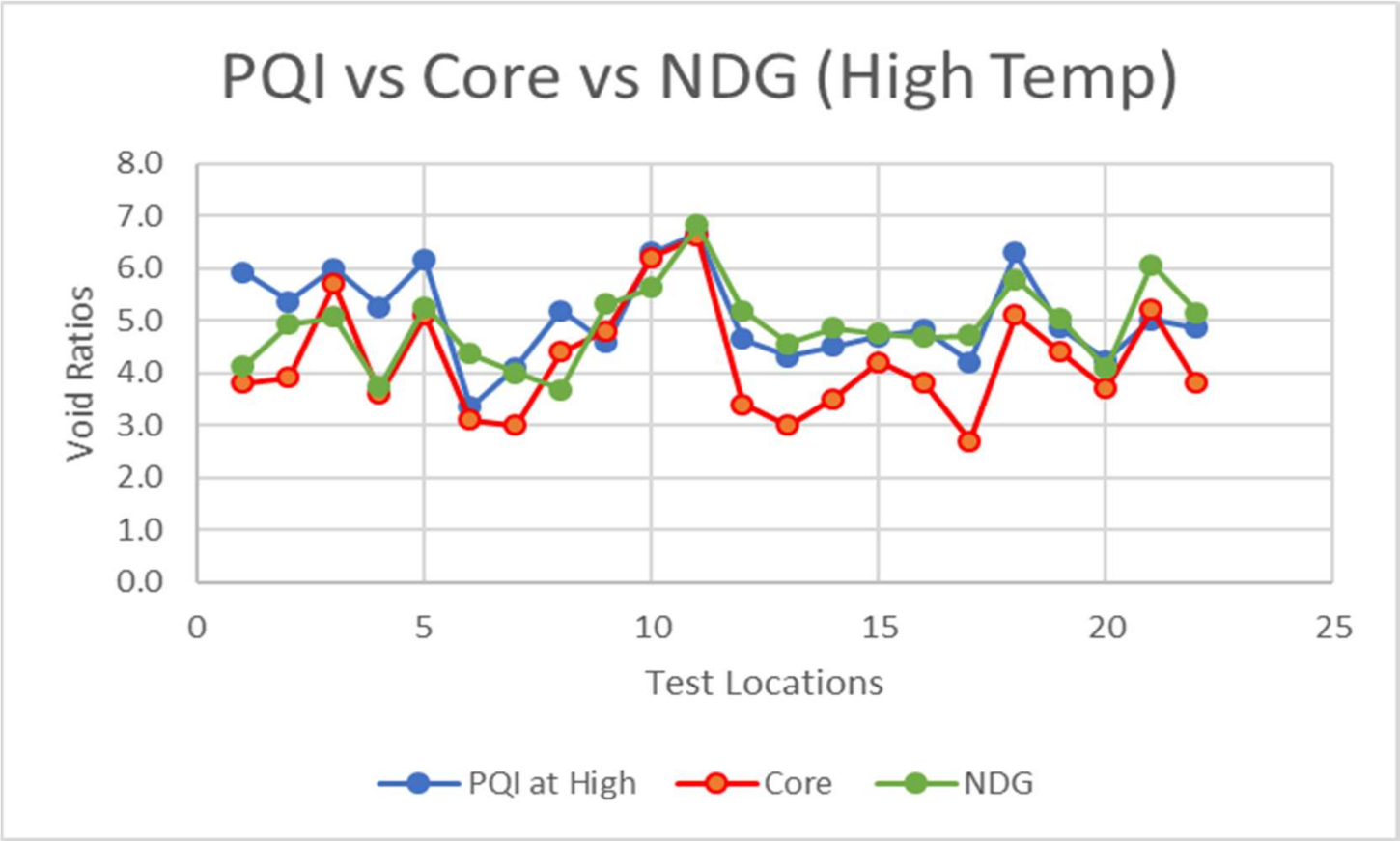

Field Trials 21/22- Observations

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- Status Quo - NDG
- PQI - Dielectric constant
  - Temperature
  - Moisture
- Accuracy Precision PQI Best @
  - > 40 °C and < 90 °C
  - Moisture - NONE

Field Trials South Island -2022/23

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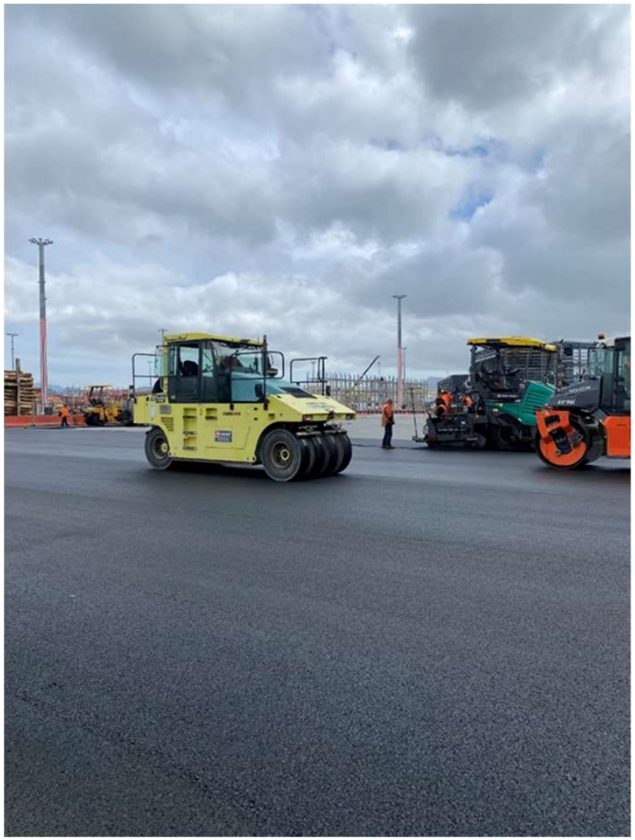
Plateau Field Trial Canterbury:

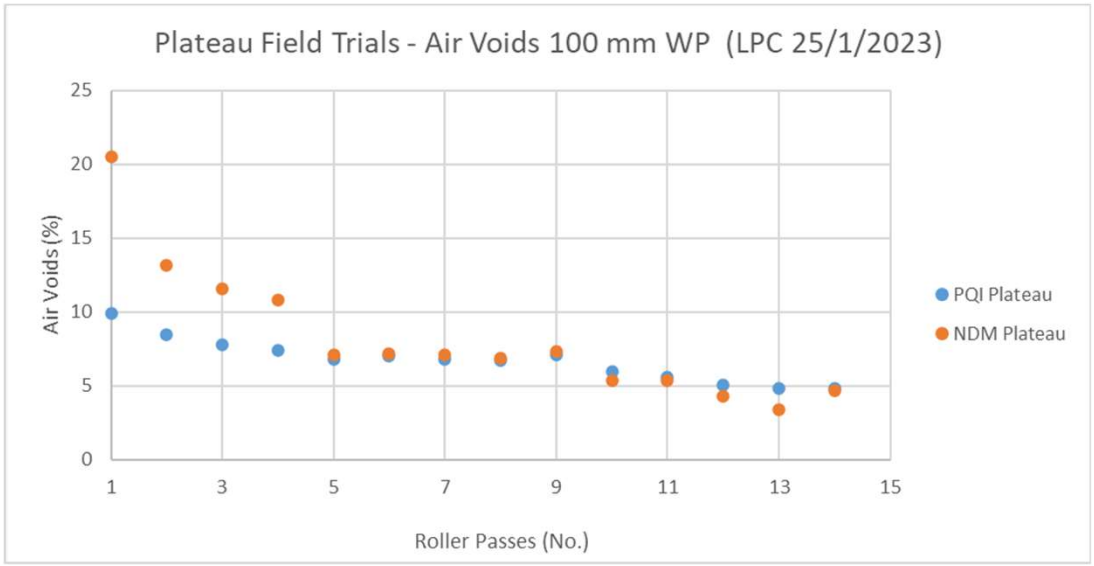
- Mark test position;
- Record pavement & air temperatures, & time of each test;
- Recorded calibration details for each device (NDM and PQI);
  - Off-set for NDM set up prior to field measurements;
  - Off- set for PQI in some instances used;
- Plateau Density Process;
- Measure density after every 2 passes (NDM & PQI)
- End once compaction plateau achieved.



Nelson PQI Vs Core and PQI Vs NDM

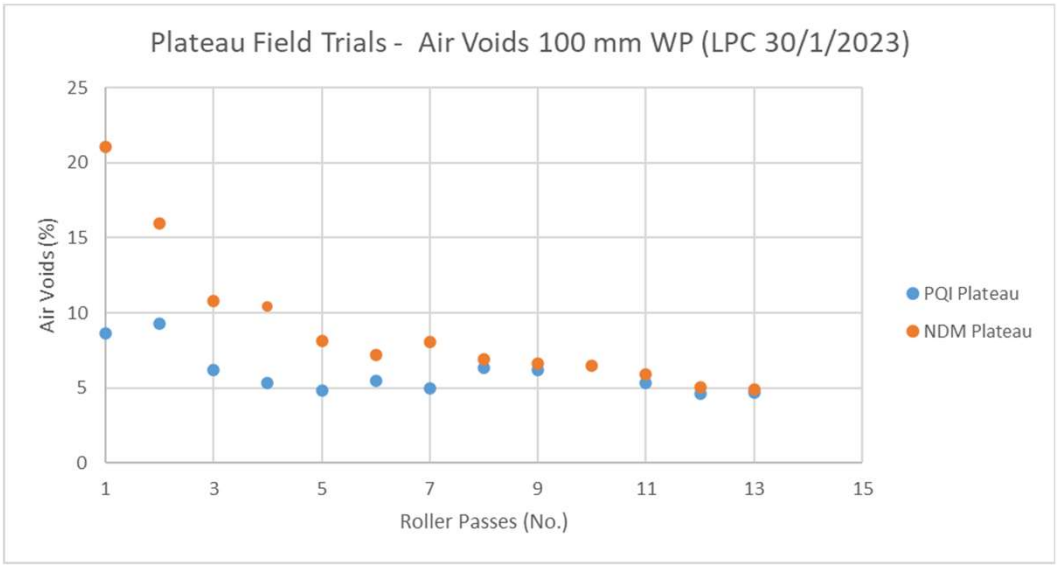
- Similar to 21/22 Field trial

Plateau Field Trial Results –2022/23



Additional Info:

- NDM Off-set +130 kg/m^3
- PQI Off-set 0 kg/m^3



Additional Info:

- NDM Off-set +130 kg/m^3
- PQI Off-set +45 kg/m^3

Field Trial Results –2022/23 Nelson

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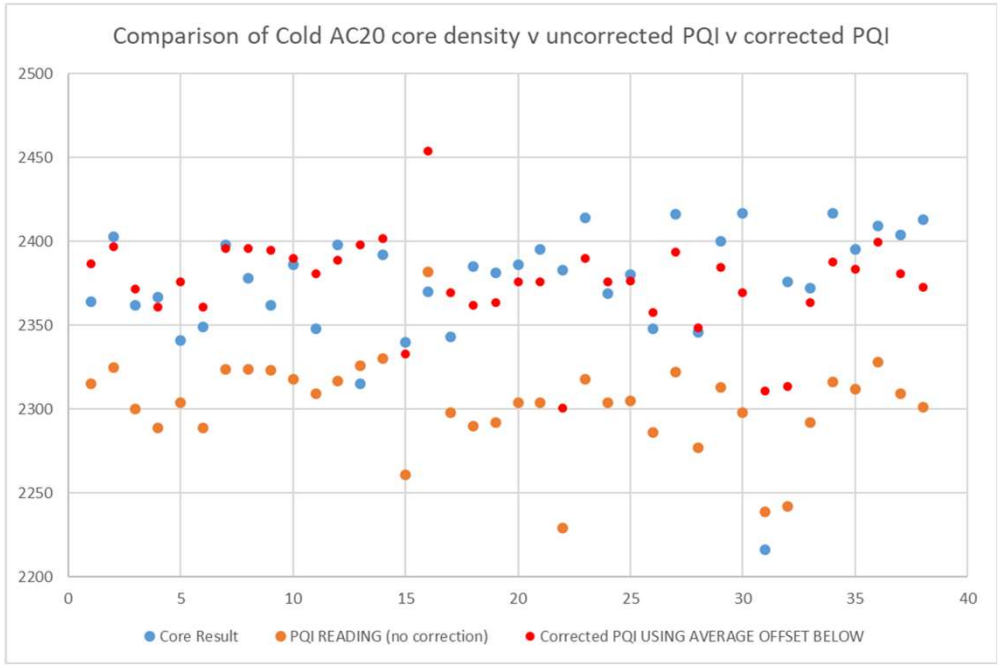

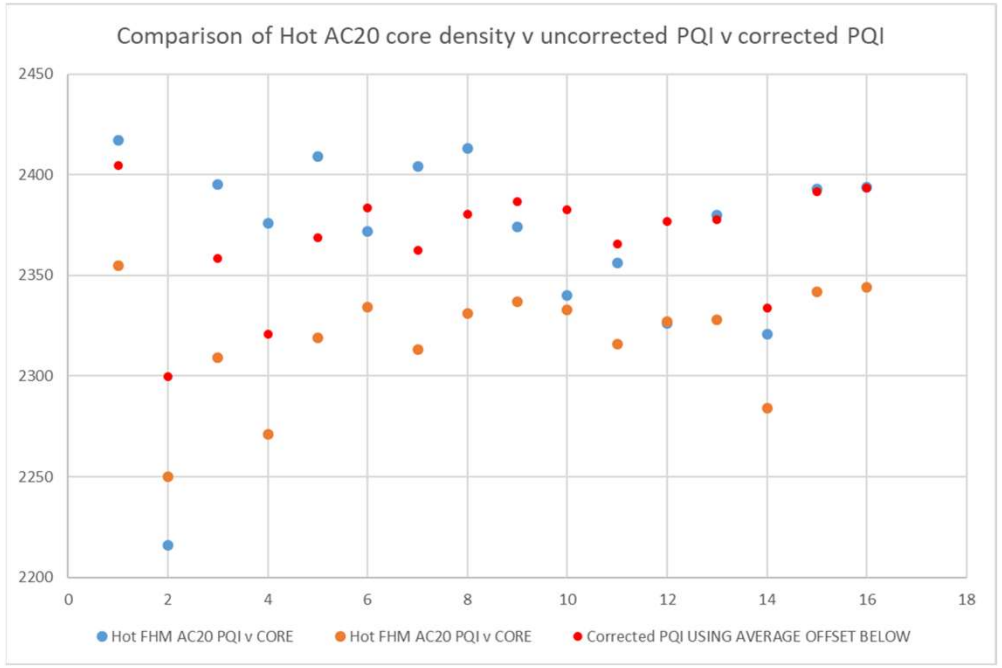

Additional Info:

- PQI Off-set 71.7 kg/m^3
- Cold temperatures 20-30^{o}C

Additional Info:

- PQI Off-set 50 kg/m^3
- Hot temperatures 70-115^{o}C

Plateau Field Trials 22/23- Observations

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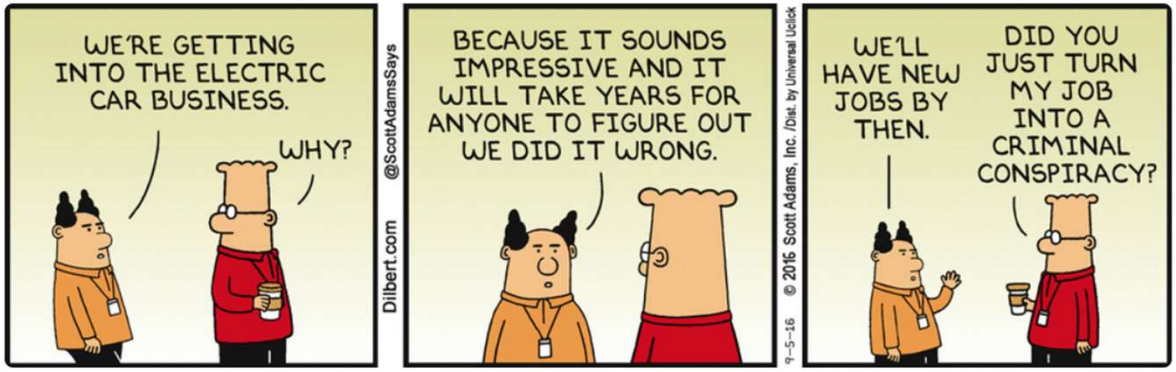
- PQI Plateau Field Trial (Accuracy and Precision)
  - High Voids Inaccurate and Precision varies and reads consistently lower voids
  - Temperature effect on dielectric constant of asphalt materials hot mix paved at 160°C
  - Temperature specific off-set may solve the issue
- PTR rolling and surface regularity
  - Surface regularity during compaction process, knitted wheel loadings;
- Limitations to
- Direct comparison to NDM,

Going Forward

- Study findings:
  - Precision
  - Accuracy
  - Correlation observations
  - Shortcomings
  - Use of off-sets & Temperature bands
  - NDG vs PQI
- Compliance Suitability……
- Process Control Tool – Aware of sensitivity



THANK YOU