New Zealand Field Trials of Non-Nuclear Density Meters

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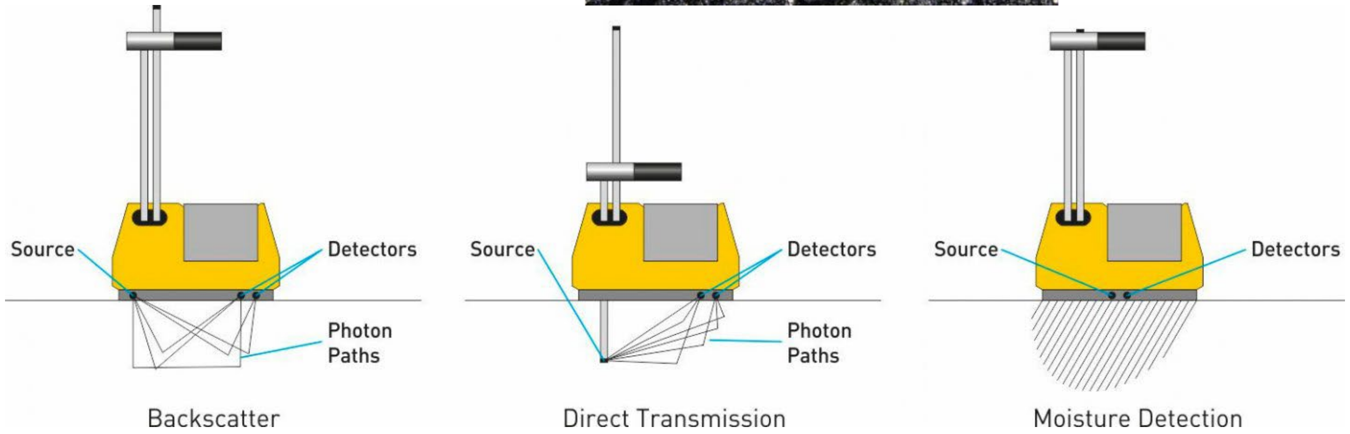
Fulton Hogan Ltd

Outline

- Nuclear density meter (NDM) & how it works
- Why replace it?
- Alternative density measurement techniques
- How they work
- Investigation methodology & Initial field trials
- Findings

Nuclear Density Meter – how it works

- Radiation source emits gamma radiation
- Hydrogen molecules slow down or deflect radiation
- Detector counts received radiation
- Calculates density & moisture content
- Advantages
  - Since 1958, well proven
  - Non-destructive
  - Accurate & Precise
  - Asphalt & Granular materials



Nuclear Density Gauges limitations

- Limitations:
  - Health and Safety (during transit)
  - Operational Ownership
  - Storage Constraints
  - Long term radiation exposure personnel
  - Radiation leakage if damaged
  - Increased regulation

Alternative Density Measurement

Destructive Tests

- Sand/seed replacement
- Water balloon replacement

Non-Destructive Non-Nuclear

- Pavement Quality Indicator (PQI)
- Soil Density Gauge (SDG)
- Troxler PaveTracker ™ 2701-B
- InstroTek NoNuke™

Selection Criteria

- Speed of operation
- PQI & SDG have
  - 30 years of development & field experience in USA
  - 7 years of usage in Australia
  - Local support

PQI Principle of Operation

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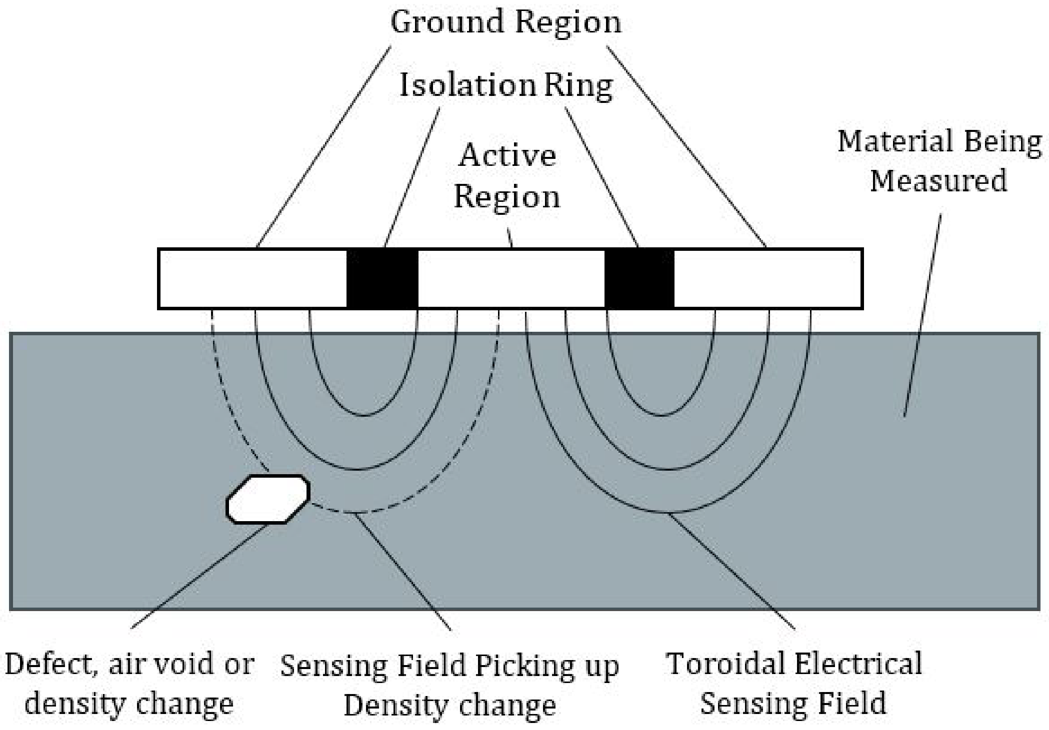
- How it works
  - Emits electro-magnetic field through material
  - Receiver measures amperage & impedance (resistance) is calculated
  - ***Impedance*** → ***Dielectric constant***
  - Density of material proportional to dielectric constant
- Dielectric Constants
  - Air ~ 1.0
  - Soil, Aggregates, Bitumen 4-5
  - Water ~80
- Dielectric constant function of relative volume of the particular material type i.e. aggregate, bitumen and air



Research Methodology -Asphalt

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Conducted PQI, NDM readings & extracted cores at same location, using 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, NDM test consisted of calculated average of two readings taken at 180-degree angles to each other (handle parallel to paving train), rotated about centre point of NDM gauge
- For each location, PQI test consisted of calculated average of 3 readings taken with PQI rotated approximately 120 degrees after each reading
- All individual readings recorded
- Cores taken from centre of 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^{o}C)

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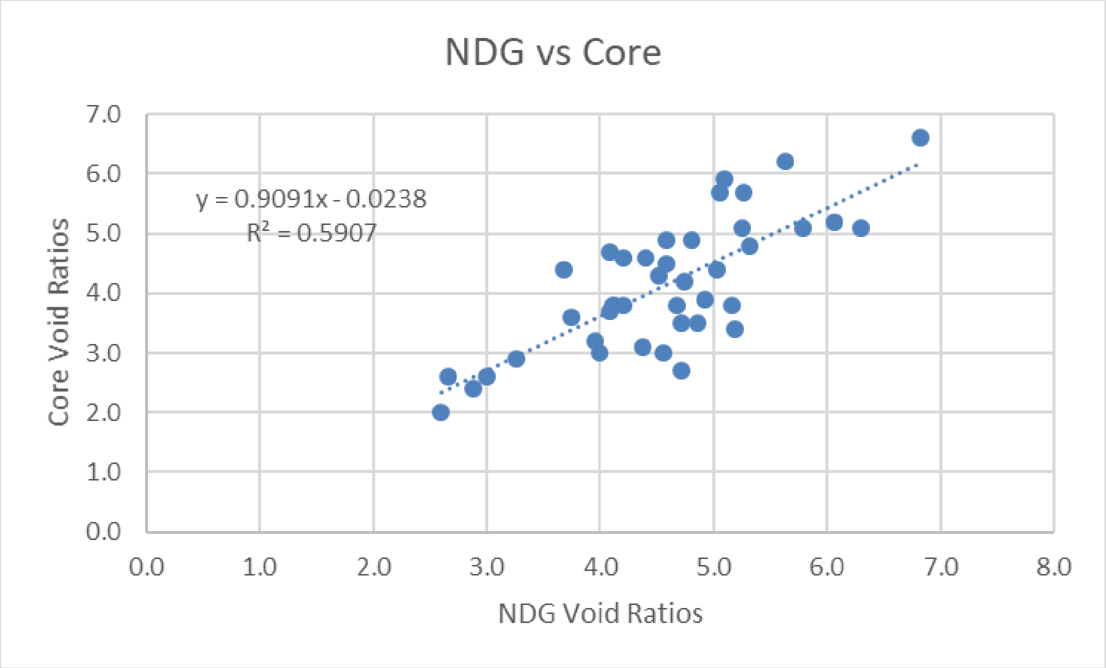

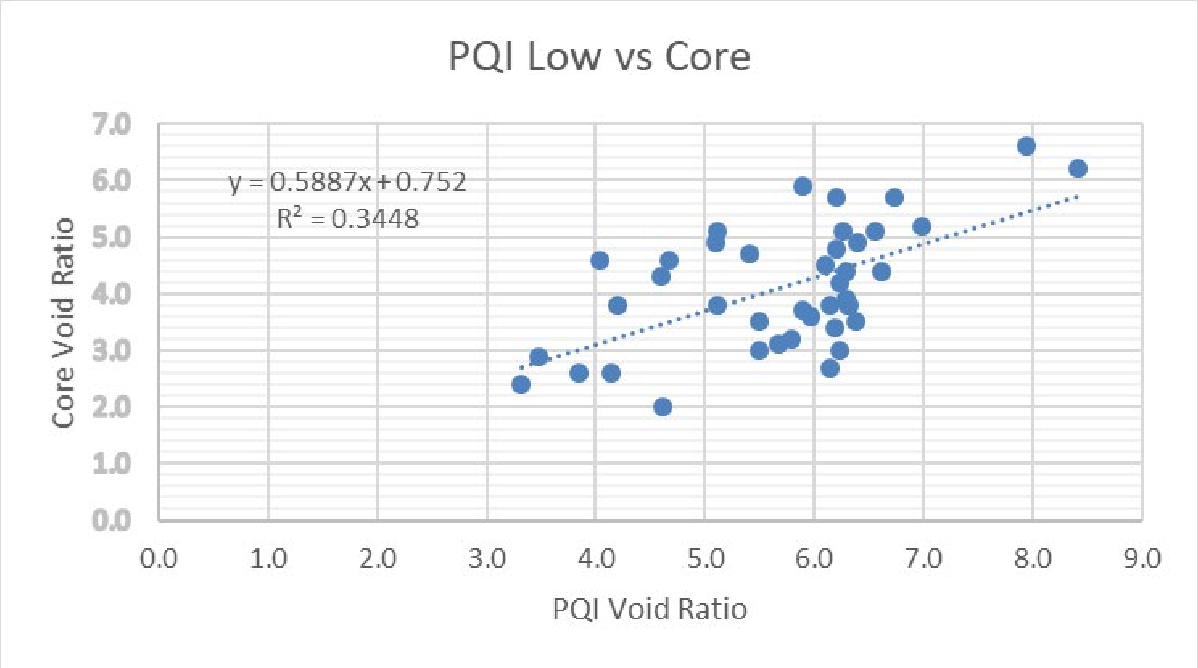

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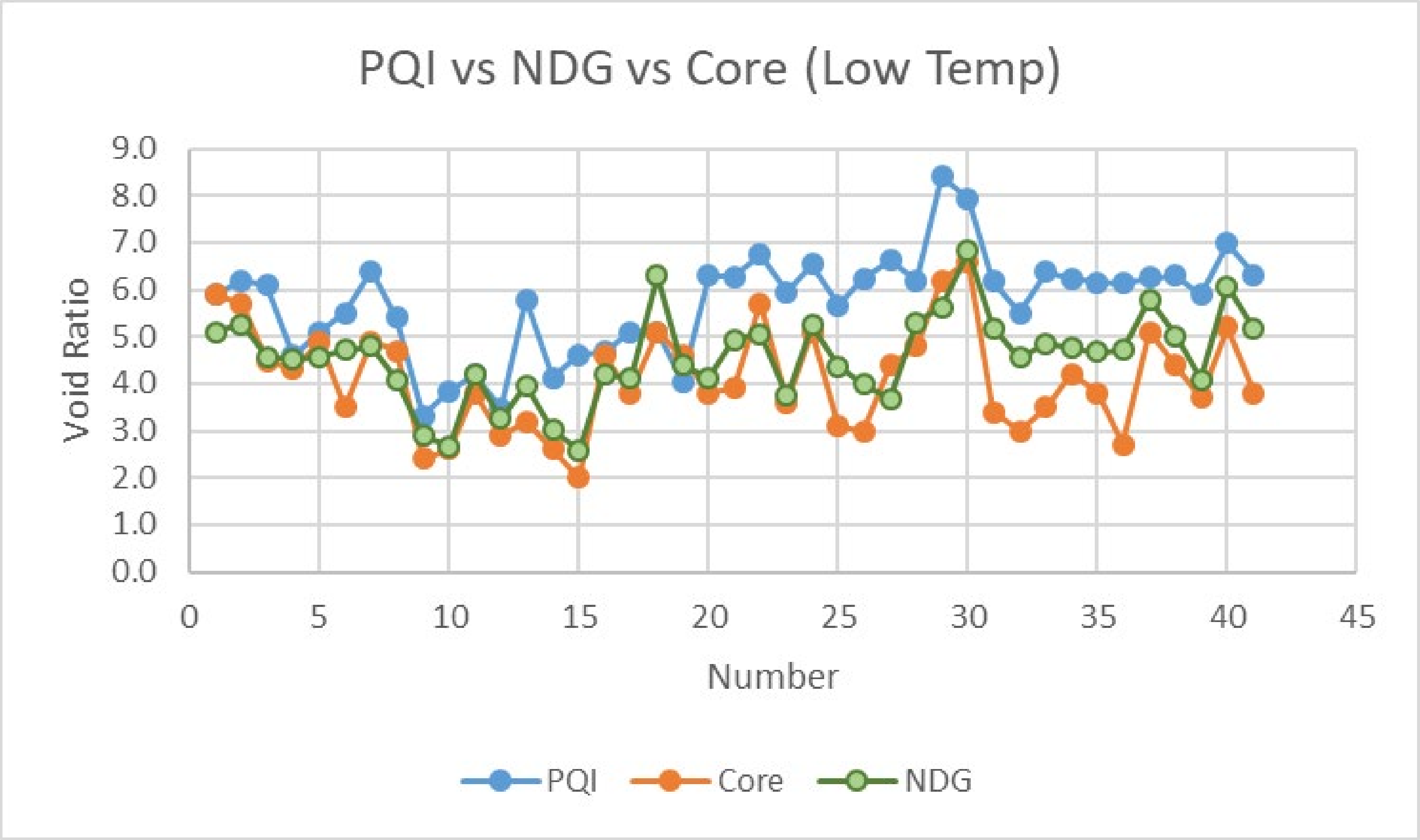

Results –High Temperature (40°C -90°C)

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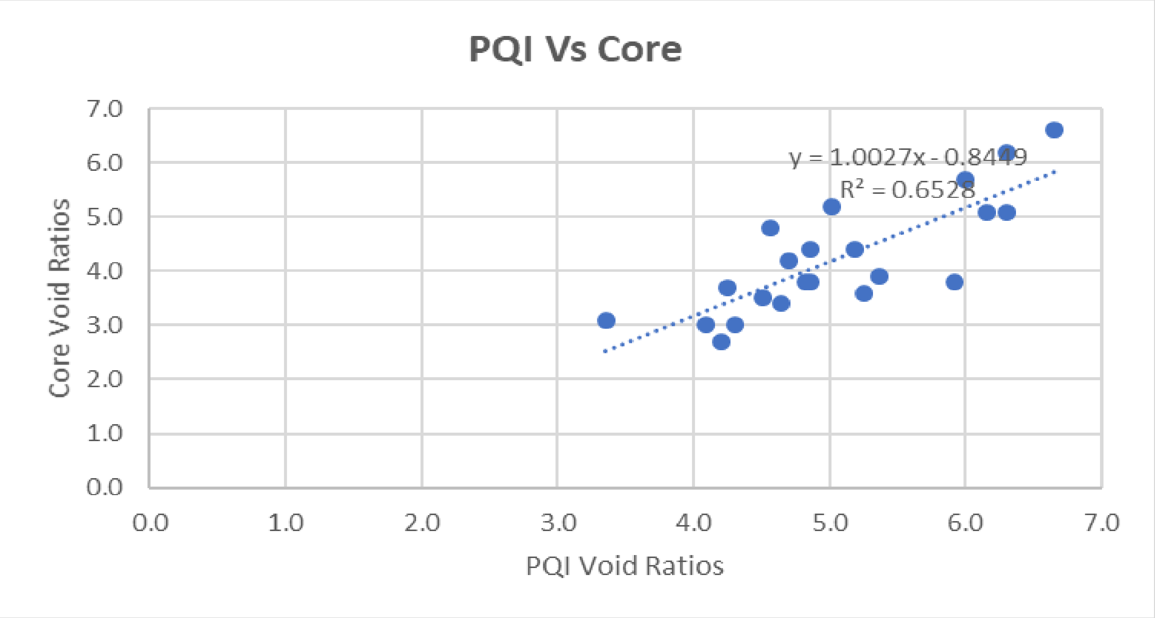

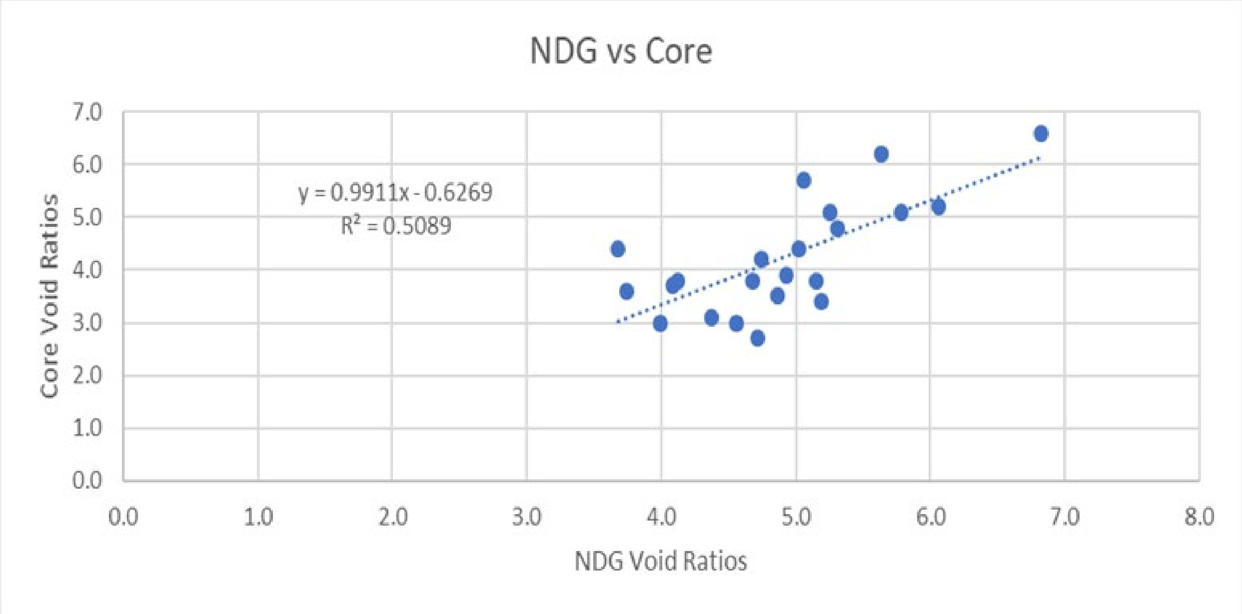

Results –Higher Temp. (40ºC-90ºC)

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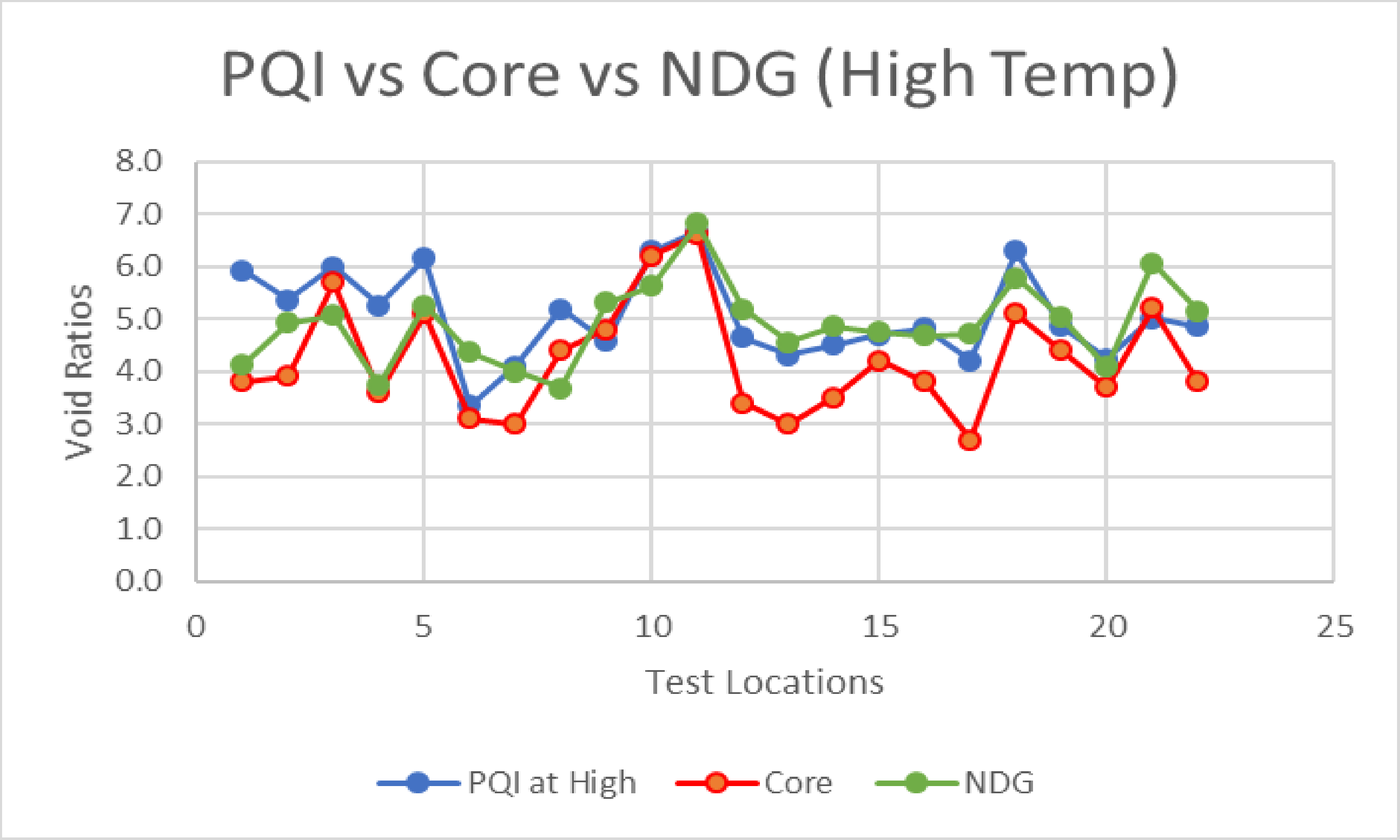

PQI & Asphalt Results

- Repeatable
- Dielectric constant affected by
  - Temperature
  - Moisture
- Accuracy & Precision best @
  - > 40 ^{o}C and < 90 ^{o}C
  - Moisture = 0
- Monitoring compaction ✓
- Does not REPLACE cores

Soil Density Gauge (SDG)

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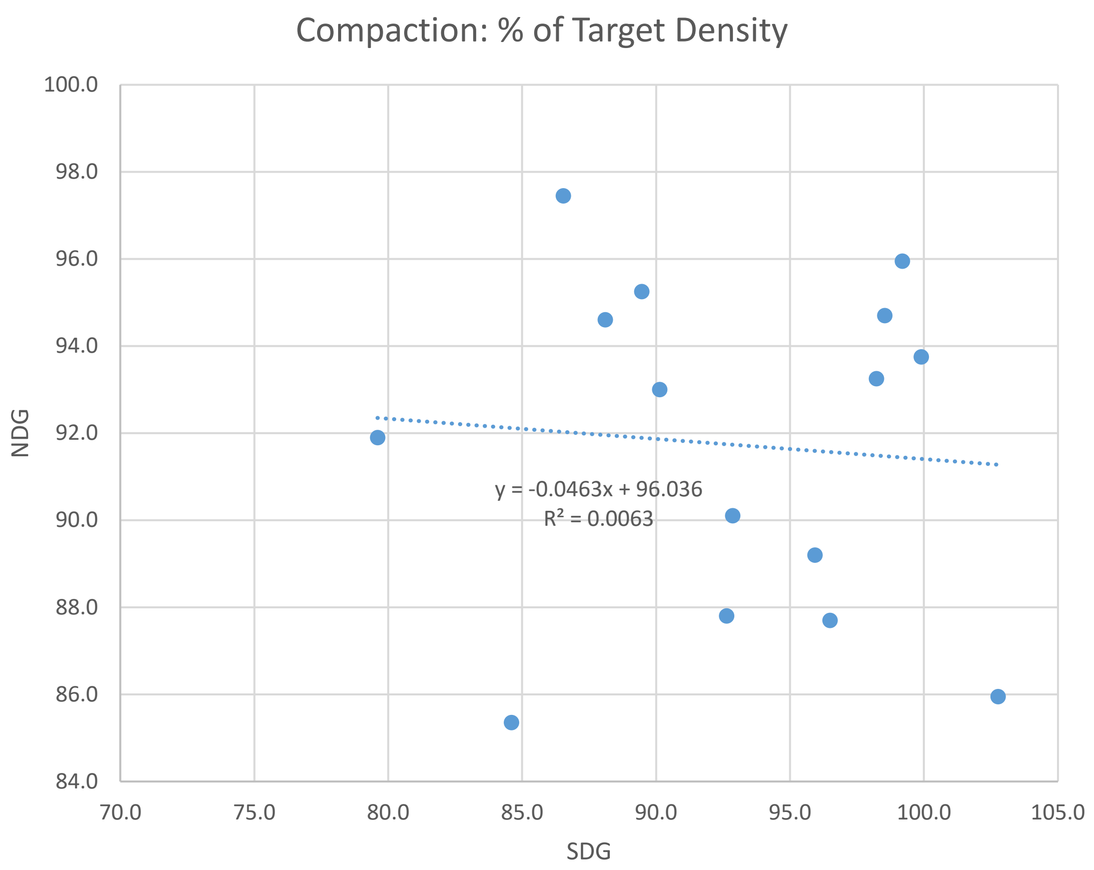
- Similar research methodology as per asphalt but on aggregates
- Accuracy requires particle size, Atterberg limits (PL & LL), uniformity coefficient (Cu) & curvature coefficient (Cc) of material
- Requires regular calibration by sampling material & measuring moisture content by oven drying



Going Forward

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- Study findings:
  - Precision
  - Accuracy
  - Correlation observations
  - Shortcomings
- Process Control Tool
  - sensitivity to temperature & moisture
- Replace NDM for asphalt compaction monitoring
- Still do cores as final control

- SDG requires too much input & frequent calibration with oven drying so not replacing NDM on soils & aggregates
- Assess other non-nuclear devices