Field evidence on the effectiveness of the geogrid/geocomposite reinforcement in reducing induced stress on weak subgrades

A/Prof Chaminda Gallage

Queensland University of Technology (QUT)

Brisbane, Australia

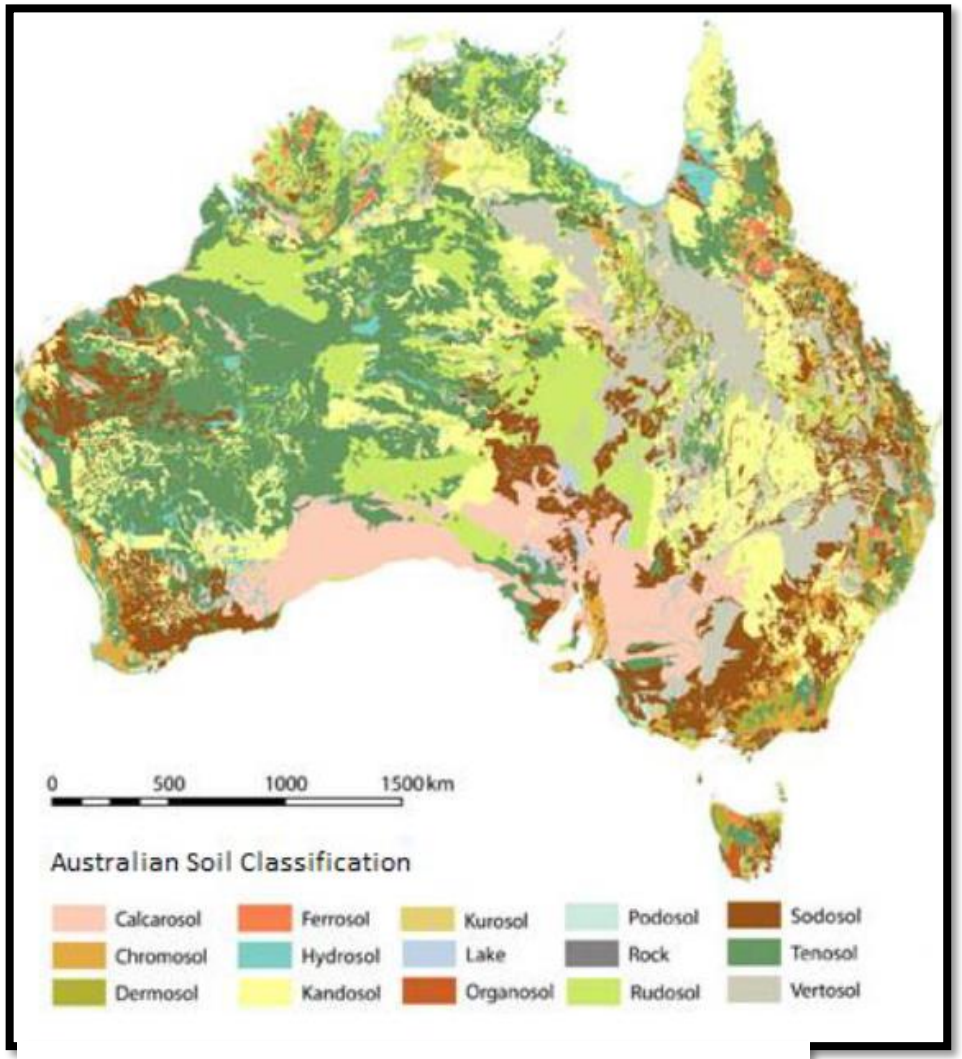
GEOANZ #1 ADVANCES IN GEOSYNTHETICS

7–9 JUNE 2022 | BRISBANE CONVENTION & EXHIBITION CENTRE

Contents….

- Background
- Pavement Field trial – Logan Street
  - Site location and trail sections
  - Instruments, calibration, installation
  - Subgrade assessments/in-situ testing
- Water truck loading test and data analysis
- Conclusion
- Acknowledgements

Background



Vertosol is widespread in Queensland

Weak Subgrade

(Subgrade CBR < 3%)

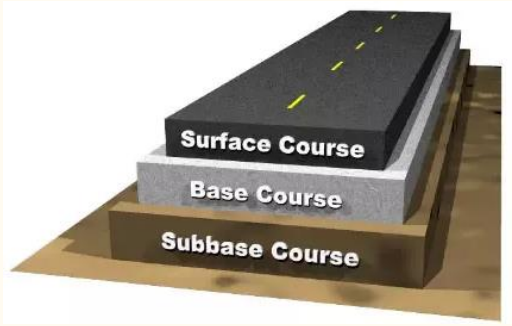
Common in **Queensland** due to **Expansive Clay** soil in most areas *(Gallage, C., 2017)*

Background

Soft Subgrade Treatment

Rock Blanketing

Increase Granular Cover



Gallage & Ramanujan (2012)

Soil Stabilization

Disadvantages

- Demand for materials
- Higher Cost
- Environmental Concerns

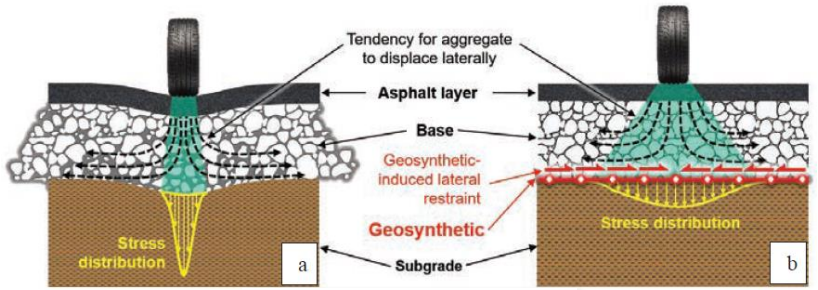
Alternative

Geosynthetics

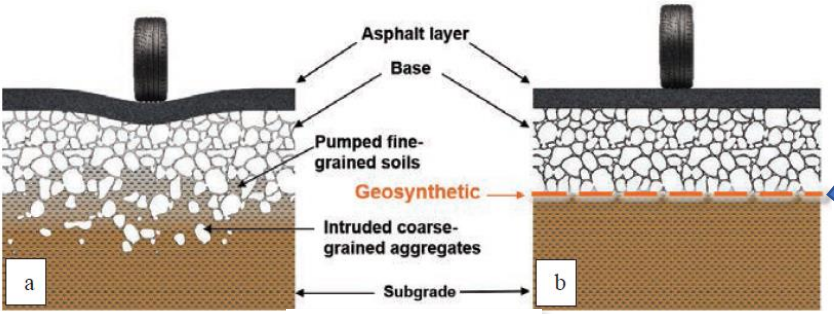
- Reduce Granular Material Requirement *(Hufenus et al. 2006).*
- Extended Pavement Life *(Duncan-Williams and Attoh-Okine 2008).*
- Reduction of Lifetime Cost of Pavements *(Al-Qadi and Elseifi 2007).*

Background

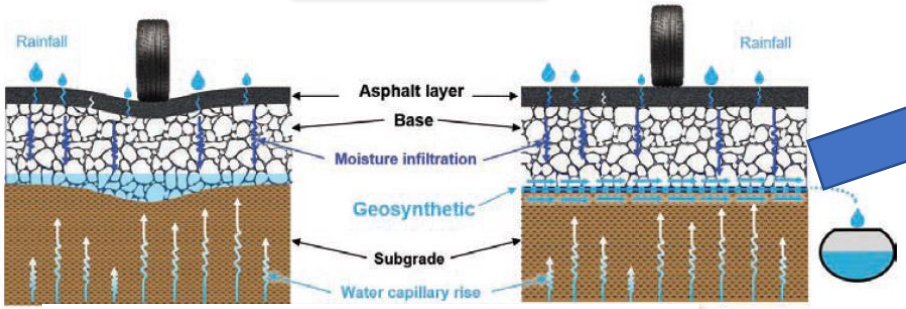
Functions of Geosynthetics *(Koerner 2005, Zornberg 2017)*



Reinforcement

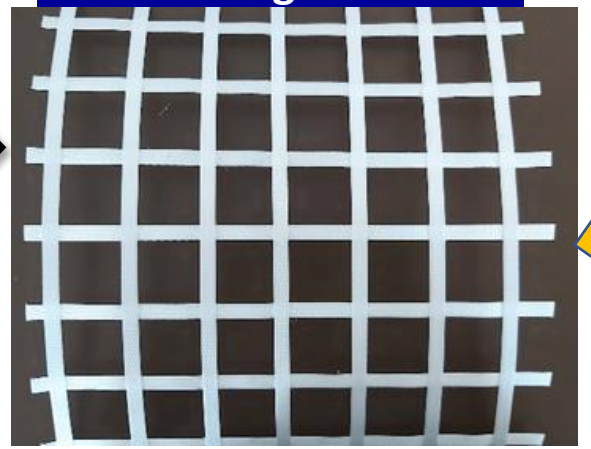


Separation



Filtration and Lateral Drainage

Geogrids

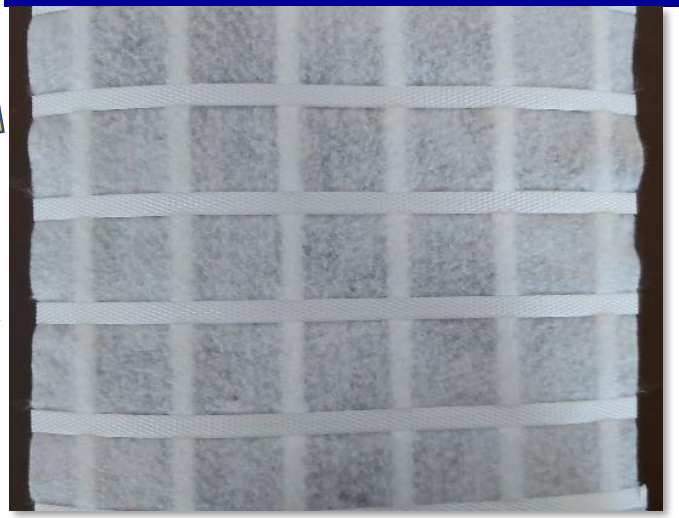


Reinforcement

Geotextiles

Separation & Filtration

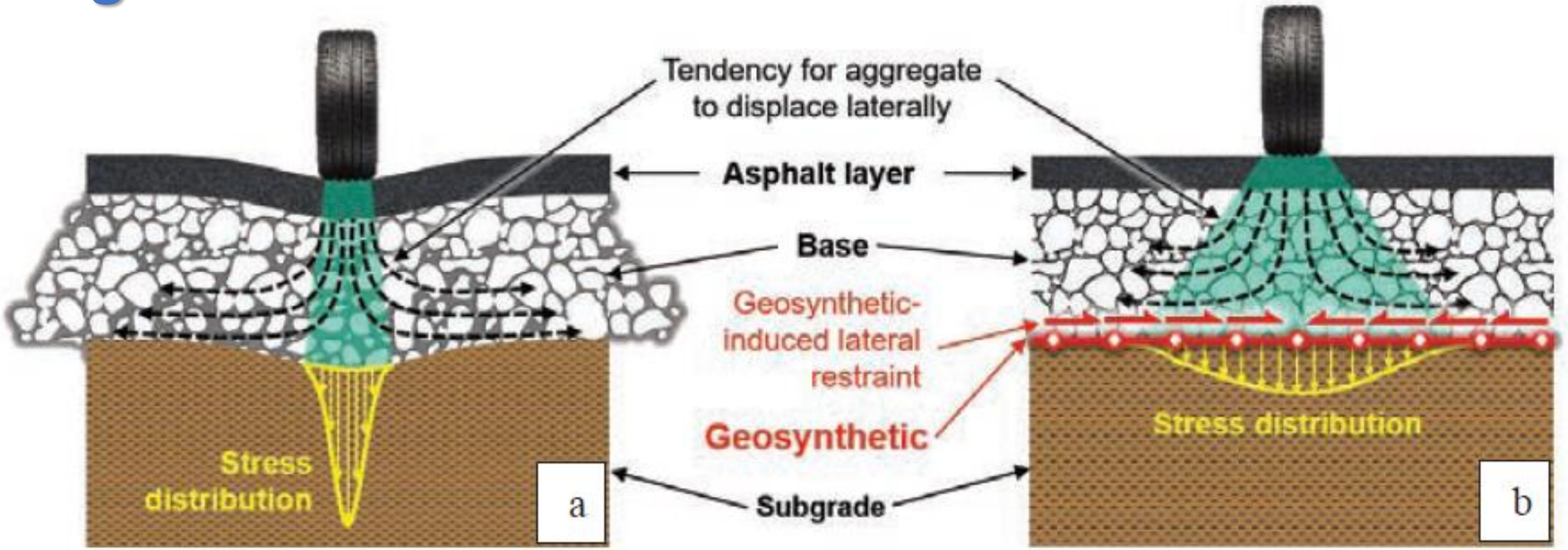
Composite Geogrids

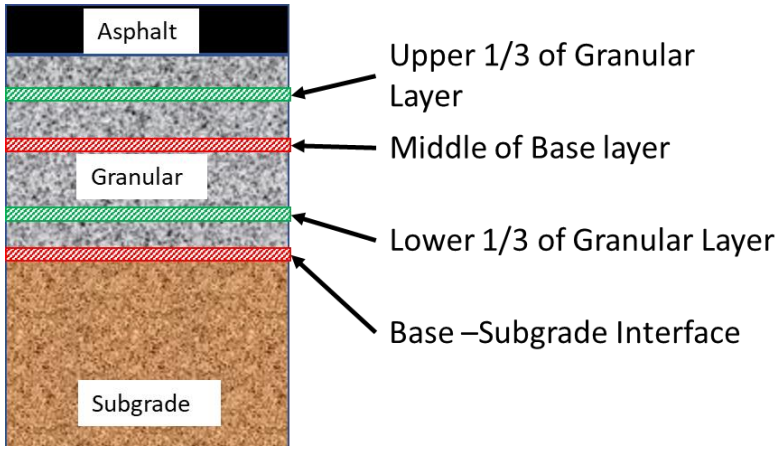


MTRS 58 → Recommends a Geotextile layer if the geogrid is directly placed on subgrade

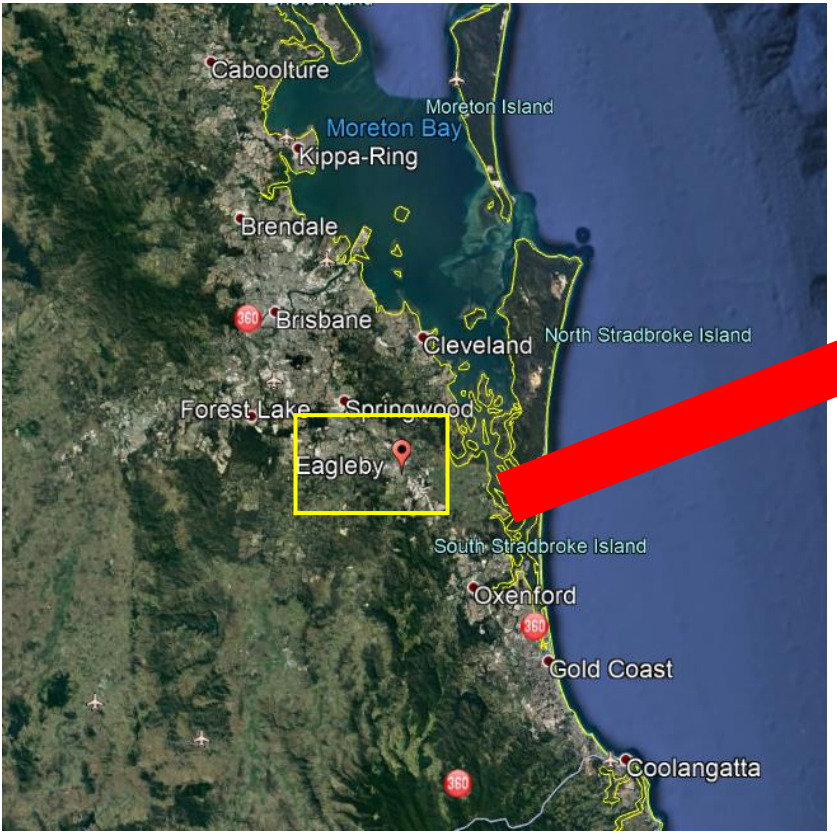
Background

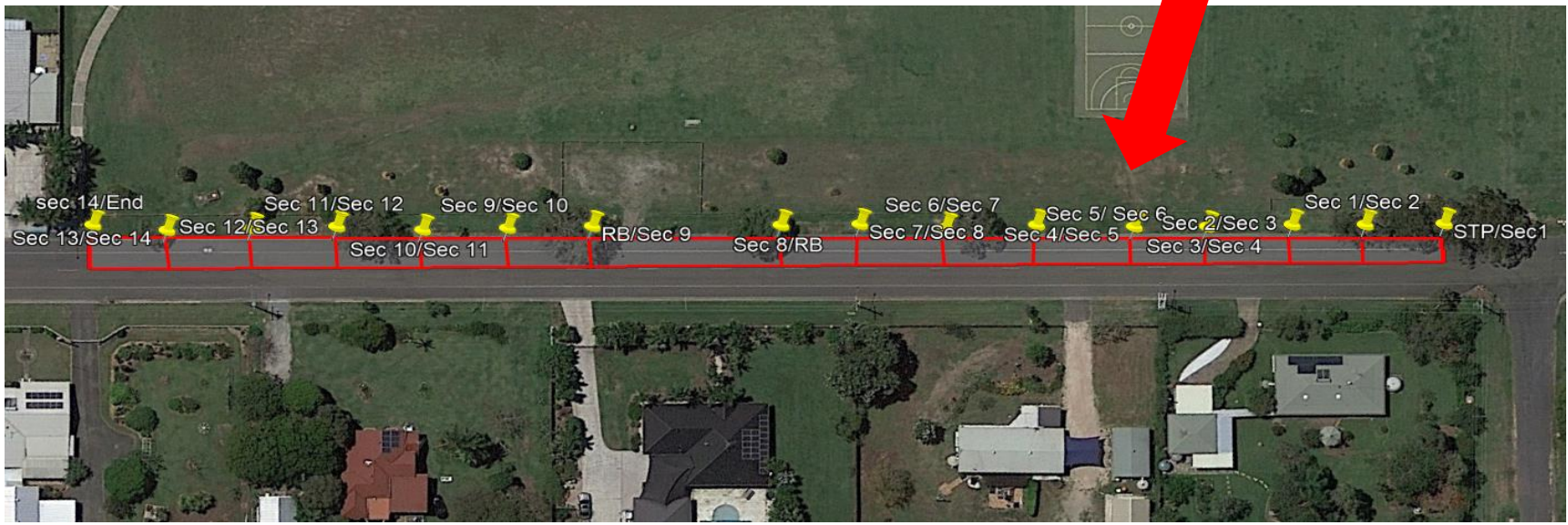
Functions of Geosynthetics/Geogrids *(Koerner 2005, Zornberg 2017)*





Pavement Field trial





Location

Latitude: -27.7120005^0
Longitude: 153.225879^0

Pavement Field trial

Project Detail

Project: Logan City Council Pavement Rehabilitation Program

Street: Logan Street

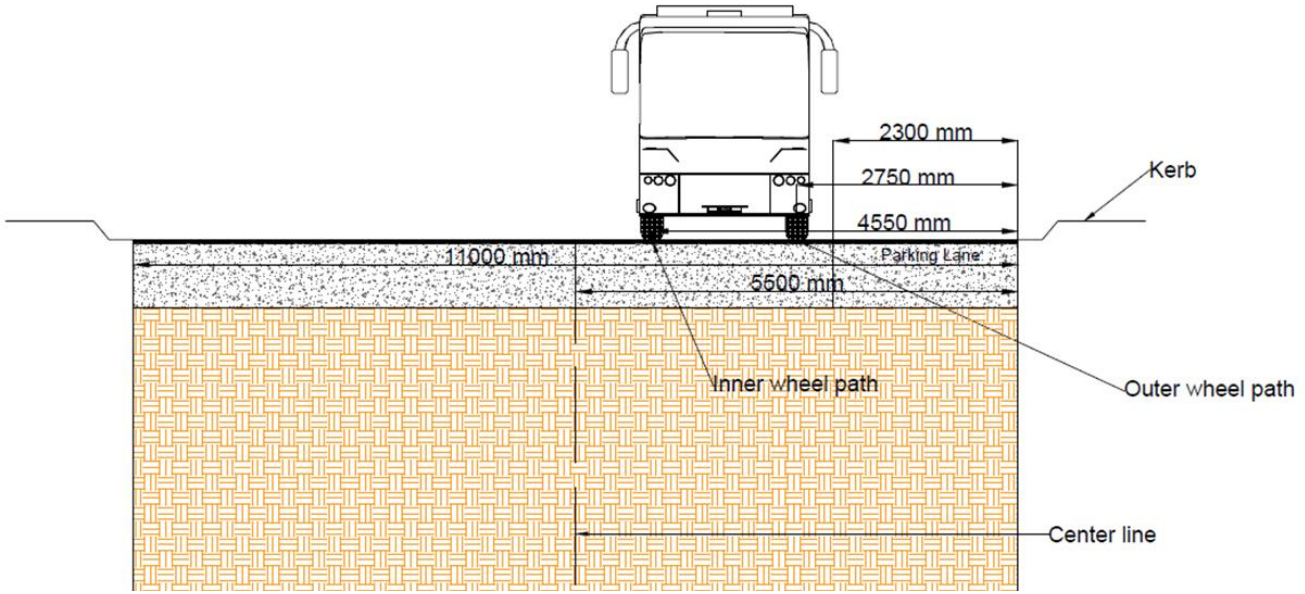
A single carriageway with one lane for each direction + parking lane

Width: 11 m (Kerb to Kerb)

Lane width: 3.2 m

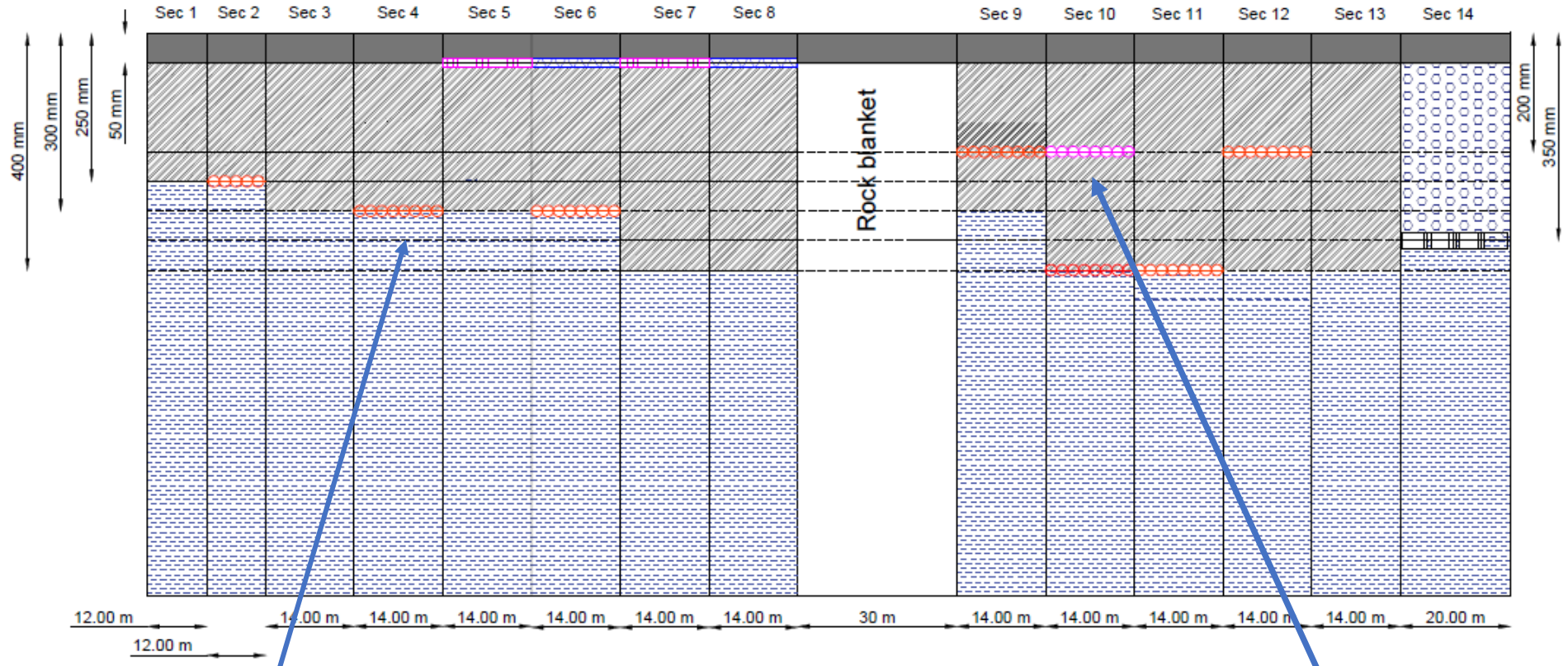
Parking lane: 2.3 m

Length of the test section: 225 m

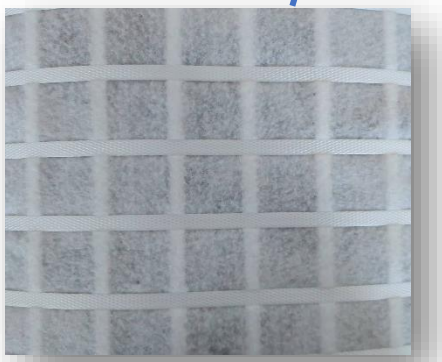


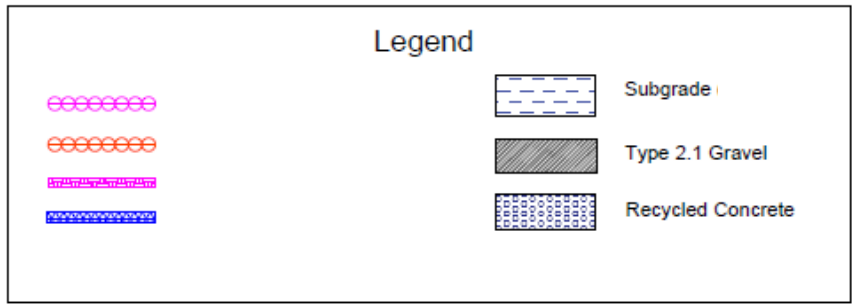
Logan Street Field Trial

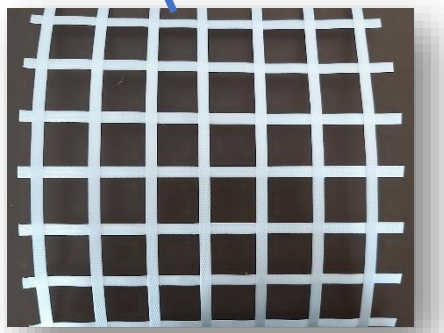
Section Profile



Cross Section

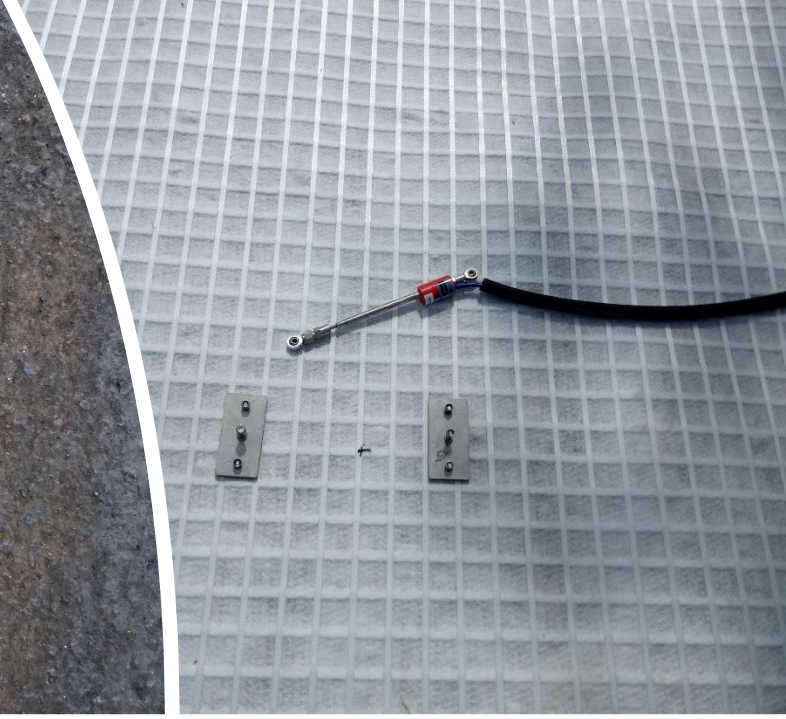




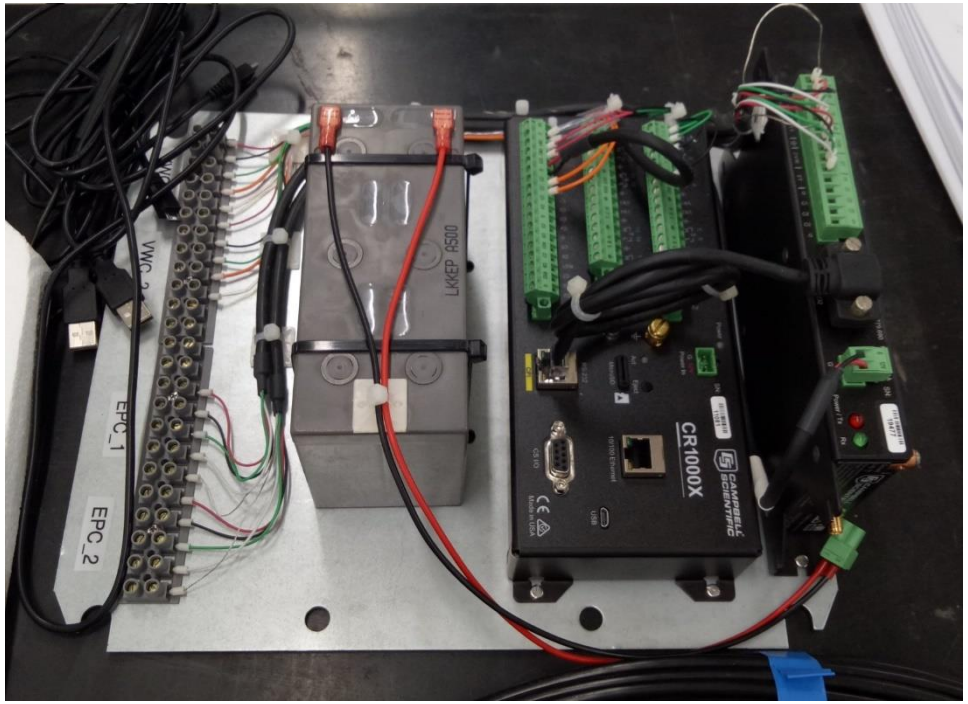


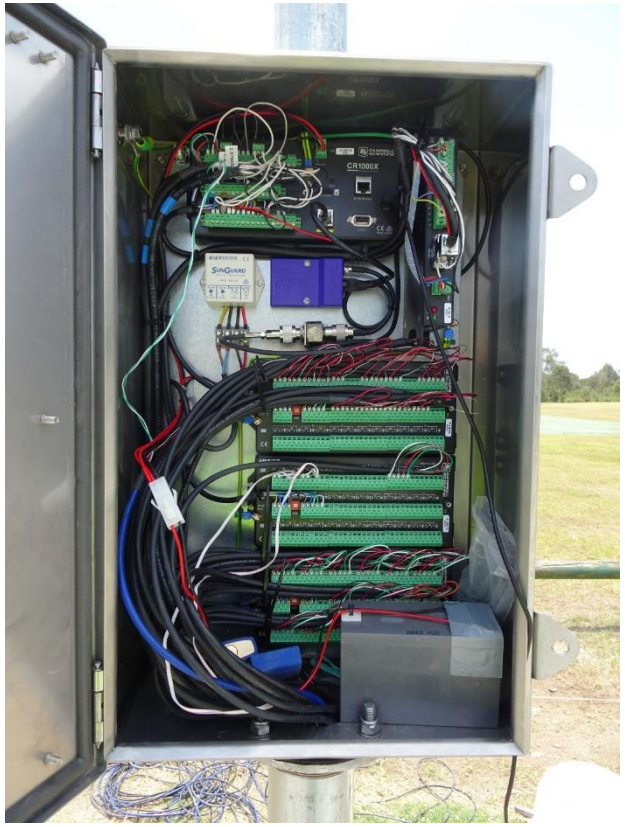
Instruments/sensors

- 90 instruments to monitor pressure, moisture, deflection and strain
- 26 vibrating wire earth pressure cells (24 – 350 kpa capacity and 2- 700 kPa capacity)
- 26 moisture sensors were installed at subgrade and base layer in all 13 sections
- 9 settlement plates were installed for the measurement of deflection in 9 sections
- 7 vibrating wire strain gauges and 6 foil type strain gauges installed to measure the strain in Geocomposite
- 14 asphalt strain gauges were installed to measure the strain in fiberglass geogrids at asphalt level



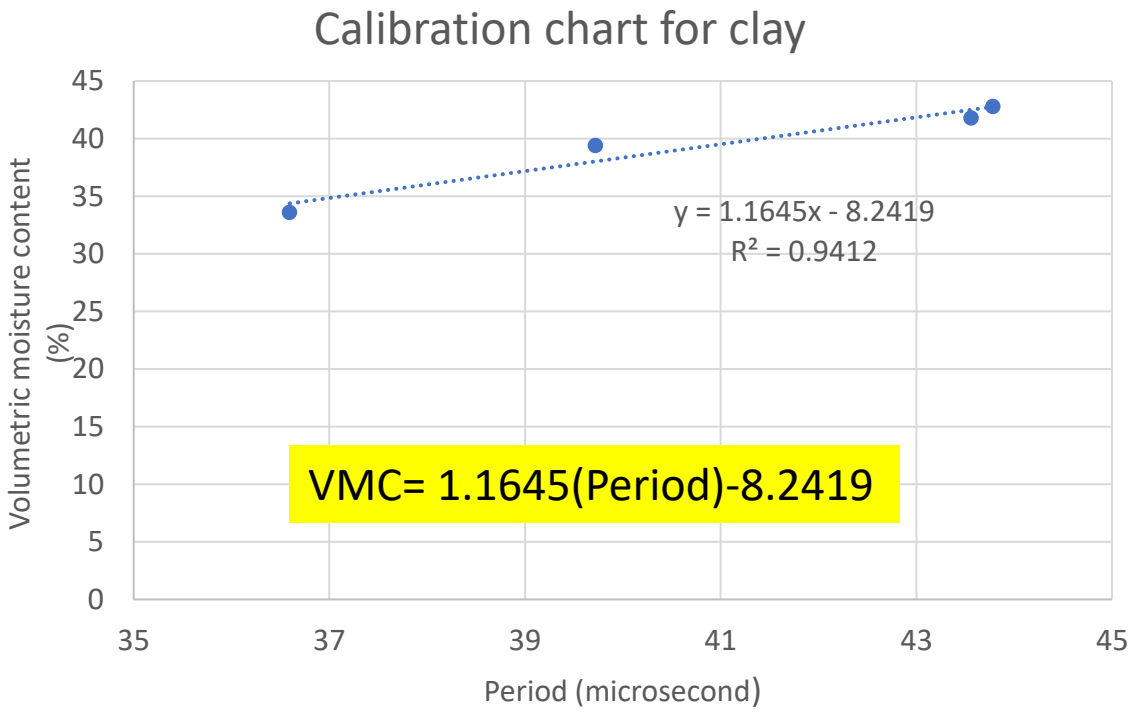
Data Acquisition

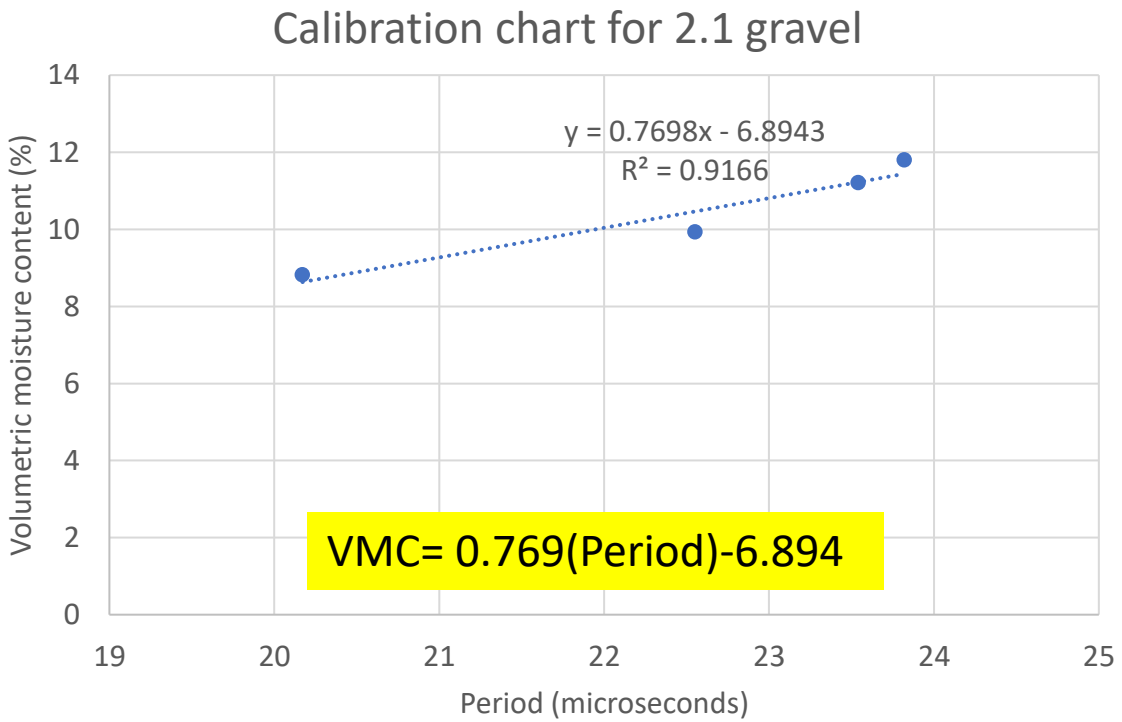




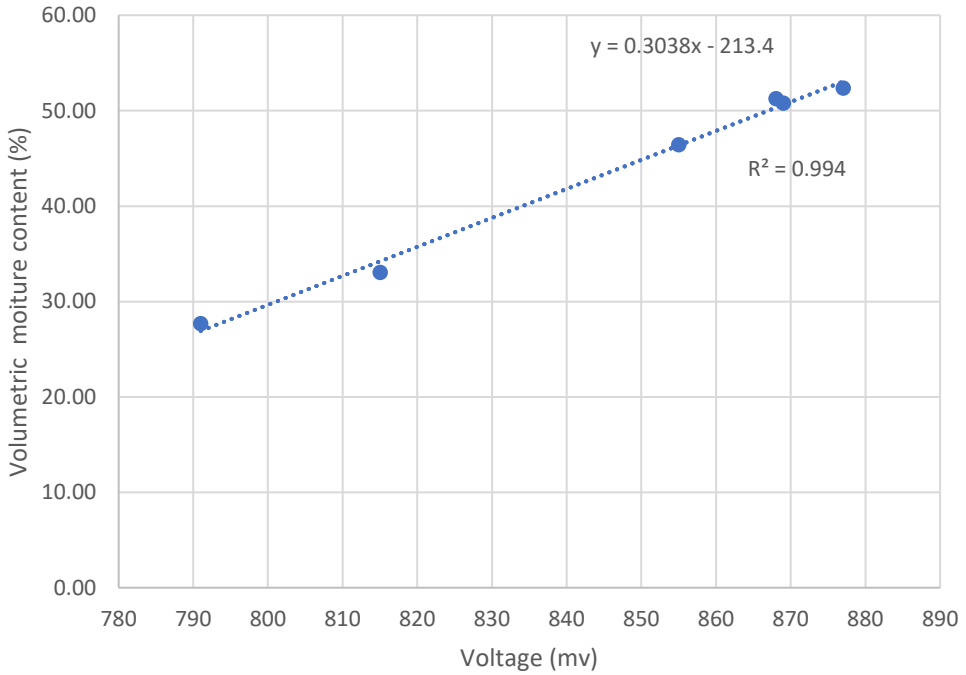
- For data acquisition CR1000X data logger is used
- This device is powered using a solar panel and a backup battery
- To increase the number of sensors that can be connected to the data logger two 32 channel multiplexers were used
- Wireless data transmission to view realtime and download from your own computer

Calibration of Moisture Sensors



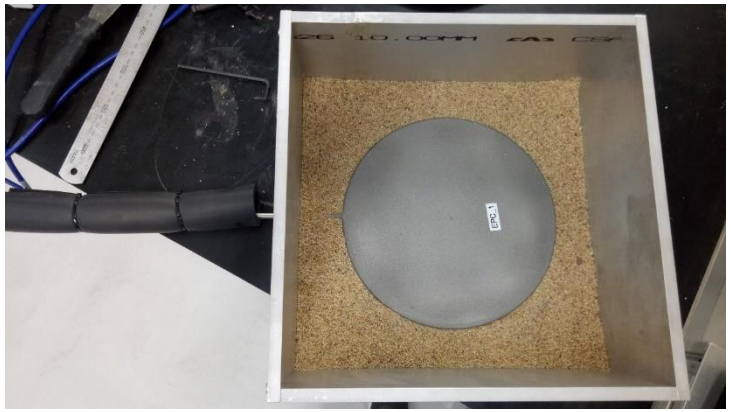


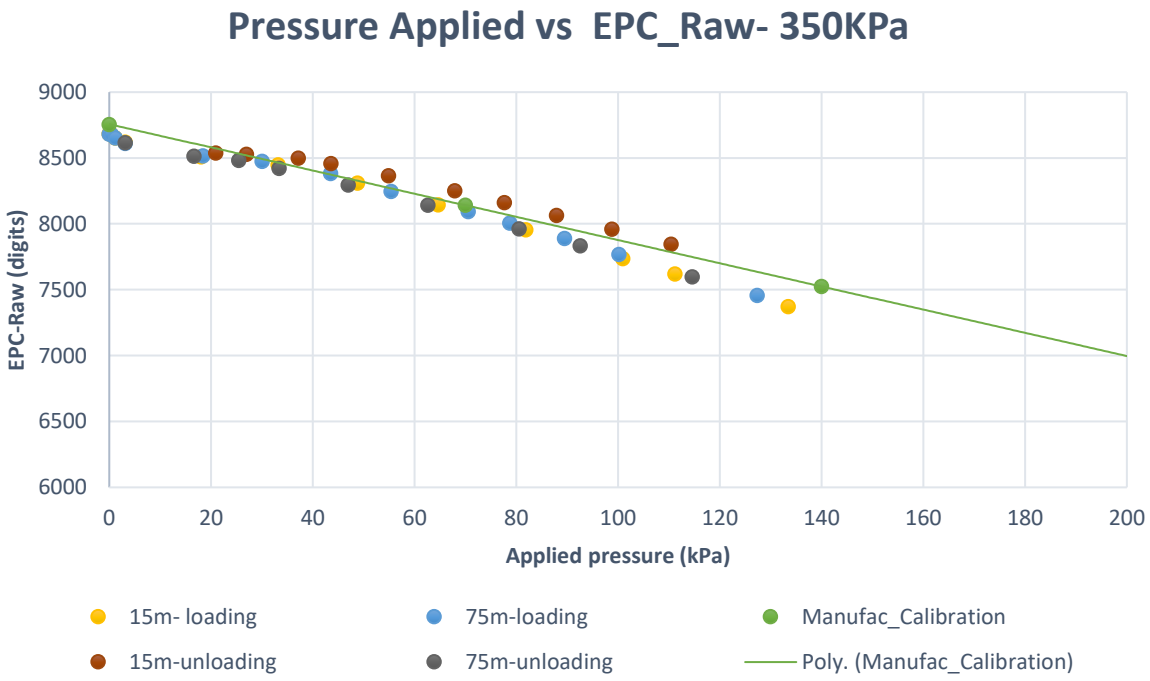
Calibration of Moisture Probe

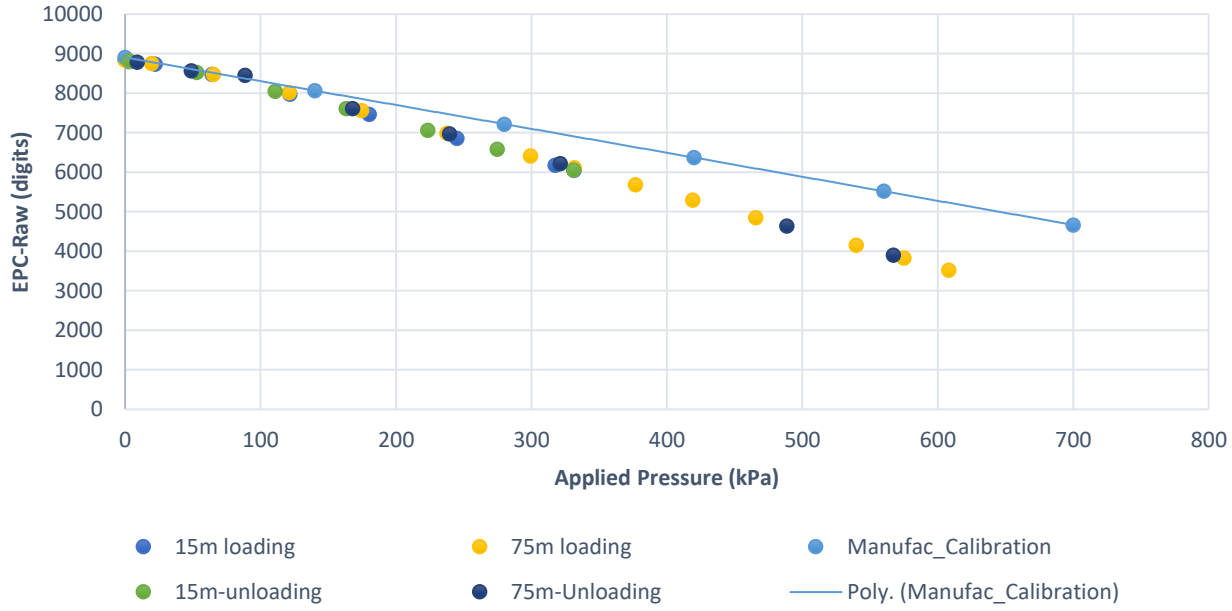


Calibration was done using the soil sample prepared in the moisture box setup as well as using the extruded cutter samples obtained from the opposite traffic lane of the road.

Calibration of the Earth Pressure Cell







Installation Pressure Plates

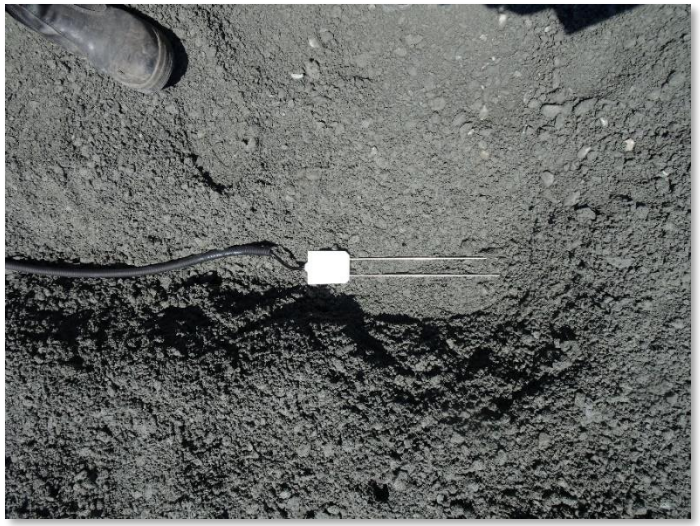
In Subgrade

In Base – just under asphalt layer

Installation Moisture Sensors

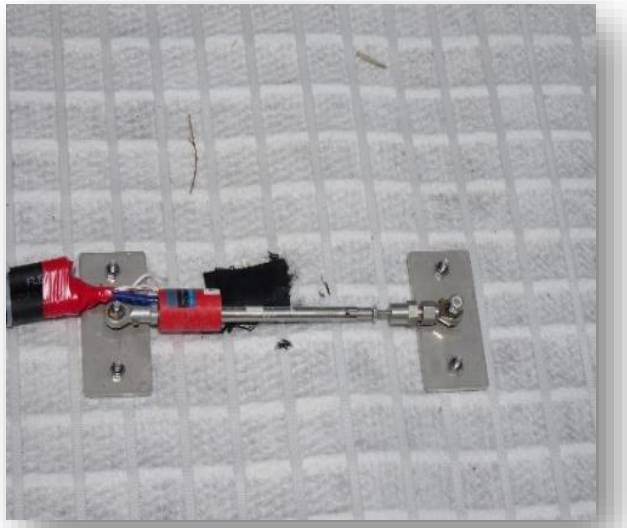
In Subgrade

In Gravel layer



Installation of Strain Gauges

Vibrating Wire Strain Gauges

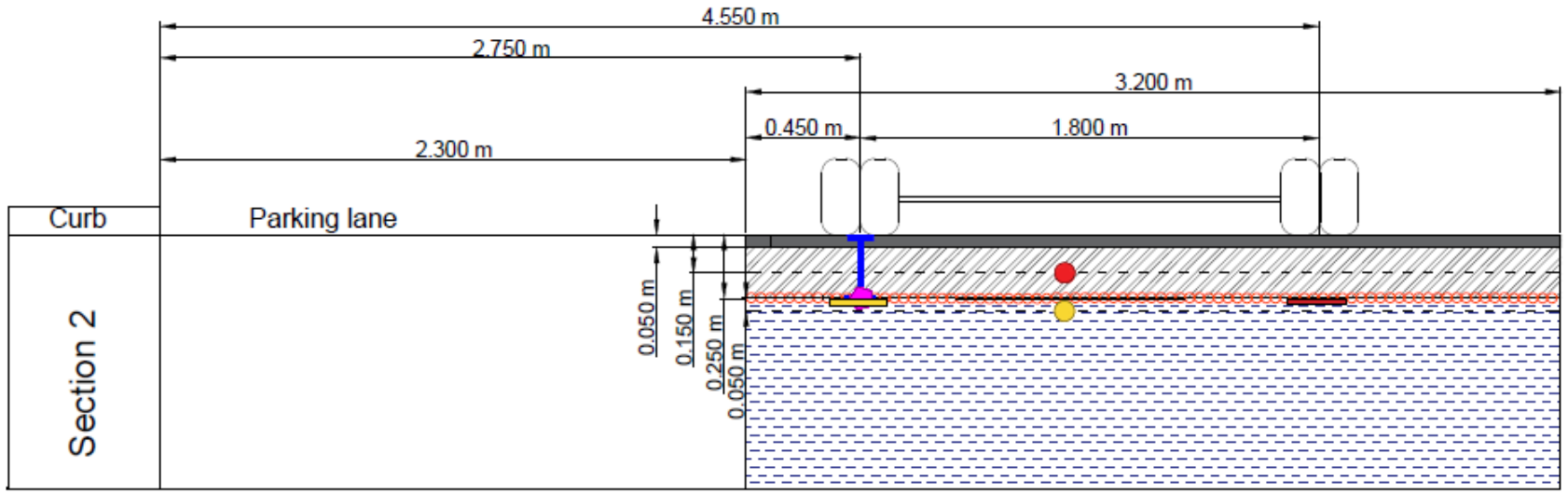


Foil Type Strain Gauges

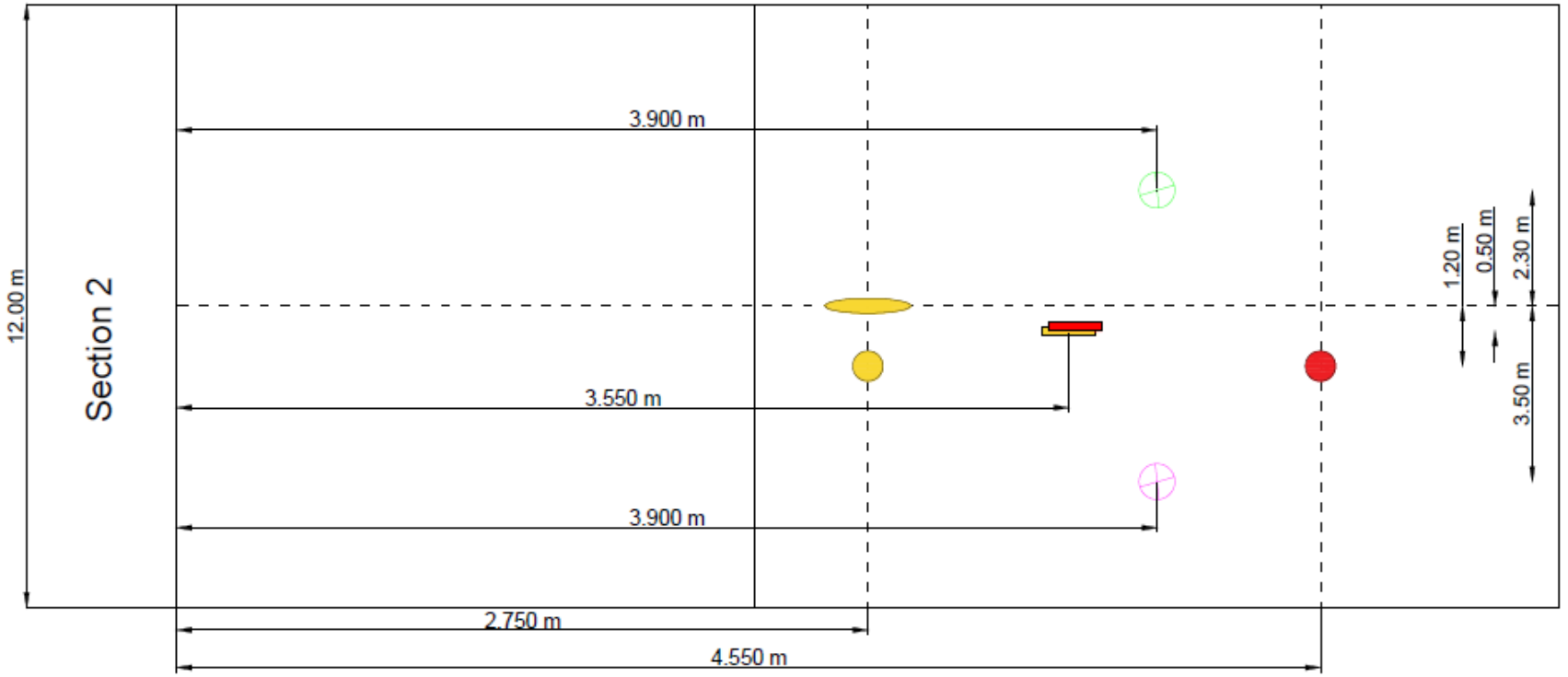
Asphalt Strain Gauges

Section 2

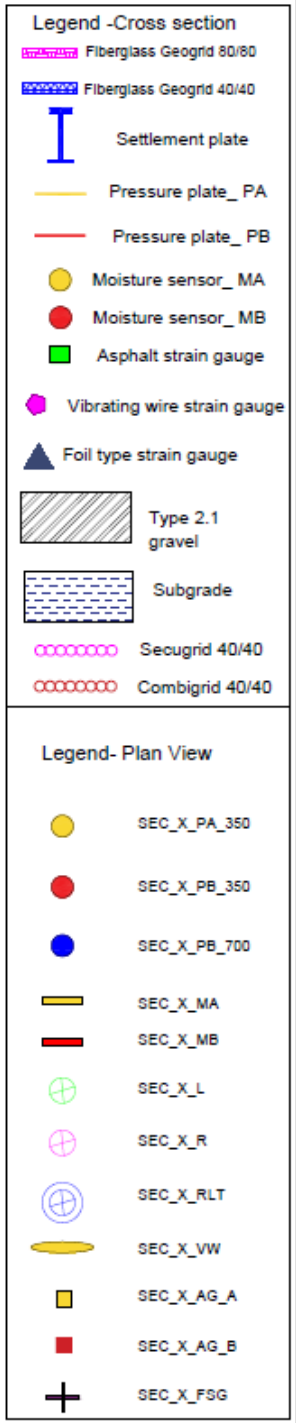
Subgrade Level	250 mm
Combigrid	✓
Secugrid	×
PA_350 kPa	✓
PB_350 kPa	✓
PB_750 kPa	×
MA	✓
MB	✓
VW Strain Gauge	✓
Foil Strain Gauge	×
Asphault Strain Gauge	×
Settlement Plate	✓
FG Geogrid 40/40	×
FG Geogrid 80/80	×



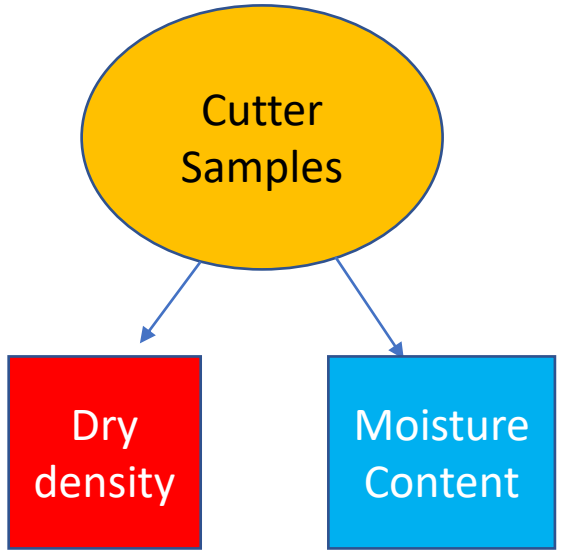
Section 2 - Cross Section

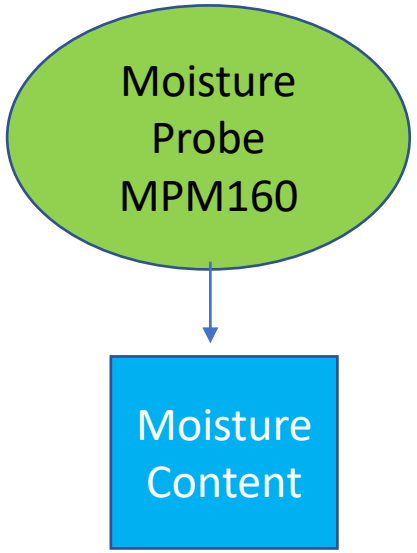


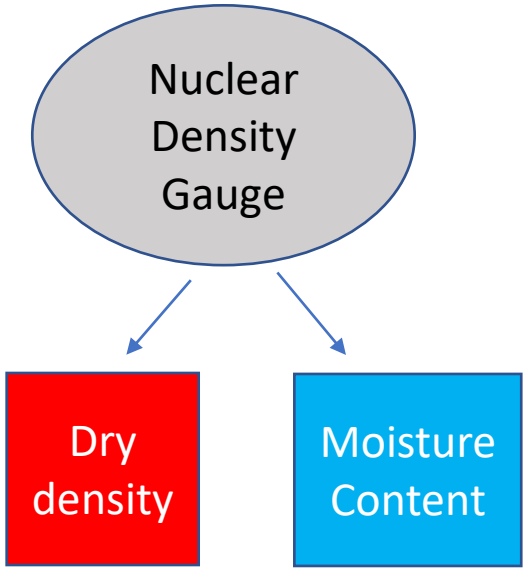
Section 2 - Plan View



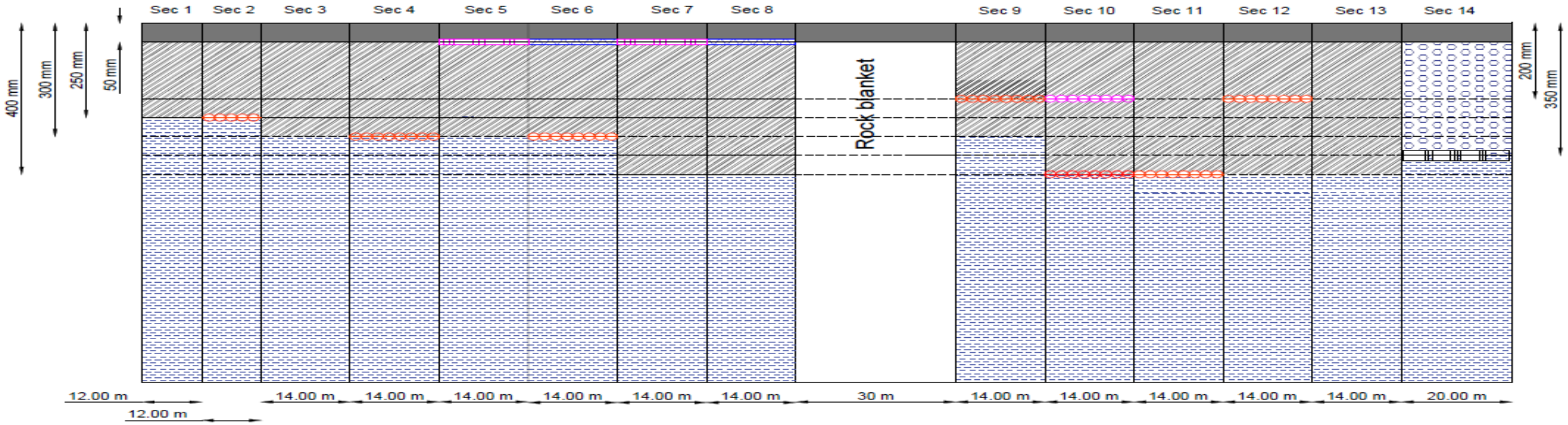
Subgrade Assessment for Dry Density and Moisture Content

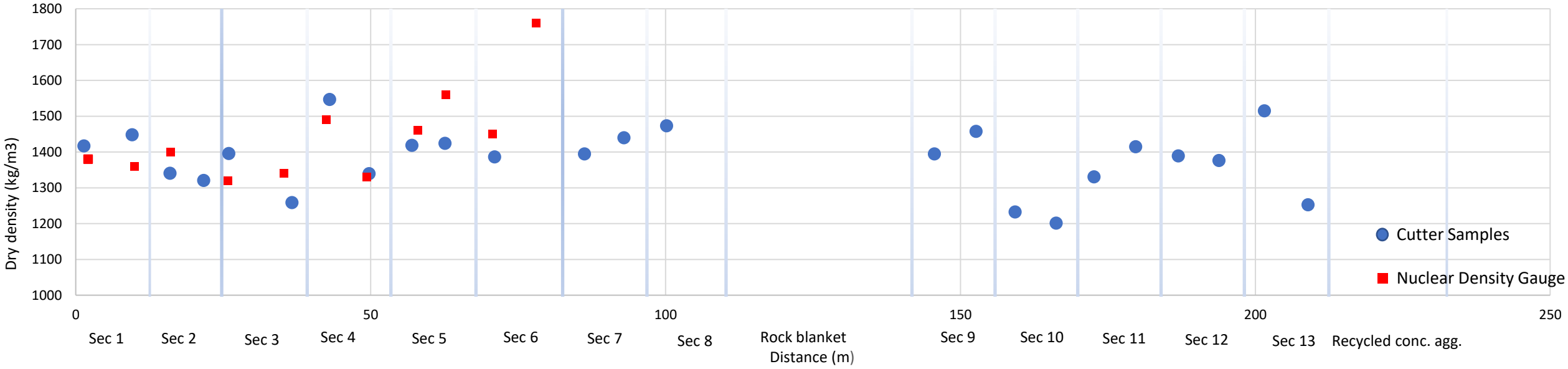




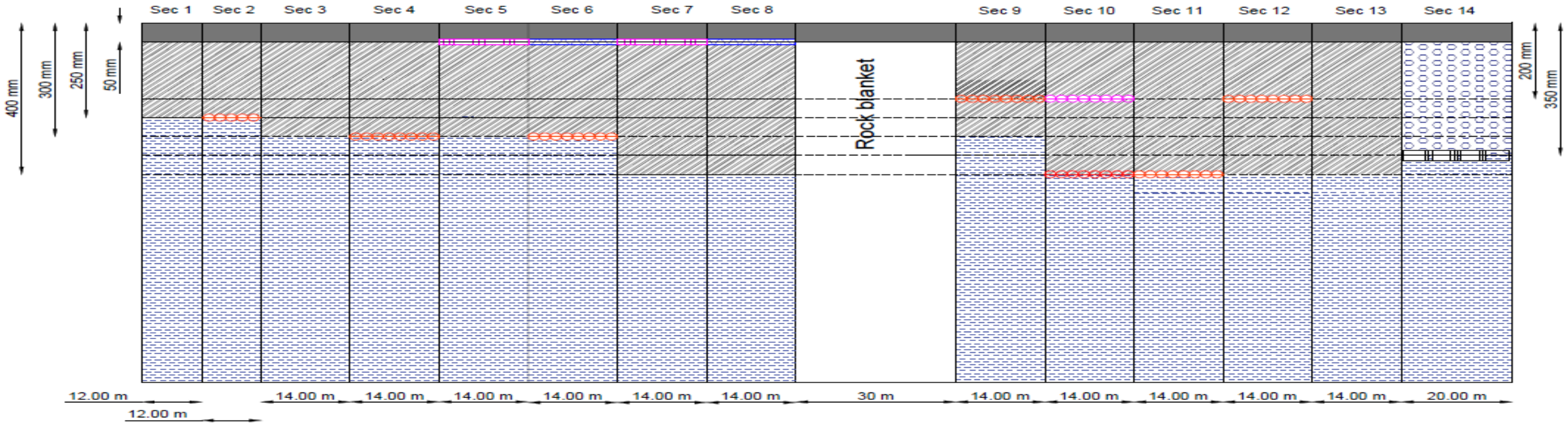


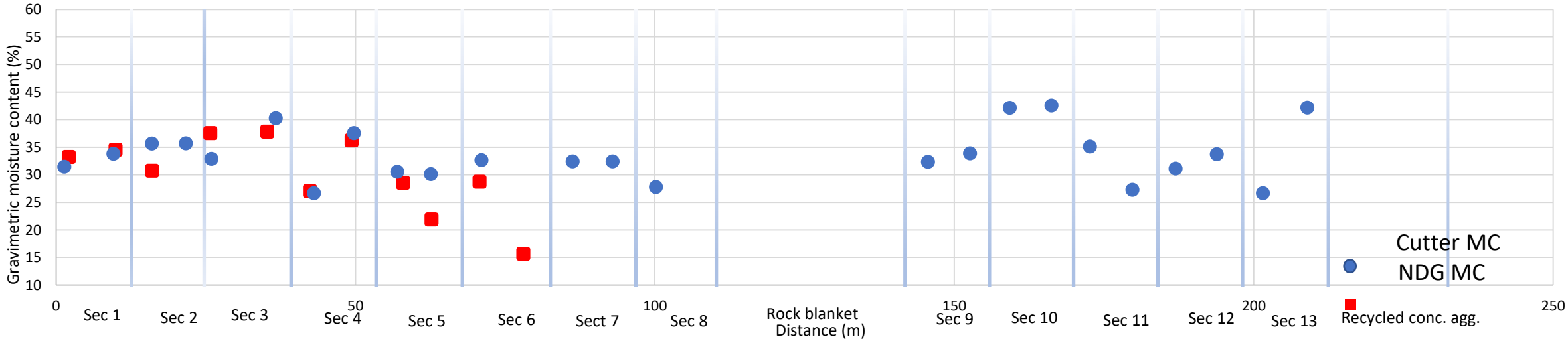
Comparison of Subgrade Dry Density from Cutters and Nuclear Density Gauge





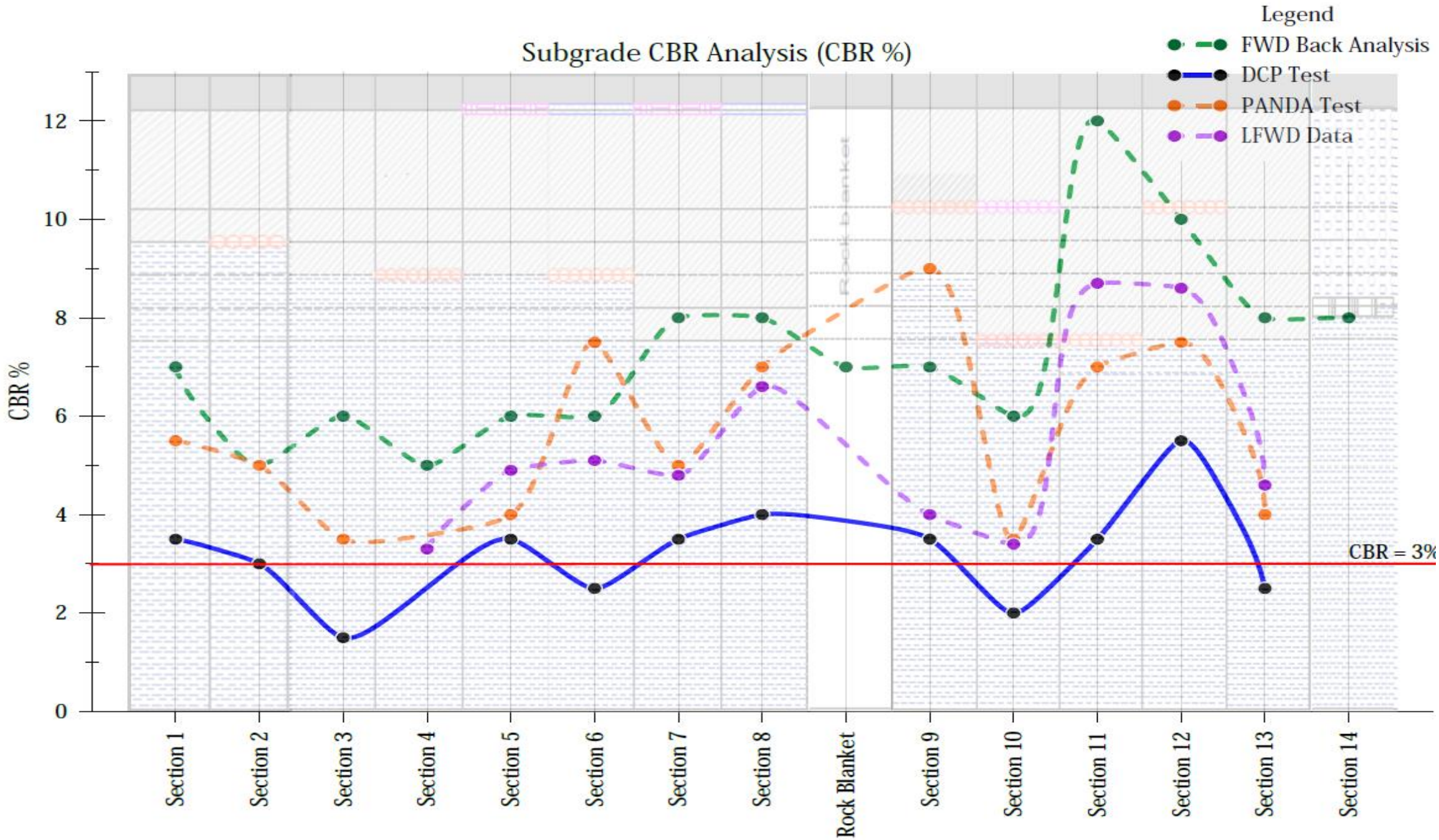
Comparison of Subgrade Moisture Content from Cutters and Nuclear Density Gauge





Other Tests Conducted for Pavement Performance Evaluation

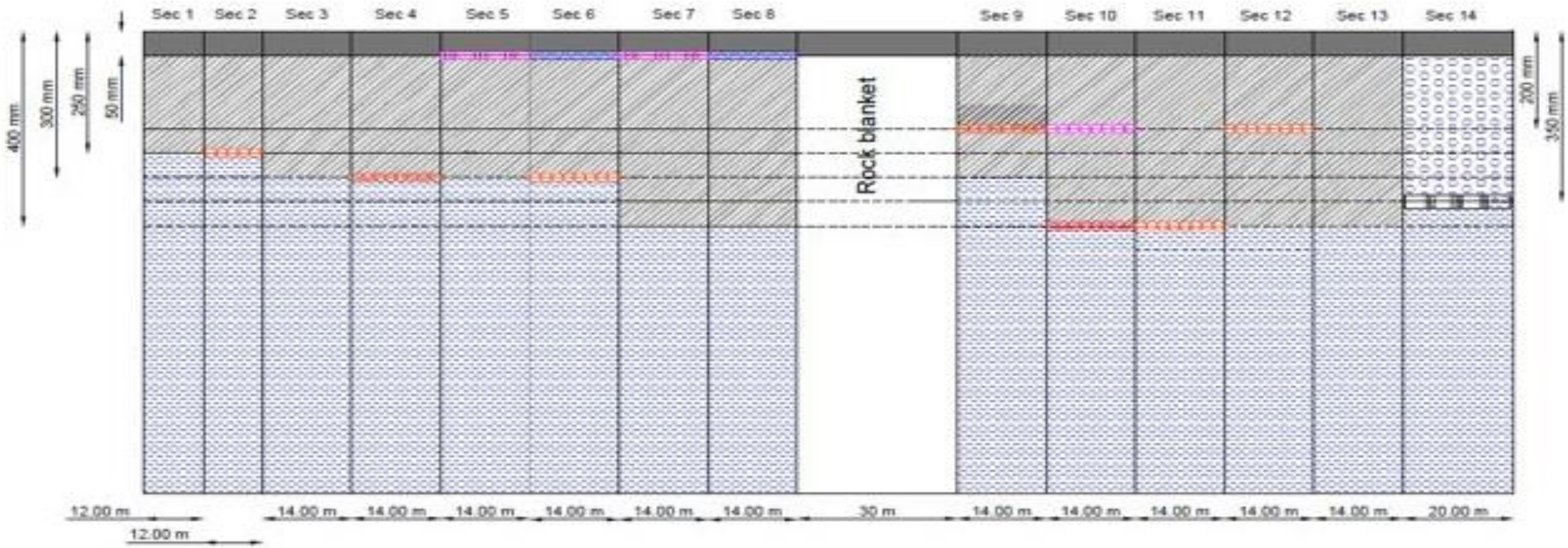
- 9 kg Dynamic Cone Penetrometer (DCP) test
- PANDA probe dynamic penetrometer with variable energy method
- LFWD PRIMA test
- LFWD Terratest 5000
- Intelligent compaction roller
- Falling Weight Deflectometer (FWD) Test


Subgrade CBR Analysis (CBR %)
Legend
FWD Back Analysis
DCP Test
PANDA Test
LFWD Data
CBR %
0
2
4
6
8
10
12
CBR = 3%
Section 1
Section 2
Section 3
Section 4
Section 5
Section 6
Section 7
Section 8
Rock Blanket
Section 9
Section 10
Section 11
Section 12
Section 13
Section 14

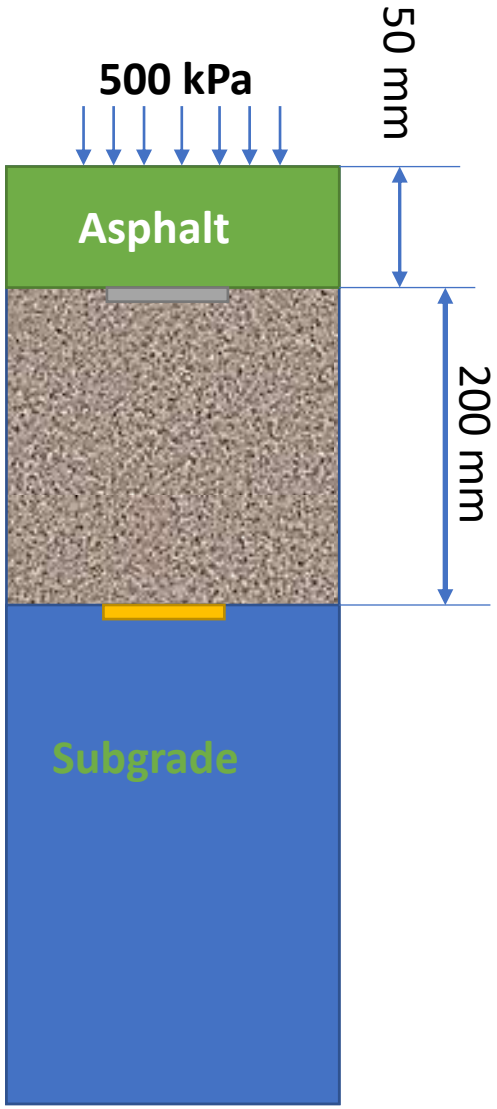
Loaded water truck applied static pressure on pressure cells (17/09/2020)

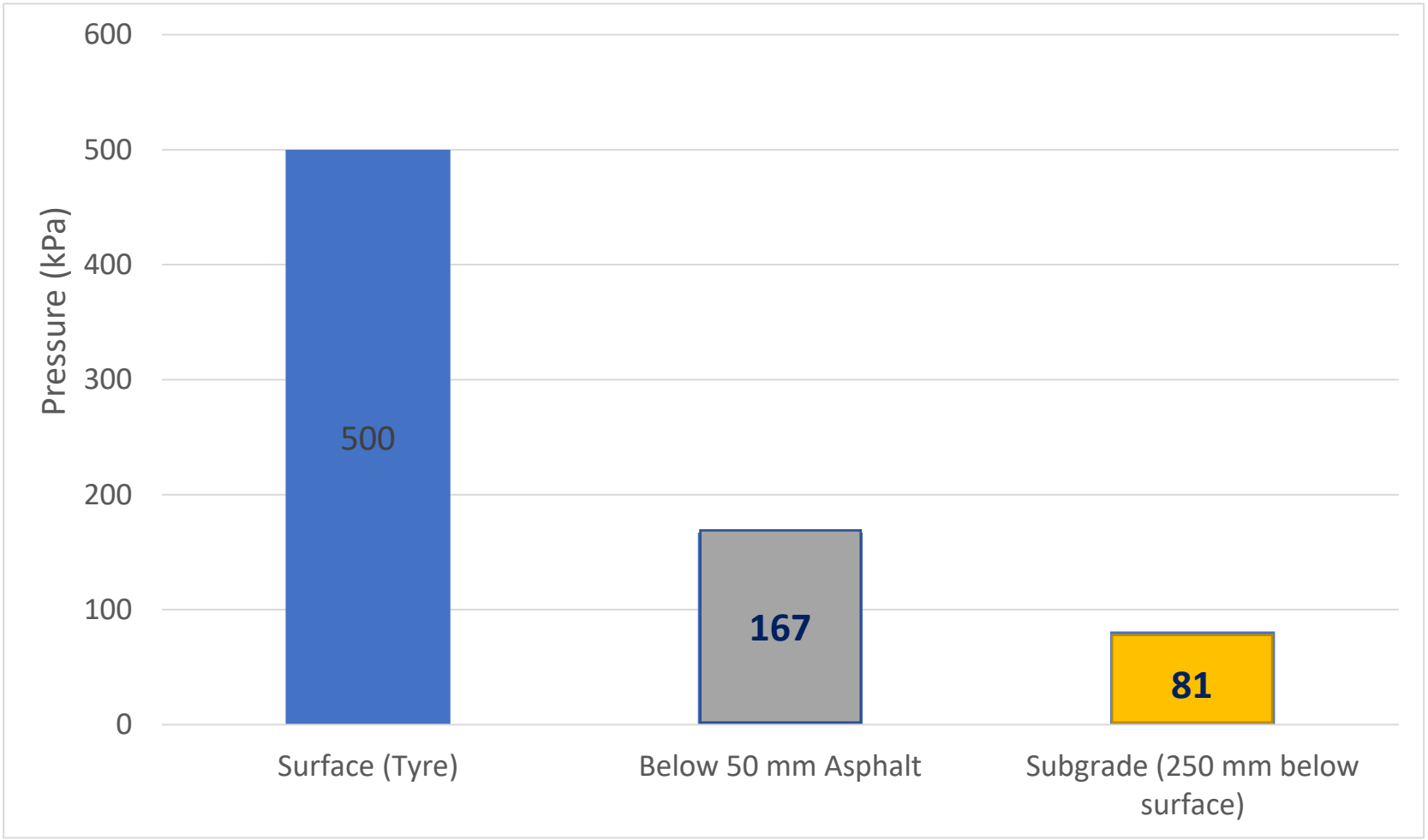
Marked pressure cell locations

Front axel tyre on each pressure cell location for 5 min (6.9 T axel load)

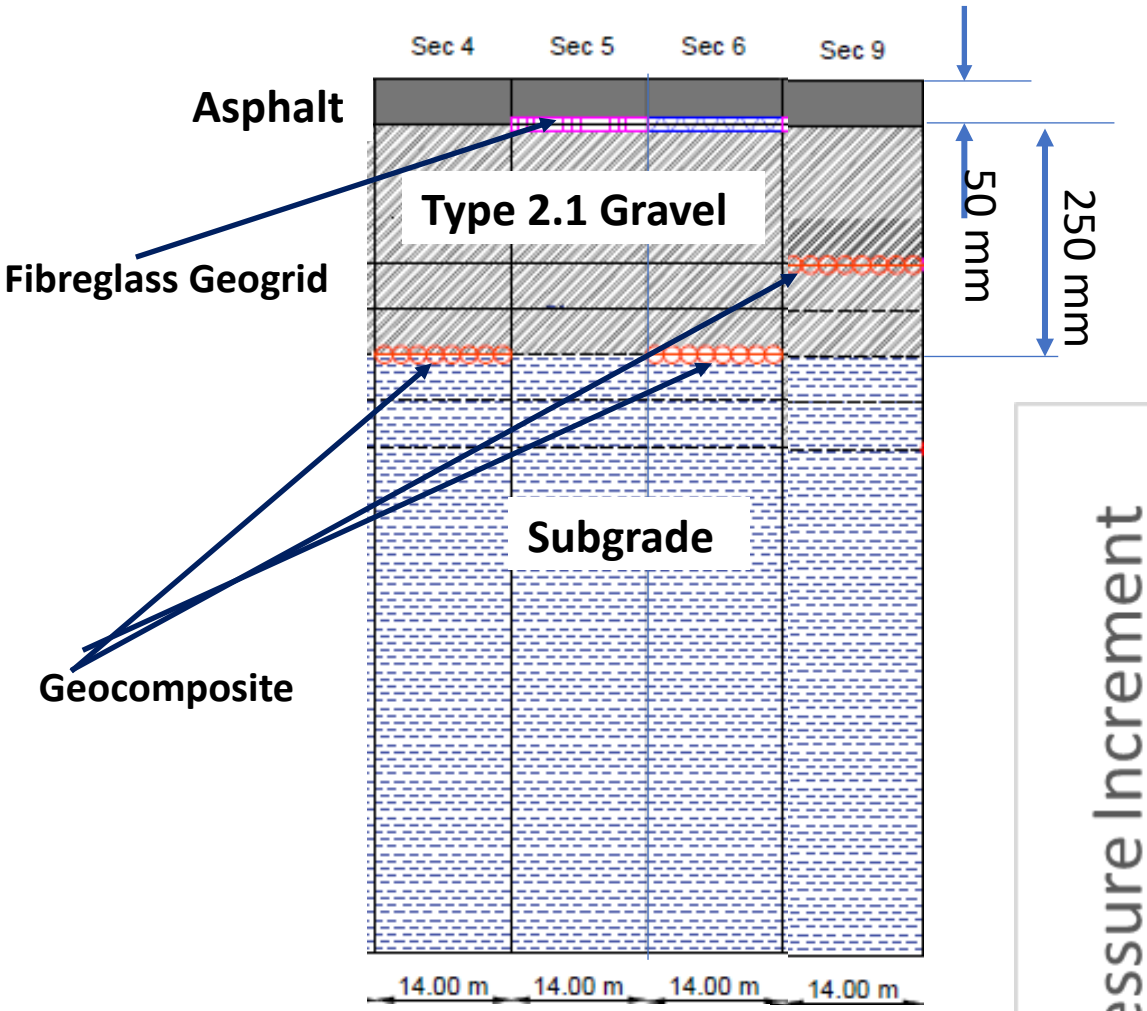

Sec 1
Sec 2
Sec 3
Sec 4
Sec 5
Sec 6
Sec 7
Sec 8
Sec 9
Sec 10
Sec 11
Sec 12
Sec 13
Sec 14
400 mm
300 mm
250 mm
50 mm
200 mm
350 mm
Rock blanket
12.00 m
14.00 m
14.00 m
14.00 m
14.00 m
14.00 m
14.00 m
30 m
14.00 m
14.00 m
14.00 m
14.00 m
14.00 m
20.00 m
12.00 m

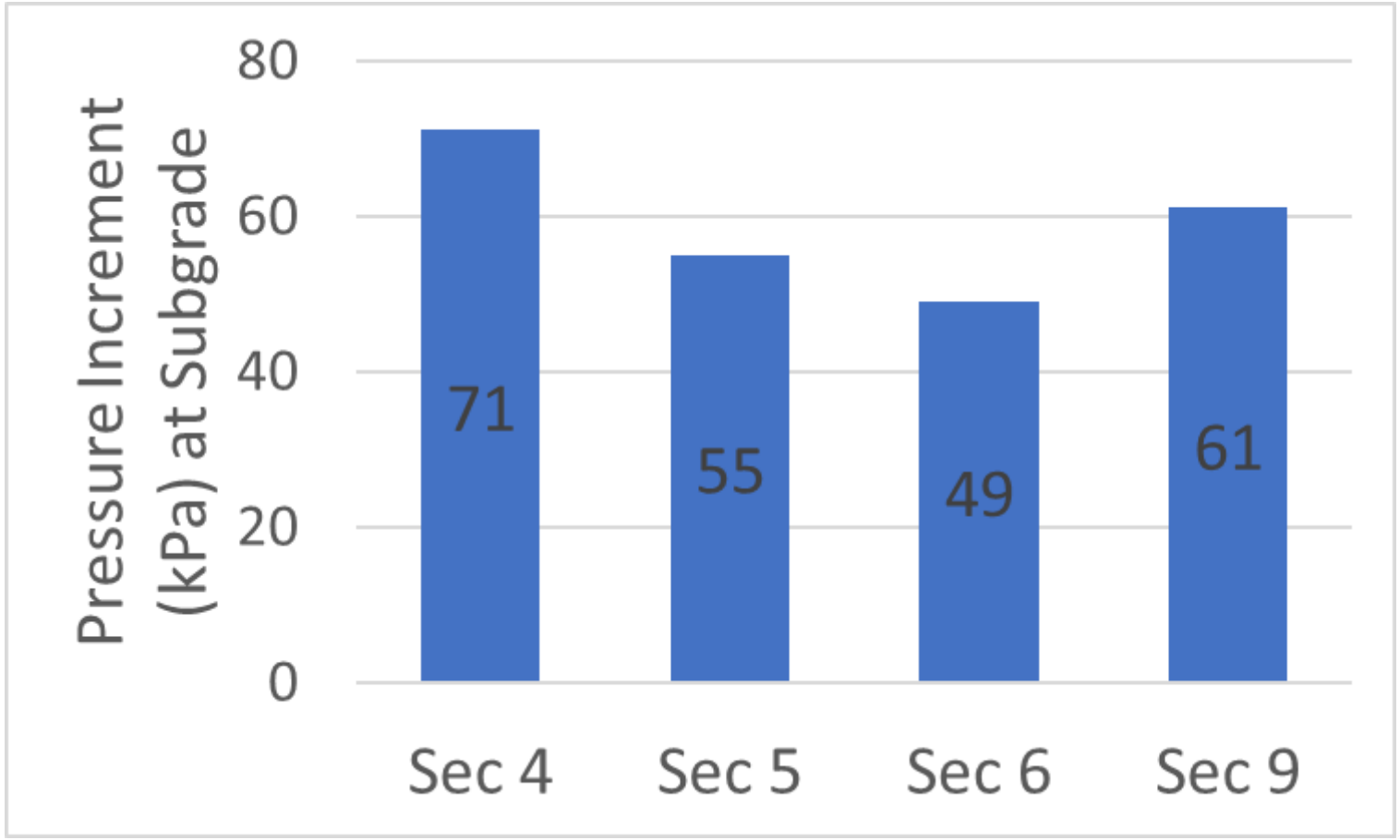
Contribution of 50 mm Asphalt layer in stress reduction





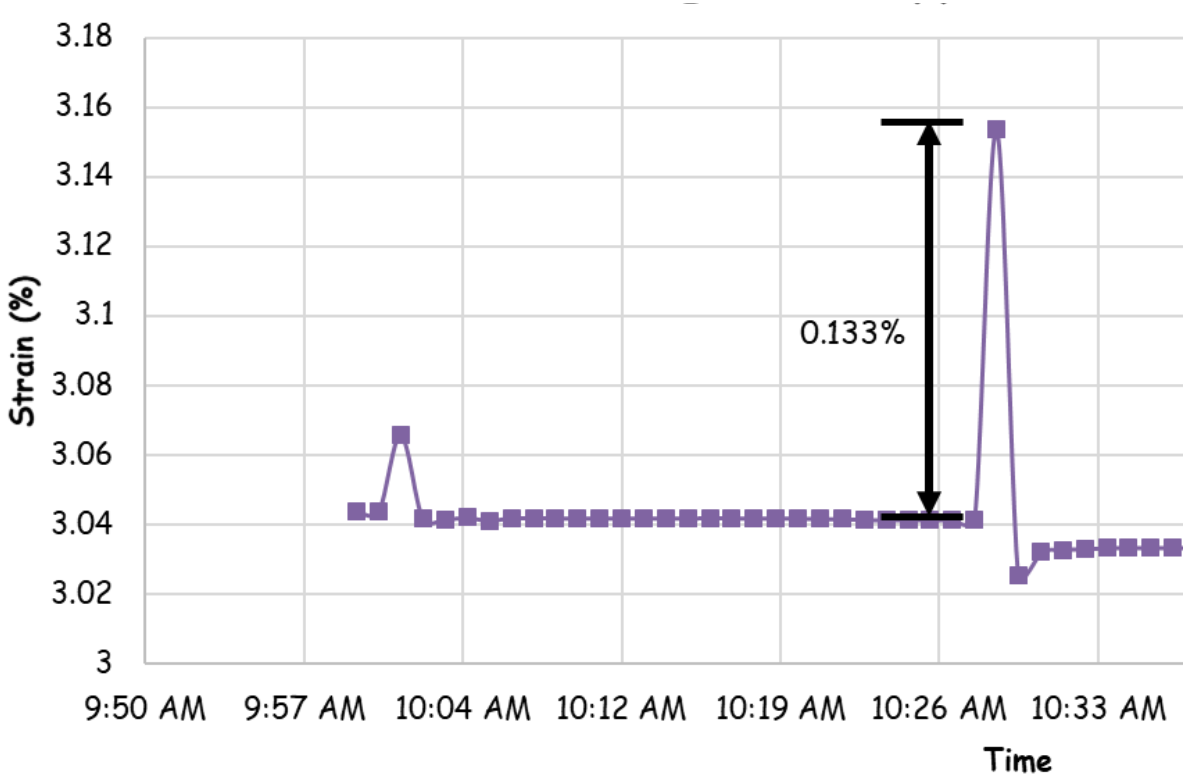
Effects of Geogrid location on Subgrade stress



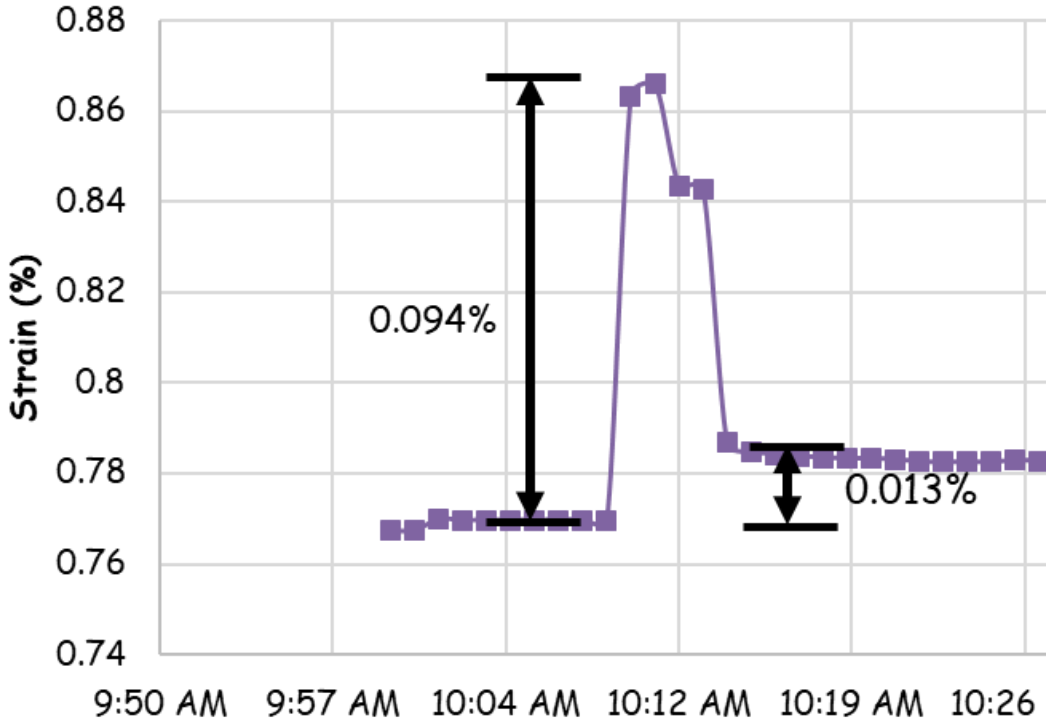


Strains in Geogrids during the water truck test

Section 6 – VW strain gauge



Section 11 – VW strain gauge



0.1 % ~ 0.2 % strain increment in geogrids/geocomposite was measured during this load test

Tentative Conclusions:

- In general, geogrids/geocomposits seem to reduce stress applied on the subgrade
- Increase in number of reinforcement layers will further decrease the stress on subgrade
- Geogrid/Geocomposite is more effective in reducing stress when it is placed close to the surface
- A 50 mm asphalt layer has a significant structural capacity (70% of applied stress)

We greatly acknowledge

- Co-authors: Dr Jianfeng Xue (UNSW), Mr Jinjiang Zhong (LCC), Mr Jothi Ramanujam(QDTMR), Dr Jeffrey Lee (ARRB)
- QUT PhD students: Chamara Jayalath, Kasun Kankanamge, Tharindu Abeykoon,
- Logan City Council Construction Team
- GEL Instrumentation and FSG for discounted service

Project Team

- Logan City Council Road Groups
- Queensland Department of Transport and Main Roads (DTMR),
- Australia Road Research Board (ARRB),
- Queensland University of Technology (QUT) and
- University of New South Wales (UNSW)

Queensland Government

Department of Transport and Main Roads

NACOE
NATIONAL ASSET CENTRE OF EXCELLENCE

LOGAN CITY COUNCIL

arrb SHAPING OUR TRANSPORT FUTURE

QUT

UNSW CANBERRA

Winner of 2020 Local Government Managers Australia (LGMA - Queensland) Award for Excellence - Collaboration Category


THANK
YOU