Presentation and Workshop:

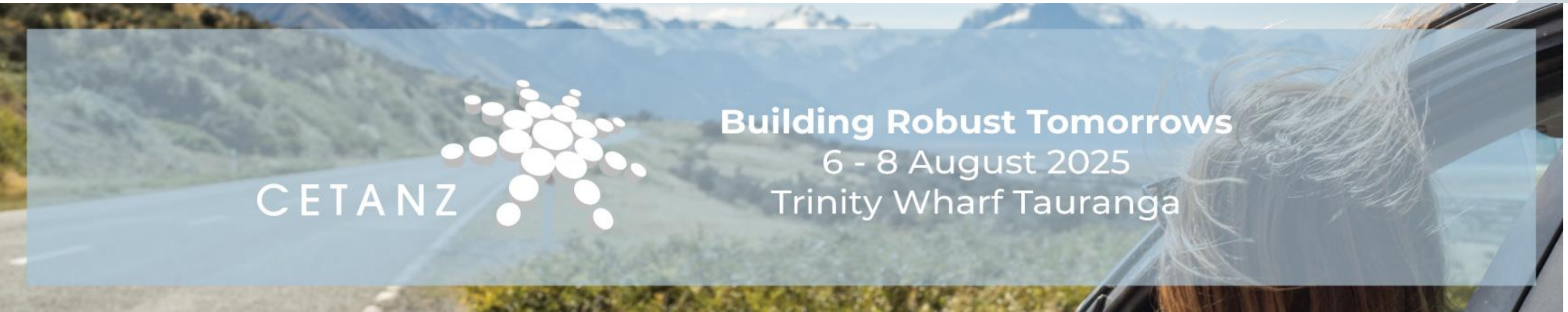
Standardised investigation requirements

&

CBR and DCP testing in pavement investigations

Rob Damhuis

NZTA Principal Pavement Engineer



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NZ TRANSPORT AGENCY

Review of State Highway Pavement Delivery

January 2020

Closing remark in the report:

“Risk could only be managed by reducing the probability of failure by

- *achieving accurate characterisation of material properties*,
- adopting *lower risk pavement designs*, and
- a focused attention on the *quality of the construction process.*”

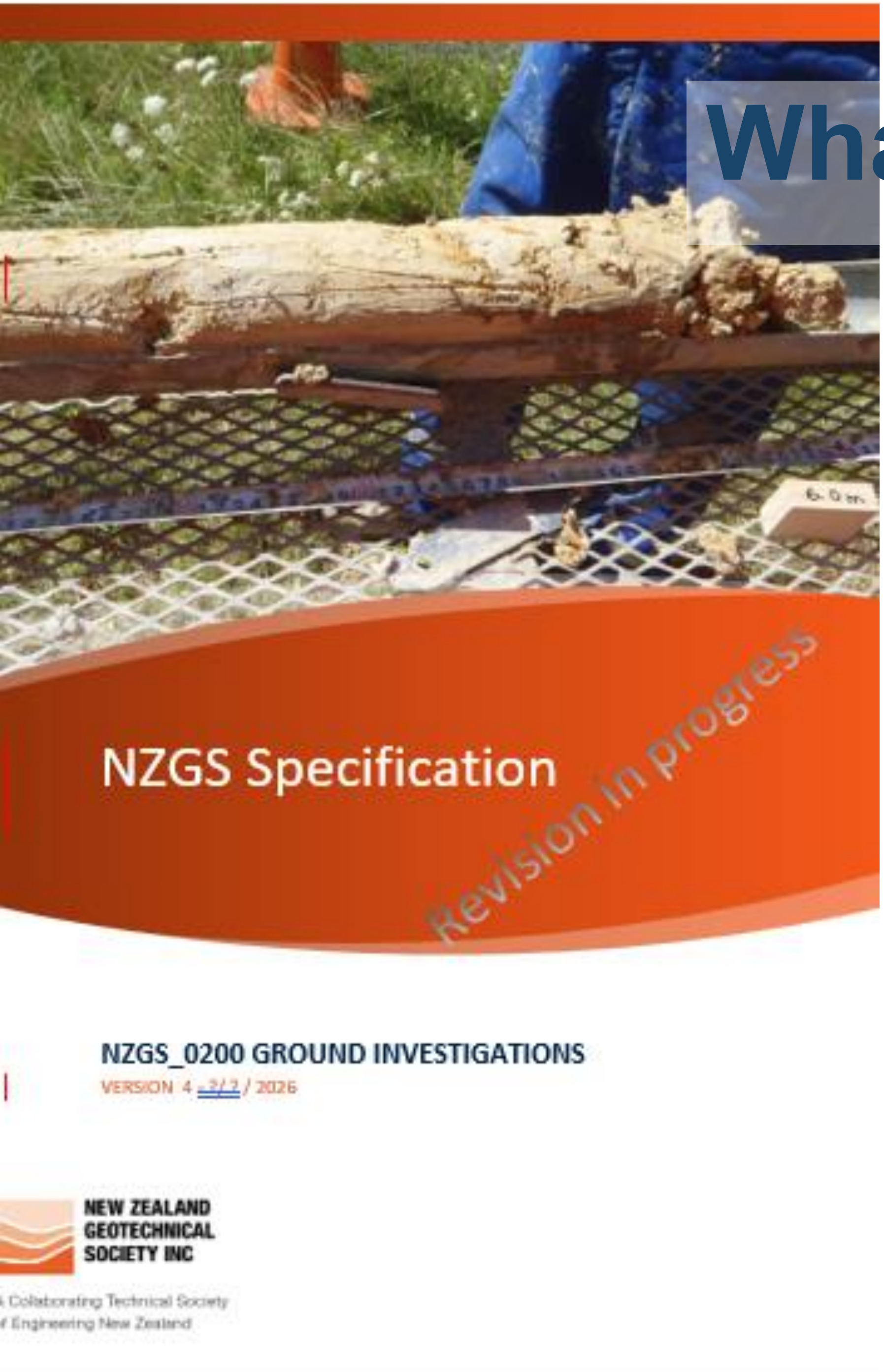
NZTA focus on pavements

Lower-Risk, Cost-Effective pavement designs

- Accurate characterisation of Subgrade Material Properties
  - Crucial for effective road design
  - Influences pavement thickness
  - Affects ultimate pavement performance!
- Uniformity of testing.
- Subgrade's resistance to deformation under load:
  - California Bearing Ratio (CBR) Vs Dynamic Cone Penetrometer (DCP)
  - Materials type: Modulus of subgrade reaction (k-value)
  - Determines design resilient modulus (MR).

What this means for laboratories

Specification with requirements



- New Zealand Ground Investigation Specifications
- Specification - not a guide.
- Standardised conditions and requirements:
  - Volume 0 - General advice: use of spec & procurement
  - Volume 1 – Master Specification: Minimum requirements for commonly used techniques.
  - Volume 2 - Project Specific Requirements – ***new version for roads***
  - Volume 3 - Bill of Quantities: Standardised.

NZGS /. NZTA Specifications

Standardised requirements for pavement investigations

- New standardised template agreed by NZGSs
  - Link to NZTA PDS Investigation & Testing minimum requirements
  - Standardised Schedule of Quantities
- NZTA driven in conjunction with
  - NZGS / NPTG (Drafting by Rob D [NZTA]);
  - CETANZ; and
  - Other Stakeholders
- Estimated completion: Late 2026.

New Zealand Ground Investigation Specification

Volume ? - Project Specific Requirements: Pavement Investigations

Document No. TBC

Revision 0

April 2026

Revision / new document starting soon

Contents

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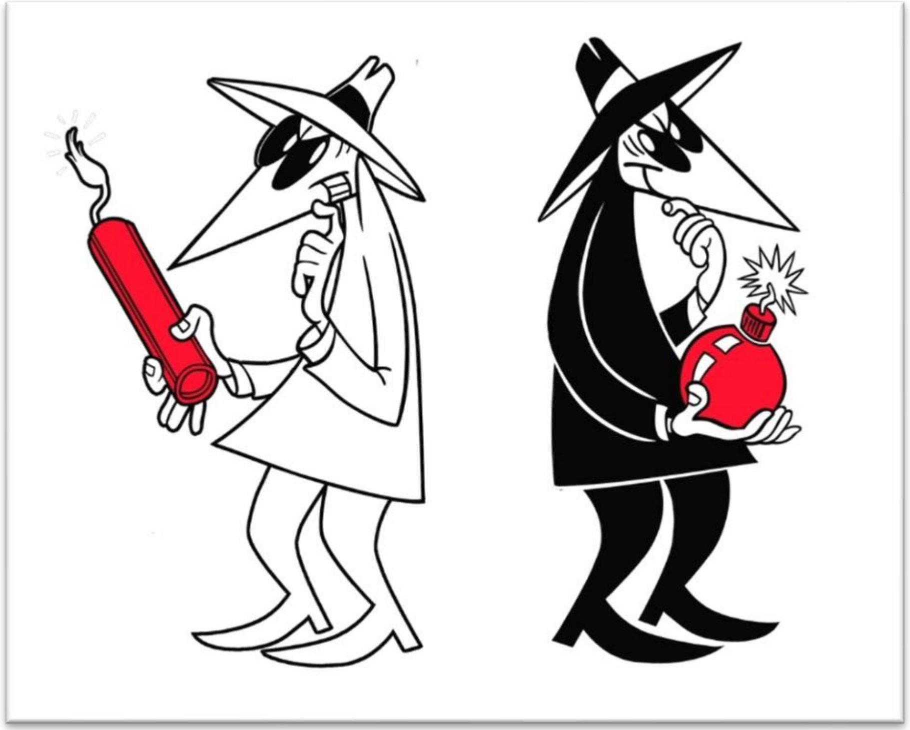
What this means for Laboratories

ISO/IEC 17025 conditions to align with NZTA Z01 & Z08



- 4.2 Confidentiality
  - Amendments to the confidentiality clauses to align with Z01 and Z08.
  - All testing data, whether conforming to contract requirements or not, to be *simultaneously* made available to Contractor, MSQA (or equivalent), and the Principal.
- This means that the lab will need to disclose this to their ‘customers’ undertaking work for NZTA.
- Intended consequence: Less bullying and illicit behaviours.
- Unintended consequences: ??

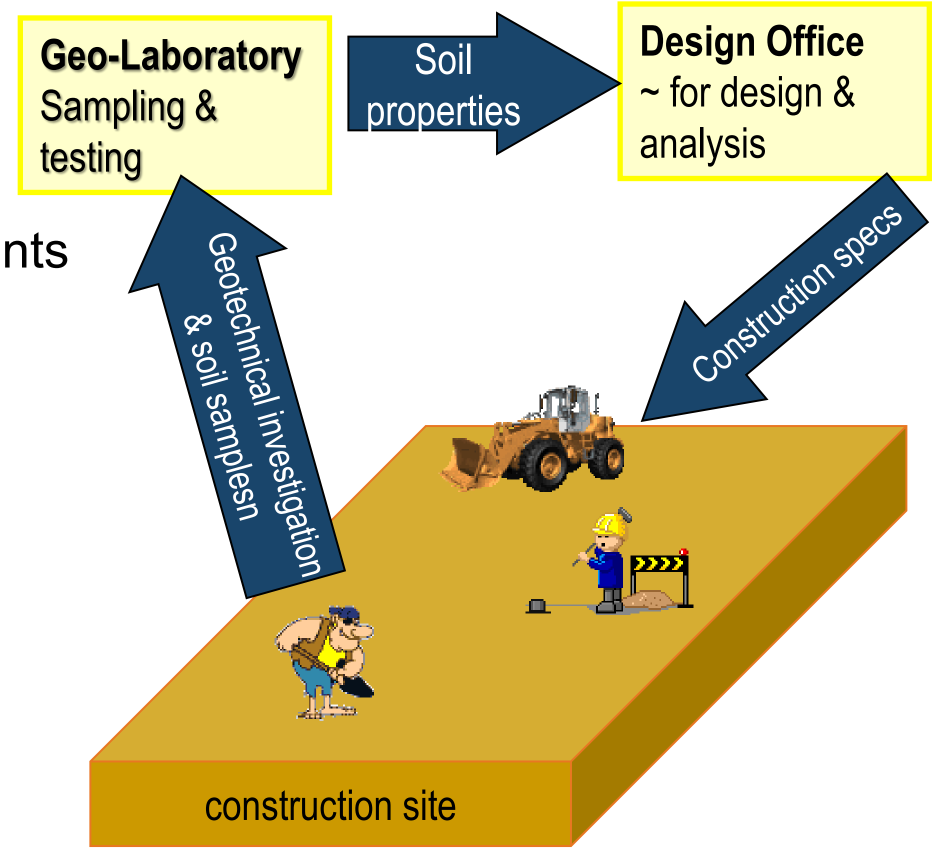
Subgrade Test pits data

NZTA AMDS

- Test pitting becoming more complex by the day, therefore data is critical.
- Standardised structure for consistency of data collection
- AMDS Standard for Test Pits
  - Soil description
  - PSD: D60, D30, D10, 0.075mm
  - Atterberg Constants: LL, PL, PI
  - DCP @ 50mm intervals
  - Shear Vane test, each value, self-calc of mean.
  - CBR (Unsoaked & Soaked), %MC, CBR%, DD, Swell

Summary of testing requirements

- NZGS / NZTA specs:
  - Transparency of contracts and conditions
  - More accurate descriptor of ‘customer’, and requirements
  - Standardised sampling & Testing requirements (TBD)
- AMDS for test pits
  - Test pit data to be stored for future usage.

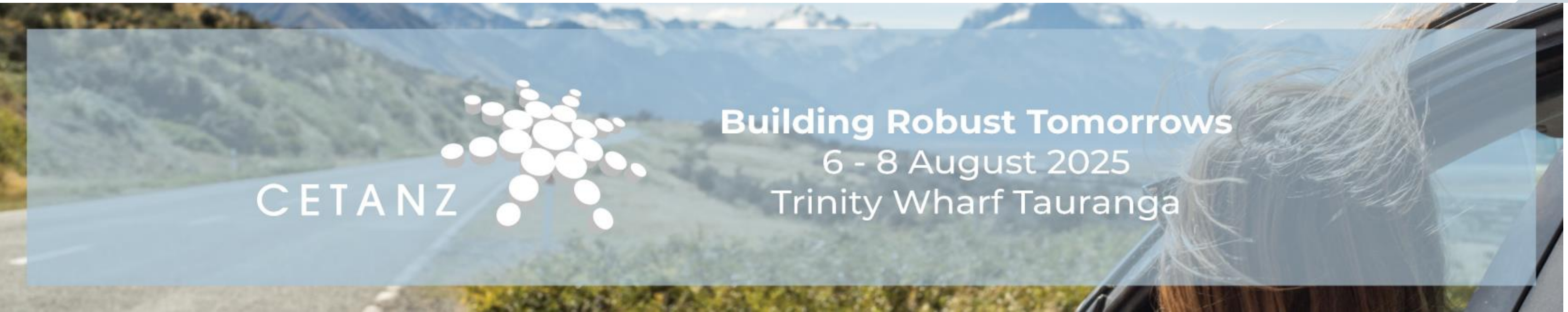


Something for lab techs to remember:

Materials is a specialised engineering field that lays the foundation for good design and construction.

CBRs & DCPs

Workshop



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NZTA focus on pavements

More accurate characterisation of Subgrade Material Properties

Subgrade's resistance to deformation under load:

- California Bearing Ratio (CBR)
  - Poor Repeatability & Reproducibility
  - Usually undertaken to determine:
    1. Subgrade cover, normally CBR<10 in NZ.
    2. Material's suitability in pavement layers.
- Dynamic Cone Penetrometer (DCP)
  - Poor Repeatability & Reproducibility
  - Usually undertaken to determine:
    1. Subgrade cover, normally CBR<5 in NZ.

"All my decisions are well thought out."

California Bearing Ratio (CBR)

CBR Working Group

- Review of recent NATA vs NZ PT/ILC Tests

NATA Programme	No. Results	Median $CBR_{2.54mm}$ Value (%)	Percentage within ±10%	Percentage within ±20%	Percentage within ±30%	Percentage over ±30%
710	49	8	20	35	45	55
396	32	18	30	45	50	50
453	50	22.5	15	35	40	60
607	58	50	20	40	55	45
695	43	113	15	40	55	45
457	38	140	30	40	55	45
CETANZ or Member Programmes	No. Results	Median CBR2.54mm Value (%)	Percentage within ±10%	Percentage within ±20%	Percentage within ±30%	Percentage over ±30%
2022 Ash	15	3	27%	47%	53%	47%
2020 Ash	15	9	53%	61%	99%	1%
2024 Silty Sand	14	14.5	29%	50%	50%	50%
2024 Sand /Silt	10	25	40%	60%	20%	80%
2020 Agg	12	70	38%	54%	77%	23%
2024 AP40	19	95	16%	16%	26%	74%

SIGNIFICANT DESIGN THICKNESS RISK

FAIR SIL NC RISK

FAIR DESIGN THICKNESS RISK

FAIR SIL NC RISK

SIGNIFICANT PASS/FAIL RISK

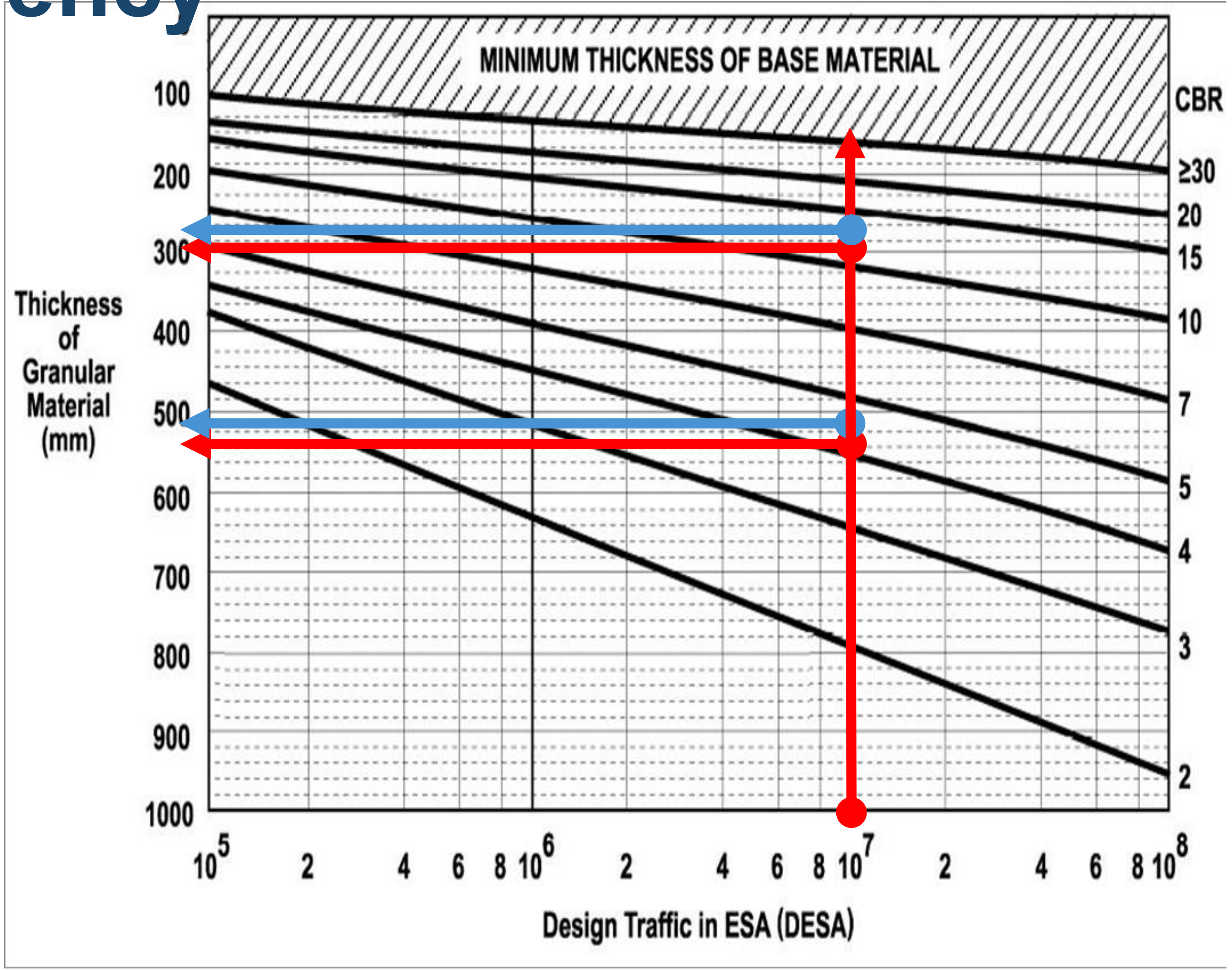
NATA vs NZ Proficiency

10 Million ESAs on AGPT02

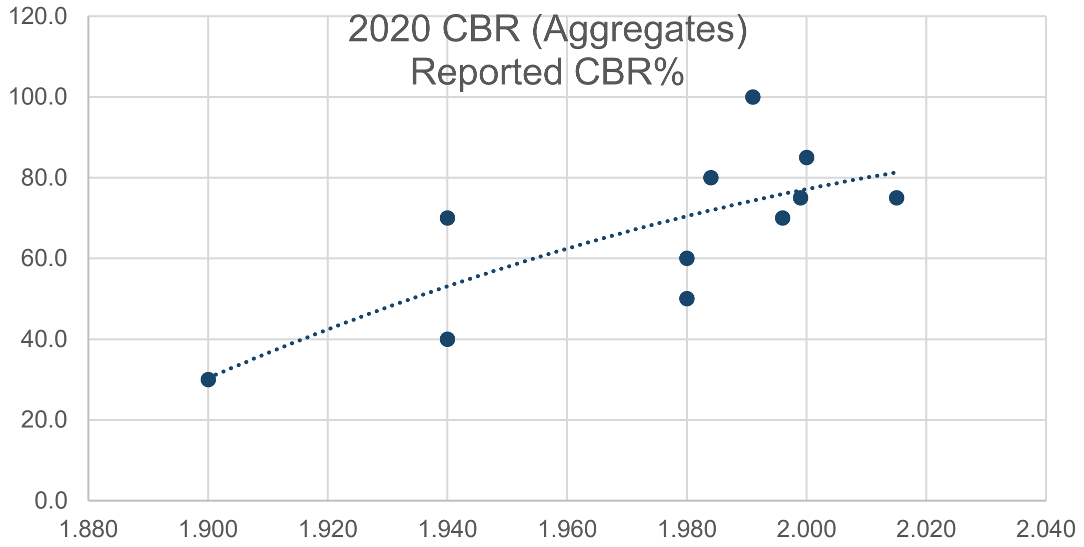
Fig 8.4 Design thickness using tested <u>Soaked CBR</u>:

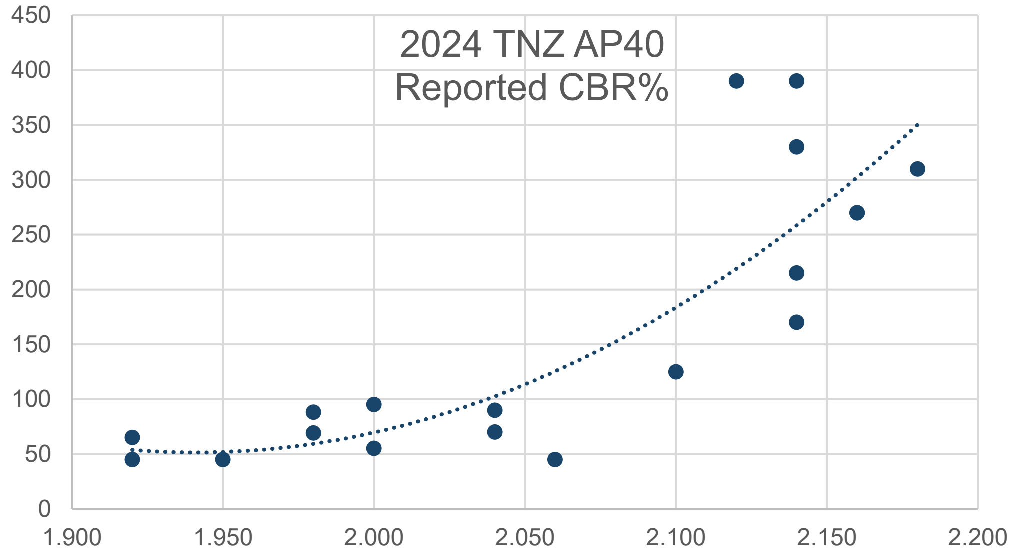
- (50% higher or lower than median)
- NATA (Median CBR 8%)
  - CBR 4% : 540mm
  - CBR 12% : 300mm
- NZ (Median CBR 9%)
  - CBR 4.5% : 280mm
  - CBR 13.5% : 540mm

Potential difference of ±260mm.



NZ PT/ILC: Medium to high Soaked CBRs

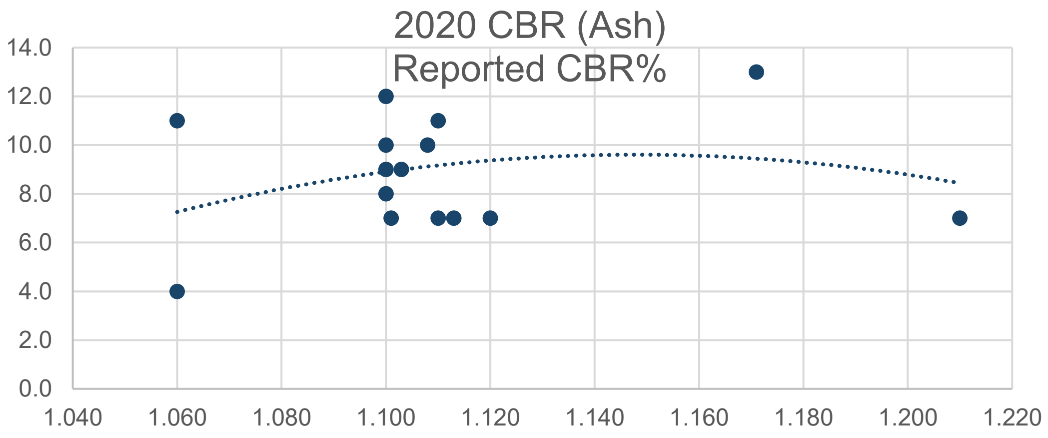


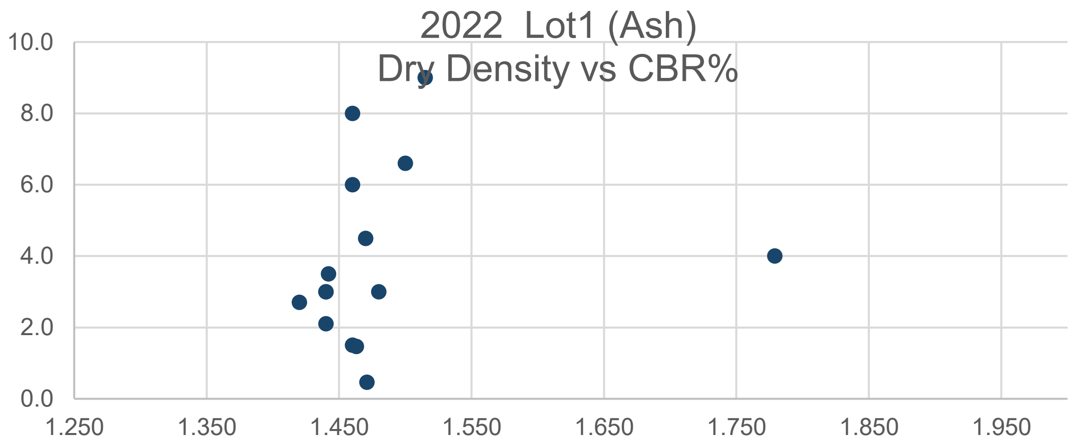


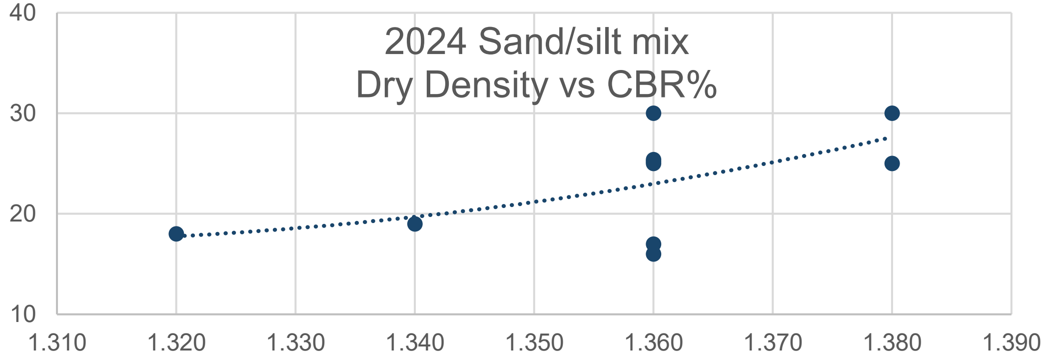
- Observations:
  - High variability in density and therefore CBR
  - Good DD:CBR increase trends
- Points to ponder in workshop
  - Have these all be compacted at same %MC? If so, what happened?
  - What other issues?

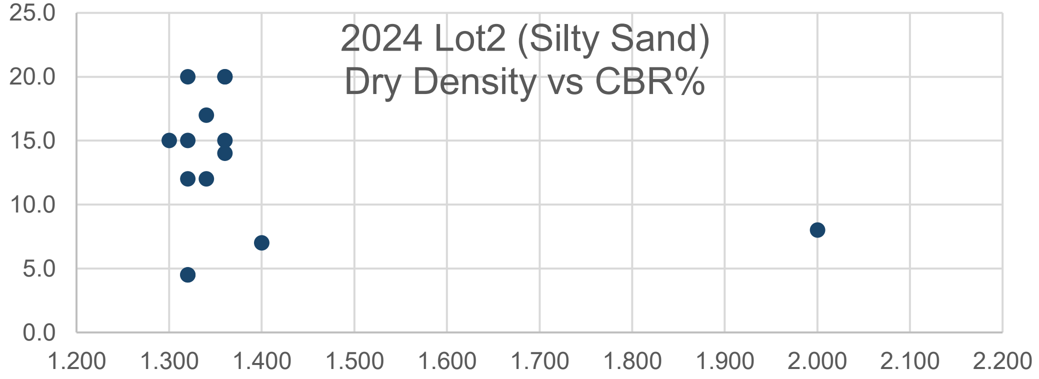
What's the problem?

NZ PT/ILC: Low to medium Soaked CBRs (0% to 30%)









Observations:
- Unclear trends in density and CBR.
- Unclear if compacted at same %MC

How to improve?:
- Test method issues?
- ???

NZTA Subgrade research to determine

Geotechnics Hamilton

Aims

- NZTA / TNZ research reports indicate best compaction MC is >80% DOS.
- Produce standardised CBR valuesfor pavement design for problematic materials.
  - Pumiceous silty sands
  - Silty clay ash mixes
  - Expansive soils
  - etc

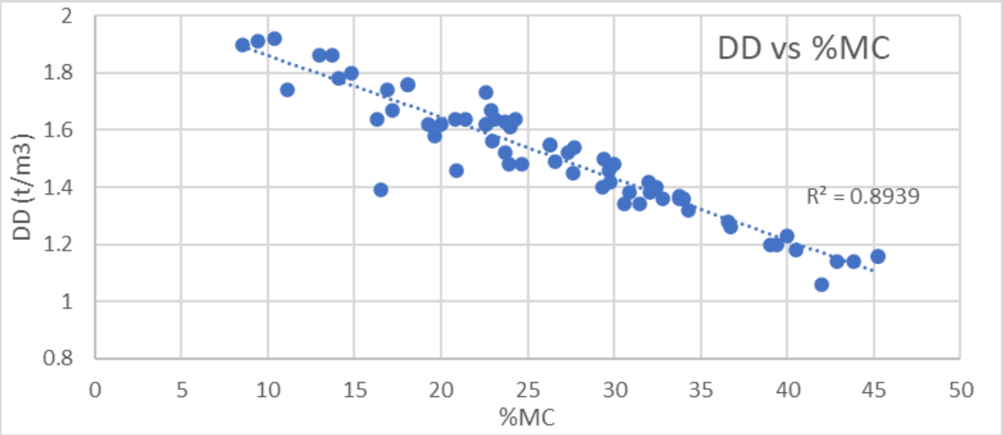
Subgrade CBR test records

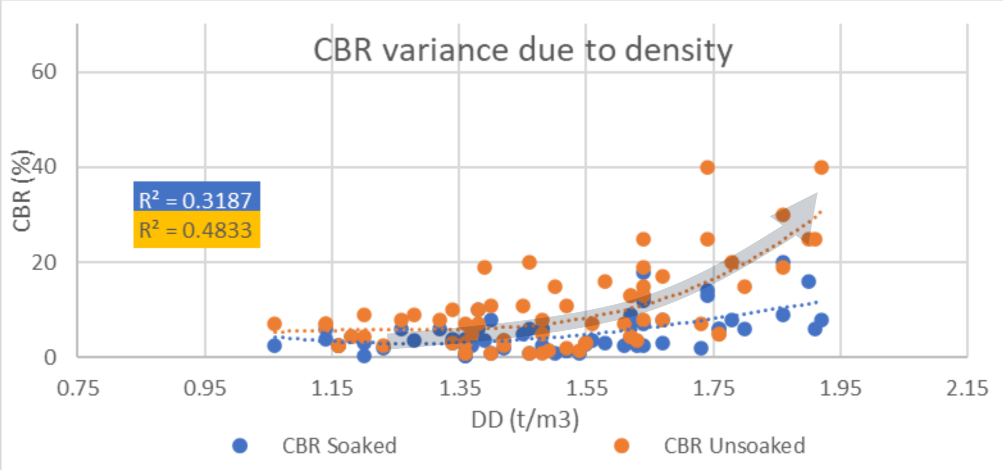
N.I Clays, Silty clays, Clayey Silts & Sandy clays Clayey sands

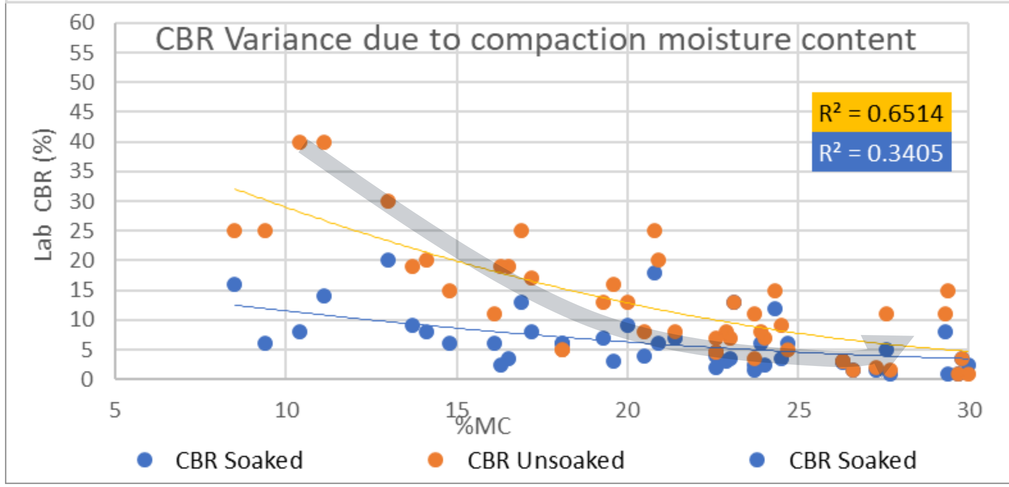
- Trends only: Not from a single source so inherent variability, however….
- MDD vs %MC: Good trend (R^2 = 0.89)
- CBR vs DD:
  - As the density increases, so does the CBR whether Unsoaked or Soaked.

  Each sample has Soaked & Unsoaked CBR.
- CBR vs %MC:
  - Both Unsoaked and Soaked CBRs have a similar trend, but the Soaked CBR reduces from 15% to 2%.

This is the expected trend…







N.I Clays and clay mixes

10 Million ESAs on AGPT02

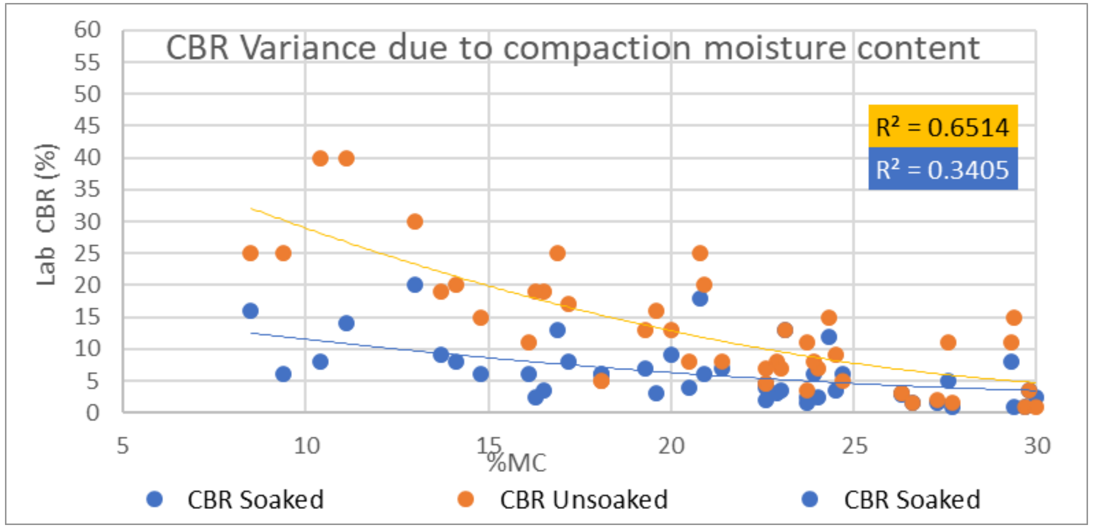
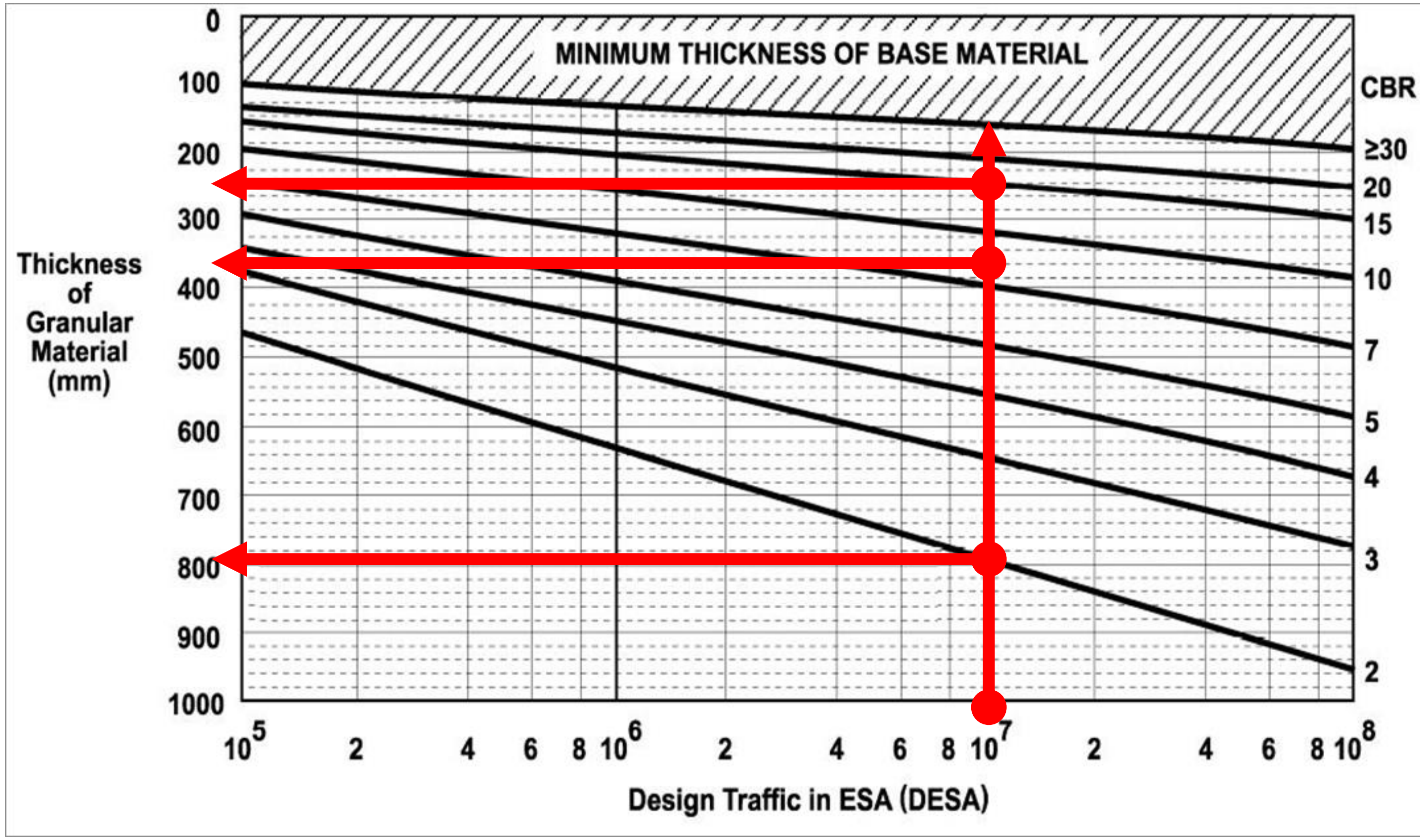


Fig 8.4 Design thickness using tested <u>Soaked CBR</u>:

- CBR 2% @ 90-120% DOS: 800mm
- CBR 8% % @ 85-100% DOS : 350mm
- CBR 15% % @ 75-80% DOS : 250mm

Potential difference of ±500mm.



Otorohanga Silty Clay

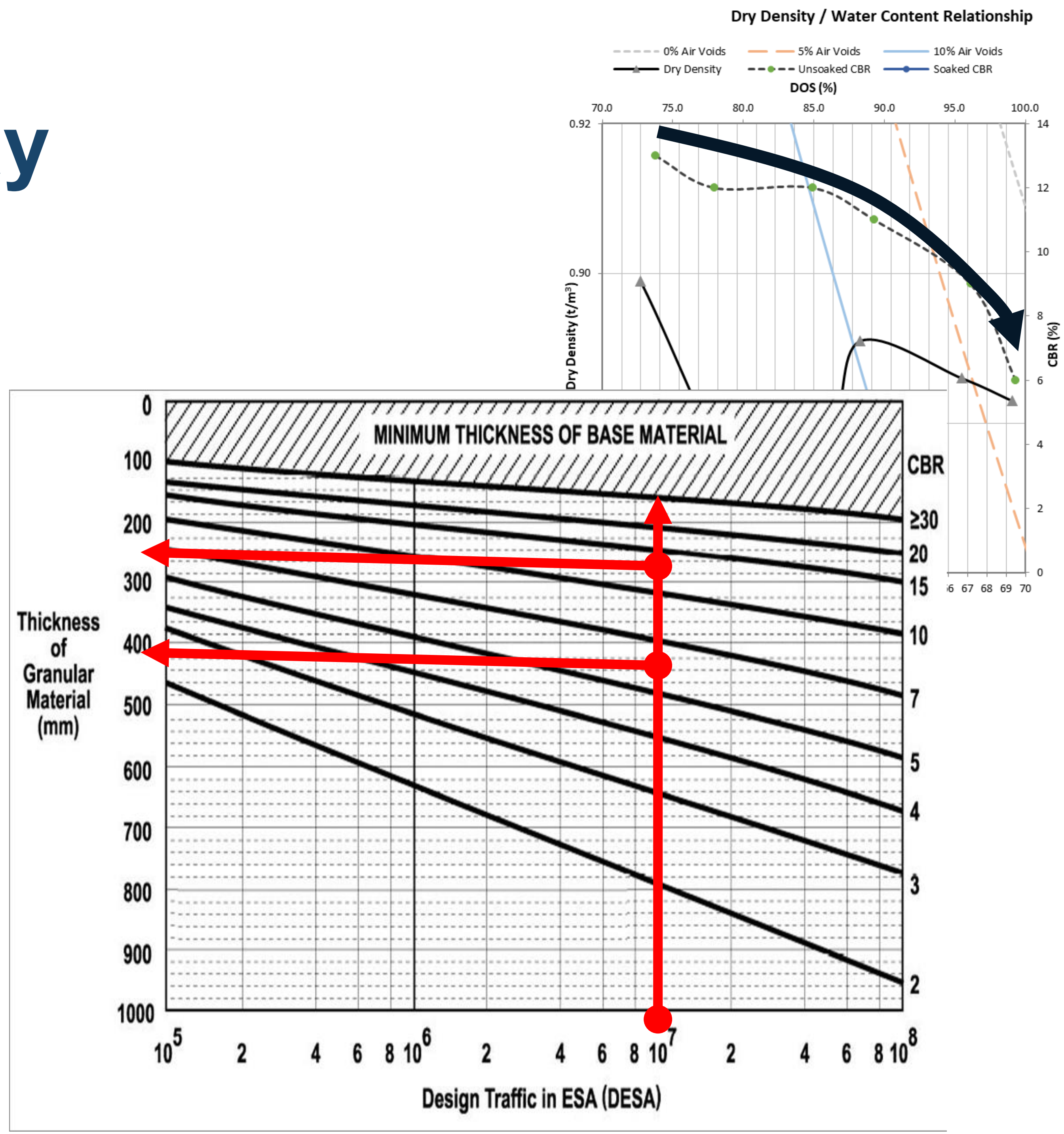
Geotechnics Hamilton: Small pilot test

- MDD curve maybe problematic, but Unsoaked CBR trend shows great picture:
- Max CBR at lower moistures contents
- Rapid reduction in ‘strength’ with moisture increase

Fig 8.4 Design thickness using tested <u>Unsoaked CBR</u>:

- CBR 6% @ 99% DOS: 440mm
- CBR 9% % @ 90% DOS : 340mm
- CBR 12% % @ 85% DOS : 280mm

Potential difference of ±160mm.



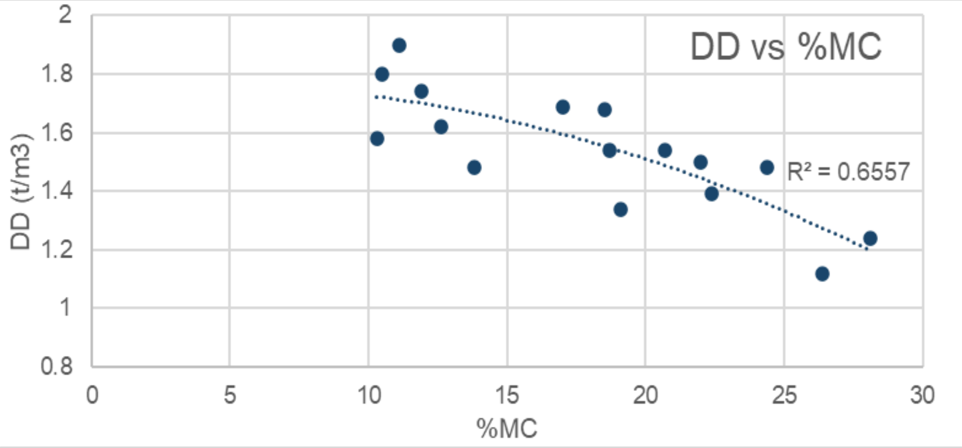
Subgrade CBR test records

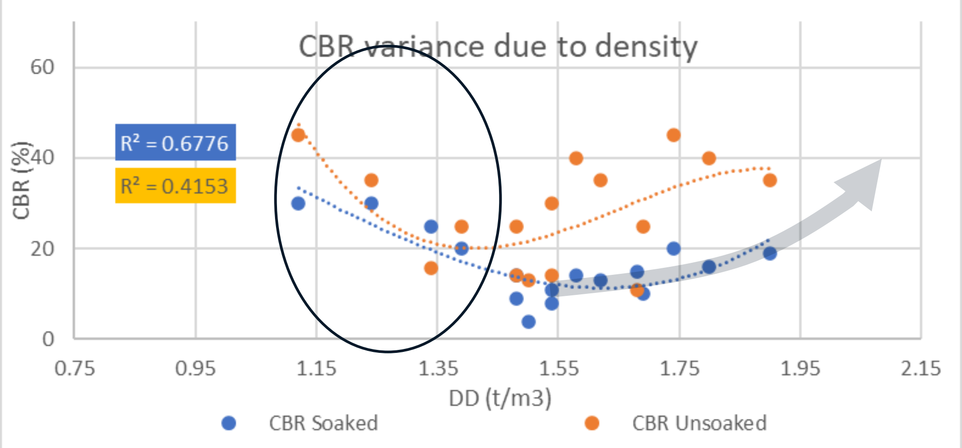
Fine-grained Pumiceous Silts, Silty sands & Sandy silts

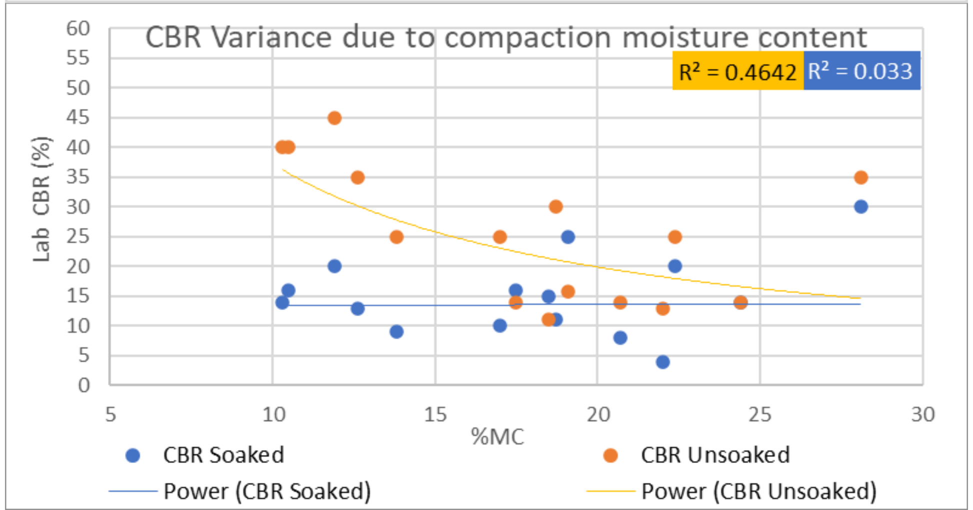
- Trends only: Not from a single source so inherent variability, however
- MDD vs %MC: Good trend (R^2 = 0.66)
- CBR vs DD:

  Each sample has Soaked & Unsoaked CBR.

  - Pumice is collapsable therefore drop in CBR at collapse density, & increase thereafter (my hypothesis)
- CBR vs %MC:
  - Max Unsoaked CBR seems to be at, or just under OWC in most materials.
  - For Soaked CBR ???



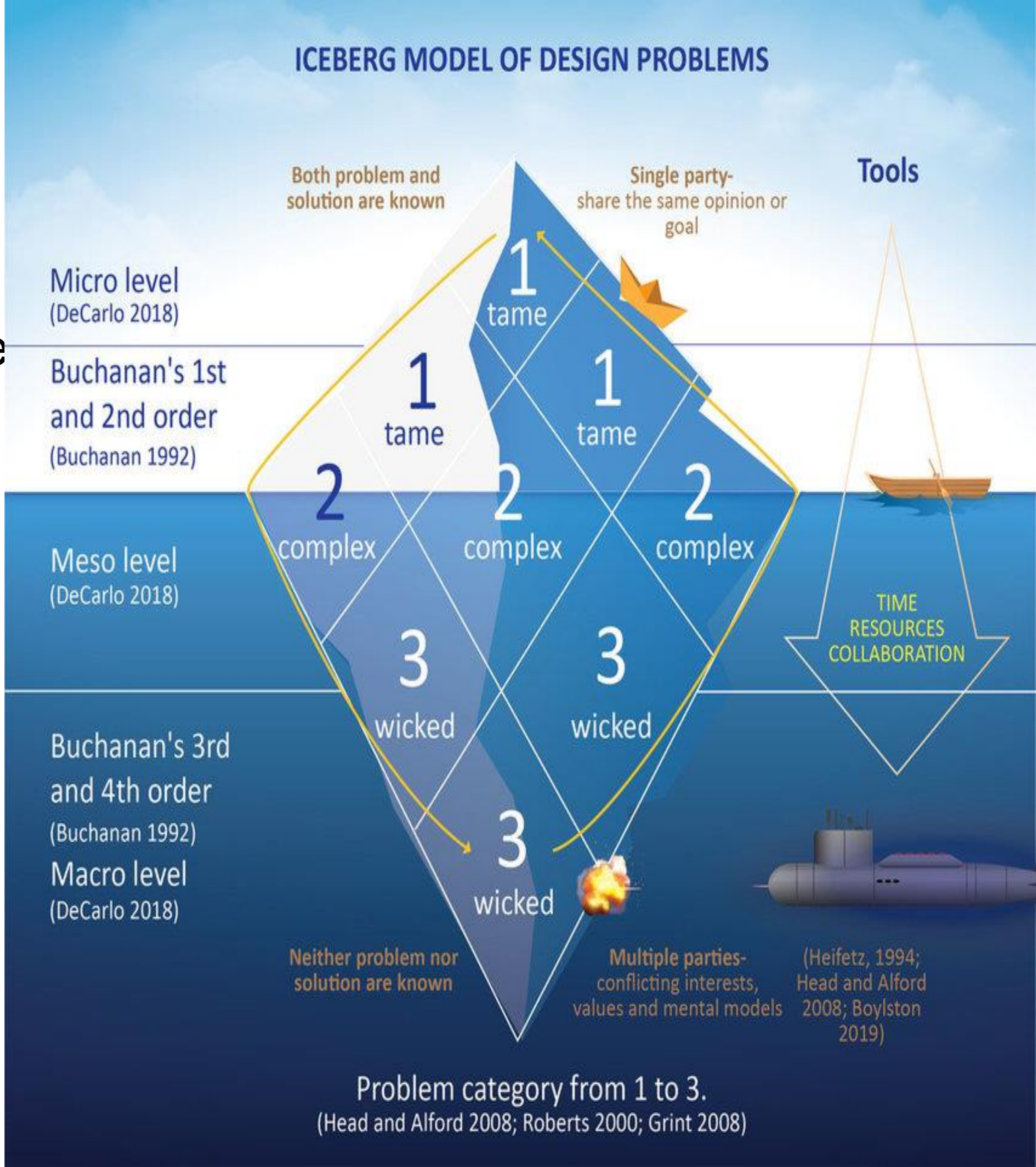




Summary

CBR

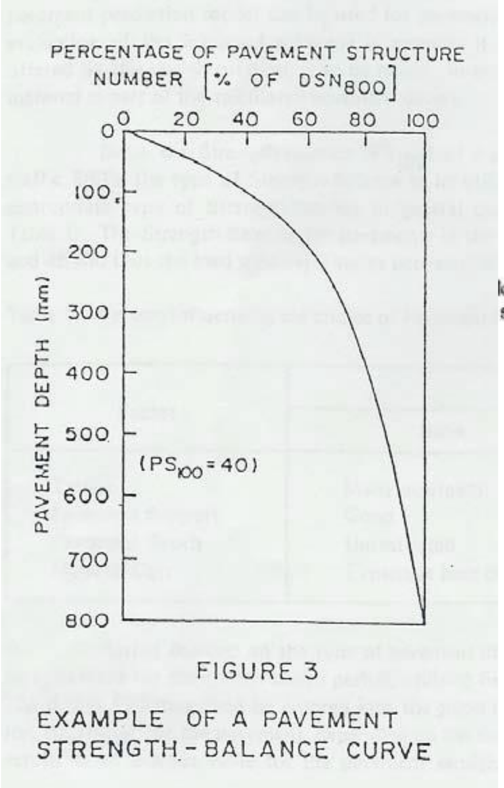
- Highly variable, even in PT/IL scheme
- Is it because of:
  - Instructions unclear?
  - Quartering issues?
  - Material variability in samples?
  - Training & competence?
  - Lack of understanding of soil science?
  - ???



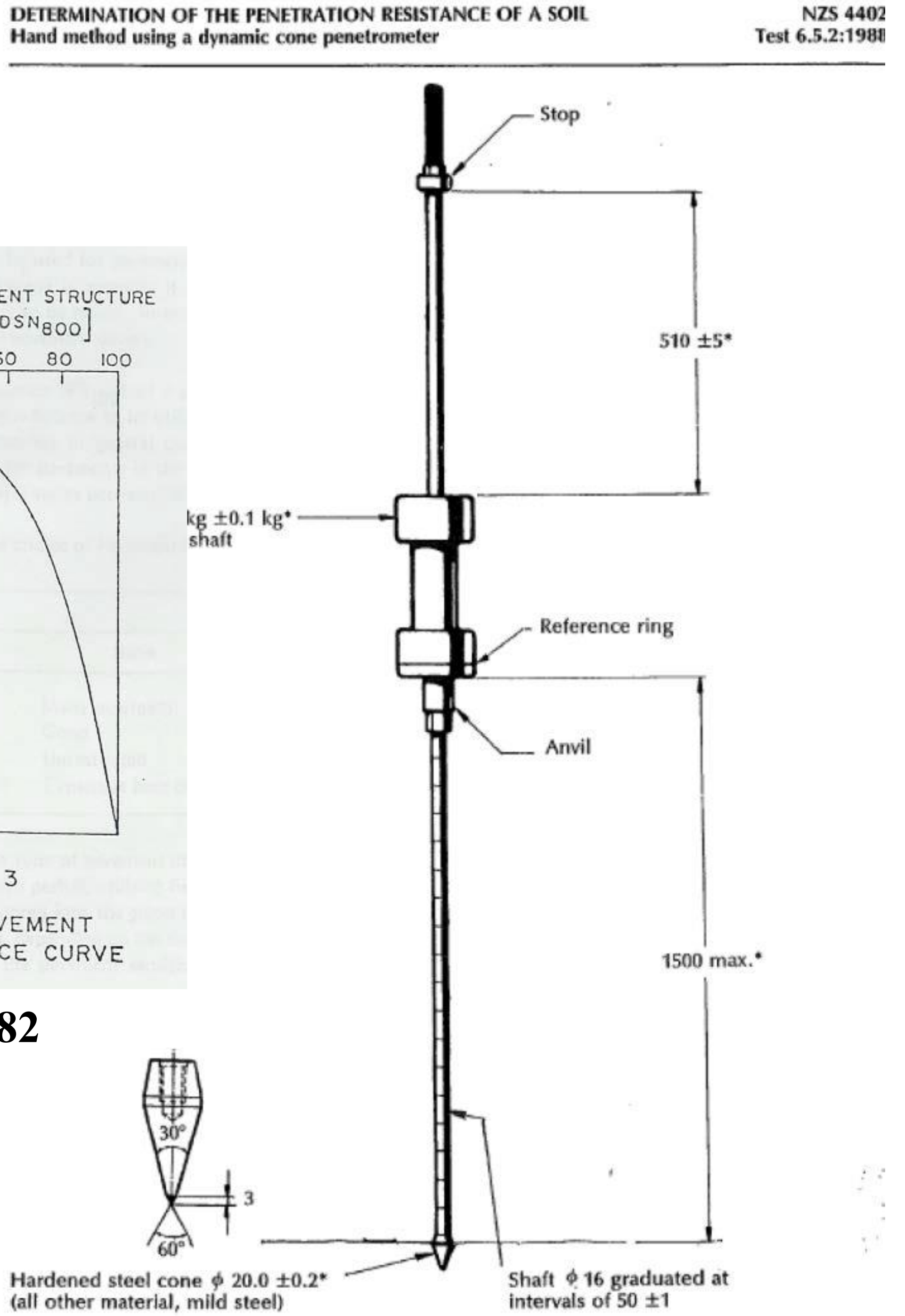
Dynamic Cone Penetrometer (DCP)

Theory

- Underlying soil strength/ stiffness measured by the penetration of the cone into the soil after each hammer blow.
- 1969 – 2000s
  - Multiple comparisons DCP vs CBR.



from Kleyn 1982



DCPs

Standardised calculations used in analysis

- AGPT02 and 05 not clear on algorithm. Found in 2004 version.
- DCP-CBR relationship based on DCP penetration per blow over the tested depth.

  CBR = $324.51*(DN)^{-1.1457}$ **(Eq 6a-1)**

  where:

  - DN = DCP penetration in *mm/blow*

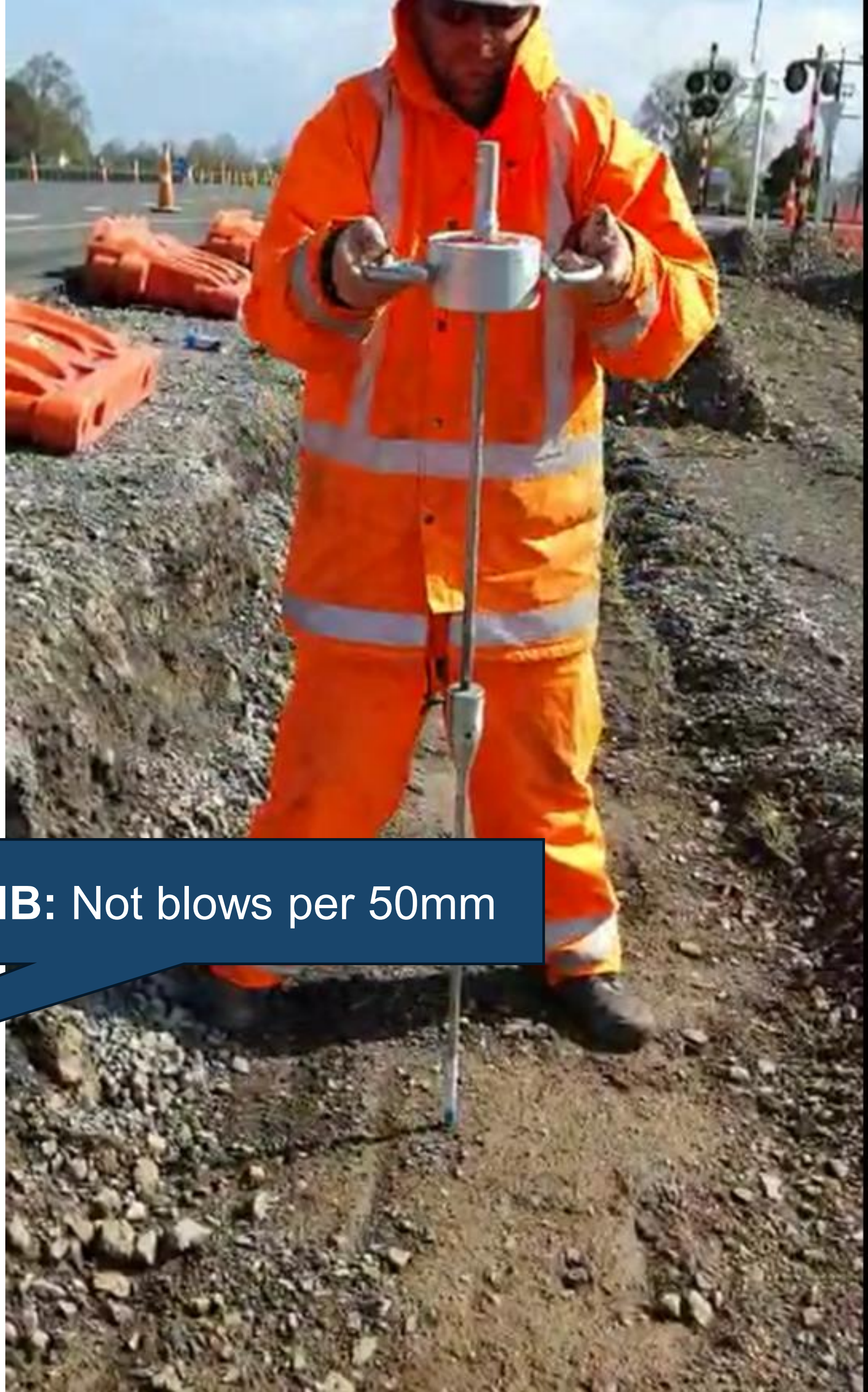
NB: Not blows per 50mm

Unless local correlations:

- RITS Waikato: Hamilton Sand & Silt mixes (eg pumiceous silts)

  CBR = $25.697*(DP\ \mathit{cm/blow})^{-0.999999}$

  Where: DP is average *cm/blow* for the top 300mm (excluding 50mm)



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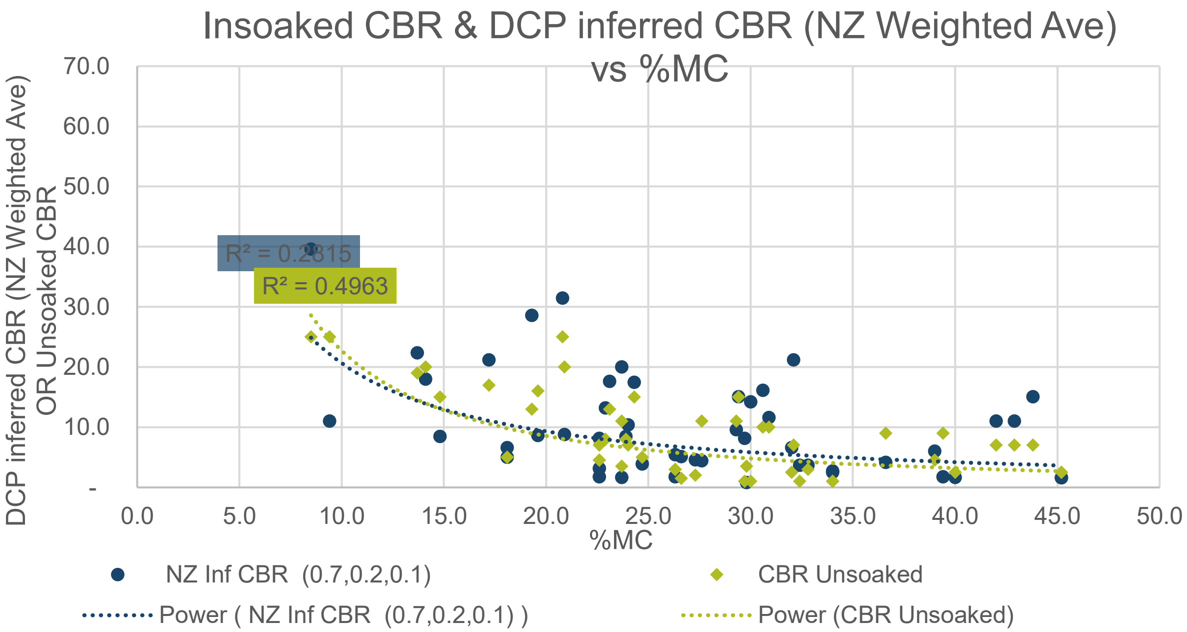
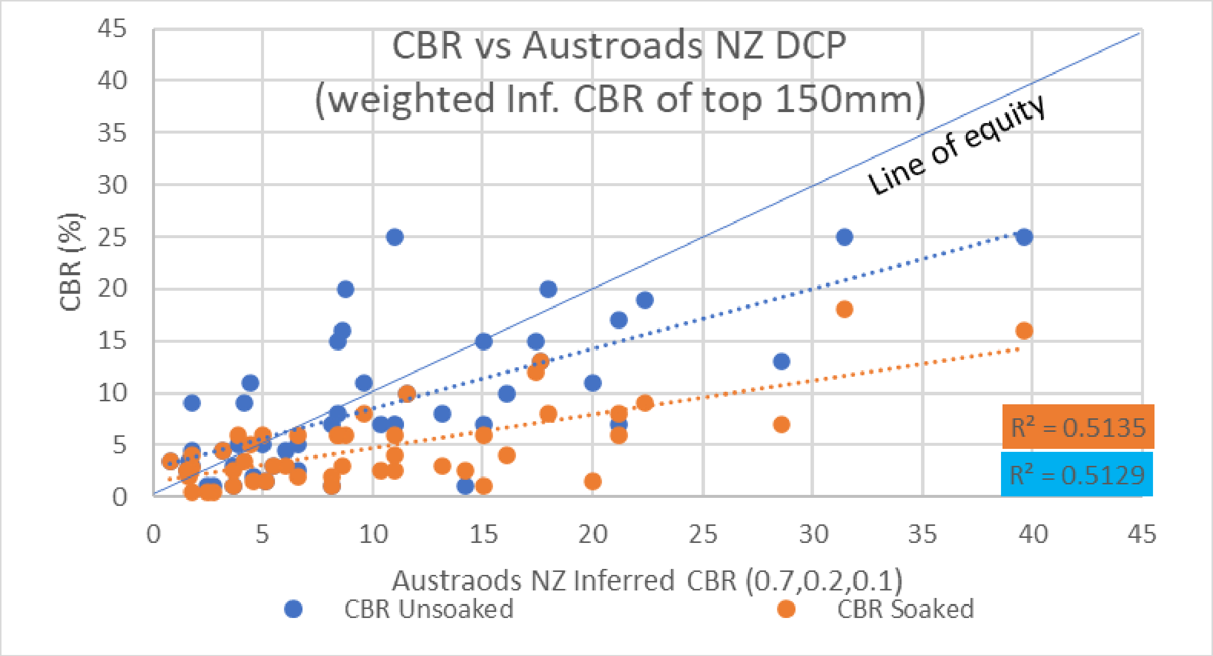
Subgrade DCP tests

N.I Clays, Silty clays, Clayey Silts & Sandy clays, Clayey sands

- Trends only: Not from a single source so inherent variability, however….
- Each sample has DCP Inferred CBR & Unsoaked CBR.
- CBR & Inf CBR vs MC:
  - Similar (?) trends
- BUT, when compared against eachother:
  - Fairly poor DCP Inferred CBR: CBR correlation

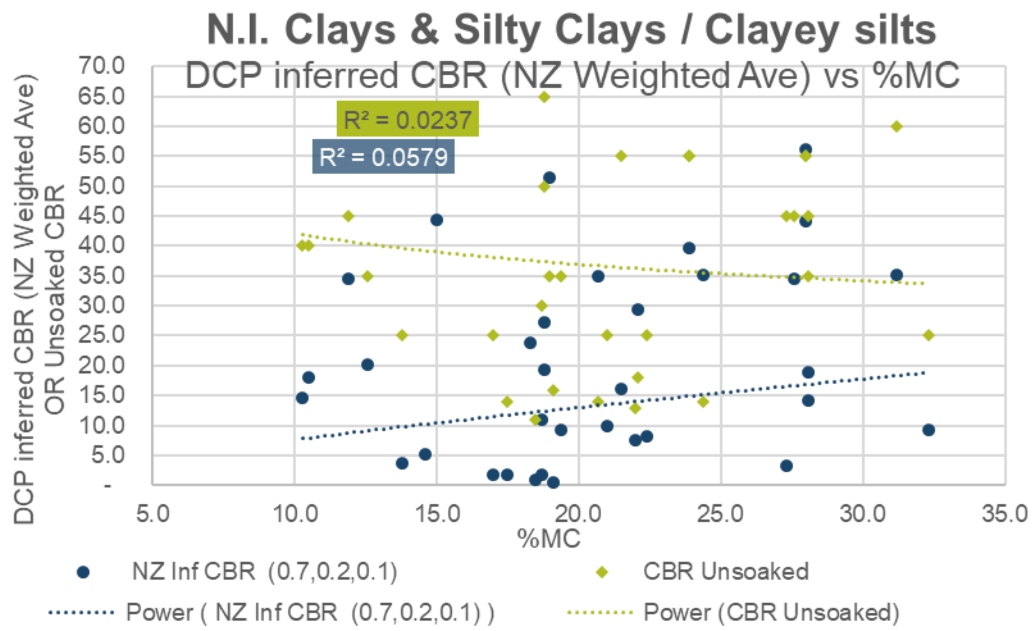


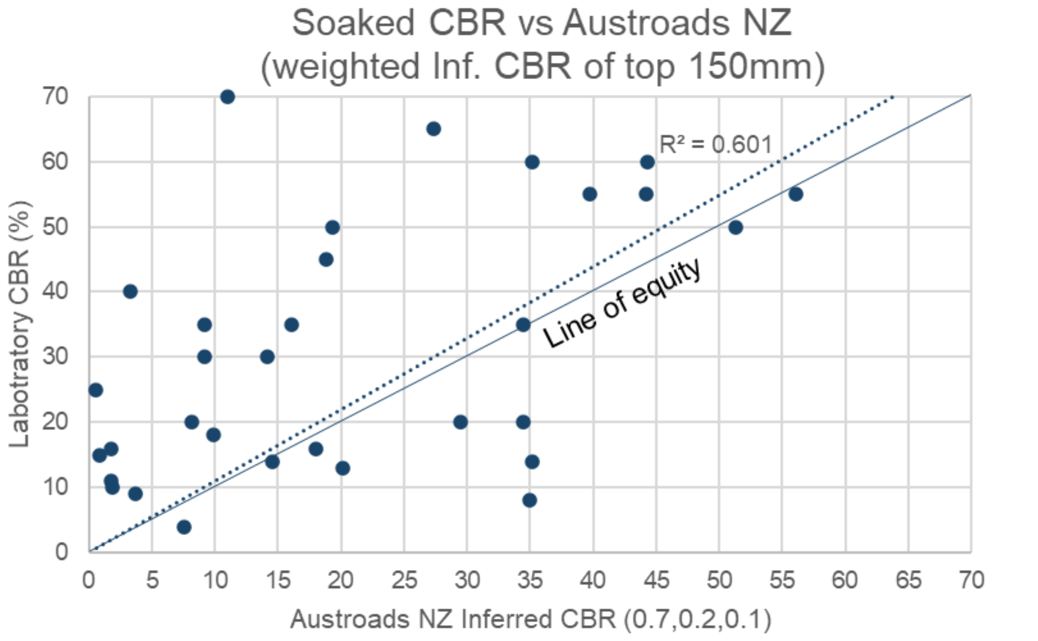


Subgrade DCP inferred CBR tests

Fine-grained Pumiceous Silts, Silty sands & Sandy silts

- Same set as previous CBR graphs
- Each sample has DCP Inferred CBR & Unsoaked CBR.
- CBR vs %MC: ??
- DCP Inf CBR relationship to Soaked CBR….?
- Is RITS relationship any better?





Summary: DCP

- What / how do we improve this?
  - Method?
  - Additional testing? Eg %MC
  - Reporting DN rather than blows/50mm?
- Can designers trust the test for design purposes?
  - Determine MR's?
  - Strength uniformity?
- What else can we do?