Procedure To Determine the Plateau Dry Density

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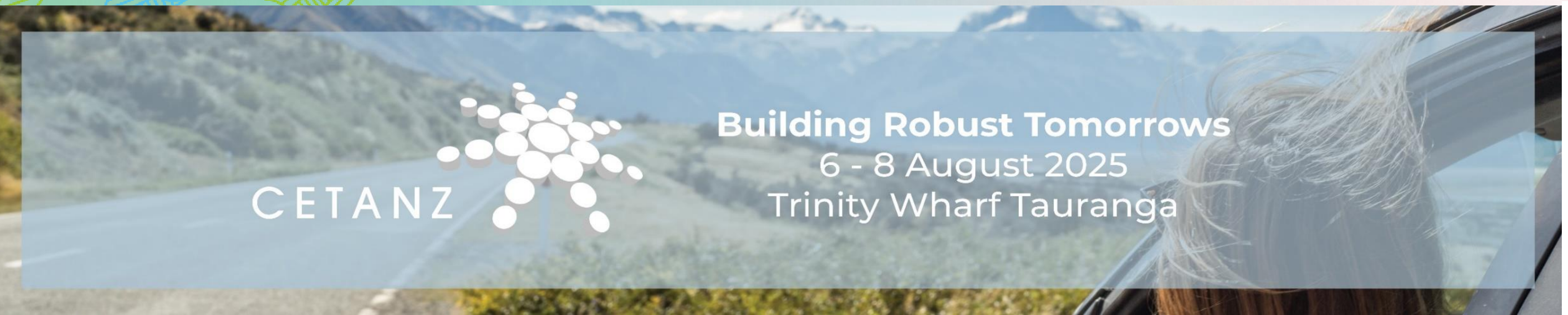


WAKA KOTAHI NZ TRANSPORT AGENCY

Downer

Procedure To Determine the Plateau Dry Density

- NZTA T24 Specification and Notes – The Journey and Questions
- Pavement Layer Density – Why is it important?
- Density Testing – The Process
- Nuclear Densometer – Test Modes
- Backscatter to Direct Transmission
- Density Lot Acceptance – What are we trying to achieve
- Plateau Density Testing – Direct Transmission versus Backscatter

NZTA T24 - The Journey

- 2019/2020: Discovered Lower Layer Compaction issues on a RONS project
- Feb’20: Raised the issue with the NPTG – endorsement to draft NZTA TAN
- May’21: 20th NZTA / NZIHT Pavements Conference, Napier
- Aug’21: CETANZ Conference, Rotorua
- Oct’22: REAAA Roadshow, Auckland, Taupo, Wellington & Christchurch
- May’23: 21st NZTA / NZIHT Pavement Conference, New Plymouth
- Aug’23: CETANZ Conference, Hamilton
- July’25: NZTA T24 issued as part of the IDC tender
- July’25: 22nd NZTA Conference, Christchurch
- July’25: REAAA Webinar
- July’25: Endorsed by NZTA Technical Ratification Group
- Xxx’25: Expected publication on NZTA website

Test of CETANZ member understanding

1. Why do we want to determine the Plateau Dry density?

A. NZTA want to create more work for the field-testing staff?

B. How and if the lab MDD can be achieved in the field?

C. Because there is no trust in what the contractor does?

2. Can the Plateau MDD, and therefore the target be lower than the Laboratory MDD?

A. No way, the laboratory MDD will always be achieved

B. Yes, it can happen, but we don't need to question it

C. Yes, but the pavement designer needs to be involved to determine the reason (investigate anvil, material, moisture, roller size)

Test of CETANZ member understanding

3. Why is Density so important?

A. Increased the strength (stiffness) of the layer

B. Increases the moisture susceptibility of the material

C. Increases the possible DOS

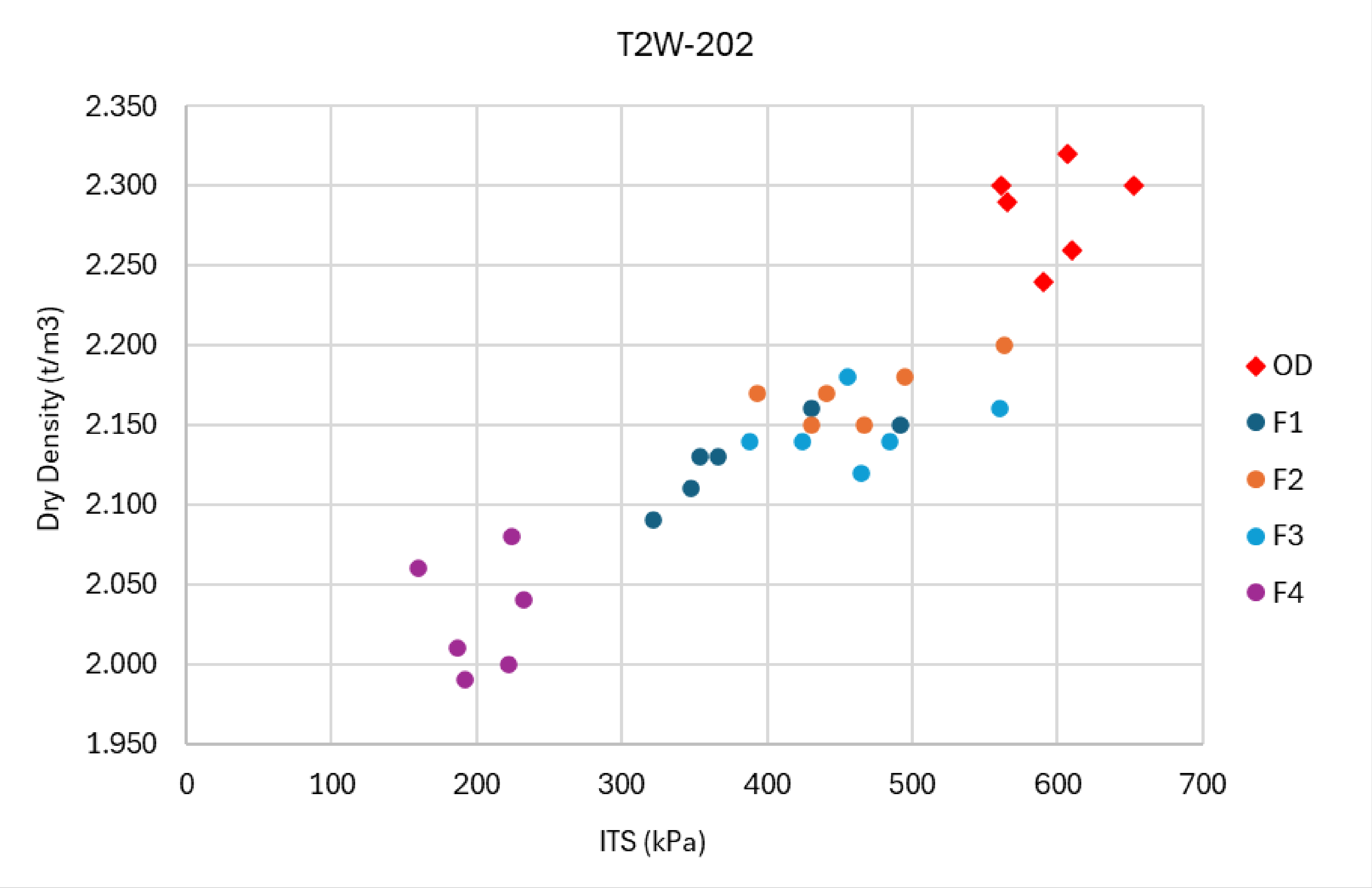
4. Can the DoC be over 100%?

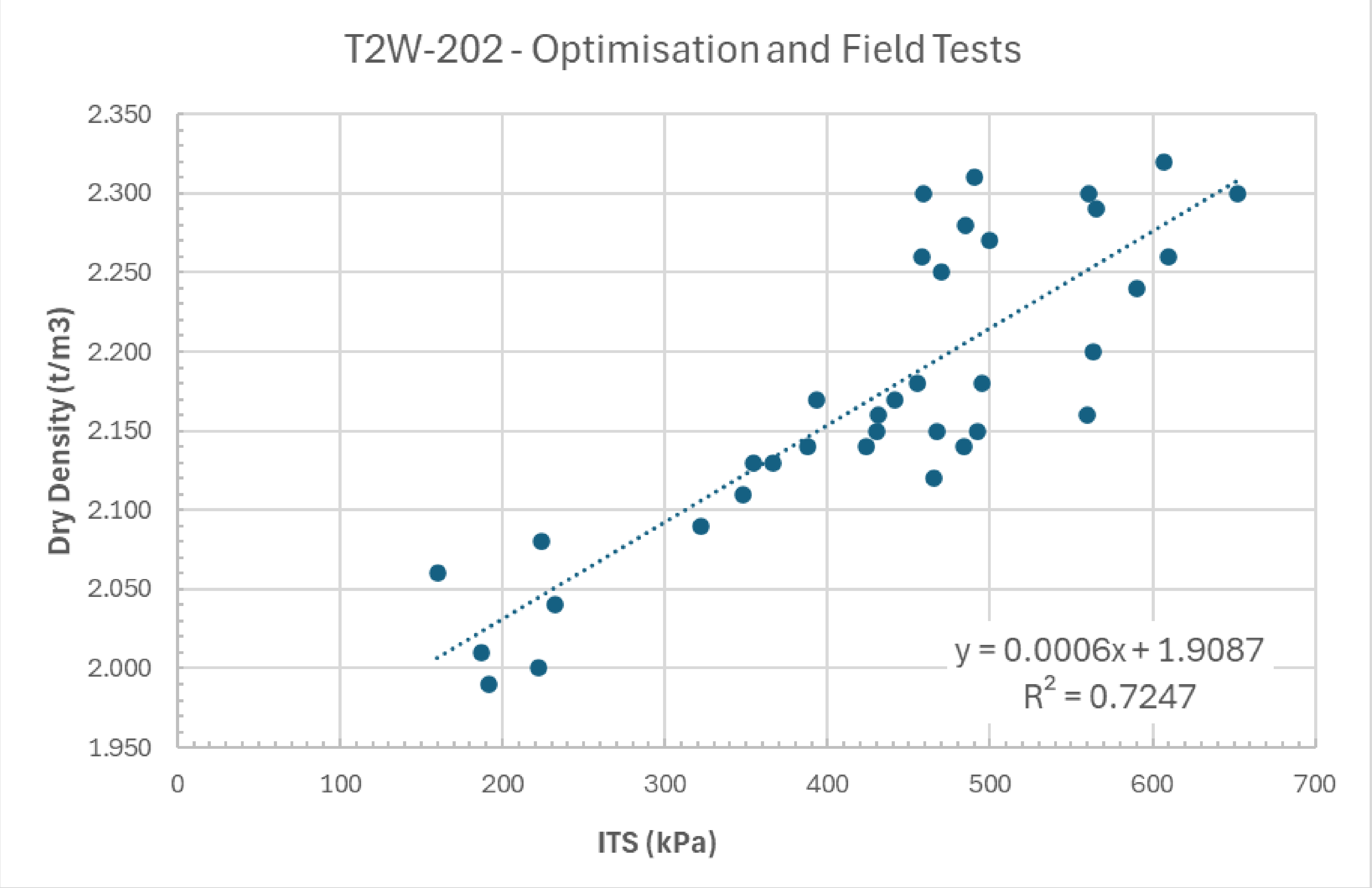
A. No, the MDD is the ultimate maximum

B. Yes, due to variances in particle size distribution it can be possible

Pavement Layer Compaction – Why is it important

- Unbound Granular Layers – Stress dependent and correlation between rut resistance and density of granular / modified granular pavement layers – reduce the shakedown -> reduce early life rut
- Cement Bound Subbase Layers – Relies heavily on density throughout the layer – strength throughout and highest horizontal stress at the bottom of the layer
- Cohesive Subgrade materials - Correlation between strength (ITS/UCS) and Density / MC





Density Targets – Achievable Density – Lot Acceptance

Laboratory MDD

- New Zealand Vibe Hammer Compaction (NZTA T28)
- This provides the initial Target Dry Density for Pavement Layers

Achievable DD

- Material Type
- Layer Thickness
- Underlying Stiffness (Anvil)
- Compaction Equipment
- Compaction Mode (Vibe – Static)
- # of Passes

Target DD

- Higher of the Laboratory MDD and the Plateau DD
- If Laboratory MDD > Plateau DD --> <u>must be accepted by ETC / IA</u>

Plateau DD

Lot Acceptance

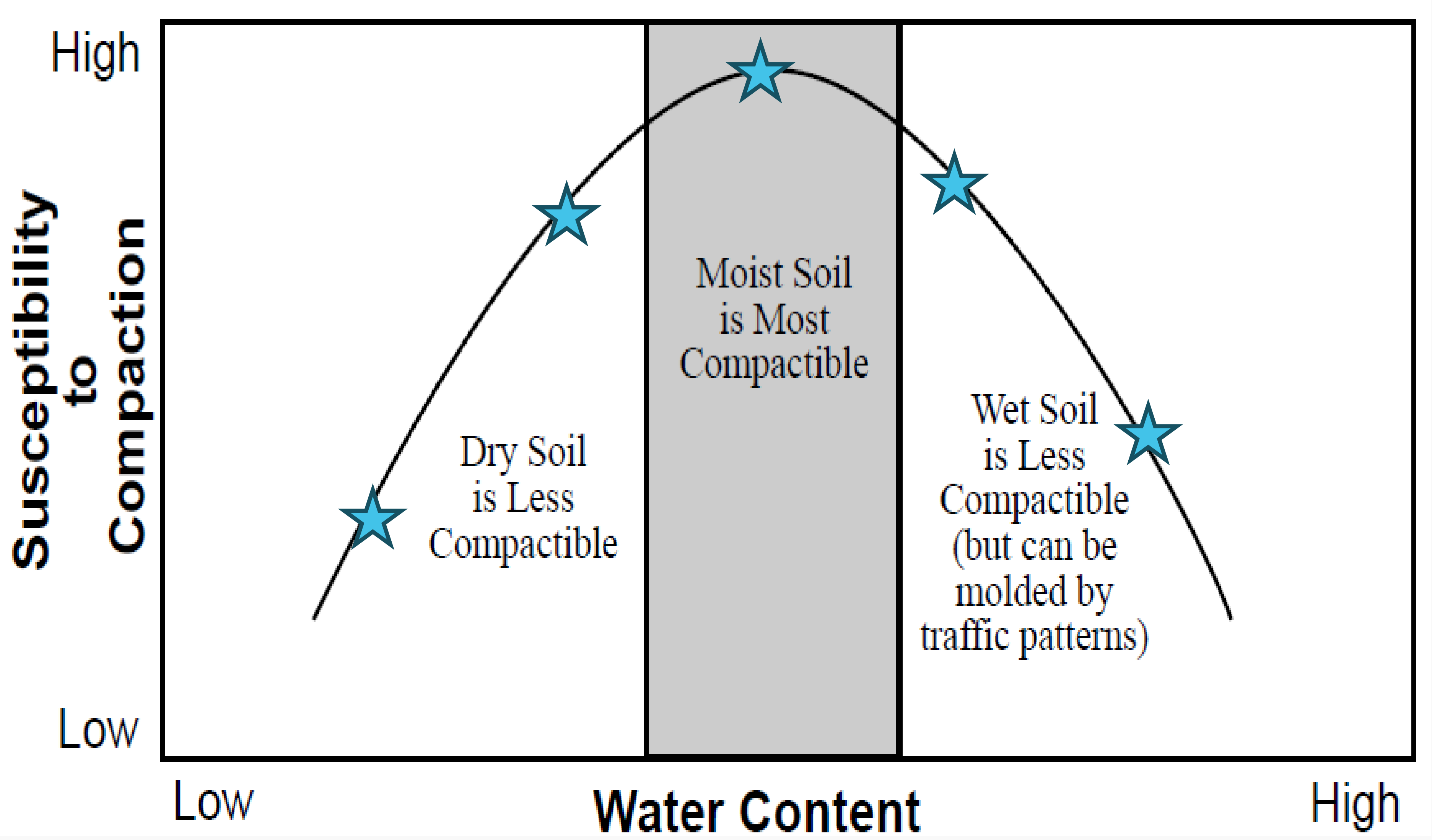
- Subbase: 92% min. 95% average
- Basecourse: 95% min. 98% average
- Uniform (in all three dimensions: x, y, z)

Pavement Layer Compaction

Factors that can influence the Density

- Moisture Content
- Material Type and PSD
- Compaction Equipment
- Layer Thickness
- Anvil given by the underlying layers
- Density test method

Moisture Content



Extract from "Soil Compaction: Problems and Solutions", Department of Agronomy, Kansas State University

MDD vs Compaction Water Content

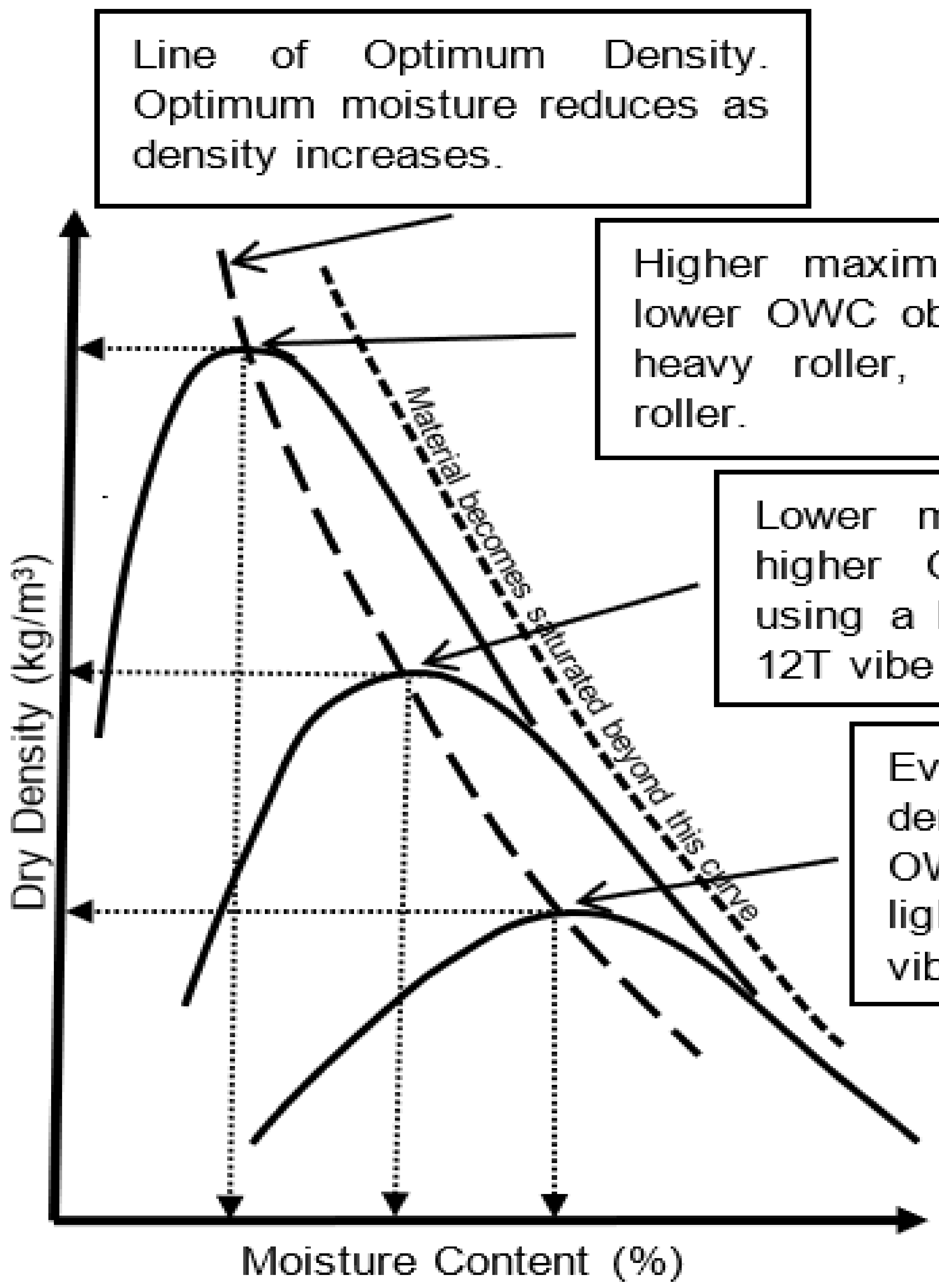
- Each point's result may differ slightly if tested over and over
- MDD and OMC is achieved when the DD starts dropping as the MC increases
- MDD and OMC is not an exact point but can be a range
- Similar trend for all material types. Note that non-cohesive can have another (apparent) MDD at very low water contents.
- This apparent MDD can occur equally in the field so be aware of this when the material "feels" too low.

Material

Material Variability

- NZTA specification (M04 and M03) have an envelope
- Quality of Fines
- Particle Size Distribution
- Stabilising Agents
- Variability in all the above factors when In-Situ Stabilising

Compaction Energy



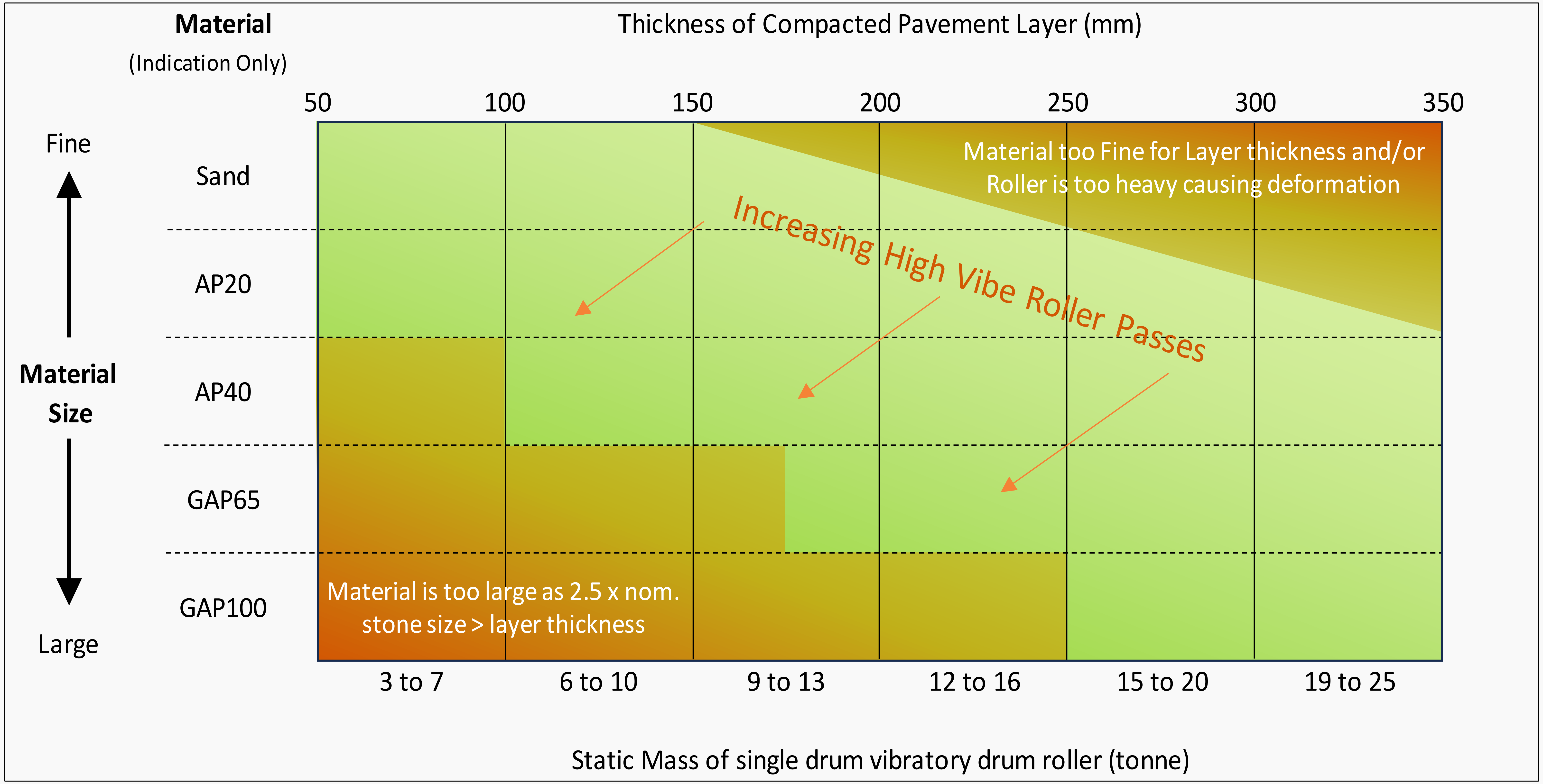
As compaction effort increases, the MDD increases, and the OWC decreases.

Similar trend for ALL materials.

Equally applicable in field and laboratory.

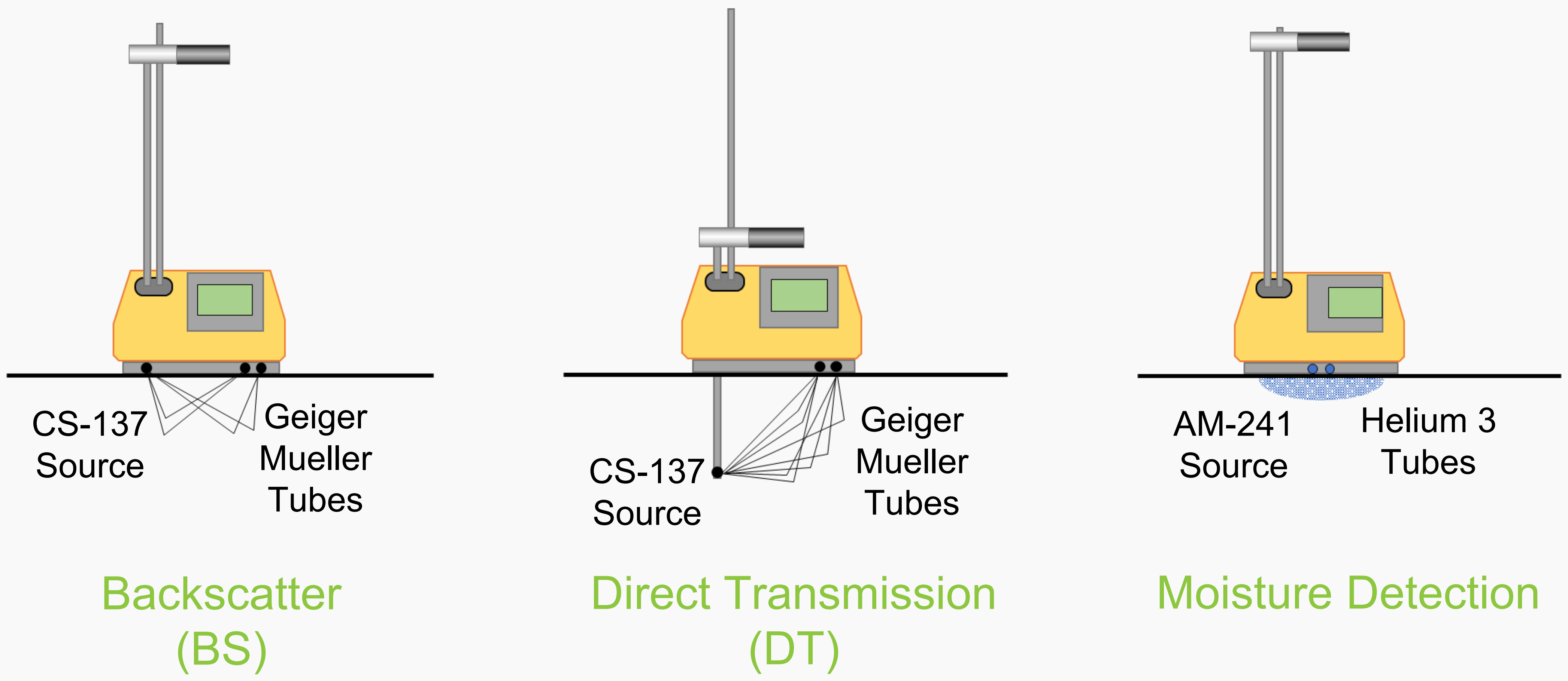
Increasing passes will increase density but …. only to the effective depth, after which the density won't increase, irrespective of the roller mass and number of passes.

Roller Size vs Material Type and Layer Thickness



Nuclear Densometer (NDM) – Test Modes

- NZS4407: 4.3 – Backscatter Mode: 75 to 100mm depth
- NZS4407: 4.2 – Direct Transmission Mode: average from probe depth
- Moisture Content detection – Helium Tubes measure to 70 - 90mm depth



Anvil – Subgrade / Subbase

- Soft / Wet / Unsuitable Subgrade
- Poor quality or wet subbase
- Keep an eye on the Compaction Drum
  - Bow Wave
  - Drum bounce

The Catalyst: Backscatter to Direct Transmission

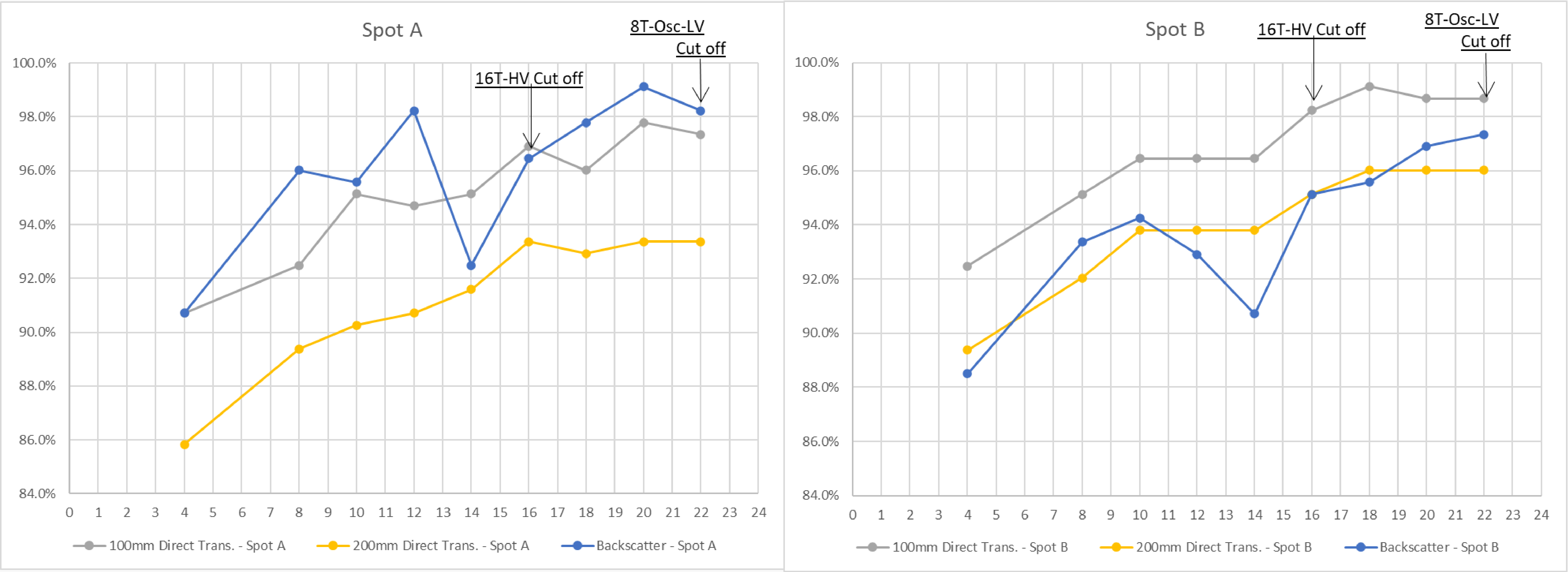
PP2O Expressway Cement Bound Subbase

- Met all PRs regarding Density (the way we have been testing to date – Backscatter)
- Issue with cores not being full depth

Extensive Trials to investigate various factors:

- Fines migration: Slurry vs No Slurry
- Particle Grading and Shape
- Compaction equipment
- Mixing energy
- Mixing Rotor (Wirtgen vs Bomag)

The Catalyst: Backscatter to Direct Transmission



Typical Plateau Density Test using Direct Transmission

The Catalyst: Backscatter to Direct Transmission

Plateau Density Test Mode	Backscatter	Direct Transmission
Primary Compaction: High Vibe	4 to 6 passes	14 to 18 passes
Secondary Compaction: Low Vibe	4 passes	2 passes
Final Compaction: Static (depends on cohesion, PSD, etc.)	20 to 50 passes	10 to 20 passes
Core extraction (% of layer depth)	30% to 60%	70% to 100%

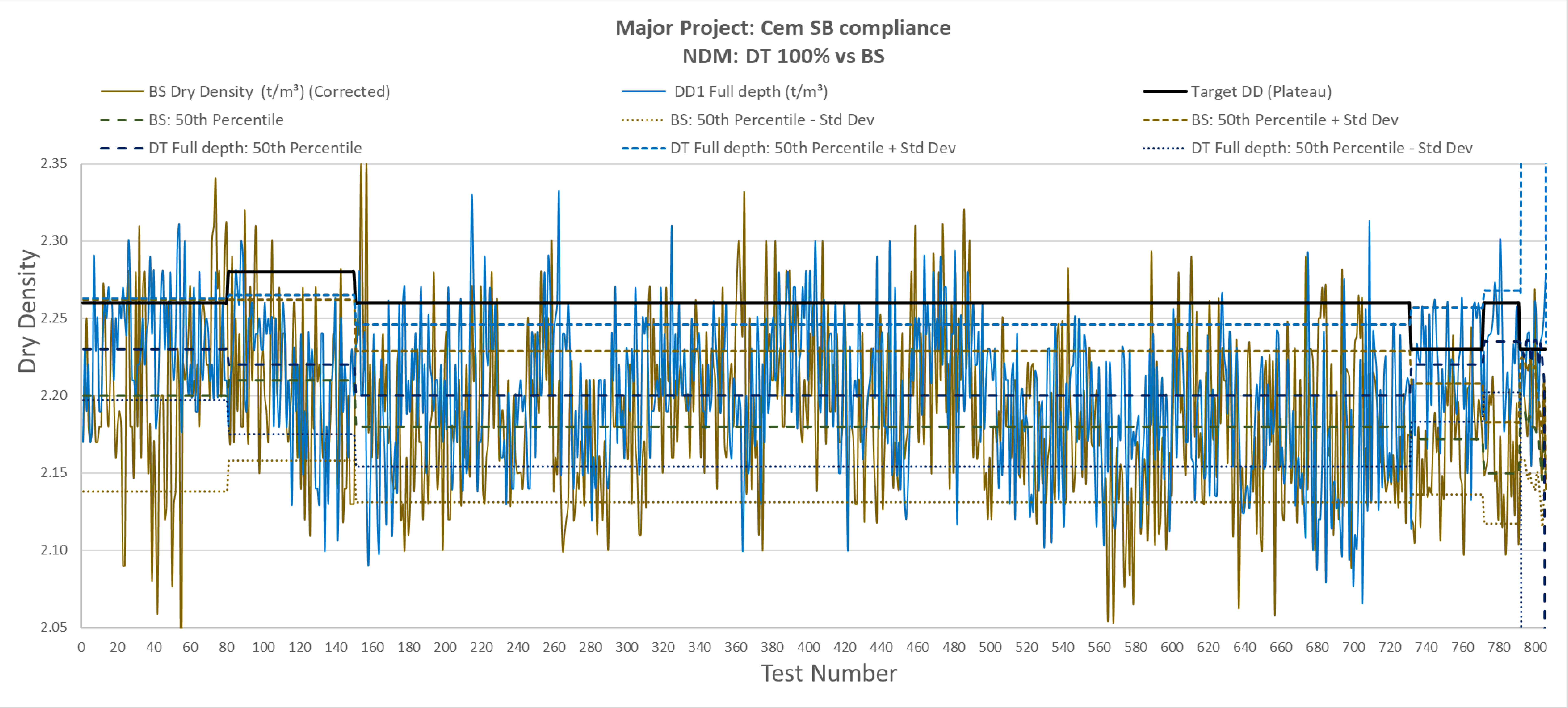
The Catalyst: Backscatter to Direct Transmission

Typical Density Results for a lot achieved with revised methodology that was driven by Direct Transmission Plateau density testing

CoV				3.95%				1.11%				2.95%
Position	Backscatter				100mm DT				200mm DT			
	WD	DD	MC	DoC	WD	DD	MC	DoC	WD	DD	MC	DoC
Pos.1	2.39	2.23	6.8	98.9%	2.33	2.17	7.4	96.1%	2.36	2.21	6.8	97.8%
Pos.2	2.38	2.25	6.0	99.4%	2.36	2.25	5.3	99.4%	2.26	2.13	6.1	94.4%
Pos.3	2.32	2.19	6.1	96.8%	2.35	2.21	6.1	98.0%	2.34	2.19	6.8	96.9%
Pos.4	2.38	2.25	5.9	99.4%	2.39	2.25	6.1	99.6%	2.29	2.15	6.6	95.0%
Pos.5	2.24	2.13	6.1	94.2%	2.34	2.21	5.8	97.9%	2.24	2.12	5.8	93.7%
Pos.6	2.27	2.13	6.6	94.4%	2.35	2.20	6.9	97.3%	2.37	2.21	7.3	97.6%
Pos.7	2.42	2.28	6.1	101.0%	2.39	2.27	5.6	100.2%	2.33	2.18	6.9	96.4%
Pos.8	2.36	2.20	7.5	97.5%	2.36	2.21	6.7	97.8%	2.40	2.21	7.9	97.6%
Pos.9	2.36	2.18	8.1	96.5%	2.36	2.20	7.2	97.5%	2.38	2.22	7.3	98.2%
Pos.10	2.29	2.14	7.3	94.6%	2.37	2.22	6.4	98.2%	2.35	2.22	6.1	98.2%
Pos.11	2.31	2.15	7.5	95.2%	2.36	2.19	8.0	96.8%	2.40	2.25	6.6	99.6%
Pos.12	2.36	2.20	7.3	97.3%	2.37	2.22	6.6	98.4%	2.32	2.17	7.1	96.0%
Pos.13	2.33	2.17	7.4	96.1%	2.34	2.20	6.9	97.3%	2.38	2.25	6.6	99.5%
Pos.14	2.33	2.19	6.5	96.9%	2.36	2.20	7.2	97.4%	2.36	2.21	6.9	97.7%
Pos.15	2.20	2.15	7.1	95.0%	2.37	2.22	6.6	98.3%	2.29	2.15	6.3	95.2%
Average				96.9%				98.0%				96.9%
10th %-ile				94.5%				97.0%				94.6%
Minimum				94.2%				96.1%				93.7%

- Do the Plateau Density test using BS, D100 & D200
- Density requirements for BS, D100 & D200 set at 95% Mean / 92% Min (usual Subbase requirements)

The Catalyst: Backscatter to Direct Transmission



NZTA T24 Specs and Notes – The Way Forward

NZTA T24 (2025) – Test Area Specified

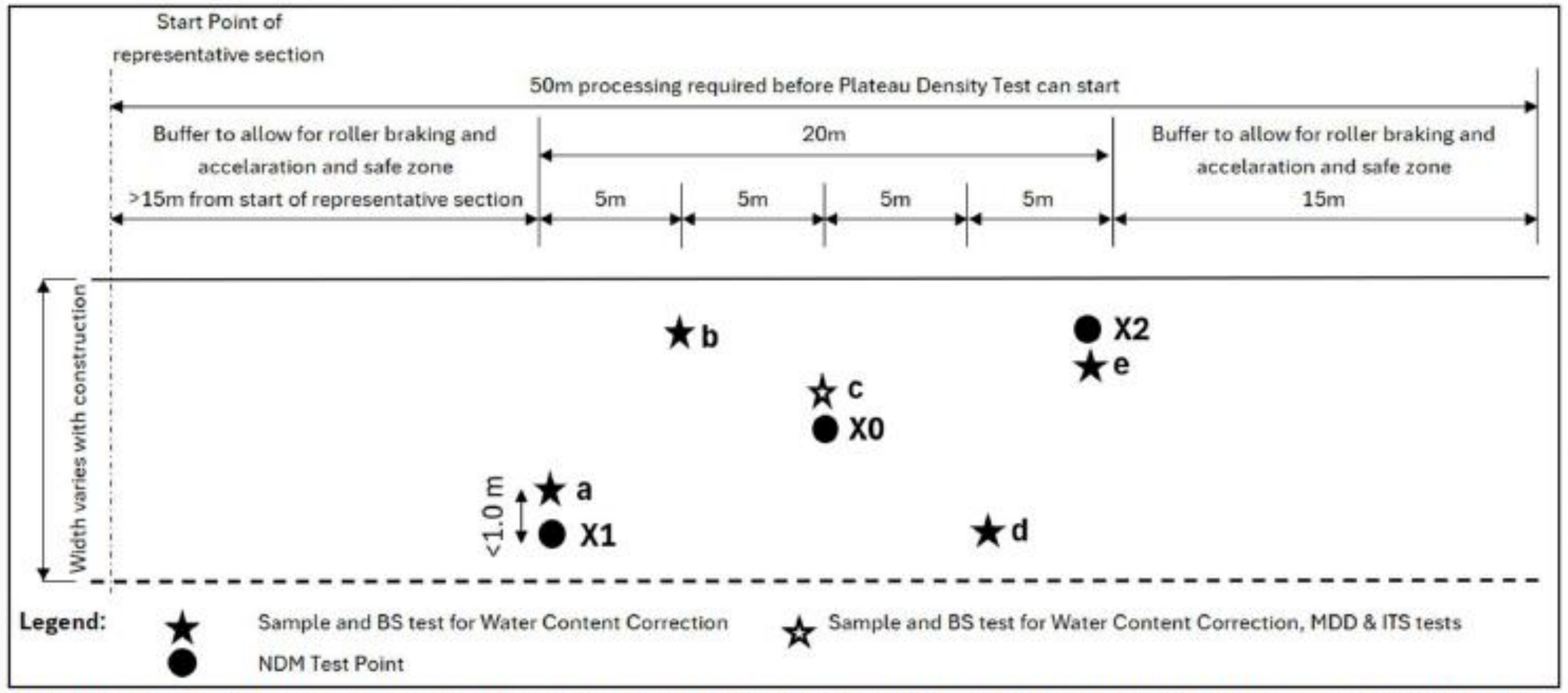


Figure 1: Test Section minimum dimensions for a grader, lane width or full road width process (generally NZTA B02 specification).

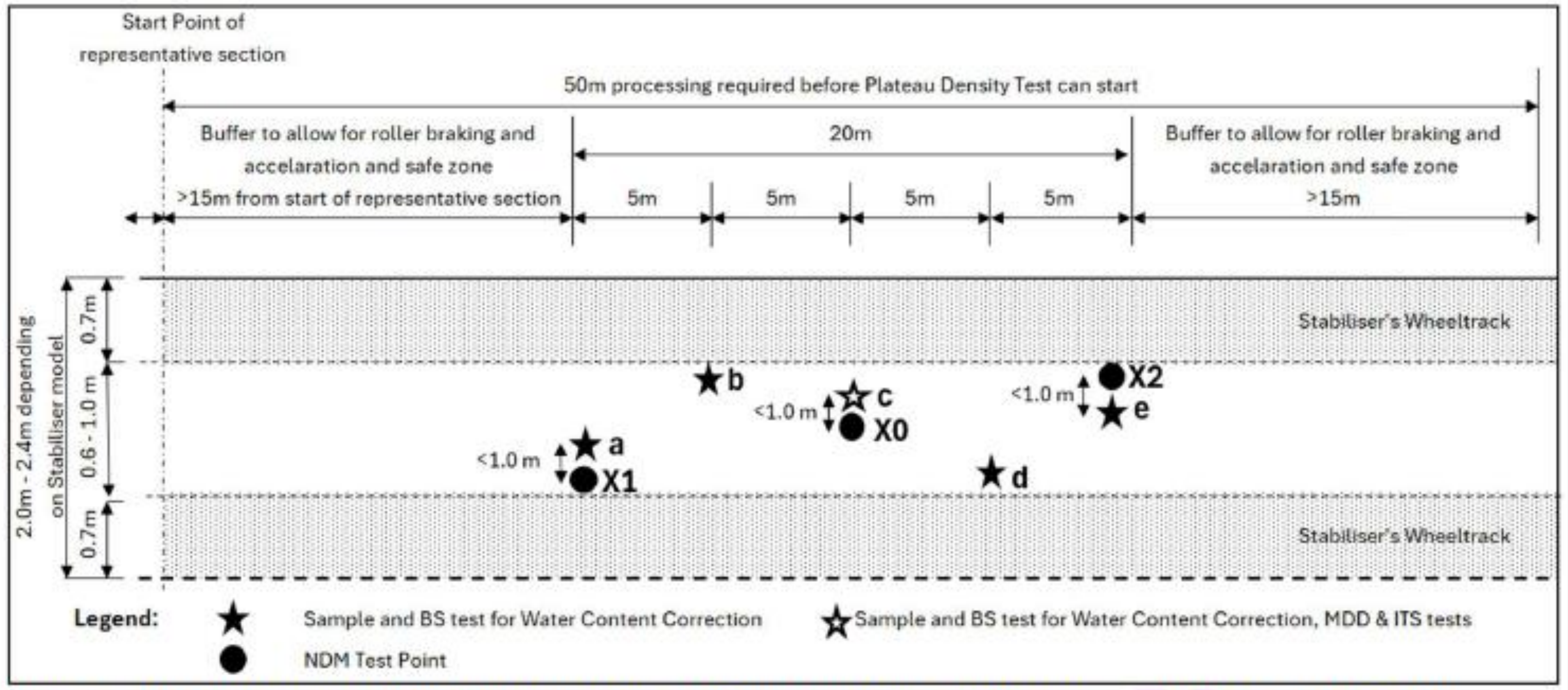


Figure 2: Test Section minimum dimensions for a stabilisation type process (generally NZTA B05 or B06 specification).

- Initial 2 Static Passes
- Record NDMs moisture content – using Backscatter (BS) at Points **a- e** (60 sec)
- Sample for Moisture Content correction from the 5 locations → Points **a – e**
- Start with sets of 4 passes using High Vibe (HV)
- NDM test at X0 using Direct Transmission (DT) (15 sec)
- Repeat 4 passes and testing until plateau has been reached (closer to plateau reduce to 2 passes)
- Validate primary plateau cutoff by testing at X0, X1 and X2 (60 sec)
- Repeat using Low Vibe (LV), test after every 2 passes at X0
- Validate secondary plateau cutoff by testing at X0, X1 and X2 (60 sec)

Acceptance Testing and Criteria

- NZTA T24 has been ratified and publication on website is imminent
- For unbound granular (B/2), modified (B/5 & B/7), bound (B/6 & B/8) pavement layers
- Has been included in the Integrated Delivery Contract (IDC)
- Density Lot Acceptance:
  - NZS 4407: 4.2: NDM by Direct Transmission
  - Acceptance Criteria given in the NZTA B-Series

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