
# TOWARDS ACHIEVING UNIFORM DENSITY IN GRANULAR LAYERS

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Higgins Group

# GRANULAR PAVEMENT LAYER DENSITY

## PRESENTATION CONTENT

- Pavement Layer Density – Why is it important?
- Density Testing – The Process
- Nuclear Densometer – Test Modes
- Catalyst – Backscatter to Direct Transmission
- Density Lot Acceptance – What are we trying to achieve
- Plateau Density Testing – Direct Transmission versus Backscatter
- NZTA T/24 Specification and Notes – The Journey and current status

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# PAVEMENT LAYER DENSITY – 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 – Rely heavily on density throughout the layer – strength throughout and highest horizontal stress at the bottom of the layer
- Cohesive Subgrade materials - Correlation between CBR and density/OMC

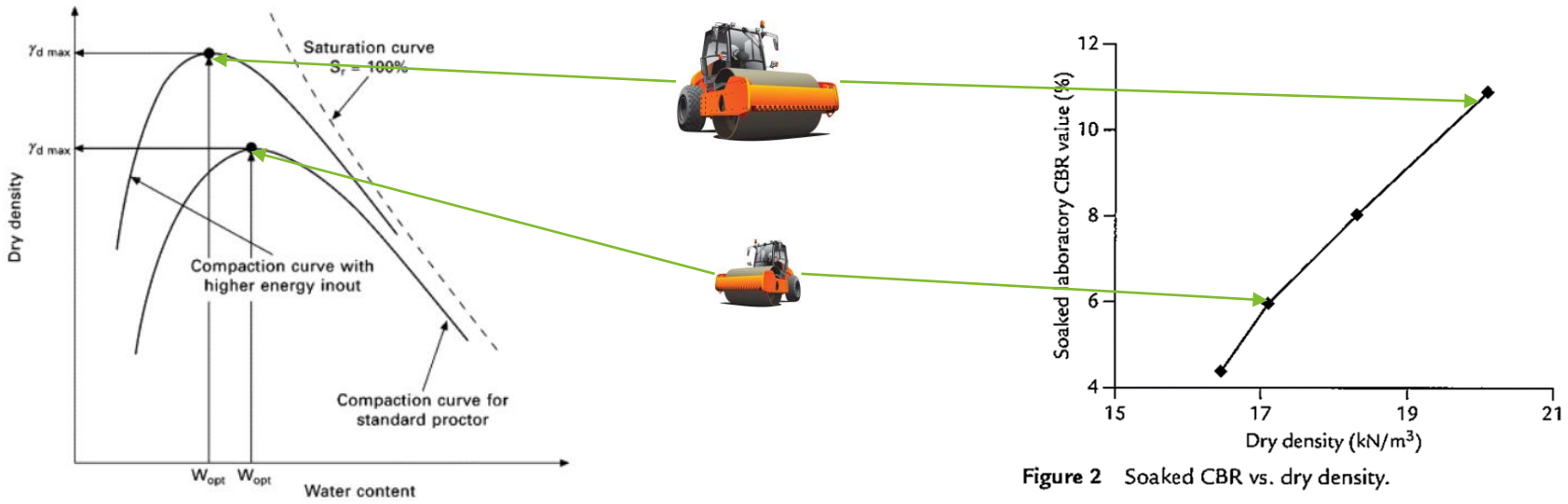


**Figure 2** Soaked CBR vs. dry density.

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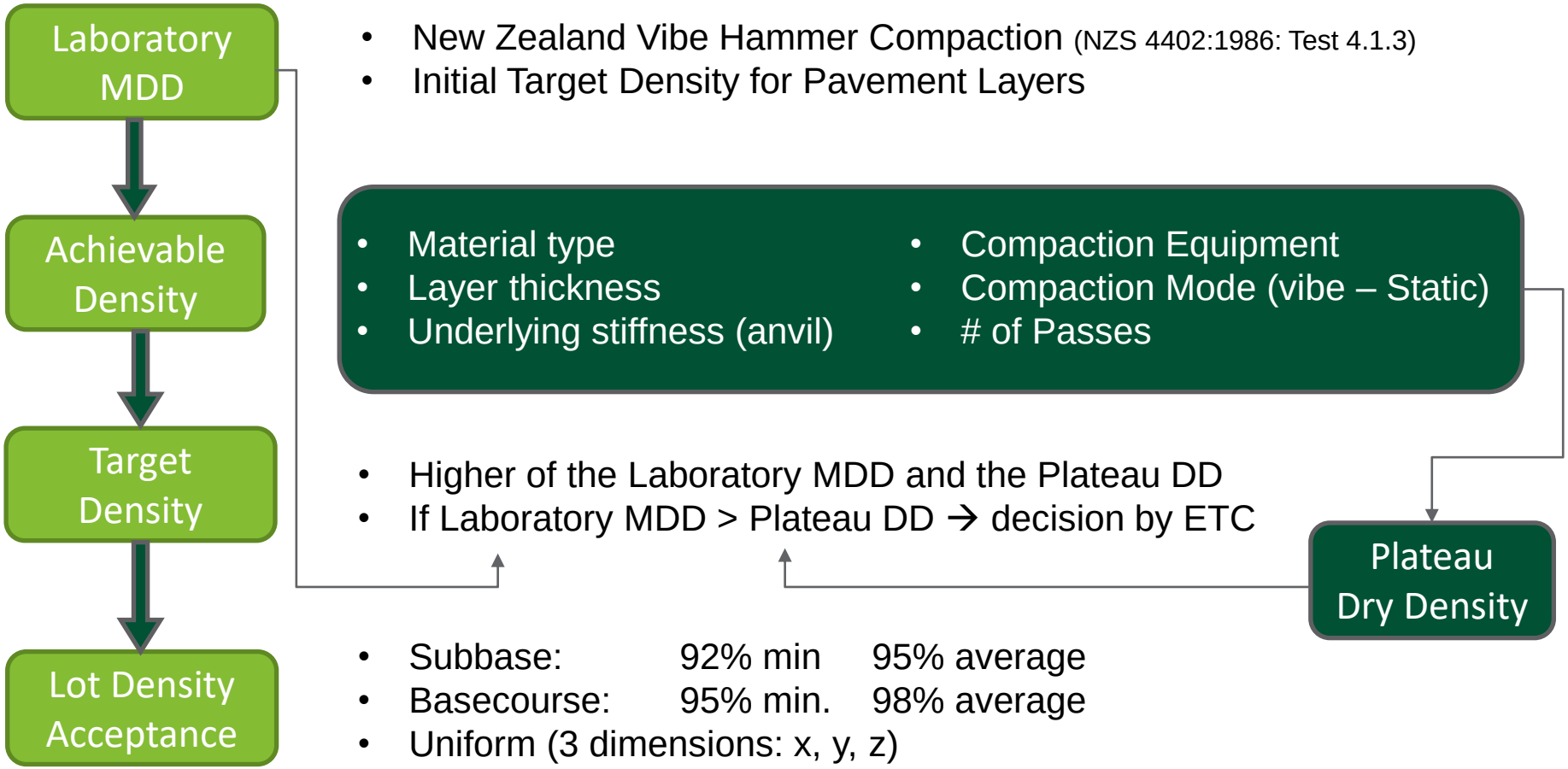
# DENSITY TESTING – THE PROCESS

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# ROLLER SIZE VS MATERIAL TYPE AND LAYER THICKNESS

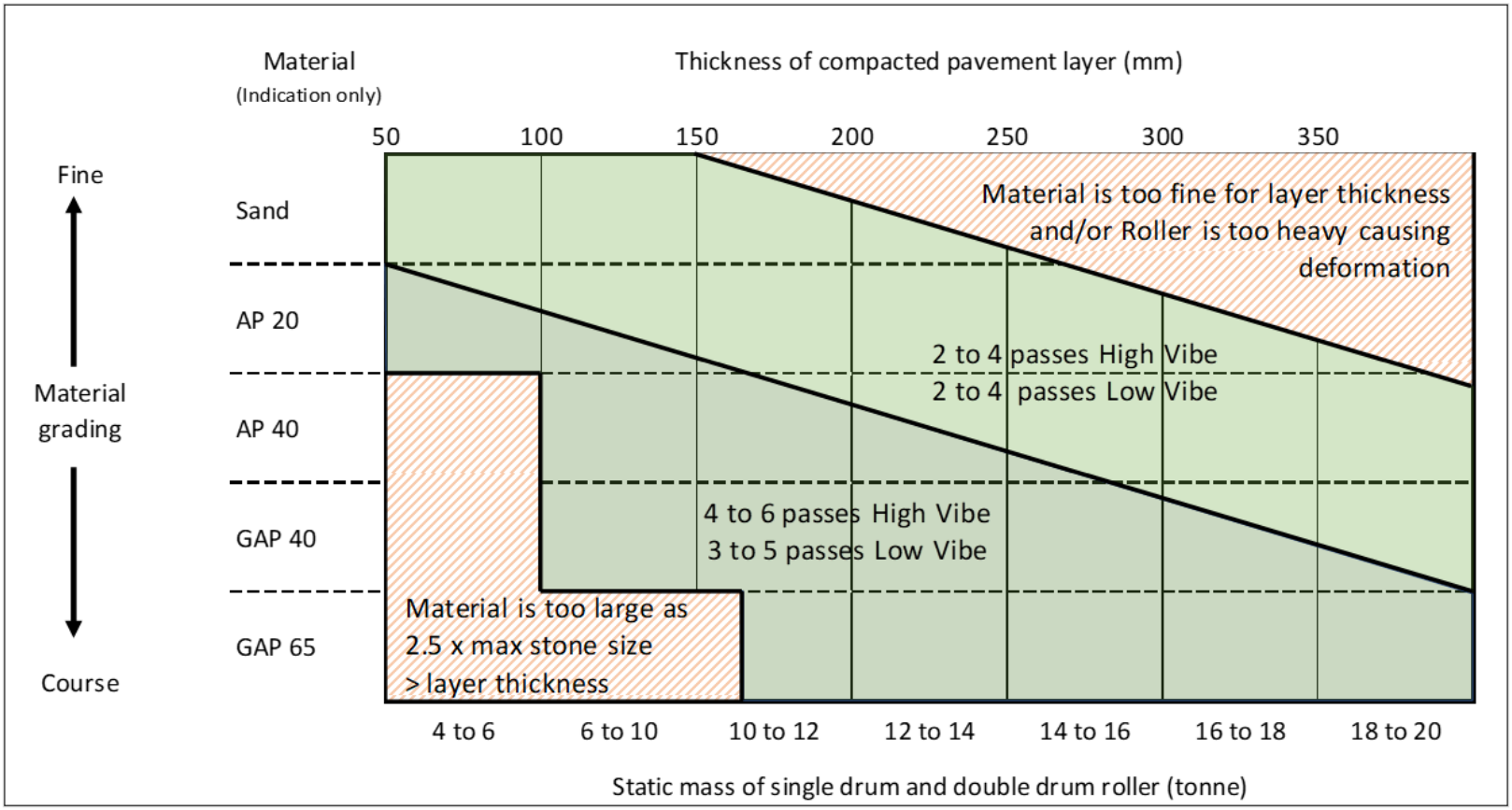


***Figure 1 Guide to determine the appropriate primary compaction plant***

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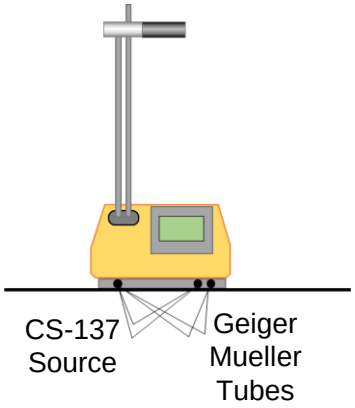
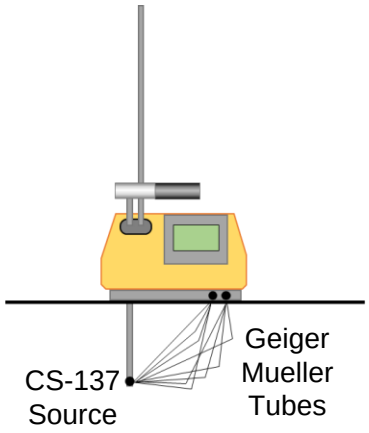
# NUCLEAR DENSOMETER (NDM) – TEST MODES

## Test Modes

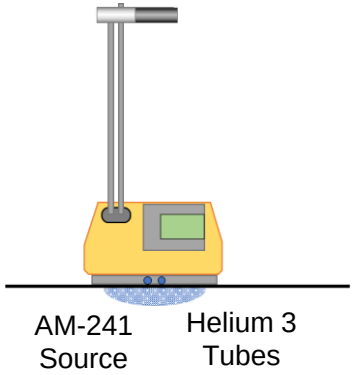
- NZS4407: 4.3 – Backscatter Mode – 75 to 100mm depth
- NZS4407: 4.2 – Direct Transmission Mode – depends on Probe depth
- Moisture Content detection – Surface to 80mm depth




Backscatter
(BS)




Direct Transmission
(DT)




Moisture
Detection

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# 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)

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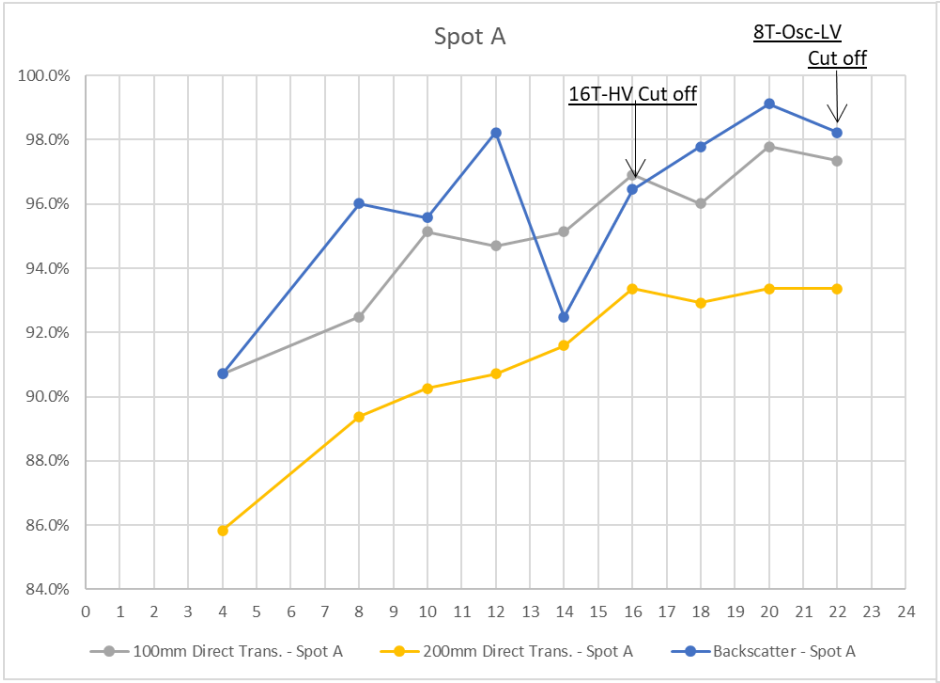
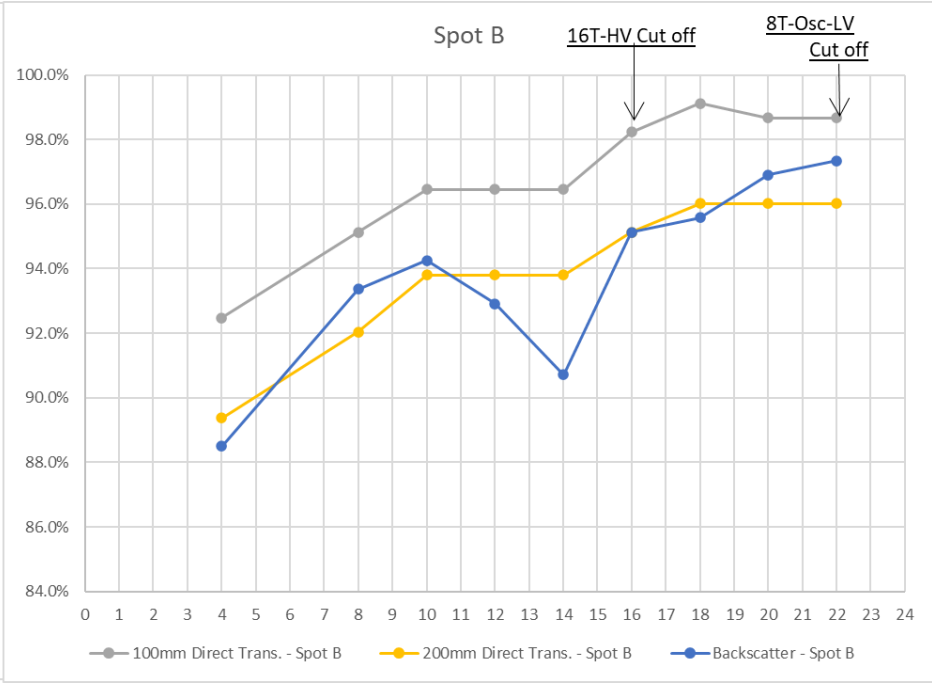
# CATALYST - BACKSCATTER TO DIRECT TRANSMISSION

## PP2O Trials




Typical Plateau Density Test using Direct Transmission

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# 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<br>(depends on cohesion, PSD, etc.) | 20 to 50 passes | 10 to 20 passes |
| Core extraction (% of layer depth) | 30% to 60% | 70% to 100% |

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# 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)

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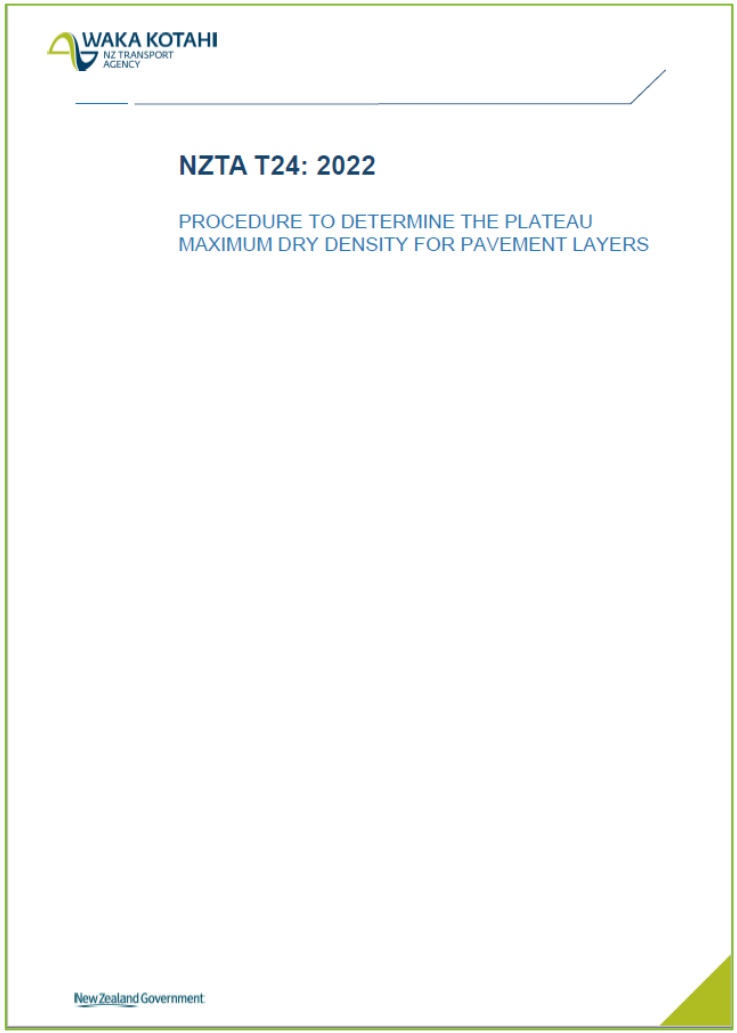
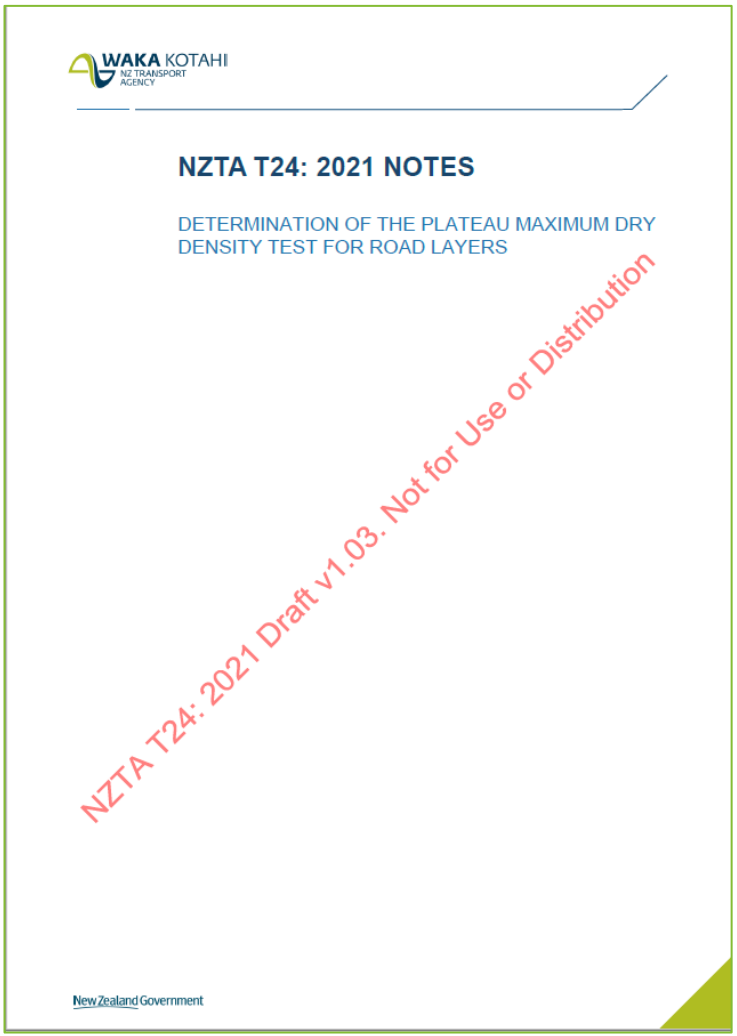
# NZTA T/24: 2021 – released as a trial

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# DENSITY LOT ACCEPTANCE – THE END GAME

## Shift towards NZTA T/23: Direct Transmission

- NZTA T/23: 2021 – Estimation of the Density of compacted aggregate layers by DT
- For modified, bound and unbound granular pavement layers
- Provides calculation of the lower half and upper half of the layer
- Density Lot Acceptance (T/23):
  - NZS 4407: 4.2 (DT) used in parallel to NZS4407: 4.3 (BS)
  - No guidance given regarding the number of BS and DT test points
- Pragmatic recommendation:
  - 1 Lot = 5 tests per 1000 m2 (ok for Greenfields but would prefer 10 tests per 1000 m2 for Renewals)
  - Greenfields: 1 locations using DT and 4 locations using BS per Lot (1 test / 200 m2)
  - Renewals: 3 locations using DT and 7 locations using BS per Lot (1 test / 100 m2)

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# NZTA T/24 SPECS AND GUIDANCE NOTES – INDUSTRY FEEDBACK

Over the past 6 months I have received several comments from industry regarding the T24 as we developed it. The general response has been:

- Fantastic, the standard is desperately needed
- Fantastic, but we need to include guidance on when to do it (it's not needed on every site), and how to decide what the most appropriate compliance MDD is
- Mmmmm, great and needed, but its going to cost a huge amount and reduce productivity substantially, especially at present frequency requirements
- Mmmmm, great and needed, but we cannot complete it during the 2 hours required.
- There are several others but all have a similar vein to the above.

I propose that we reconvene the work group in order to reassess the process so that we get a robust outcome that will accommodate the issues raised.

Kind regards

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# NZTA T/24 SPECS AND GUIDANCE NOTES – THE WAY FORWARD

## T/24 Working Group Meeting Outcome (May'2023)

- 15 sec until HV, LV and final cut off pass
- 60 sec test time at cut offs
- 2 test points
- Test pad: avoid transitions, safety zone considerations, roller > 10m away from NDM
- T/24 released with requirements in the B-Series through a TAN

| Layer Thickness | ≤ 100mm | ≤ 200mm | > 200mm |
|---|---|---|---|
| Primary Compaction (HV) | BS | DT-Full Depth | DT-Full Depth & DT-Half Depth |
| Secondary (LV) | BS | DT-Half Depth | DT-Half Depth |
| Static | BS | BS | BS + Half Depth |
| Notes: When nearing cut off add next level testing. | | | |

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# THANK YOU

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