98% of what?
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Introduction

• A brief summary of how ‘98% Compaction’ is applied to NZ road construction

• How MDD is typically measured in a lab

• How the % of MDD is verified in the field using NDM’s

• Issues around the lab and field tests
What is 98% of MDD

- A fairly typical target for compaction in the field
- Literally means ’98% of Maximum Dry Density’
- MDD is laboratory based
- B/2 and associated specs call for testing to NZS4402:1986, test 4.1.3, which is Vibe Hammer
Introducing the NZ Vibrating Hammer Test...!

• Where do we start!

• A controversial MDD/OWC test that forms the basis for most road construction

• Apparatus consists of 3 main items:
  1. The hammer
  2. The frame
  3. The base
Test methodology

- Test calls for material < 37.5mm, hence AP40
- Does not test a representative sample for coarse aggregates, e.g. AP65/75/100
- 5 – 6 ‘points’ are taken from a lab sample
- Points are conditioned to have a moisture range between dry and wet
Test methodology...con’t

- Individual points are allowed to equalise before testing

- Each point is subjected to fixed amount of compactive effort from the lab’s hammer/frame

- Bulk density, moisture content and dry density is calculated for each

- Plotted to form a ‘Compaction Curve’
Problems with this...

- The NZS allows for large tolerances on the gear used
- Hammer output can be between 600w – 1200w
- VSDF between 300 – 400N
- Think about labs operating at opposite ends of the tolerances??
More problems with vibe hammer

- Sample relevance/integrity
- Splitting/riffling of samples
- Problems with ‘over-wet’ points and the loss of fines from the mould
- Does the curve have a wet edge?
- Ambiguous calibration
Proof of potential issues with vibe hammer

• CETANZ began proficiency testing in 2009 around the test and presented the results to industry stakeholders

• Results did not surprise anyone who knew the test well!

• Results showed huge variance on the SAME material (basically a range of a few hundred kg’s)
But wait....there’s more!

- All participating labs received a free set of Steak Knives!

- Only joking, but seriously..

- This is only half the problem

- The rest lies with how the % of MDD is verified in the field for the contractor
Introducing the NDM...!

• Most commonly used tool in NZ to measure the field dry density, and thus confirm relative compaction

• However NDM’s don’t measure dry density (the main parameter for compaction compliance)

• They simply calculate it based off two completely unrelated things...!
• NDM’s can measure a soils’ wet density fairly accurately

• But to calculate dry density they must also measure the MC%

• NDM’s do this in a rather bizarre way which can lead to major issues

• $DD_{(NDM)} = WD - MC$ (mass of water)
How do they measure MC%?

- By assumption!
- Fast neutrons are emitted from a Am – 241:Be alpha/neutron source in the middle of the gauge
- Has significant penetration into matter, but becomes ‘thermalised’ in the presence of H⁺ (hydrogen)
More on MC and NDM’s

- It is assumed that thermalised neutrons received at the detector have bombarded the water molecule ($\text{H}_2\text{O}$) in the top 75mm of material

- $\text{H}^+$ can (and often is) present in other parts of the soil

- Thus $\text{DD}_{\text{NDM}} = \text{WD} - \text{H}^+$ content

- Hmmm
Sources of H⁺ in construction materials

- NDM’s can measure MC reasonably well most of the time, however this is not always the case

- Stabilised materials (cement, lime, foamed bitumen)
- Bitumen inclusion during milling
- Mineralogy of the host rocks
- All can lead to an ‘apparent increase in MC’
- Remember DD\(_{(NDM)}\) = WD – H⁺ content?
- This can result in an erroneous % compaction reading and a possible ‘fail’ on paper
Now combine the two together

- NZ Vibe Hammer + NDM = possible headaches for uninformed contractors/labs/engineers

- Unless the facts are known and considered

- Lab MDD reference test can be subjective to say the least and chasing this ‘target’ becomes the problem of the contractor

- Poor use and understanding of NDM (often down to insufficient training) can lead to subjective results and a possible ‘failed’ result
Cloud to Silver lining ratio (CSLR)!

- Do not fear, there are ways around this

- For a start EVERYONE should be aware of how their local lab performs their reference tests

- Compare with other labs if you have too – you could be surprised with the difference
CSLR...con’t

• Be aware of how an NDM actually goes about its work

• Question technicians on their knowledge of the NDM, after all the success of the project could be sitting in their hands

• Oven correct NDM measurements that appear low
And more...

- Encourage Plateau Testing on site
- But only with relevant gear
- Encourage the correct use of primary and secondary compaction
- Should reduce ‘over’ compaction
Why is this important?

- Possible gradation loss due to over compaction to achieve a false target

- Segregation of aggregate, possibly leading to deep-seated air voids (over vibing normally)

- Inefficient plant use by the contractor
Conclusions

• Vibrating hammer MDD can be subjective

• Poor NDM use on site could jeopardise the relevancy of the results

• False targets?

• Stabilised aggregates may need special attention due to presence of excess H+

• Look at sensible Plateau Testing as an alternative
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