IPENZ Transportation Group Conference 2016

Investigating aggregate marginality through their water absorption capabilities

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ENGINEERING

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- **Unbound basecourse aggregates are very sensitive to water, which is an important factor influencing pavement performance. (Werkmeister, 2003; Arampamoorthy and Patrick, 2010).**
- **Using non-stabilised marginal materials with higher optimum moisture content (OMC) in road basecourse is likely to cause significant problems, such as rutting.**

Road rutting

OMC

- **Compaction effort**
  - **Compaction mode**
  - **Compaction time**
  - **Surcharge weight**
- **Aggregate type**
  - **Particle shape (not included)**
  - **Particle size distribution (PSD)**
  - **Percentage and type of clay minerals in materials (XRD test)**
  - **Water absorption capability**

Objectives

- **To determine the OMCs of the greywacke aggregates**

- **To determine the reasons for the observed difference in OMC between each other through PSD, XRD, and water absorption test**

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- **Five greywacke aggregates sourced from two hard rock greywacke quarries, in the Auckland / Waikato Region of New Zealand's North Island**
- **In accordance with NZTA M4 specification**
- **Quarry 1: M4 compliant aggregate1 and marginal aggregate 1A and 1B**
- **Quarry 2: M4 compliant aggregate 2 and marginal aggregate 2**

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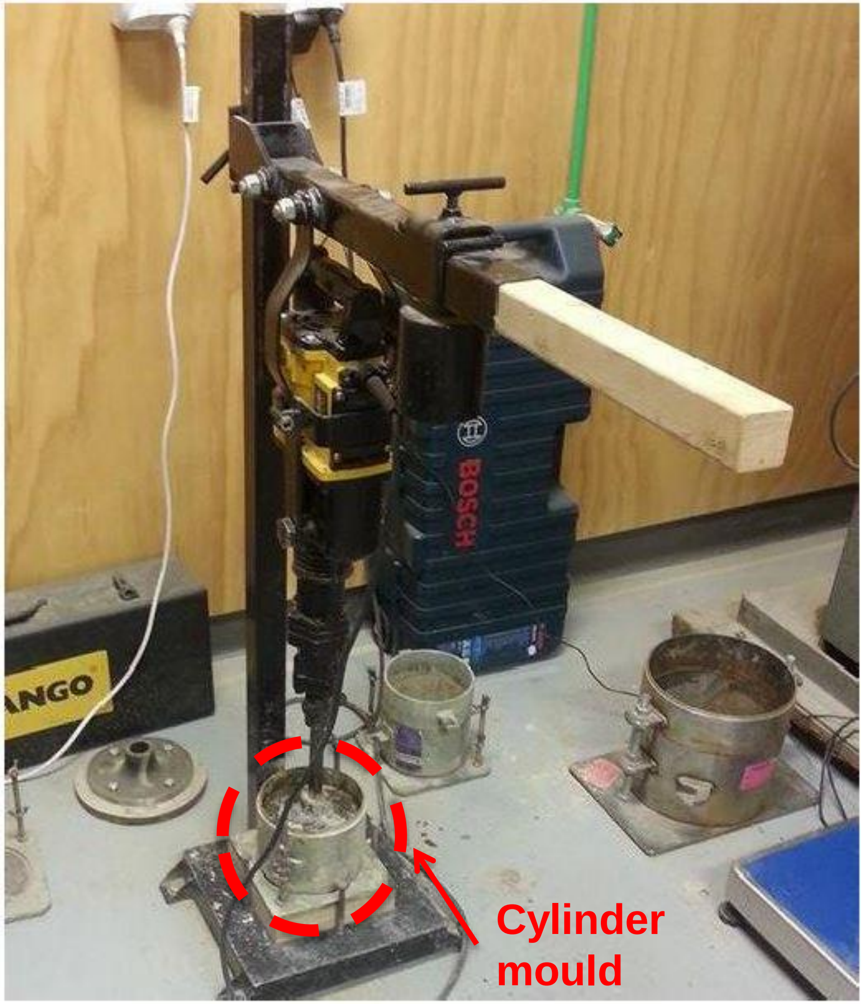
Vibrating compaction test

- Kango 950K electric vibrating hammer
- Input energy of 1050W and frequency of 2000 blows per minute
- Cylindrical moulds of approximately 152 mm diameter and 127 mm height
- Compact in two equal layers with a compaction time of 180 (±10) seconds per layer
- Approximately 5.5kgs of aggregate sample for each test

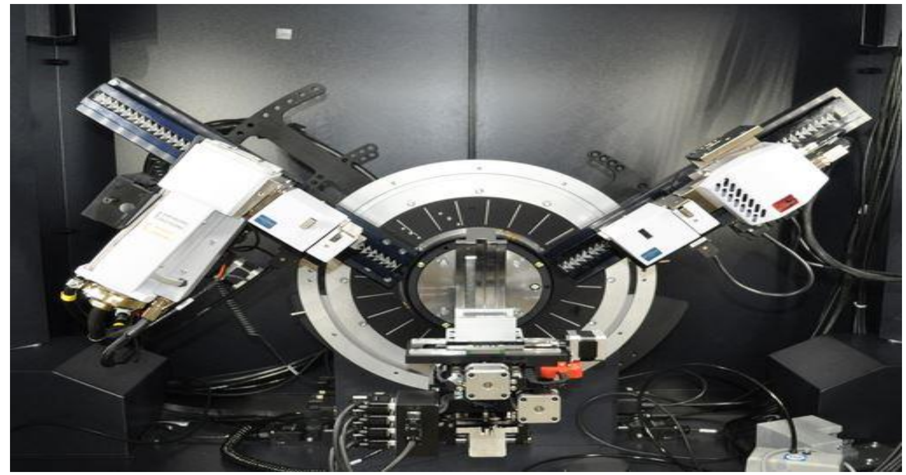


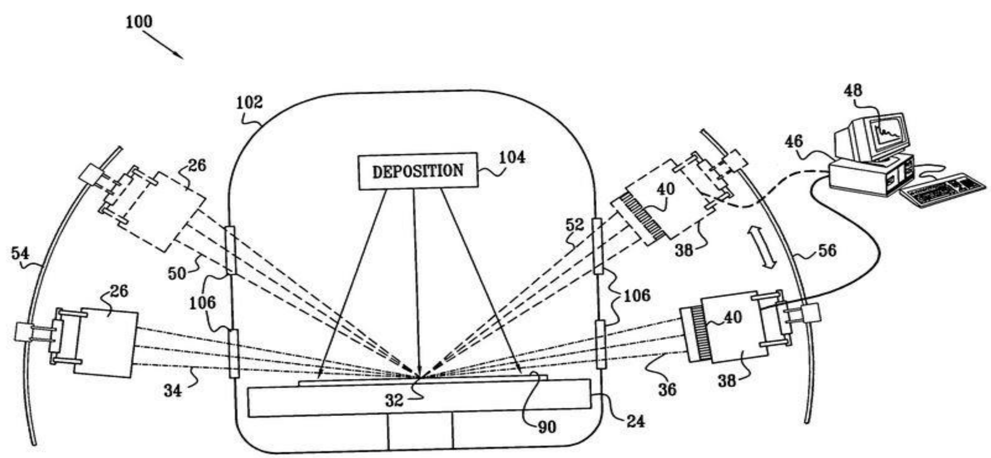
Vibrating compaction test

Aggregate	Optimum moisture content, %		Maximum dry density, t/m³	
	Test value	Variation, %	Test value	Variation, %
M4 aggregate 1	5.0	0	2.34	0
Marginal aggregate 1A	6.4	28	2.30	-1.71
Marginal aggregate 1B	6.7	34	2.26	-3.42
M4 aggregate 2	6.5	0	2.28	0
Marginal aggregate 2	8.0	23	2.20	-3.51

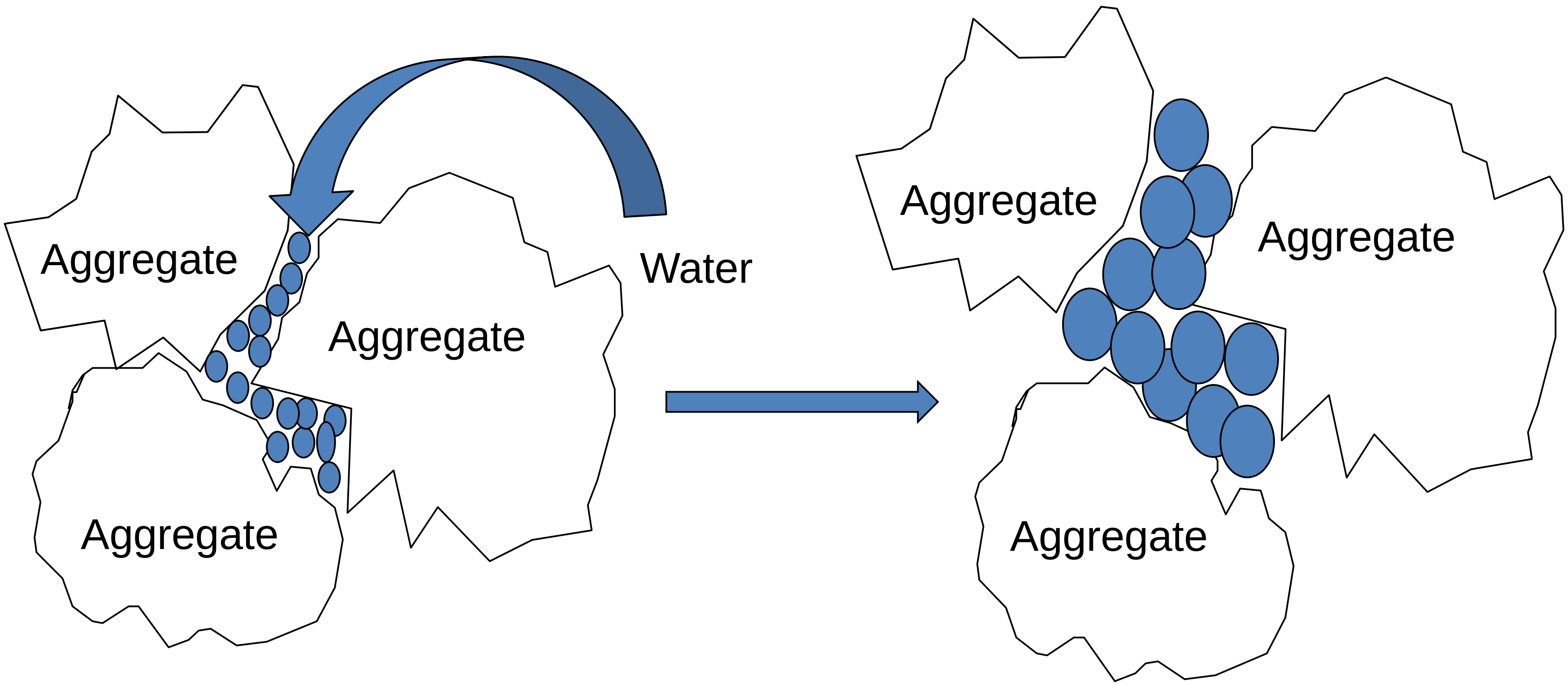
X-Ray Diffraction test (XRD)

- **Identify the mineralogical composition of materials**
- **Detect the structure and physical properties of crystalline materials in aggregates**



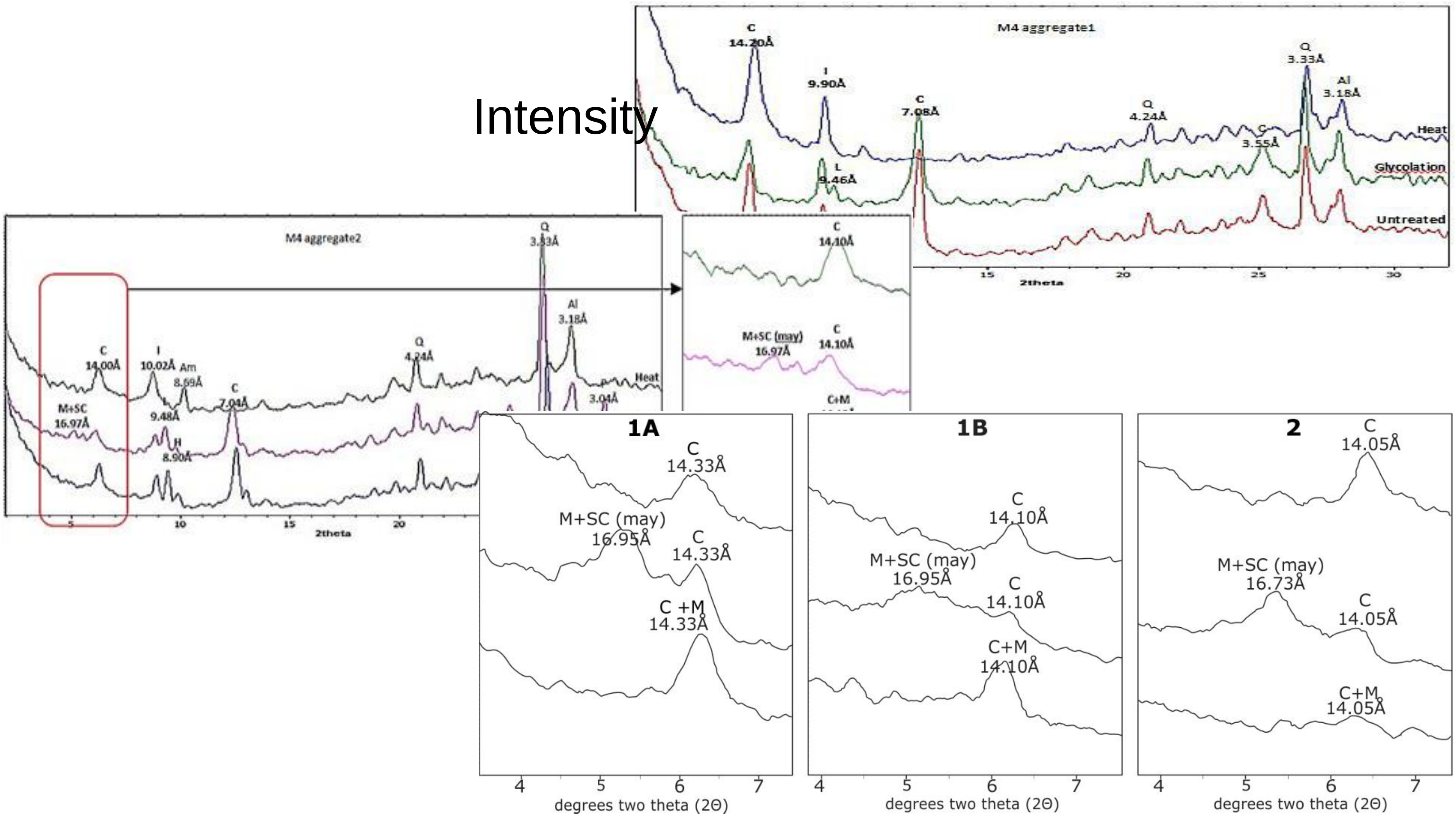


X-Ray Diffraction test (XRD)



represents swelling mineral, such as smectite (montmorillonite), laumontite, or swelling chlorite

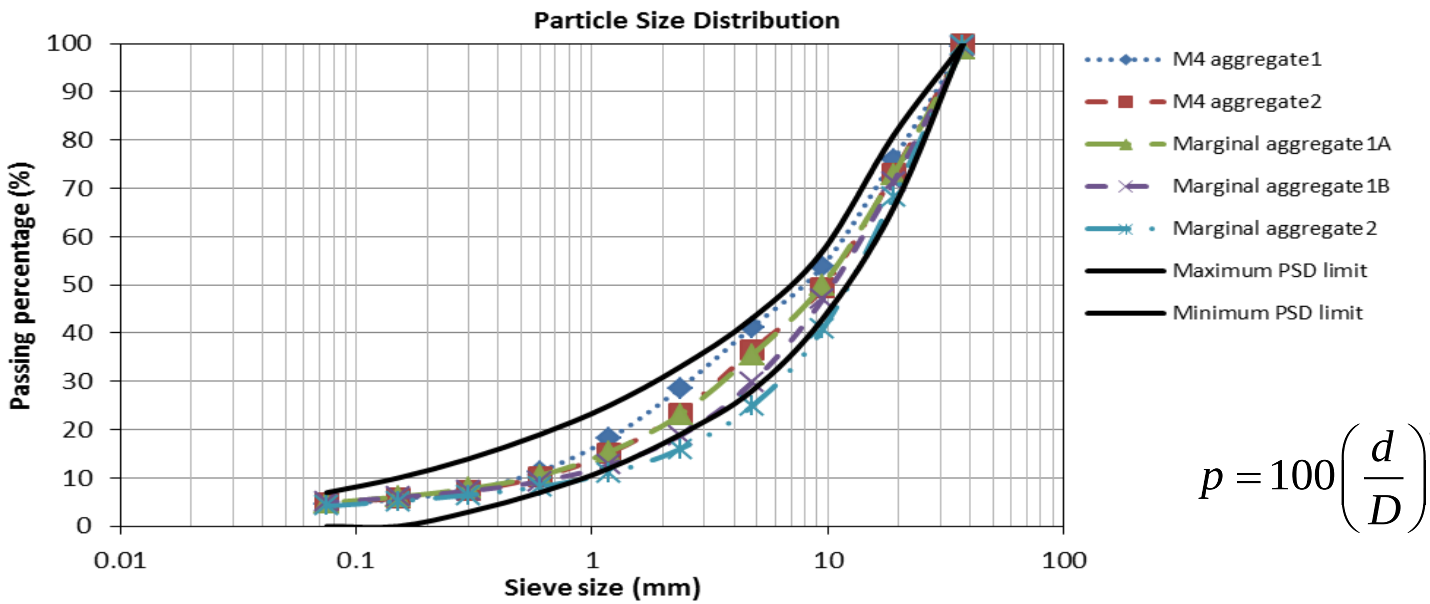
X-Ray Diffraction test (XRD)



Particle size distribution (PSD)

- **Define the relative amount (by mass) of particles present according to size**
- **Predict the air void of compacted materials, which can be filled with water**

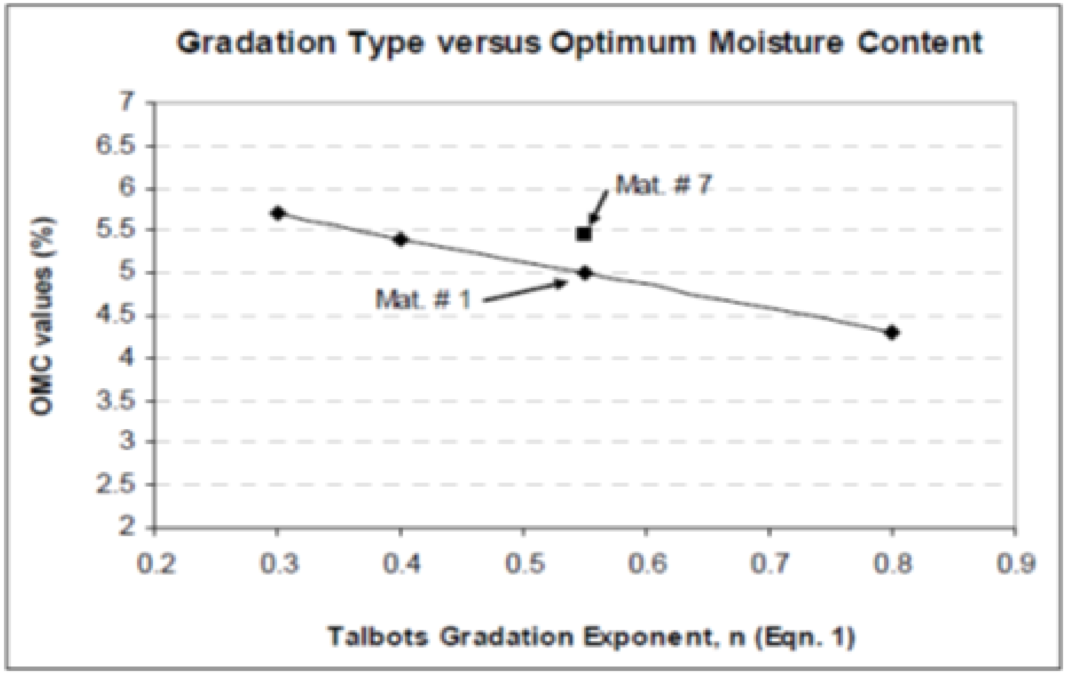
Particle size distribution (PSD)



$$p = 100\left(\frac{d}{D}\right)^n$$

(Talbot and Richart, 1923)

	M4 aggregate 1	Marginal aggregate 1A	Marginal aggregate 1B	M4 aggregate 2	Marginal aggregate 2	Lower limit of NZTA specification	Upper limit of NZTA specification
n	0.54	0.55	0.61	0.55	0.65	0.61	0.40



(Arnold et al., 2007)

	M4 aggregate 1	Marginal aggregate 1A	Marginal aggregate 1B	M4 aggregate 2	Marginal aggregate 2	Lower limit of NZTA specification	Upper limit of NZTA specification
n	0.54	0.55	0.61	0.55	0.65	0.61	0.40
OMC/%	5.0	6.4	6.7	6.5	8.0		

Water absorption capability

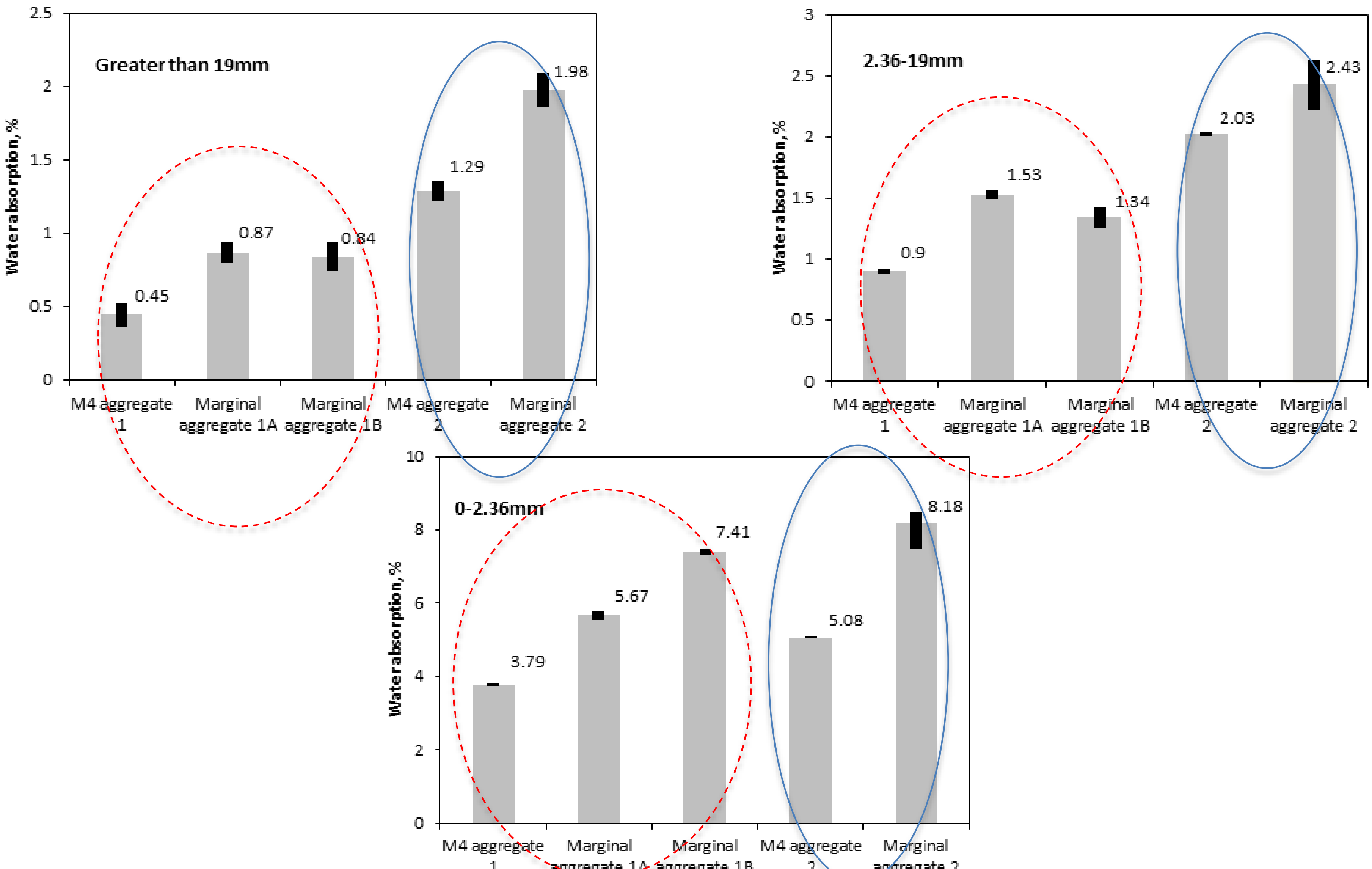


Greater than 19mm and 2.36-19 mm fraction



0-2.36 mm fraction

Water absorption capability



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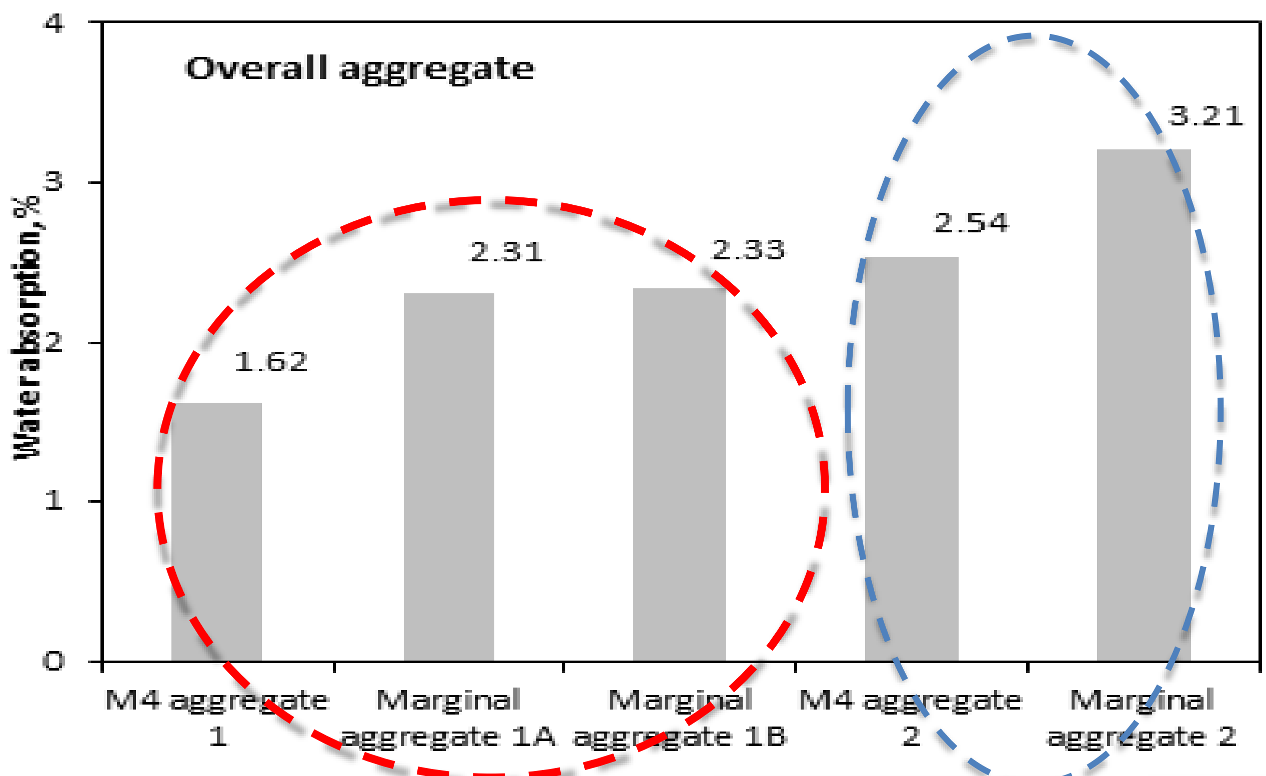
Water absorption capability

$$\text{Overall water absorption capability} = \frac{\sum(\%\text{of each fraction} * \text{water absorption capability of each fraction})}{100}$$



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Conclusions

- **Vibrating compaction test shows the marginal aggregates have much higher OMCs than the M4 aggregate.**
- **The results of particle size distribution indicate that grading is not the cause of the higher OMC recorded in the Marginal aggregates 1A, 1B and 2.**
- **The swelling minerals, found in the three marginal aggregates, are responsible for their higher OMC.**
- **The three marginal materials have higher water absorption capabilities than M4 compliant aggregates.**

Thanks for your attention