Use of 3D modelling techniques to better understand road surface textures

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Road surface textures

- Influence a wide range of properties including:
  - Friction, noise, rolling resistance to how load is transferred from the vehicle tyre down through the pavement structure.
- Texture is important at differing scales:
  - micro-level on the aggregate surface
  - macro-level on the road surface
  - mega level when roads become rutted, cracked or form pot holes.

- The use of PSV to measure aggregate micro-texture, volumetric sand-patch or 2D laser types of measurement have been used for many years.

- However, their data is limited particularly when trying to understand what is happening.

Thermal image showing heat transfer from friction tyre
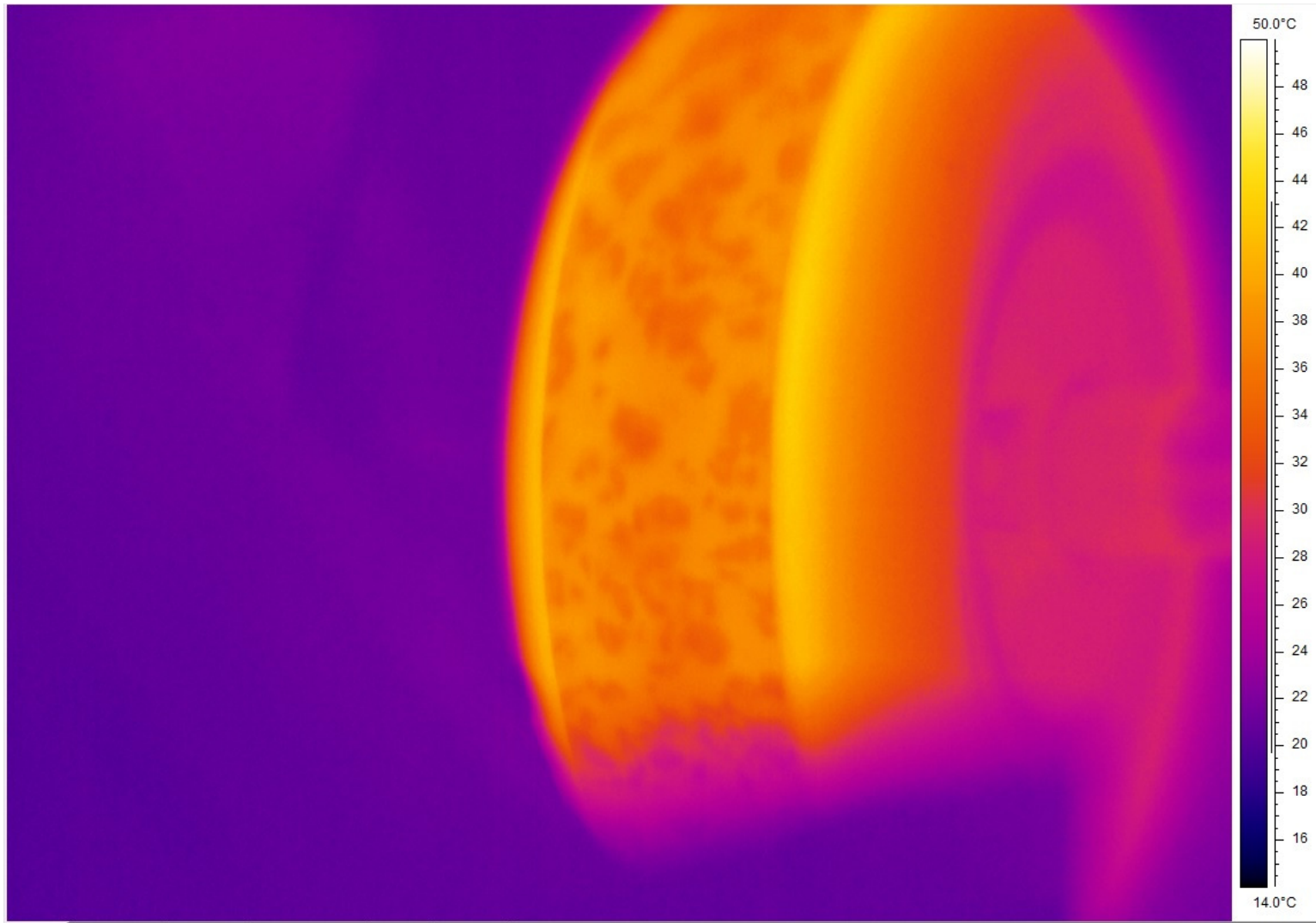
This paper

- Considers 3D modelling as a means of getting more information.

- Two techniques considered:
  - close range photogrammetry (CRP)
  - 3d laser scanning (3dLS) using a hand held 3D scanner.

- These produce 3D models.

- Analysed using proprietary software to produce parameters in accordance with harmonised European Standards for 3D Areal Surfaces.

Texture – data v. cost

Sand Patch Test

Close Range
Photogrammetry (CRP)

3D Laser System

Data

Cost
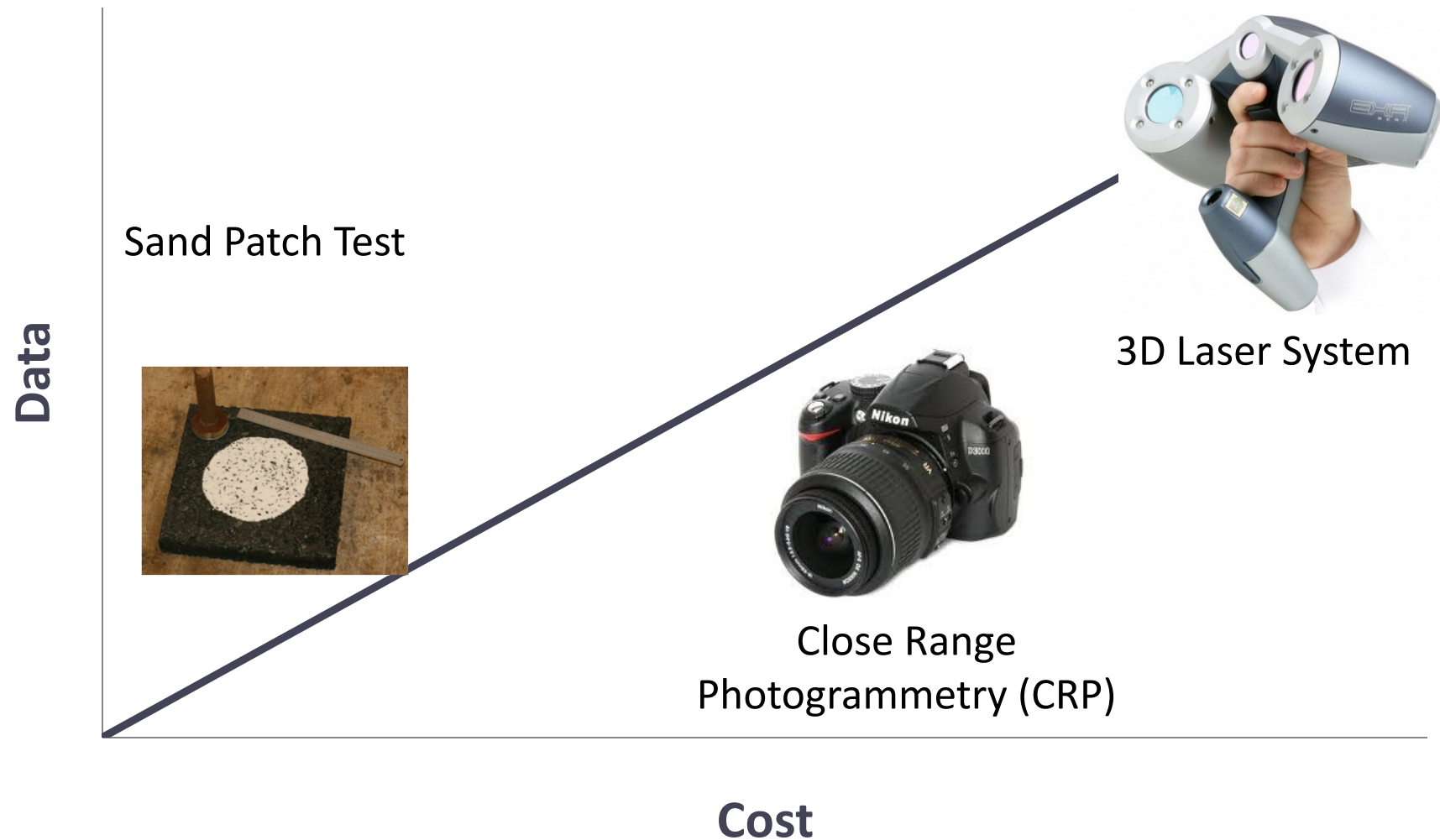
CRP methodology

- Apply a control framework

- Obtain a stereo image pair
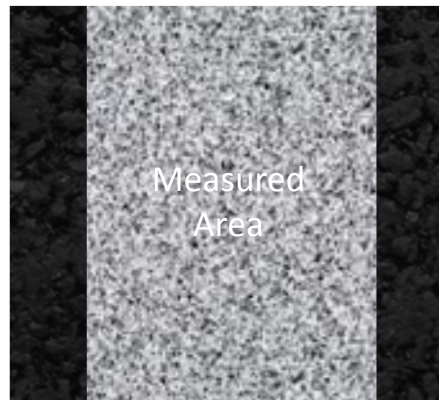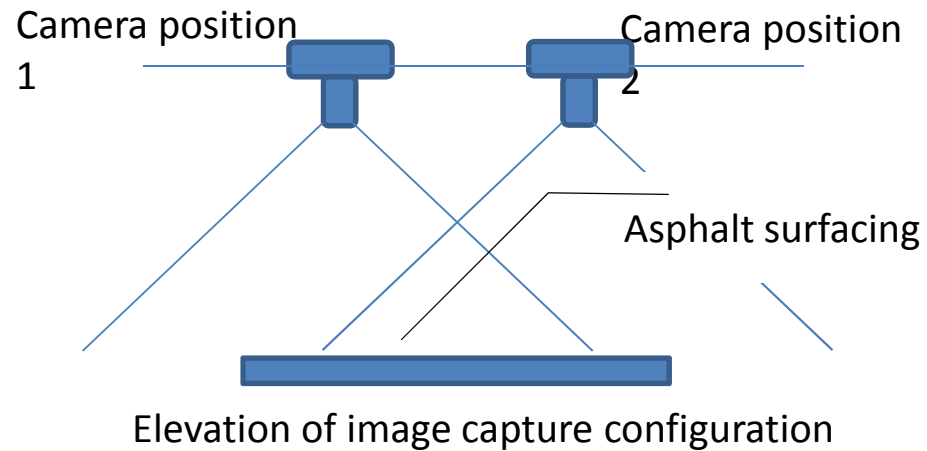
- Prepare a 3D model using photogrammetric software

- Spatial analysis

Control framework

Stereo image pair

Camera position
1

Camera position
2

Asphalt surfacing

Elevation of image capture configuration

Measured
Area
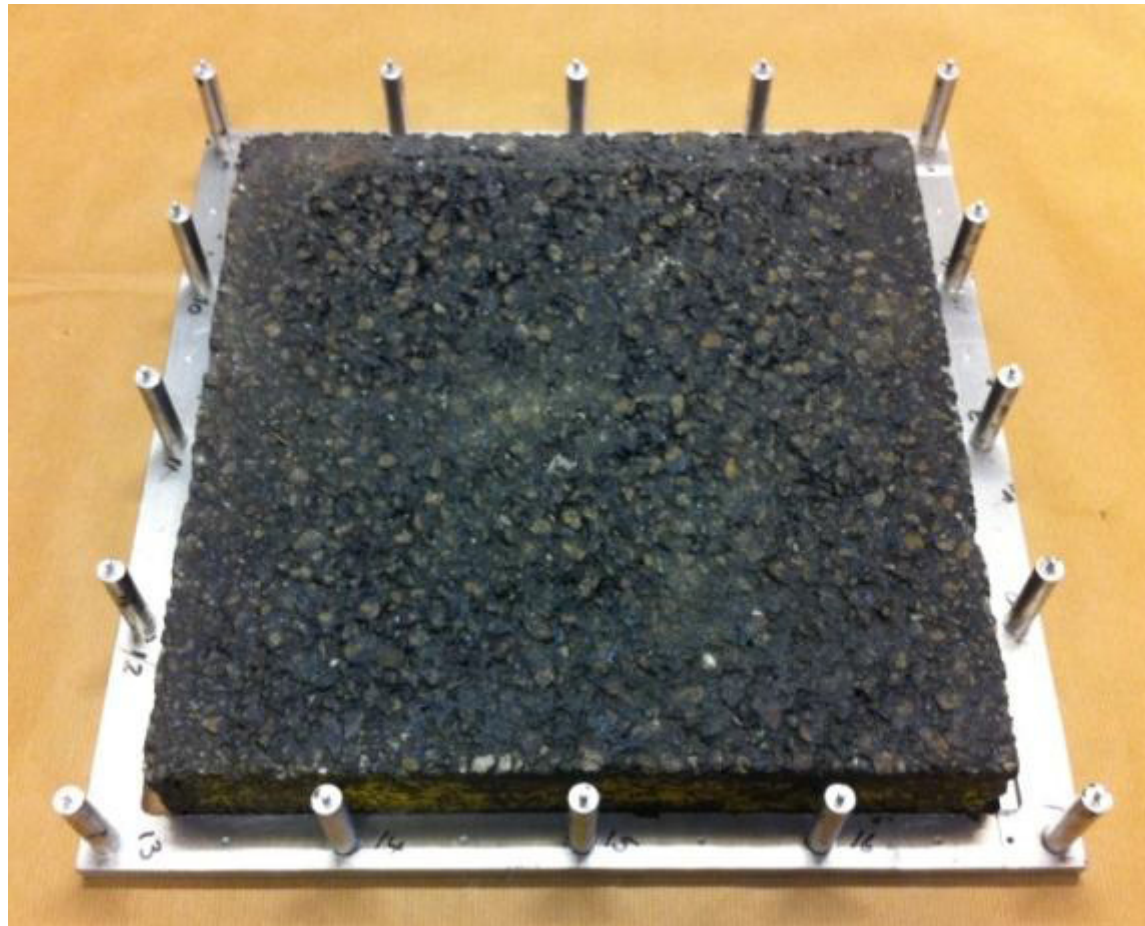
Plan view of asphalt surfacing

Software

3d laser scanning methodology

- Preparation of test specimen for scanning
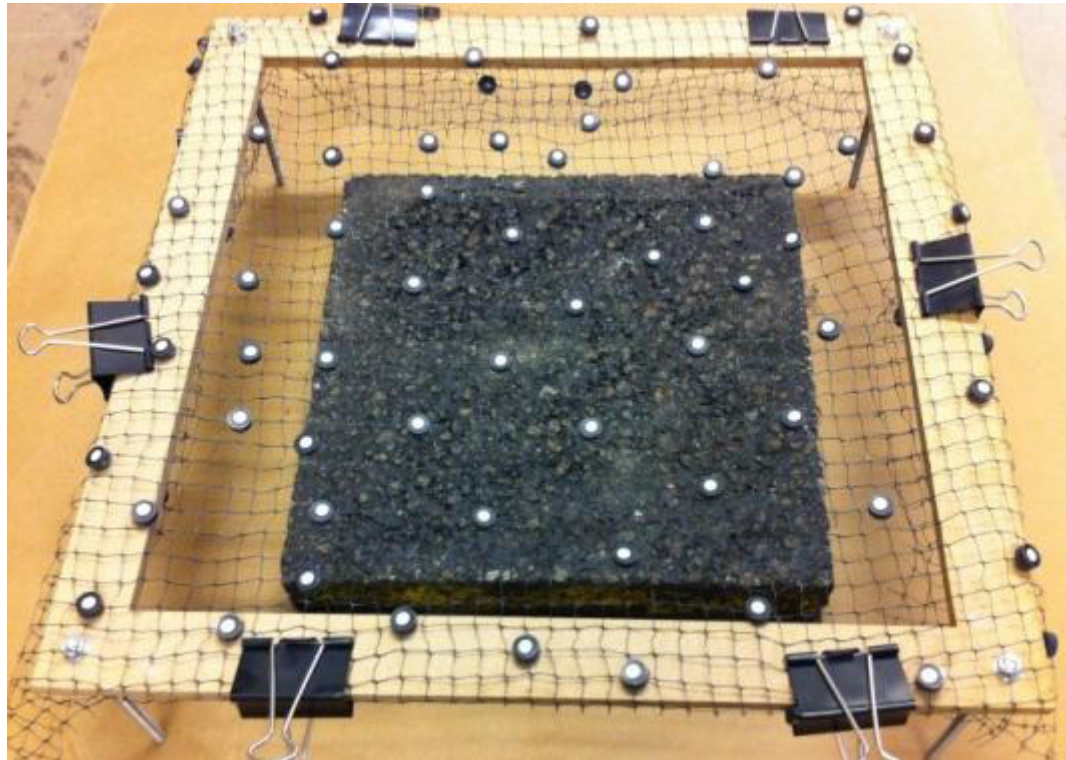
- Apply a control framework

- Obtain a point cloud

- Edit point cloud
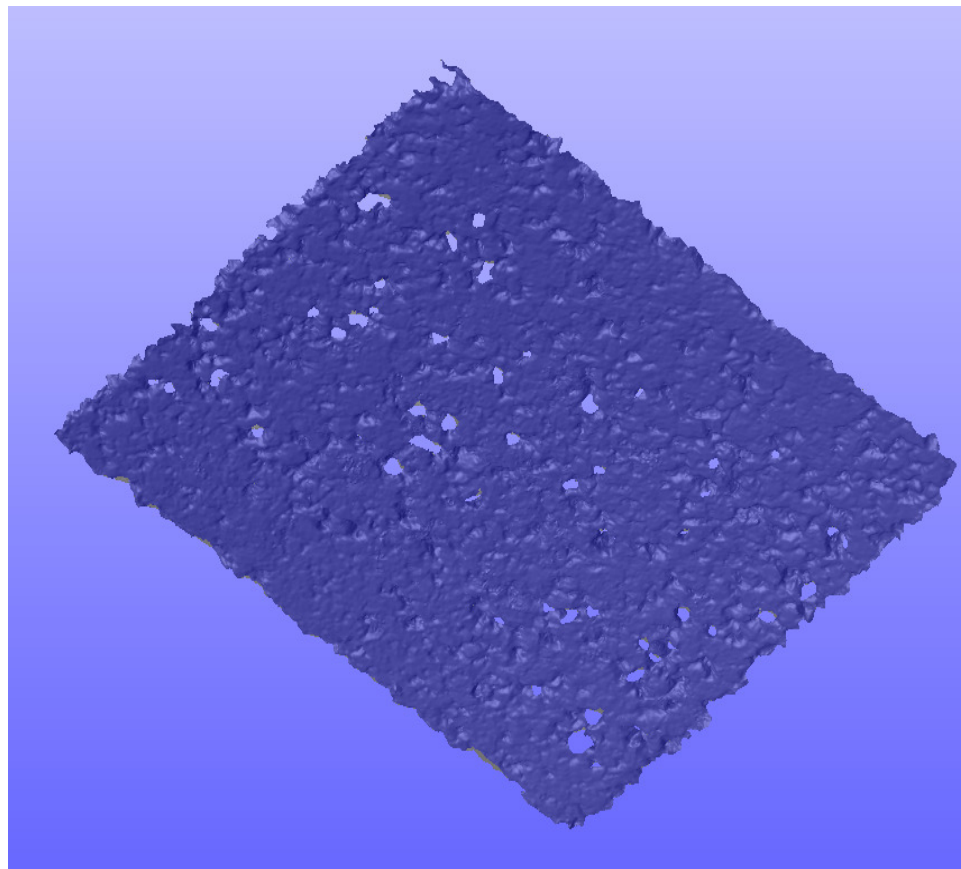
- Spatial analysis

Preparation of surface
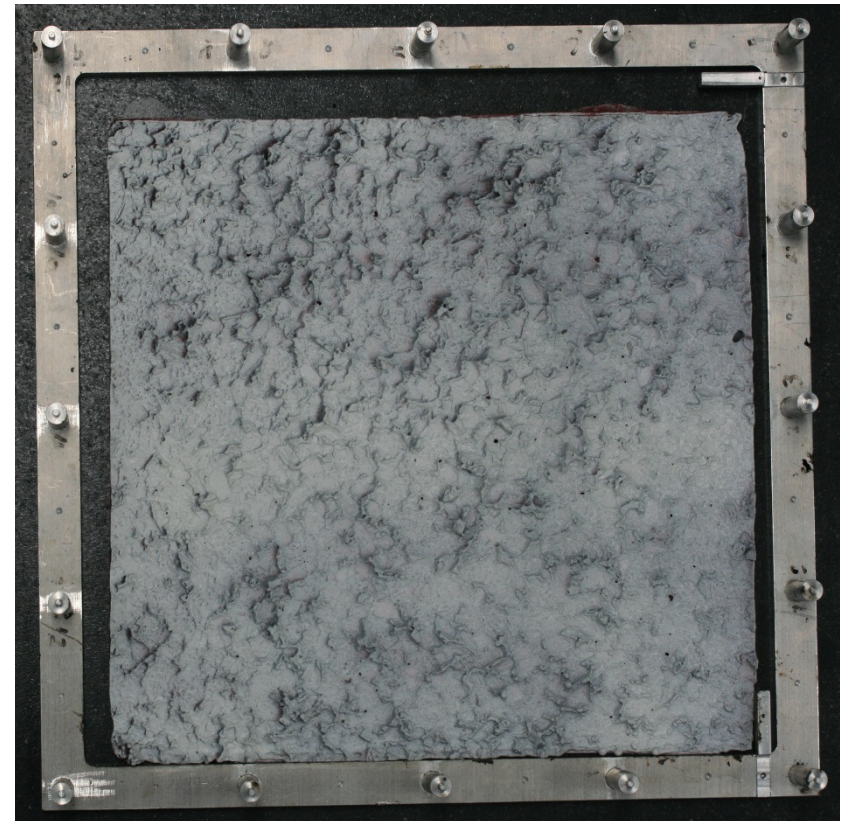
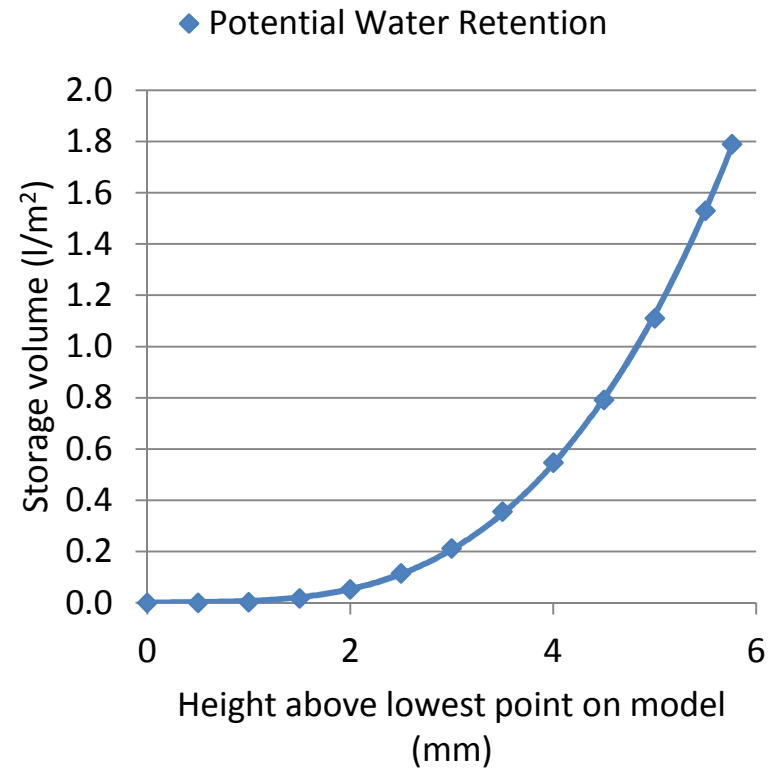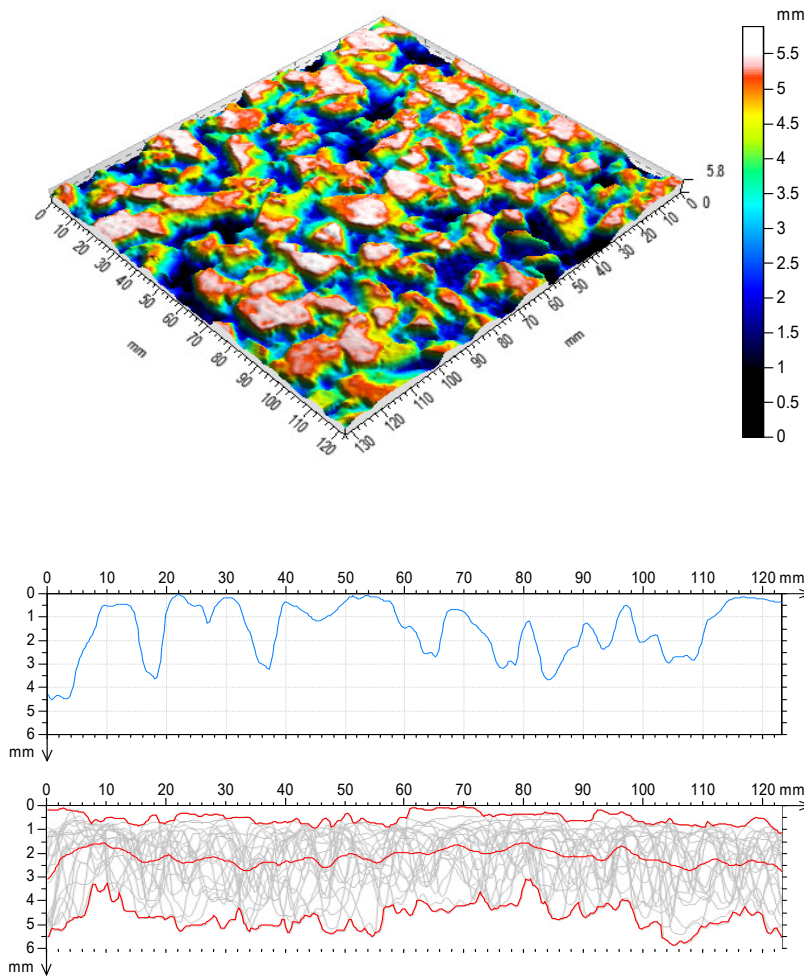# Control framework

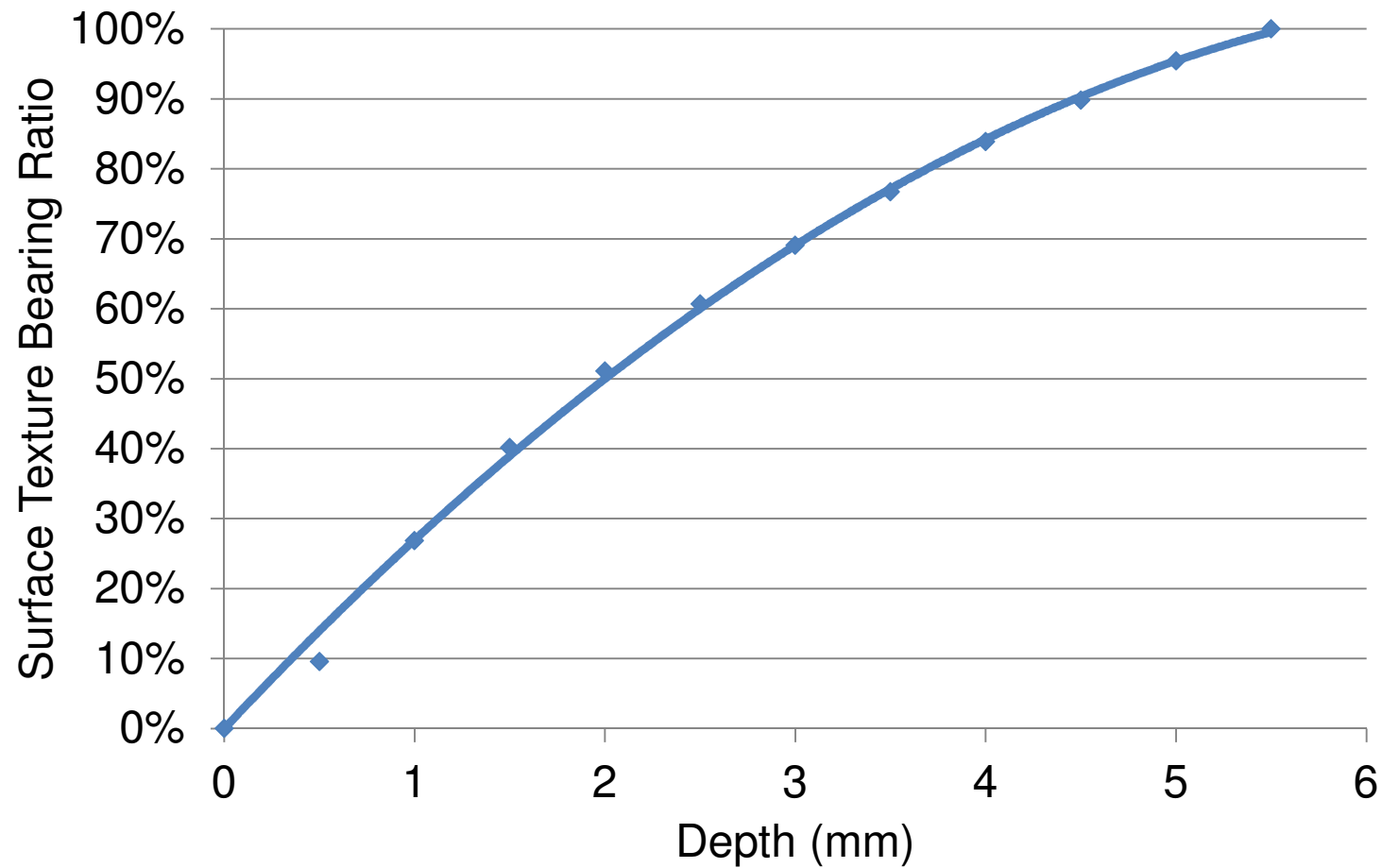# Point cloud before editing
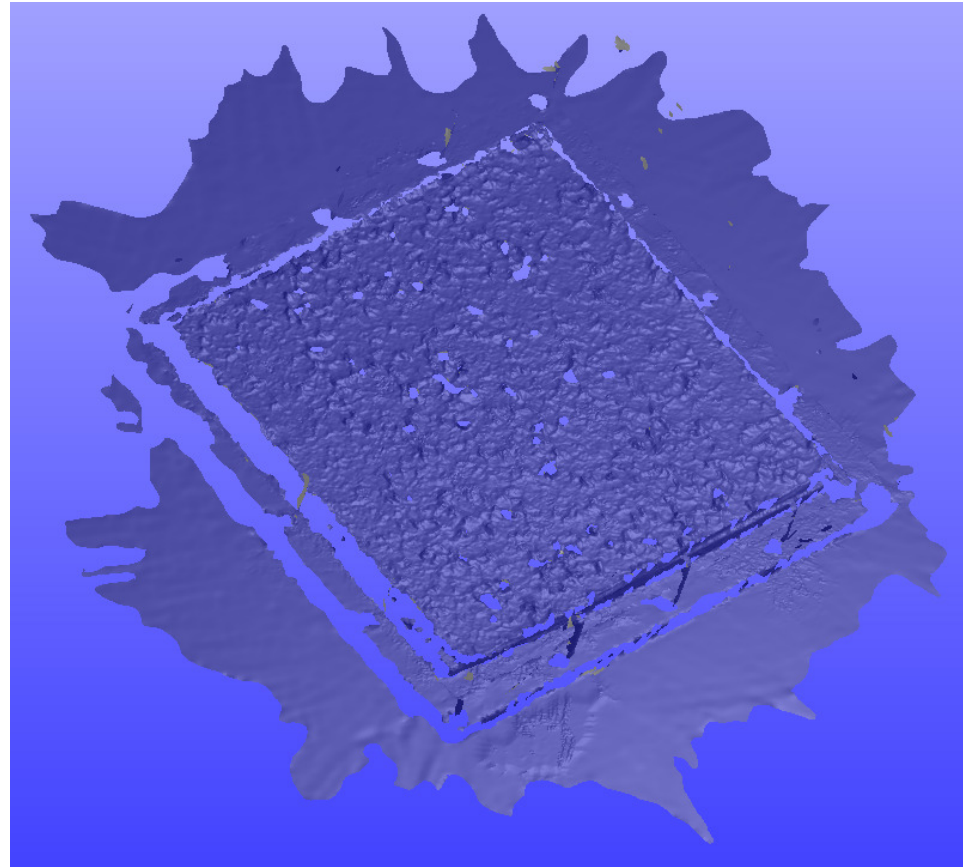
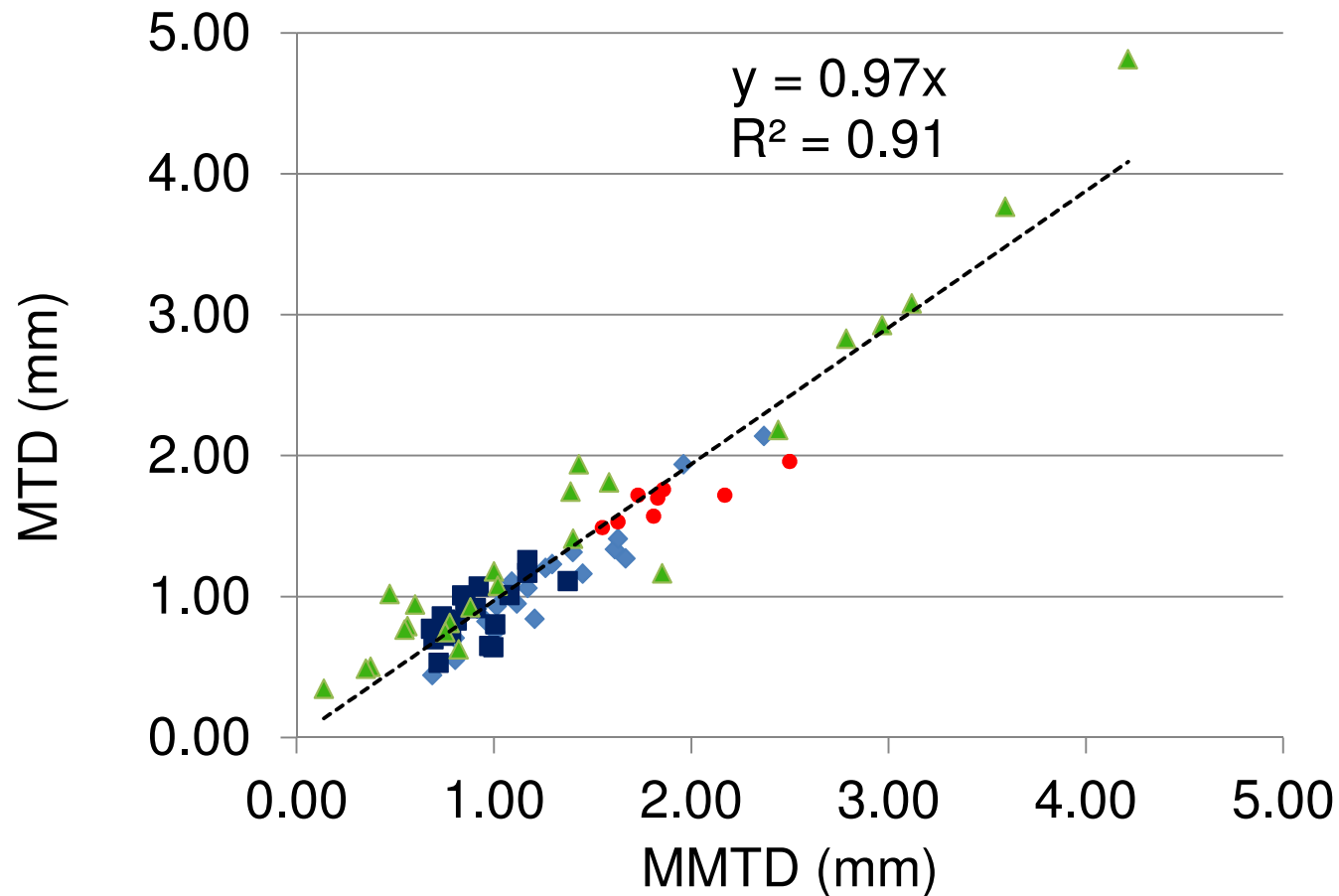# Point cloud after editing

3D model of a newish, dirty road surface
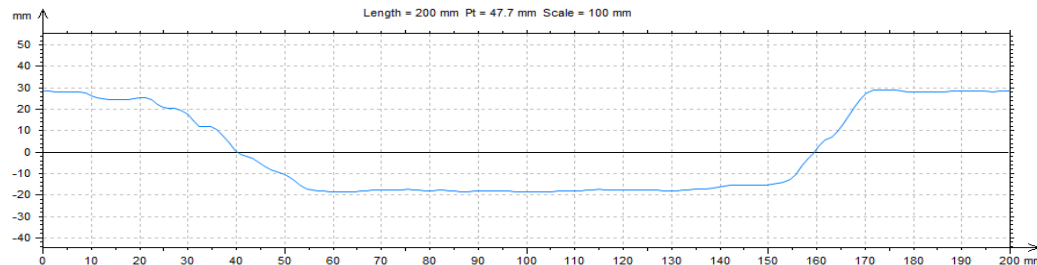
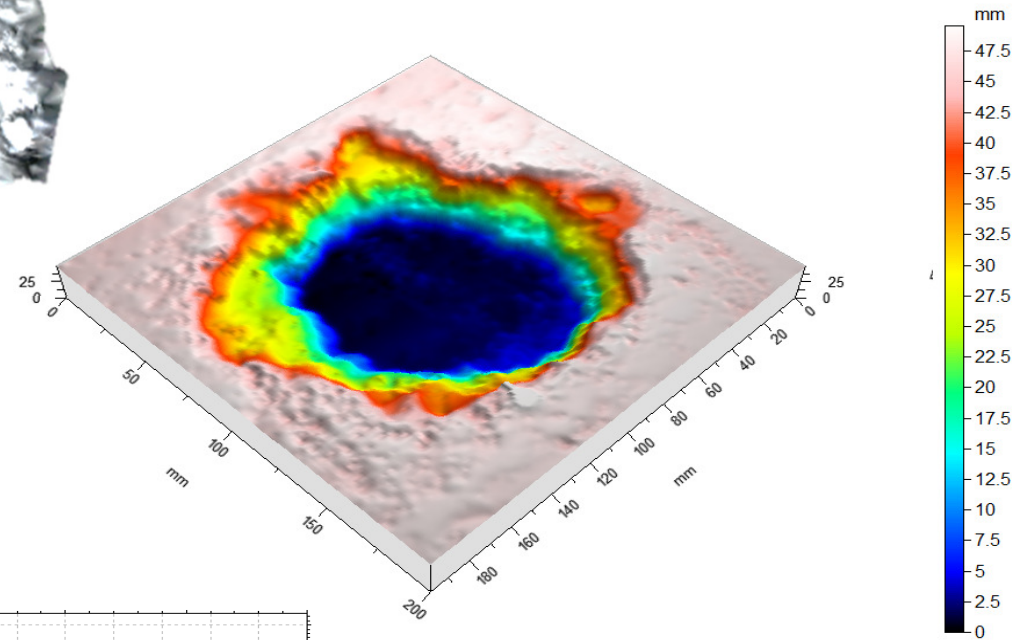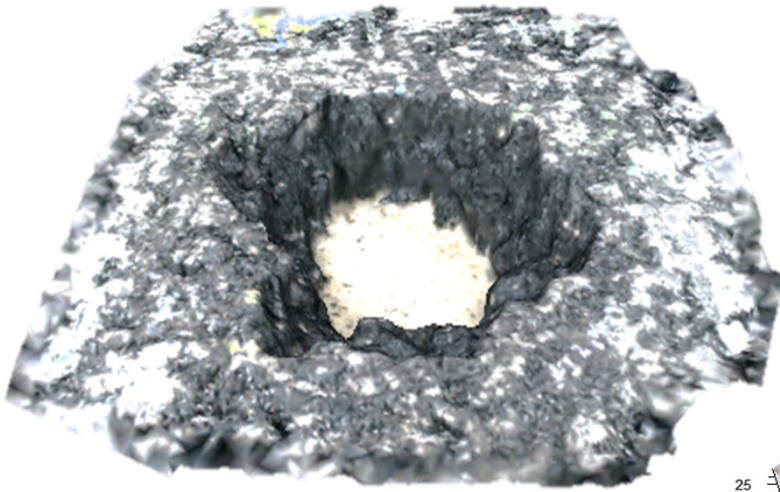# Extracting data from the 3D model
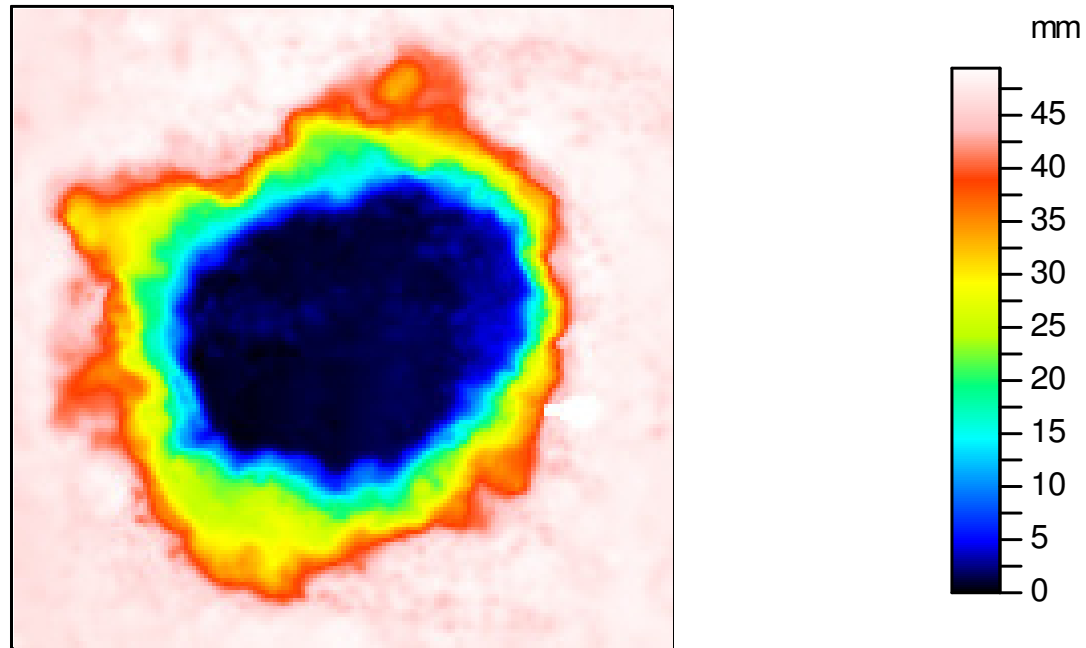
Texture bearing ratio v. depth

Comparison of texture depth data using CRP and volumetric sand patch
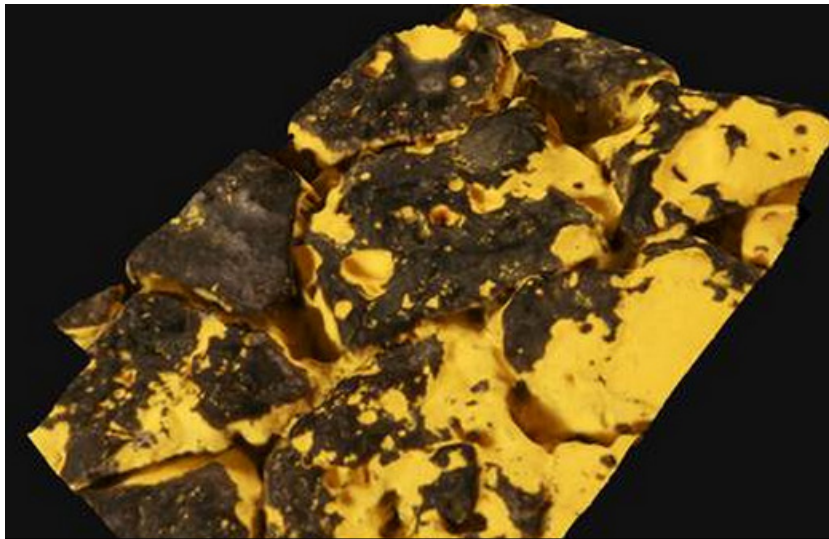
Laboratory made pothole 3D modelled in Zephyr
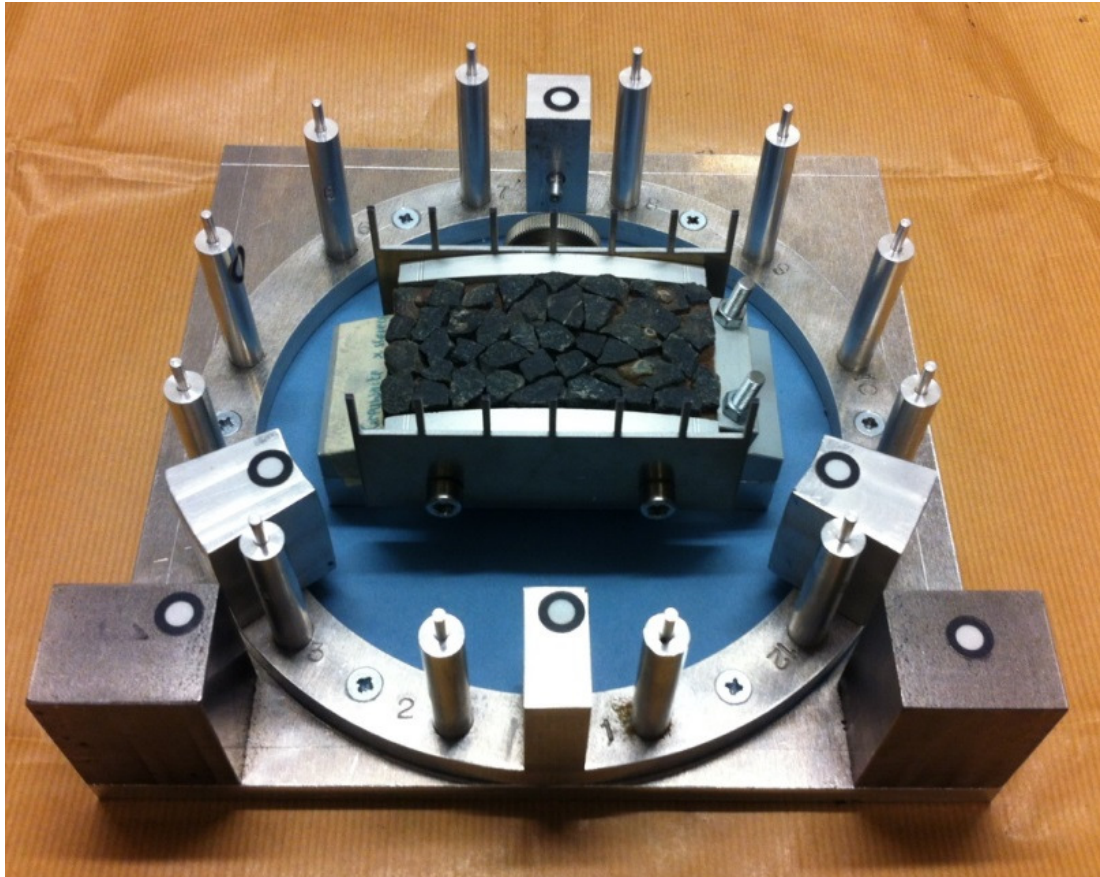
Some usable data about the pothole

Horizontal Area	18916 mm²
Developed Area	29165 mm²
Complexity	54.2 %
Depth	46.2 mm
Volume	469959 mm³
Perimeter	568 mm

Examples of PSV 3d models

3D models generated by Zephyr Software

PSV control framework for CRP

Modified PSV testing

| Aggregate	Time0	Time3	Time6	Time9
Carboniferous Limestone A	68	61	40	22
Carboniferous Limestone B	72	65	56	57
Quartz Dolerite	71	68	55	39
Tertiary Basalt	79	70	53	34
Silurian Greywacke	73	71	62	58
Carboniferous Sandstone	85	81	70	44

PSV test specimen colour banded 3D model - curved (left image) and flattened (right image)
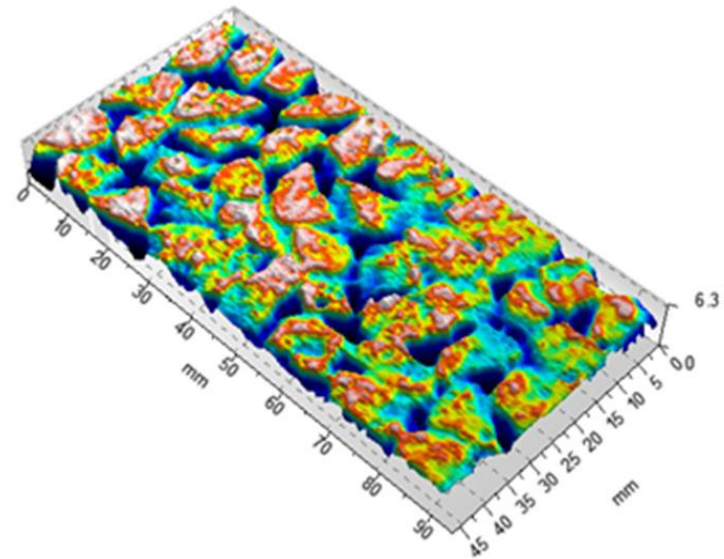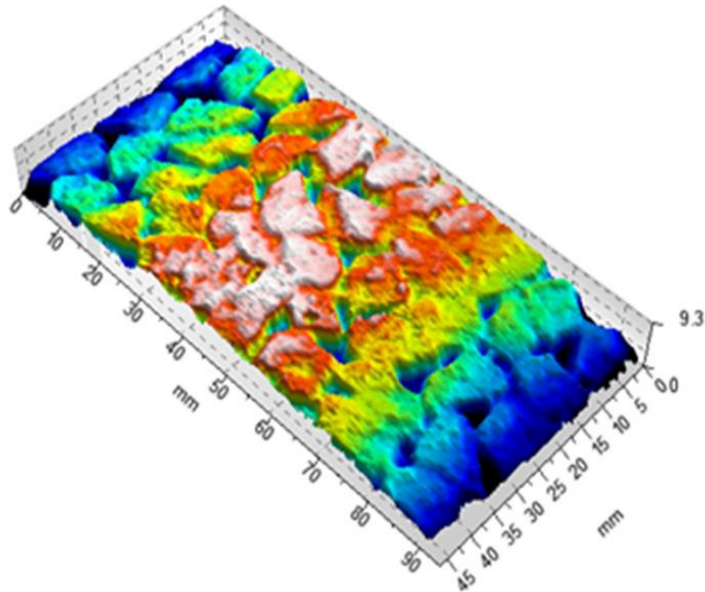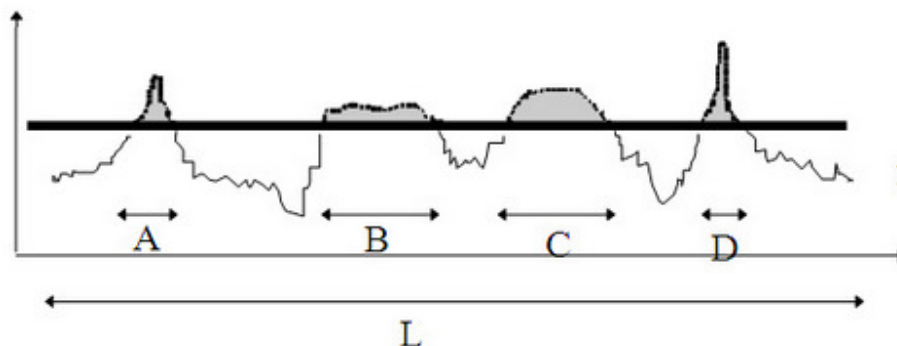
Single greywacke aggregate particle at Time 0 (left image) and at Time 6 (right image)
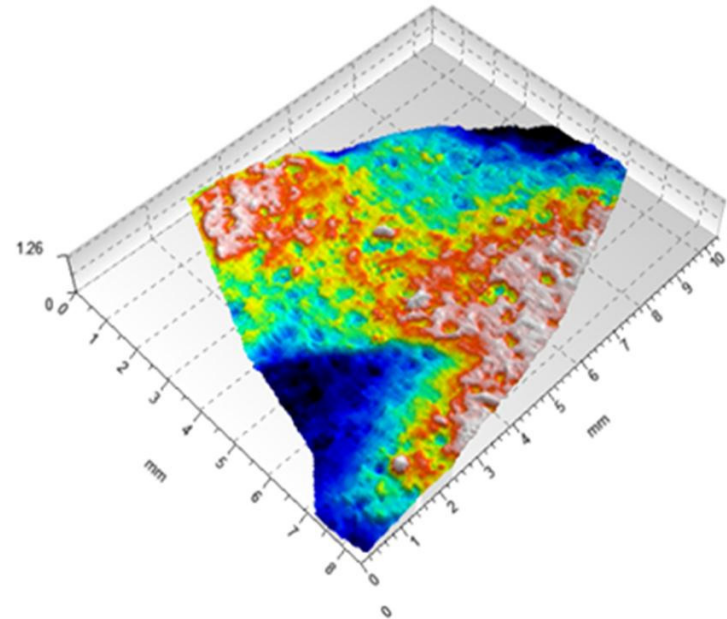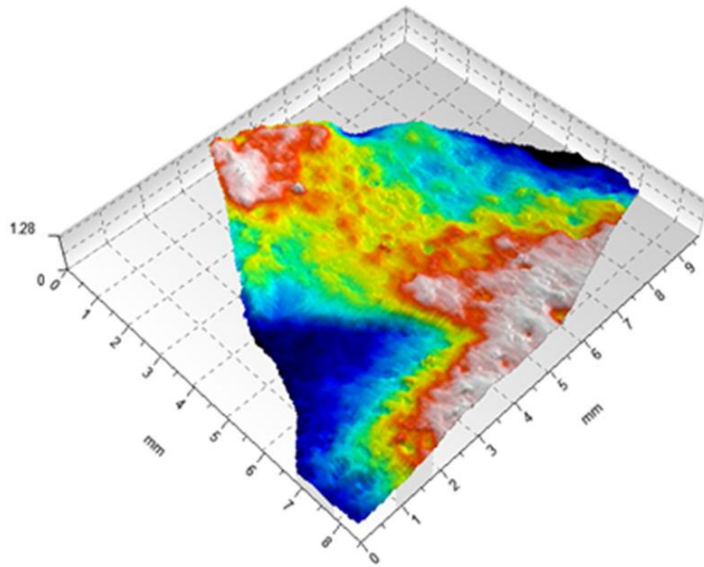
Use of Abbott-Firestone Curve to describe surface textures (BS EN ISO 25178-2-2012)
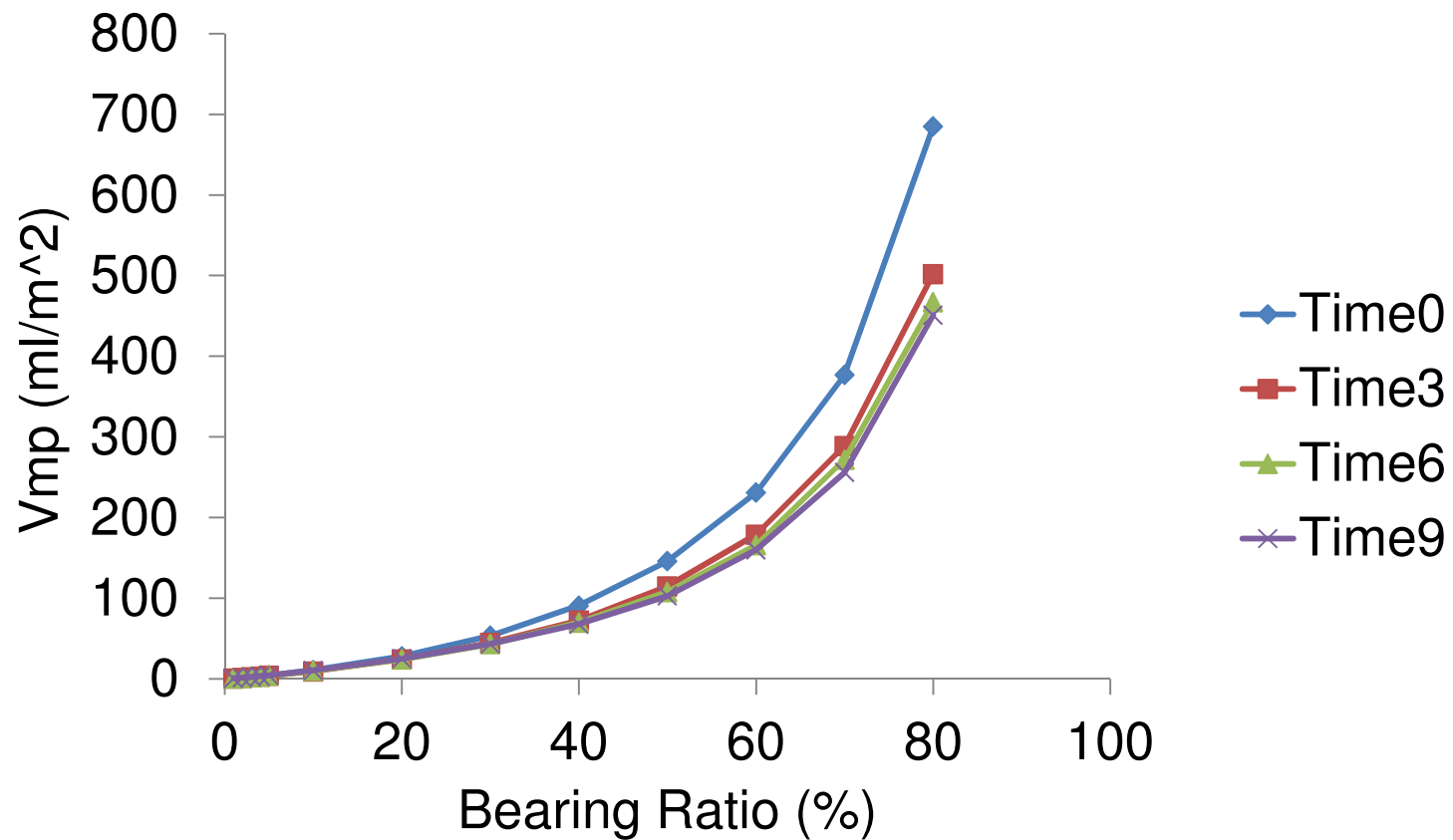

Peak Zone

Core Zone

Valley Zone

Vmp

Vmc

Vvc

Vvv

Material volume V_m
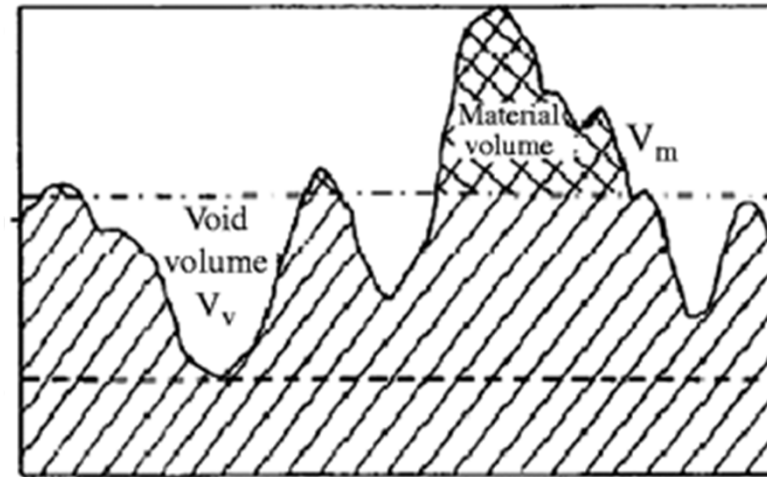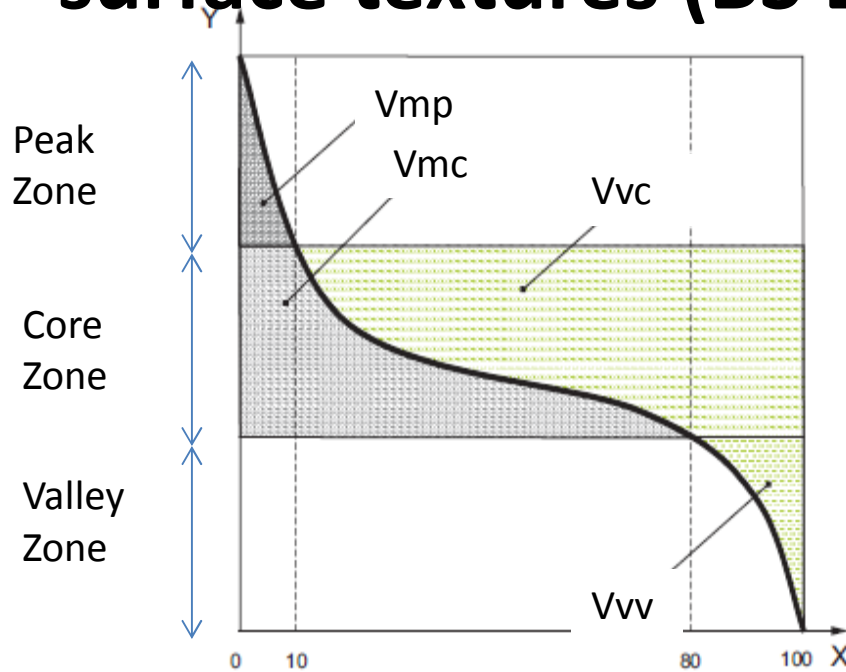
Void volume V_v

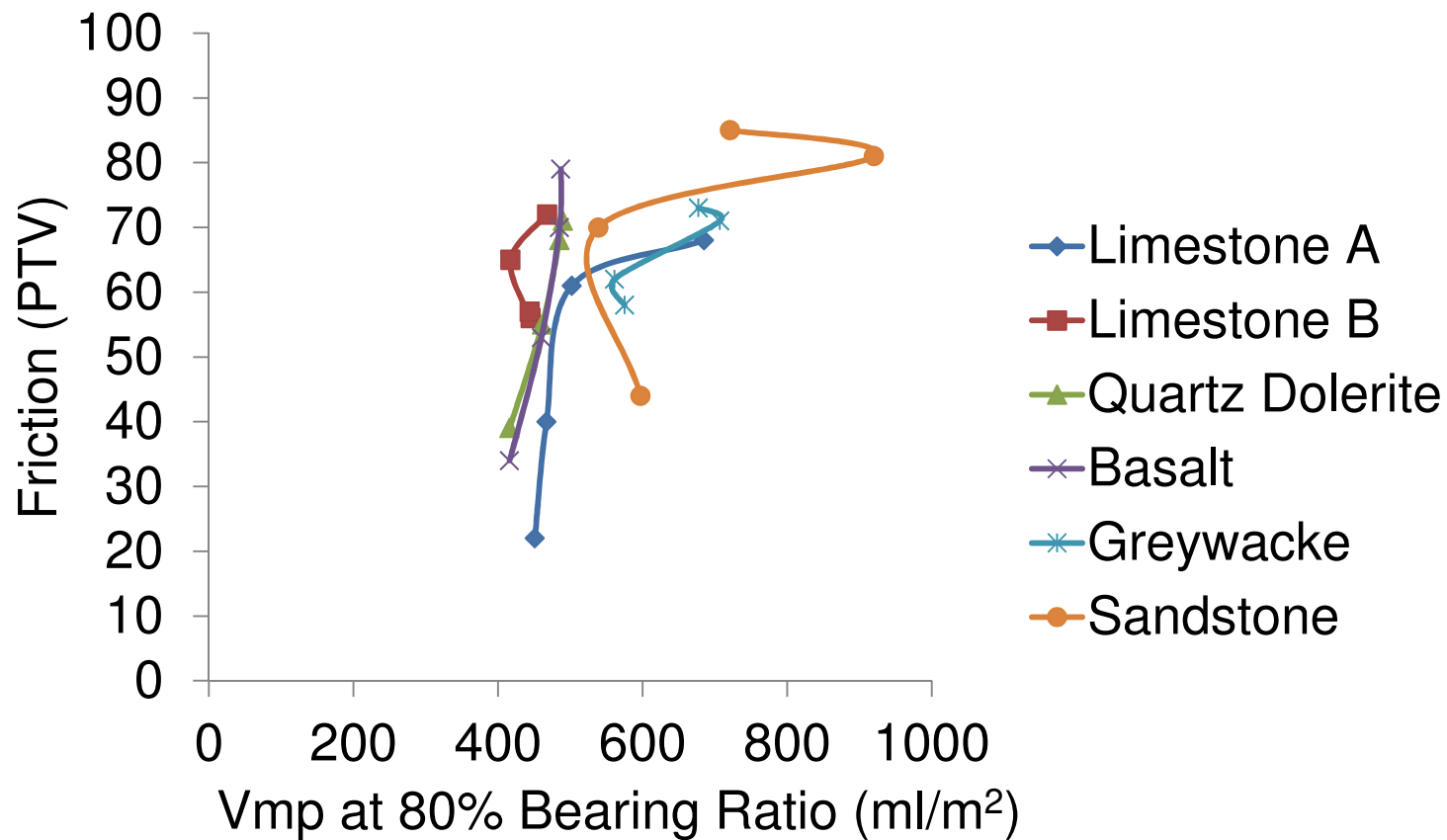|	
Vmp	Peak material volume
Vmc	Core material volume
Vvc	Core void volume

$$mr = 100\% \times (A + B + C + D)/L$$

Vmp v. Bearing Ratio for Limestone A

PTV v. Vmp at 80% Bearing Ratio

Friction (PTV)

Vmp at 80% Bearing Ratio (ml/m²)

Limestone A
Limestone B
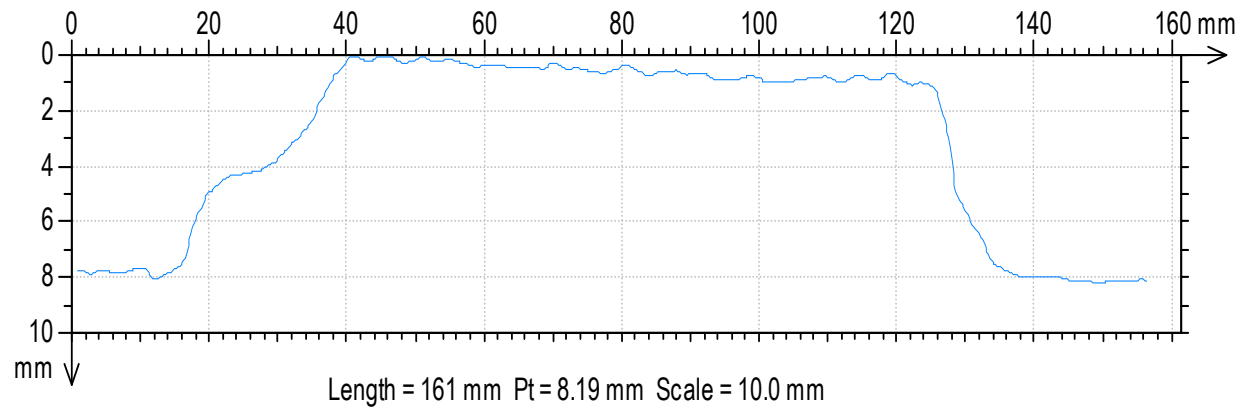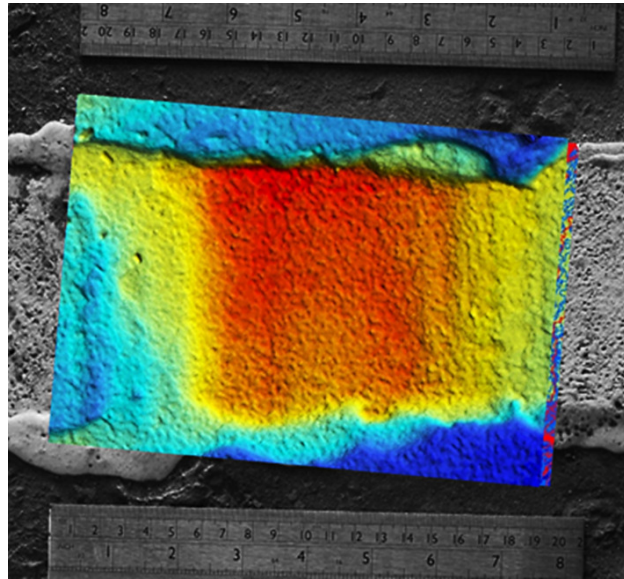Quartz Dolerite
Basalt
Greywacke
Sandstone

Gyratory test specimen after modified wheel track test
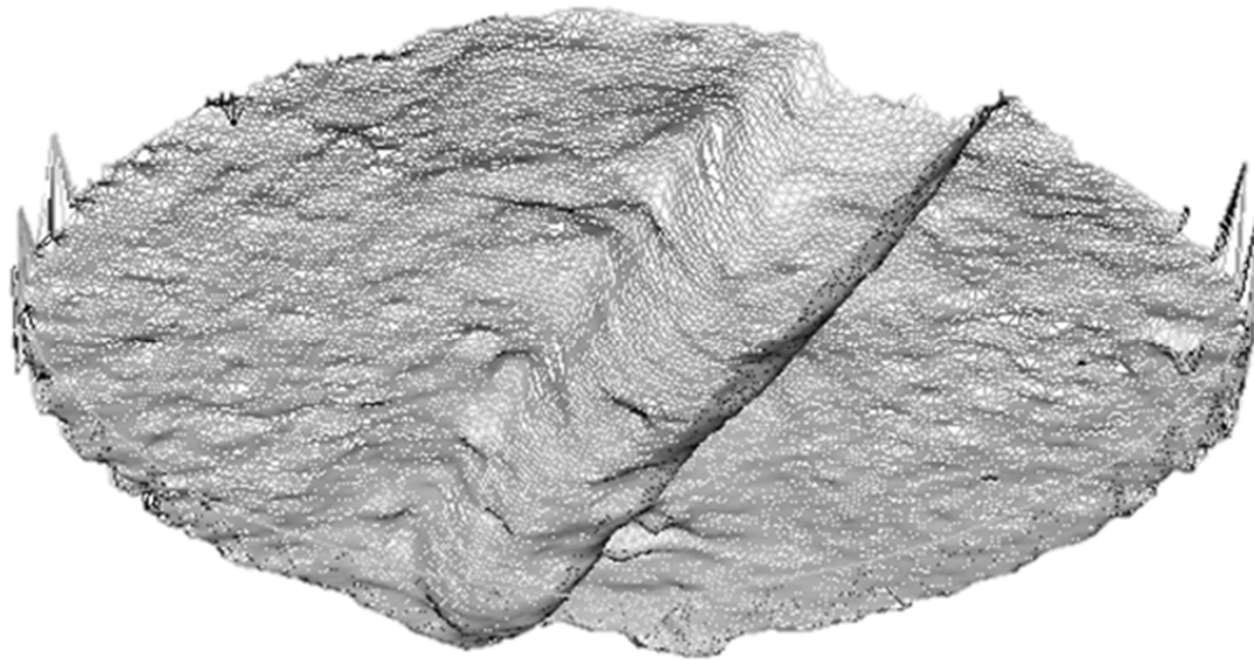
3D model generated by ImageMaster Pro Software

Surface texture recovery of a white road marking

Length = 161 mm Pt = 8.19 mm Scale = 10.0 mm

Failing in-situ construction joint

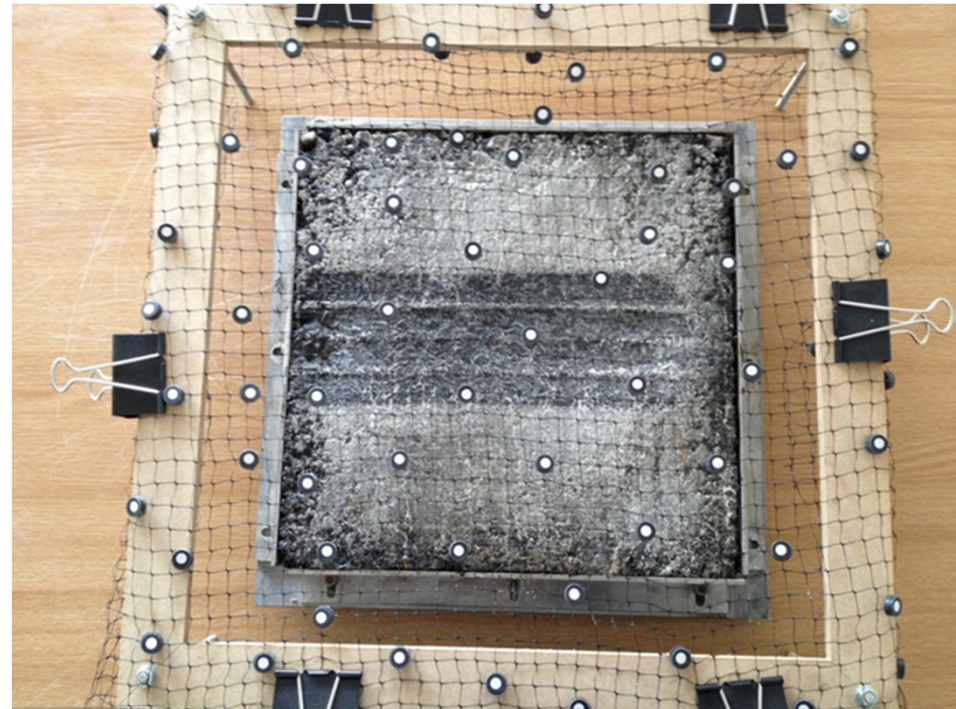With overlaid raster
image of the surface
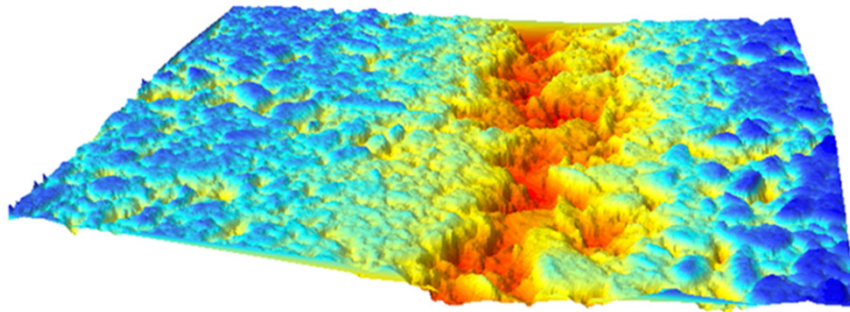
Depth classified model

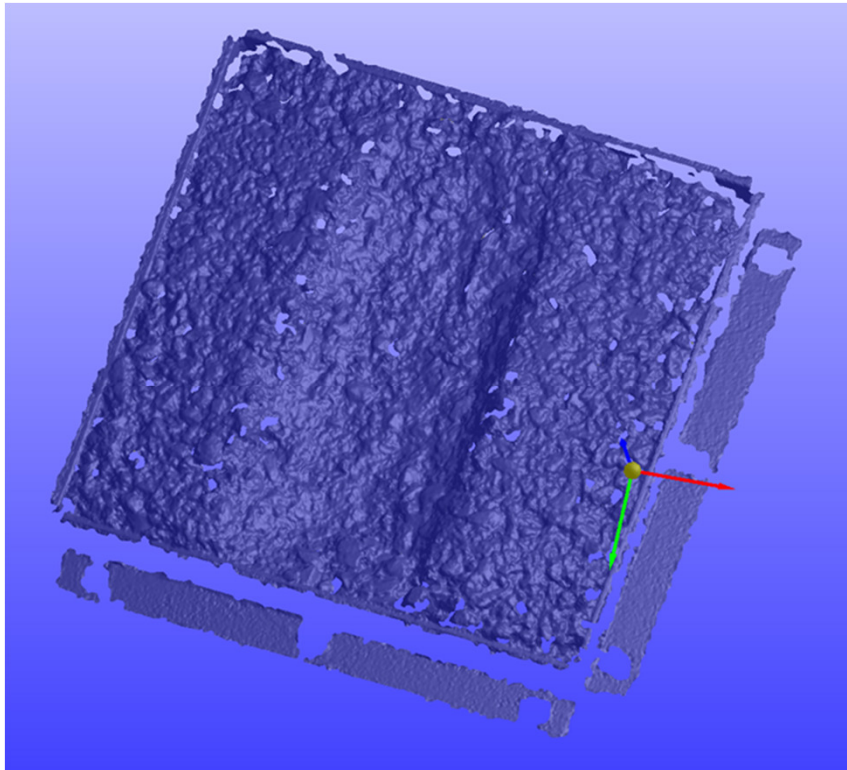3D model generated by CRP, ImageMaster Pro Software and ArcGIS

Test Mould and Braking System

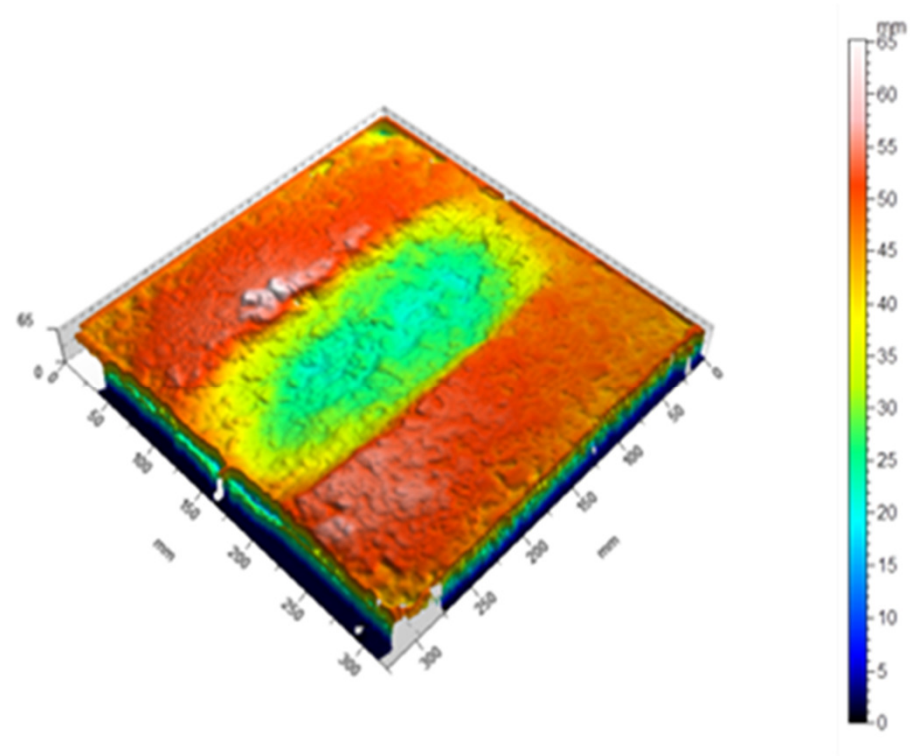# Measuring material loss in a new durability test

Poorly compacted AC14 slab tested in water at 60^0 C for 5 minutes
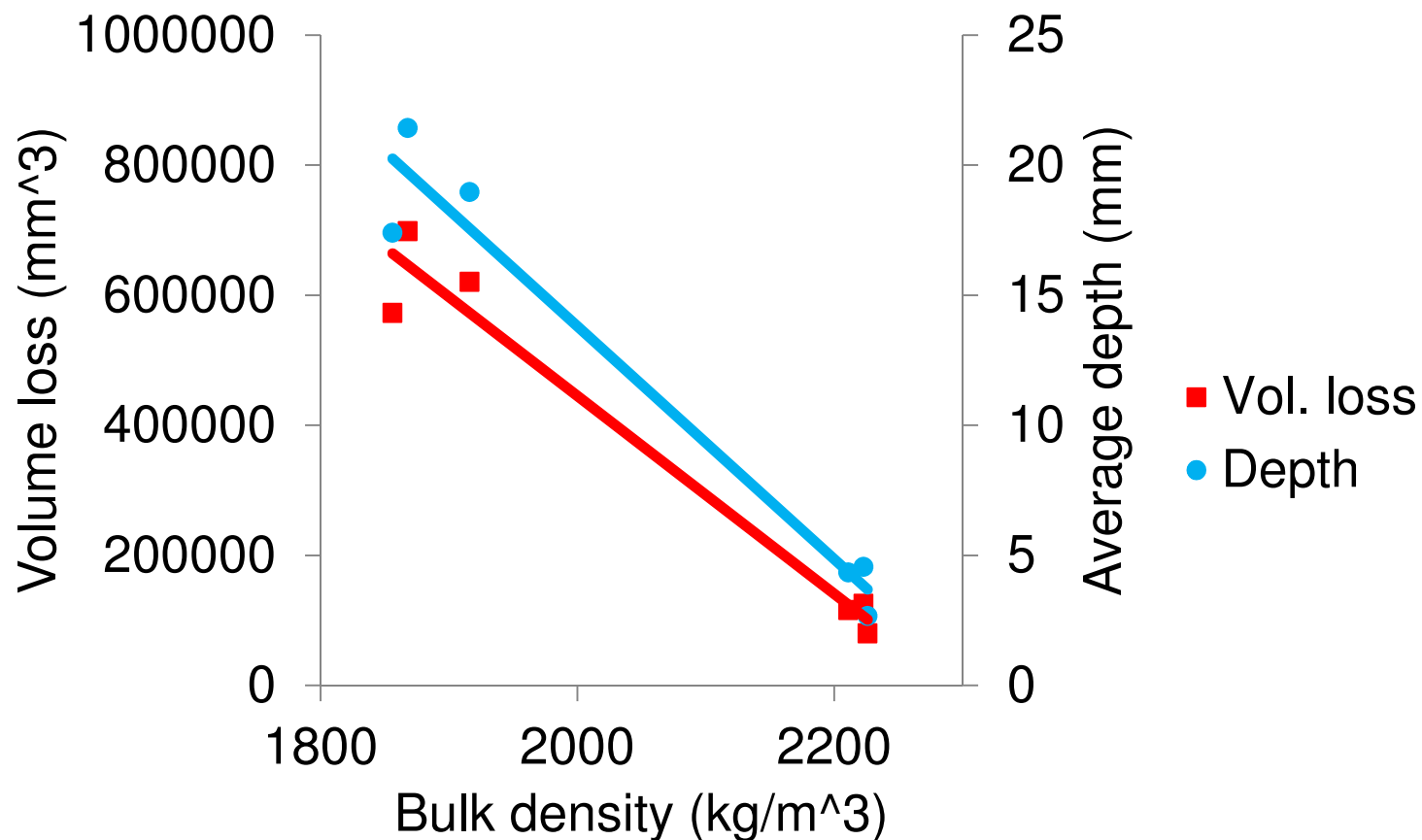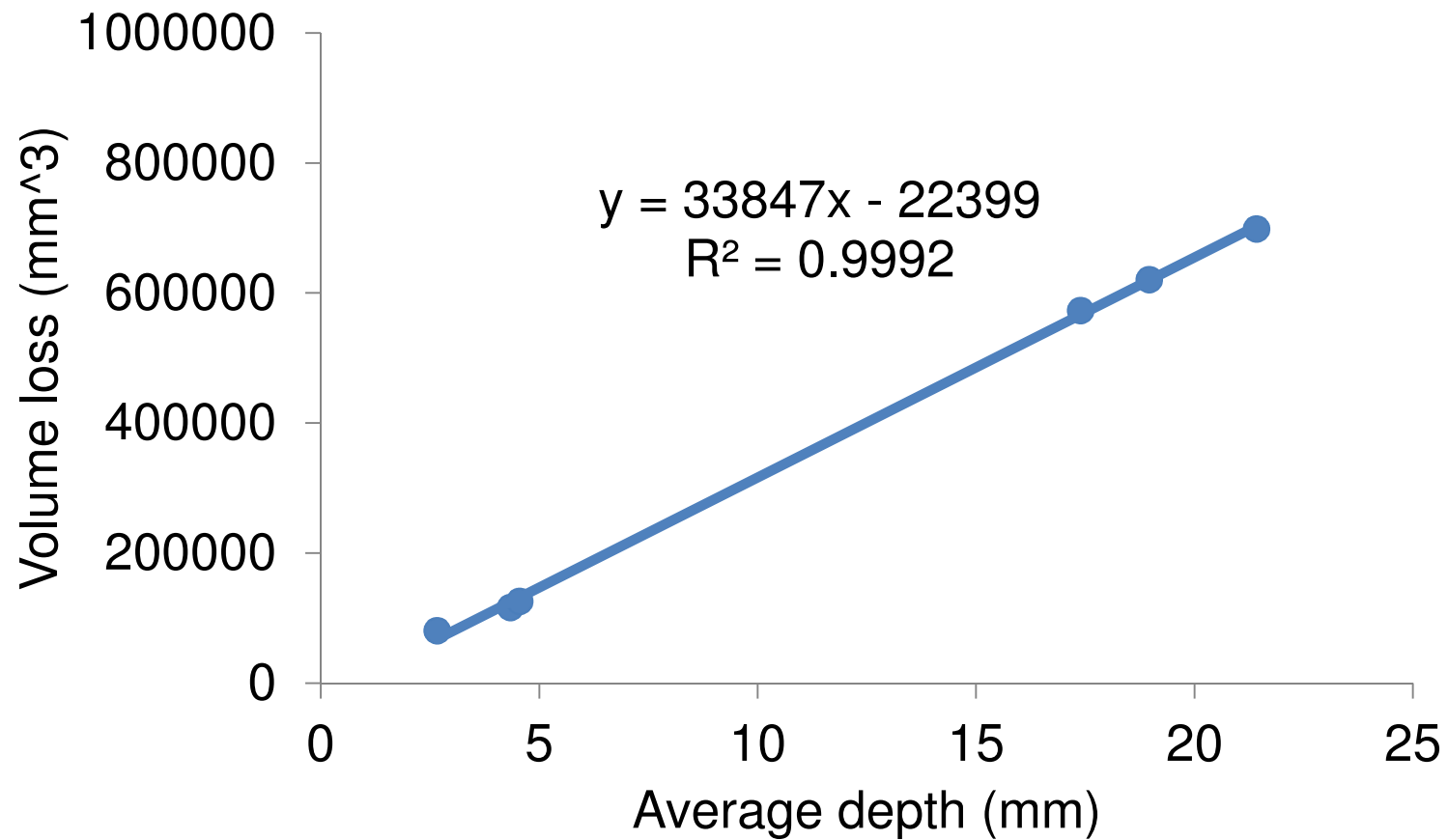
Recovered data

Digital Surf MountainsMap7

Compaction (bulk density) v. average depth and volume of ravelled material

Volume loss v. average depth

$y = 33847x - 22399$
$R^2 = 0.9992$

Volume loss (mm^3)

Average depth (mm)

Conclusions

- CRP and 3DLS based 3D models can be used to better understand texture related issues for surfacing materials.

- The 3D models can be manipulated and analysed using proprietary software to achieve otherwise unattainable surface parameters.

- This ability to easily measure and quantify parameters opens new opportunities to investigate issues at scales ranging from the macro to the micro.