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BSSM 2012: Test and analysis of materials in sports engineering

Understanding the traction of tennis surfaces

James Clarke
Sports Engineering Research Group
The University of Sheffield

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Project Overview

Biomechanics Research Team

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Background

Traction in tennis:

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*Dunn *et al*. Assessing tennis player interactions with tennis courts, 29th international conference on biomechanics in sport (2011).

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Background

Traction in tennis:

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Background

Injury Risk:

Acrylic Hard Court – higher occurrence of injury.

Clay – lower occurrence of injury.

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Background

Injury Risk:

Acrylic Hard Court – higher occurrence of injury.
COT ~ 0.8 – 1.2 (Nigg, 2003)

Clay – lower occurrence of injury.
COT ~ 0.5 – 0.7 (Nigg, 2003)

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Background

Injury Risk:

Surfaces which do not allow sliding increase the potential to cause injury.

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Project objectives

- Identify parameters that influence traction
- Design and develop a test rig
- Develop predictive models

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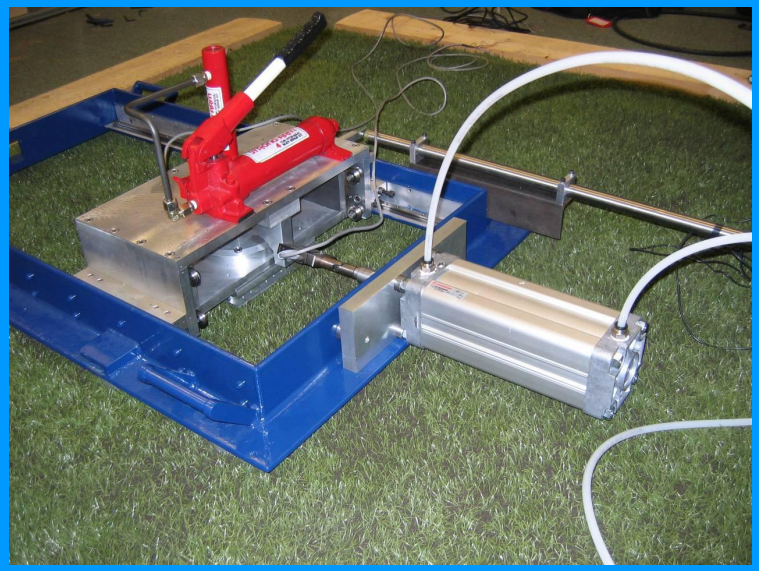
Methodology

Bespoke UoS1



STM 603

Slip resistance tester

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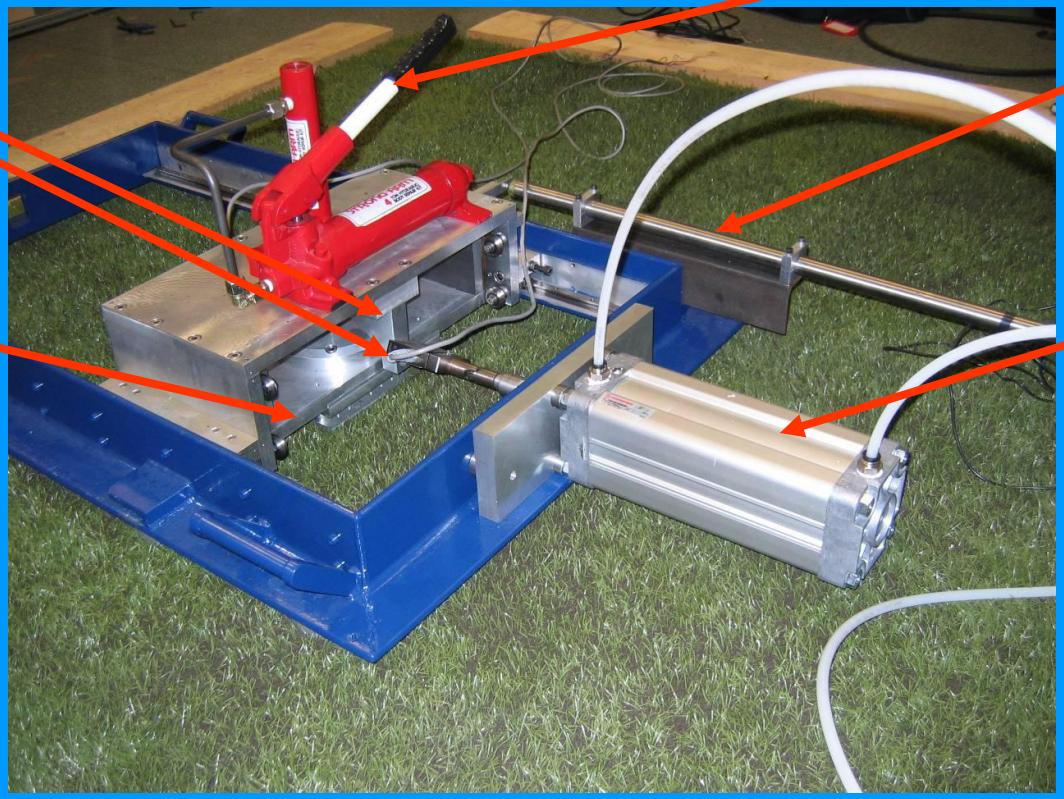
Methodology

UoS1 Rig

Horizontal and vertical load cells

Mounted footwear on plate



Hydraulic ram – normal force

LVDT (displacement)

Pneumatic ram – force controlled displacement

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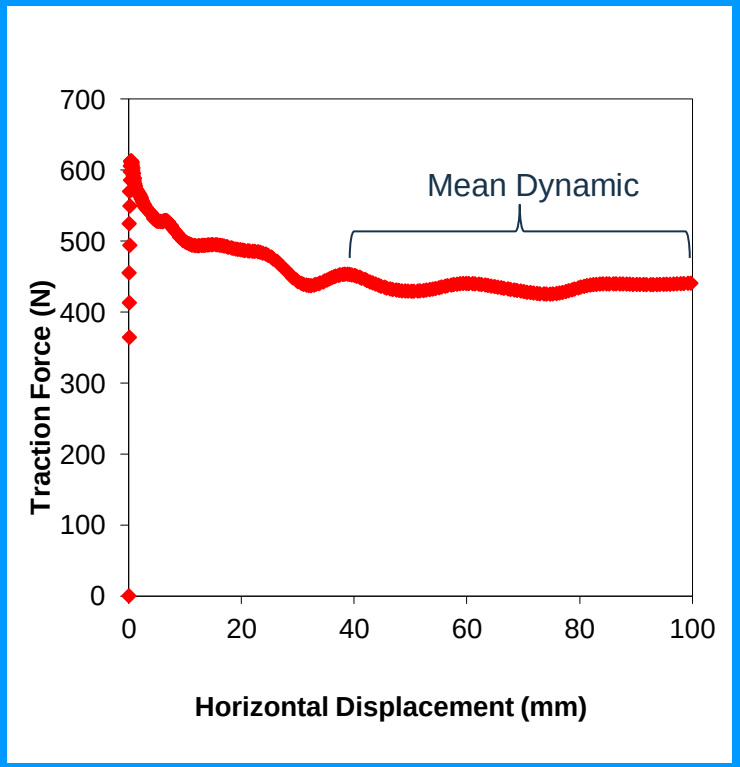
Methodology



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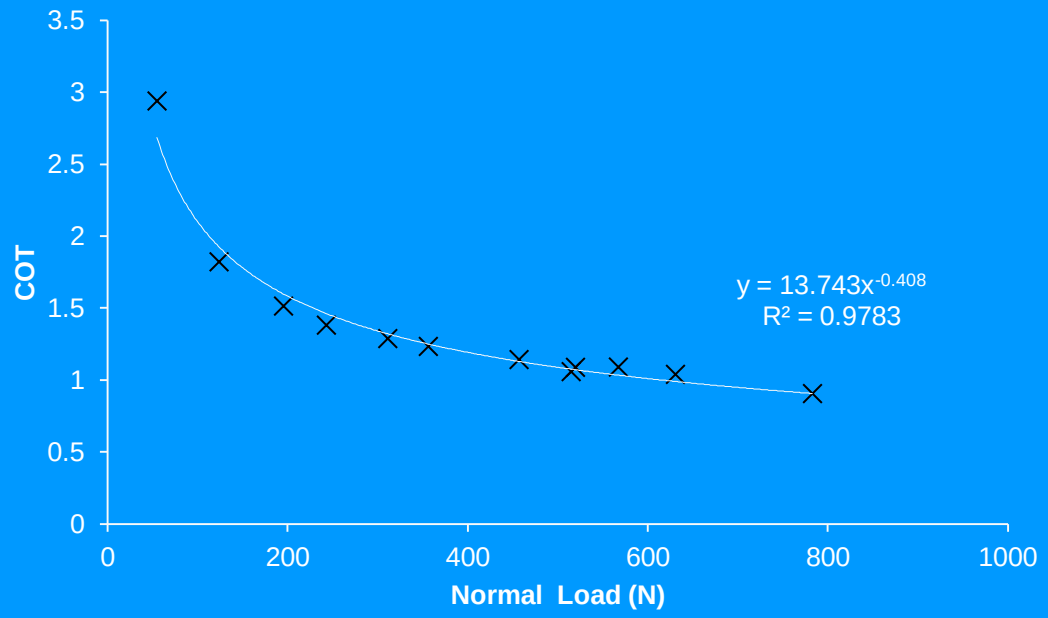
Results

Strong power relationships were found between Normal Force and COT.



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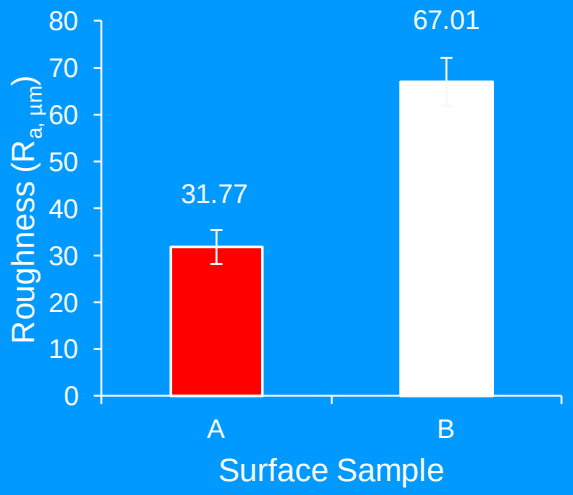
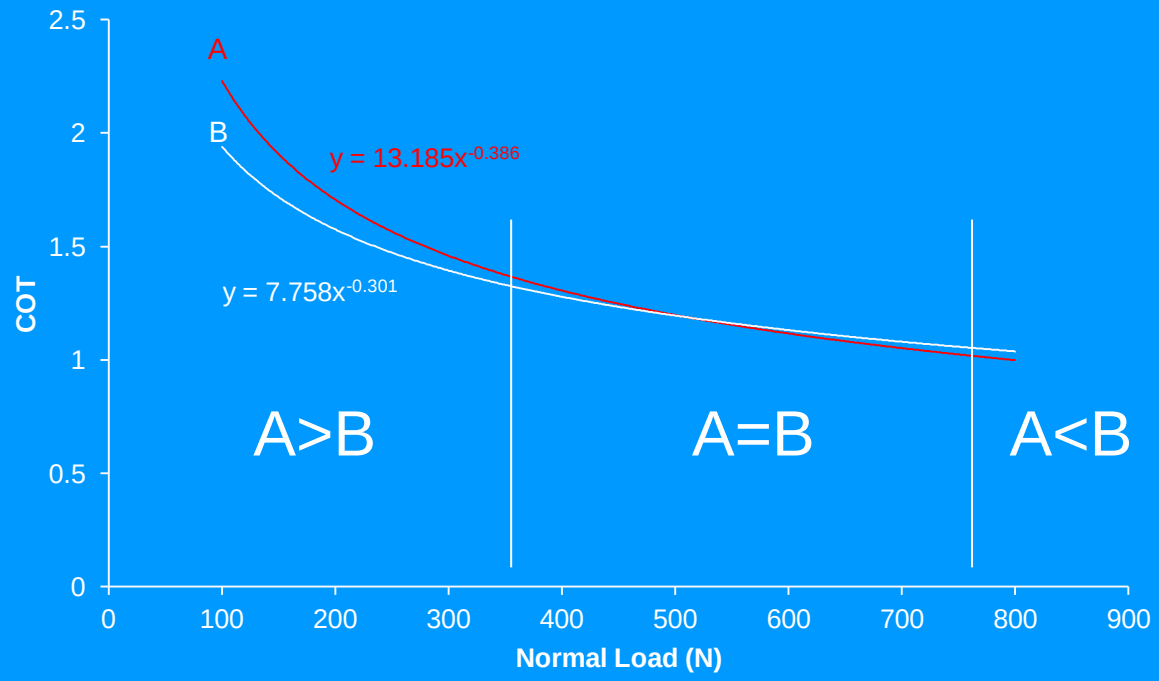
Results

- Effect of Roughness





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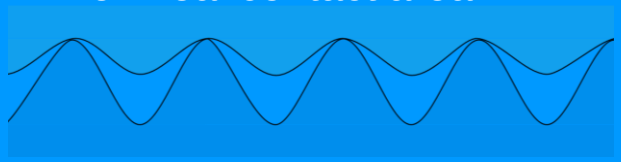
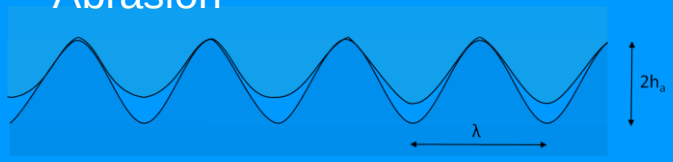
Results

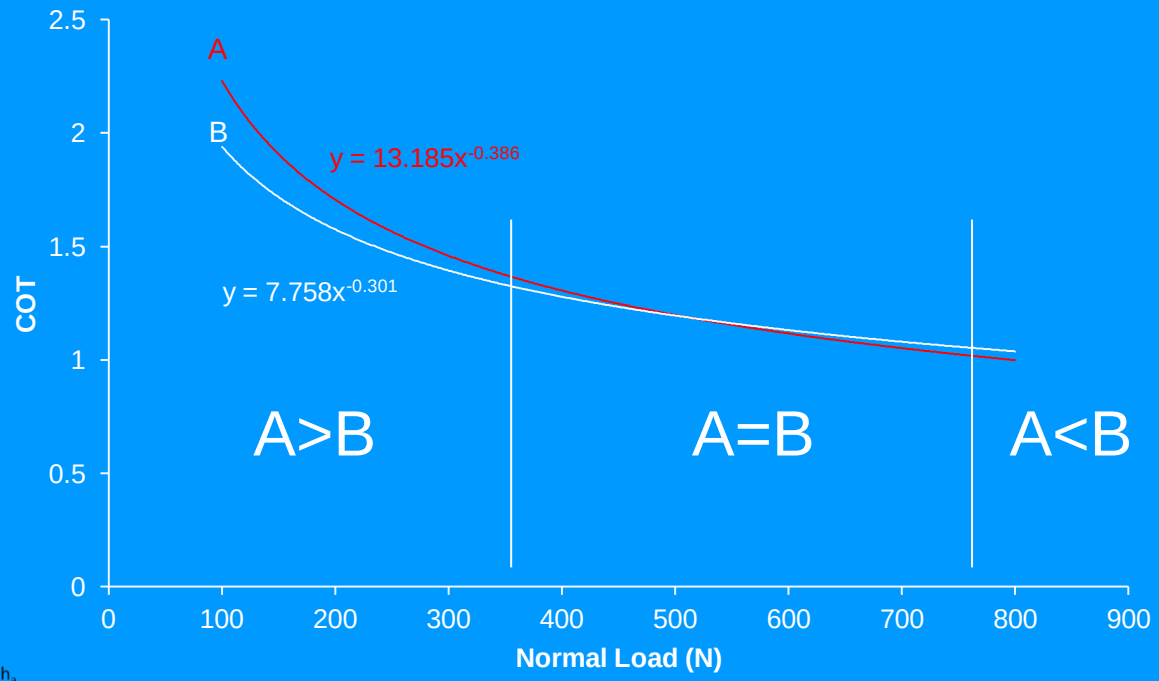
- Effect of Roughness

Surface B:
Lower Loads:
Low real contact area



Higher Loads:
Real contact area increases
Hysteresis friction
Abrasion





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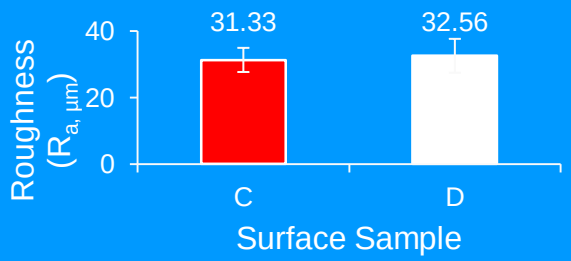
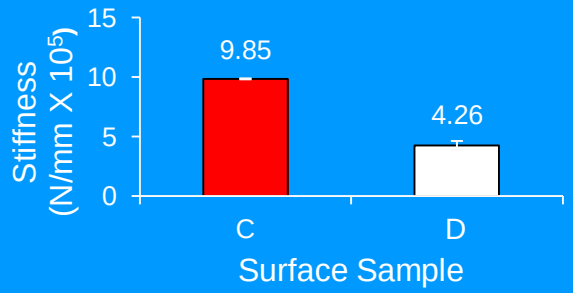
Results

- Effect of Stiffness





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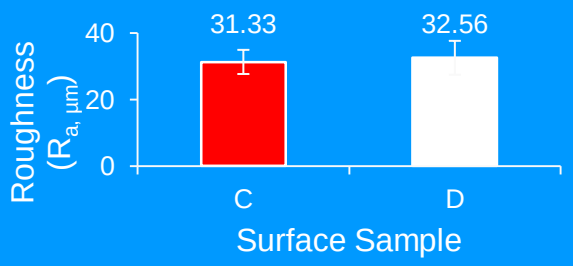
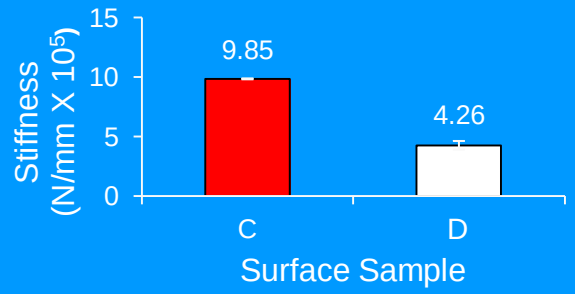
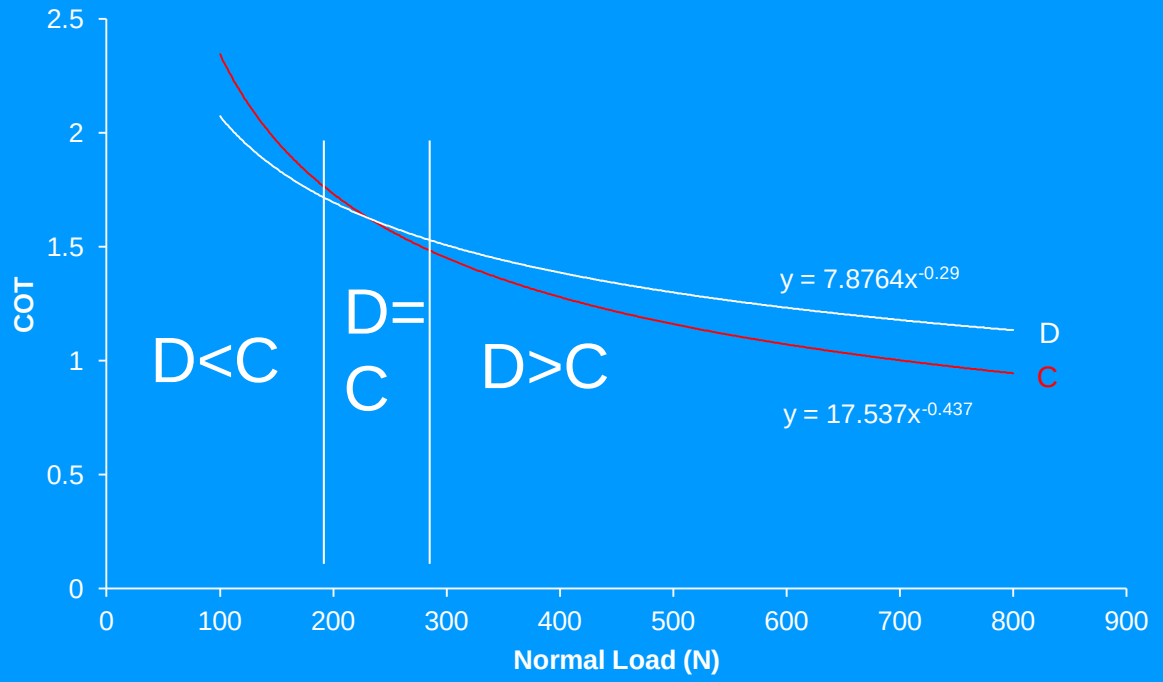
Results

- Effect of Stiffness







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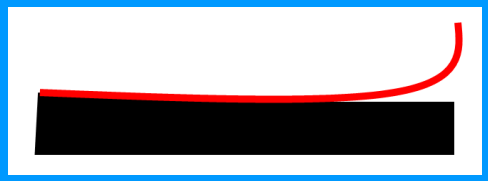
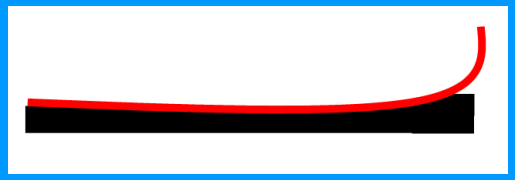
Results

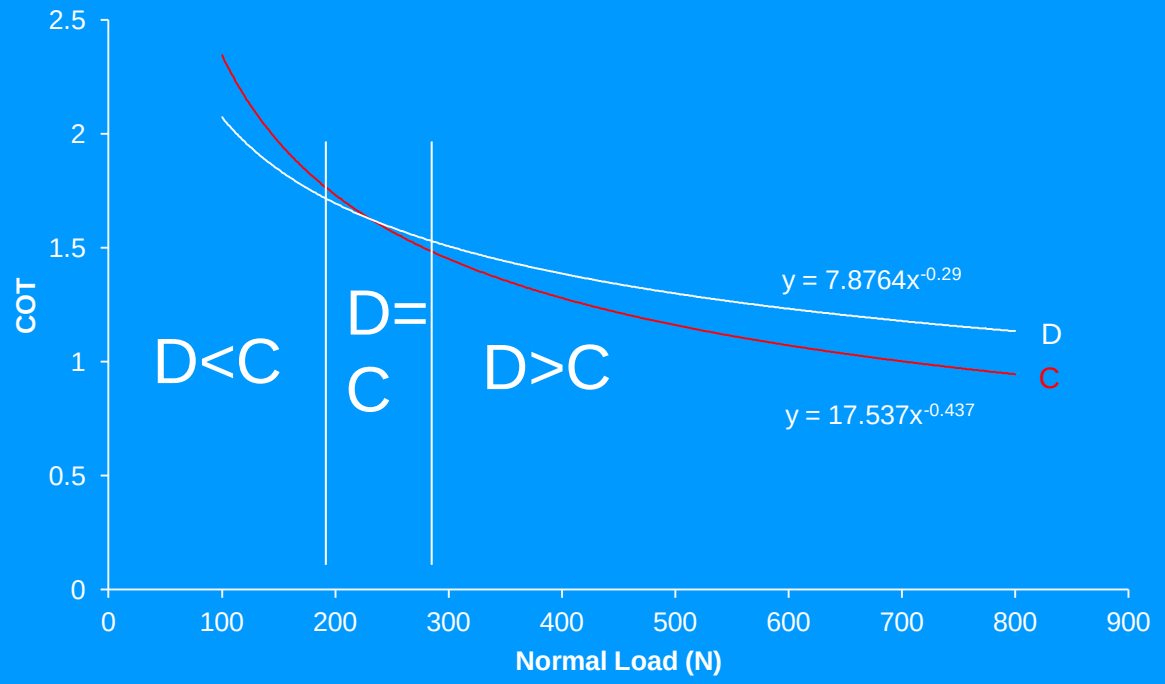
- Effect of Stiffness

Lower Loads:
Low deformation



Higher Loads:
Surface Deforms
Energy losses





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Initial Findings

- Loading conditions change the tribological interaction at the shoe-surface interface
- Testing under inappropriate loading conditions may give misleading results

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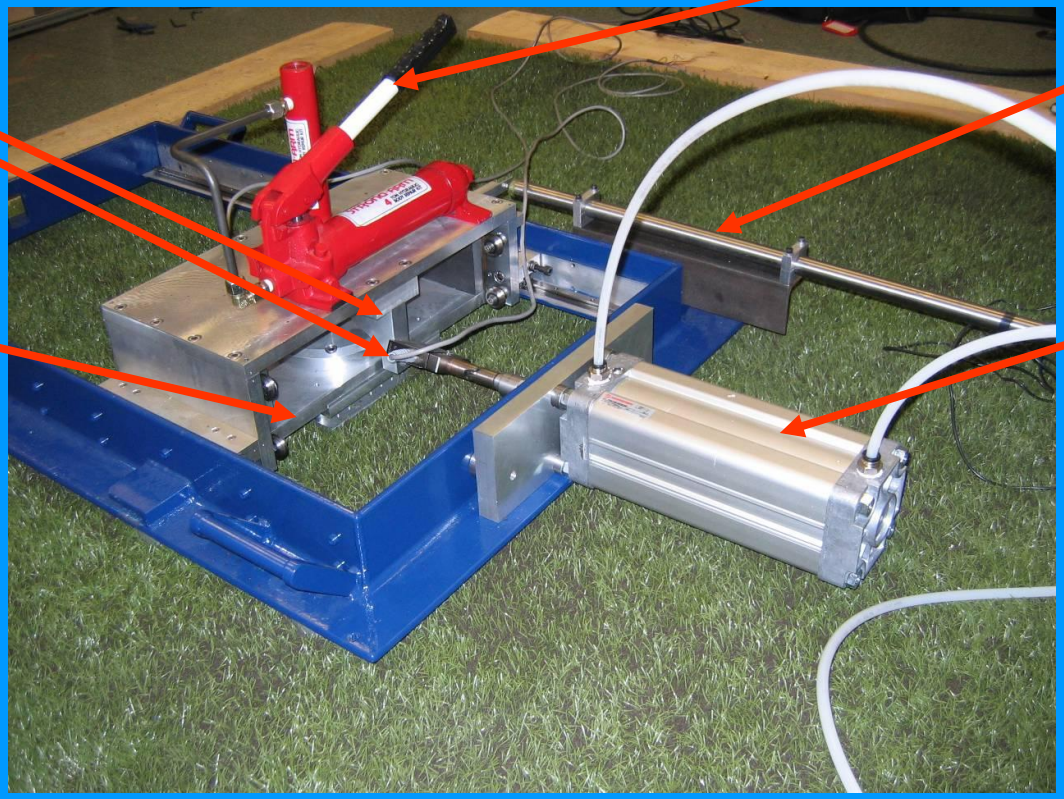
UoS1 Rig - Limitations

Horizontal and vertical load cells

Mounted footwear on plate



Hydraulic ram – normal force

LVDT (displacement)

Pneumatic ram – force controlled displacement

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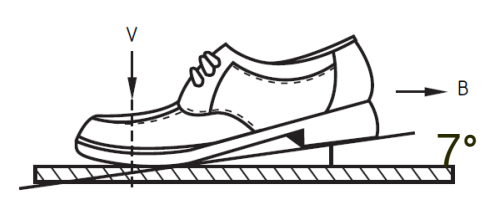
Further Testing

STM 603 - Slip resistance tester



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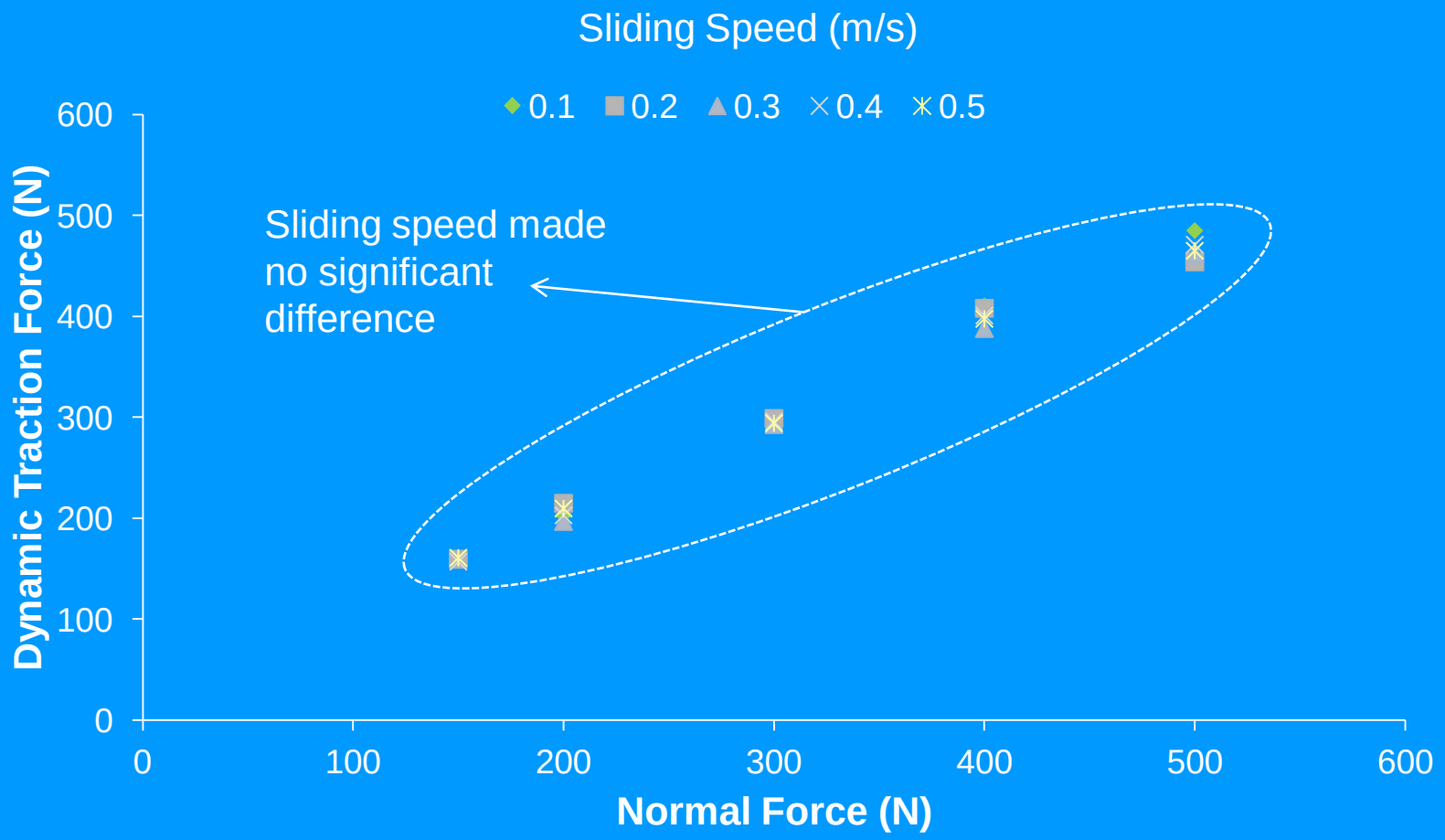
Results



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Methodology

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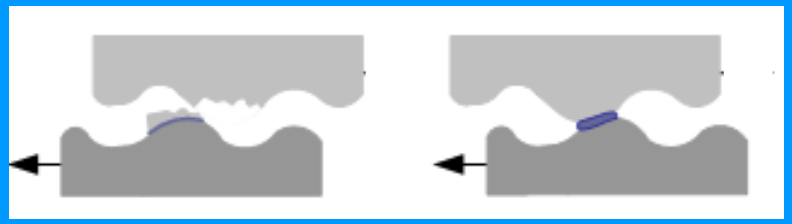

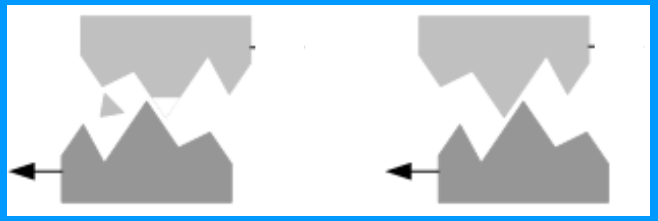

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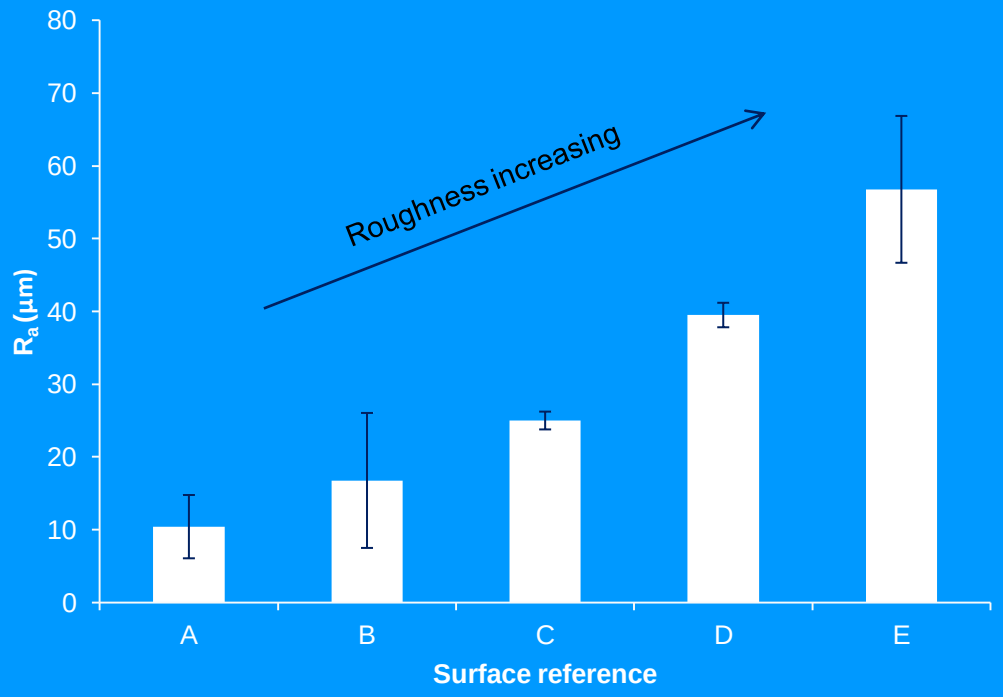
Results



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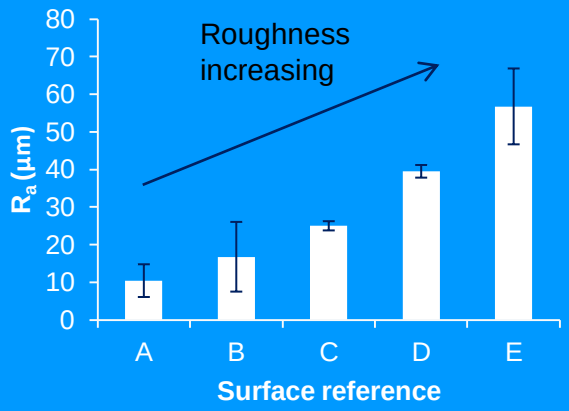
Results



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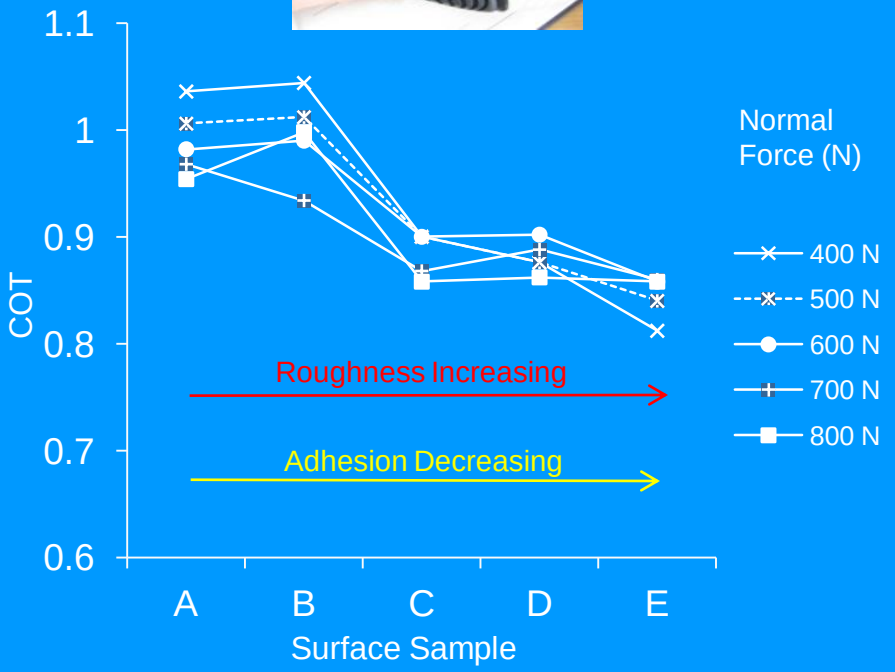
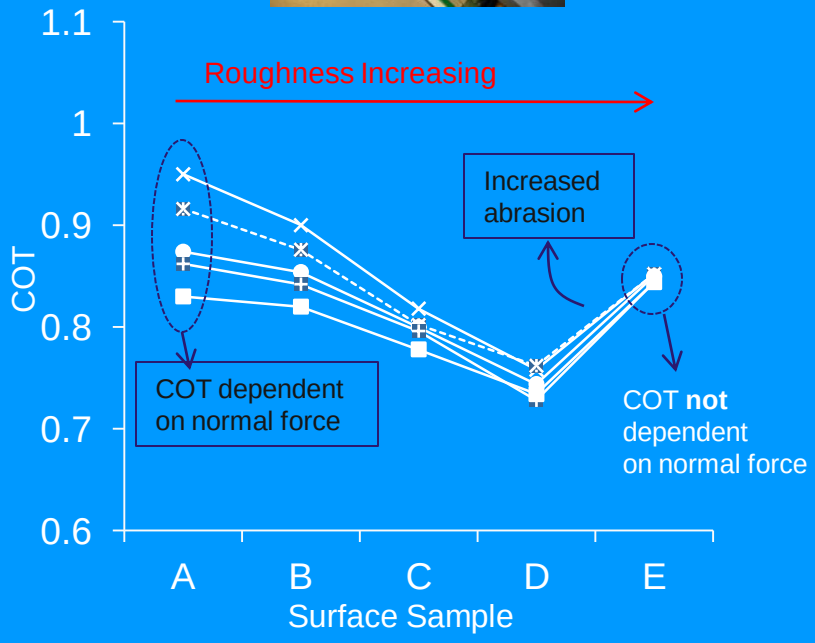
Results





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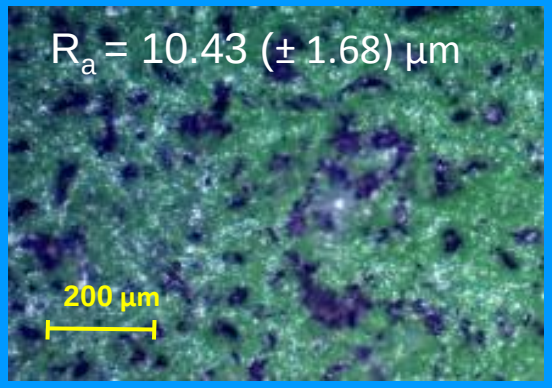
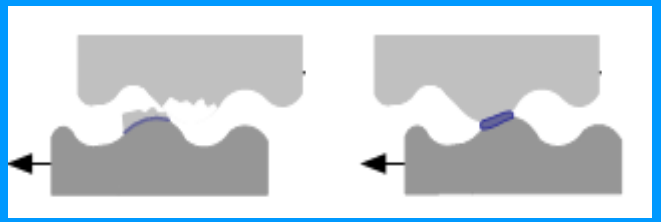
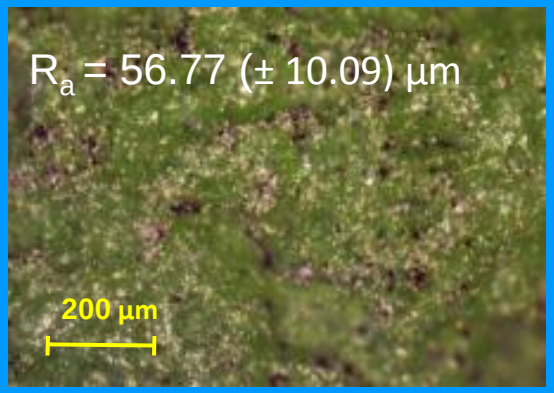
Results (observation)

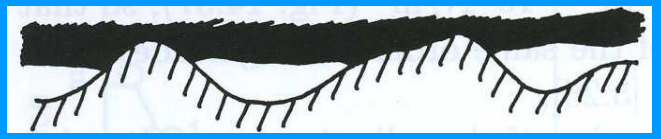
Surface A

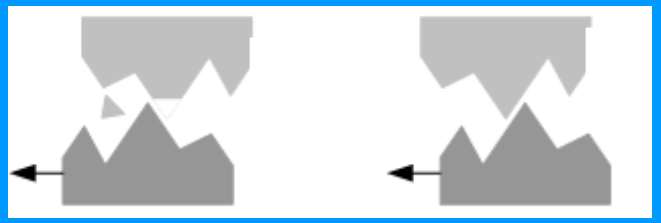




Surface E







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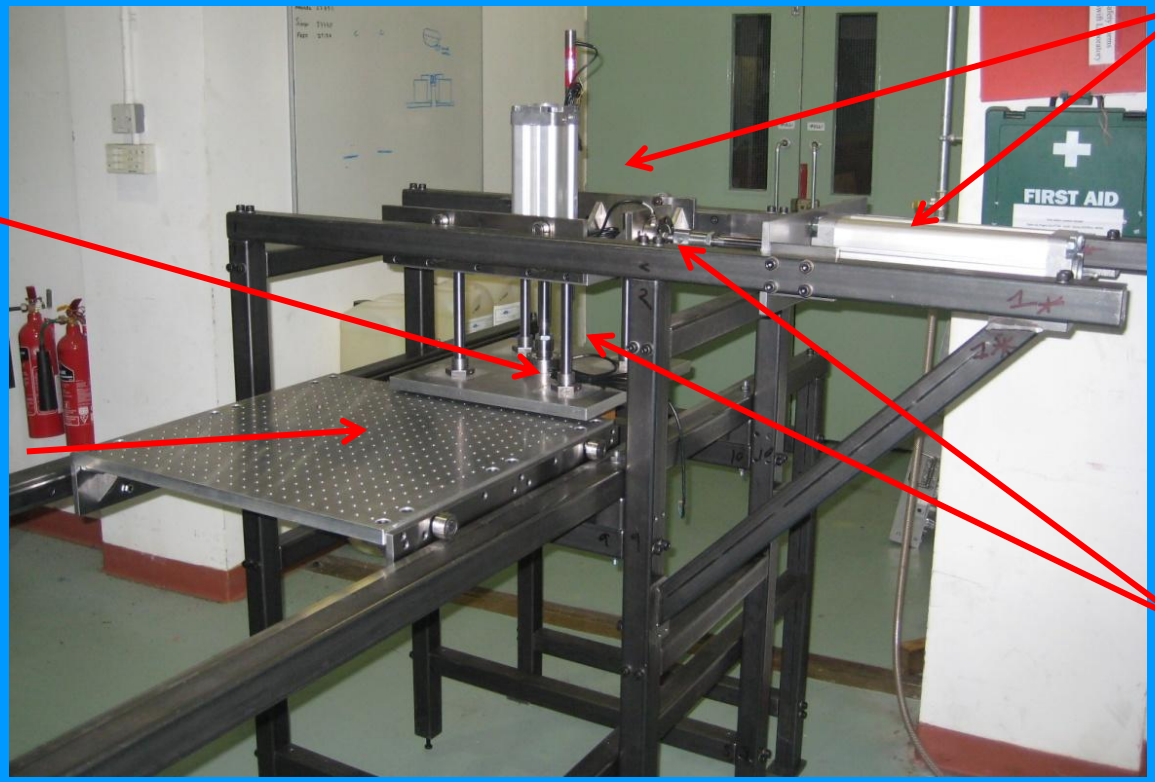
Test Rig (UoS2)



Pneumatic cylinders

Shoe Plate

Surface Platform

Load Cells and LVDTs – Force and Displacement

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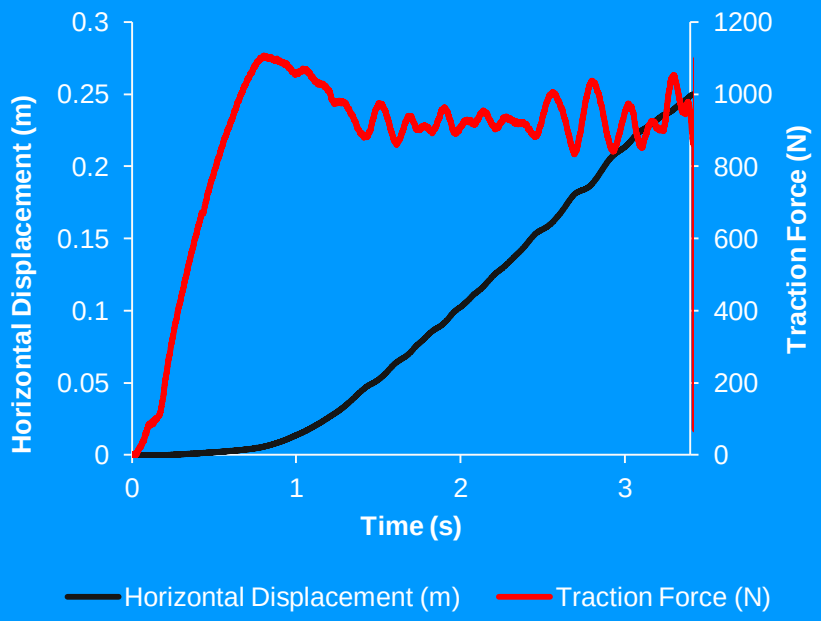
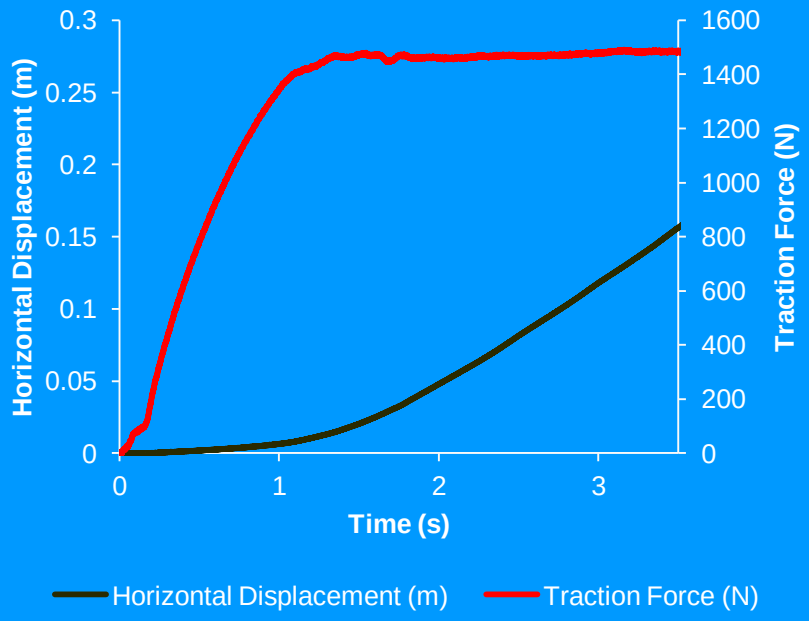
Initial Testing (UoS2)

Typical Traces:

Wet Artificial Clay



Dry Acrylic Hard Court



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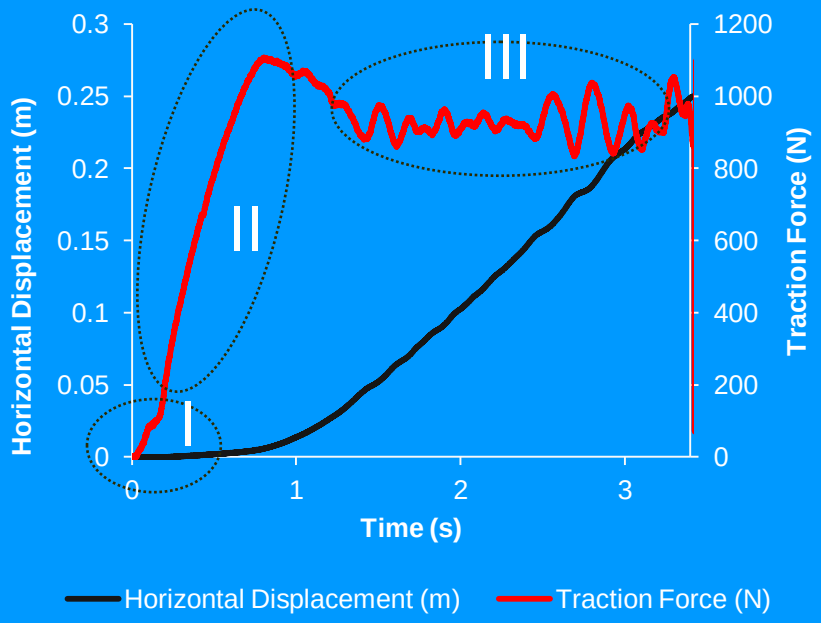
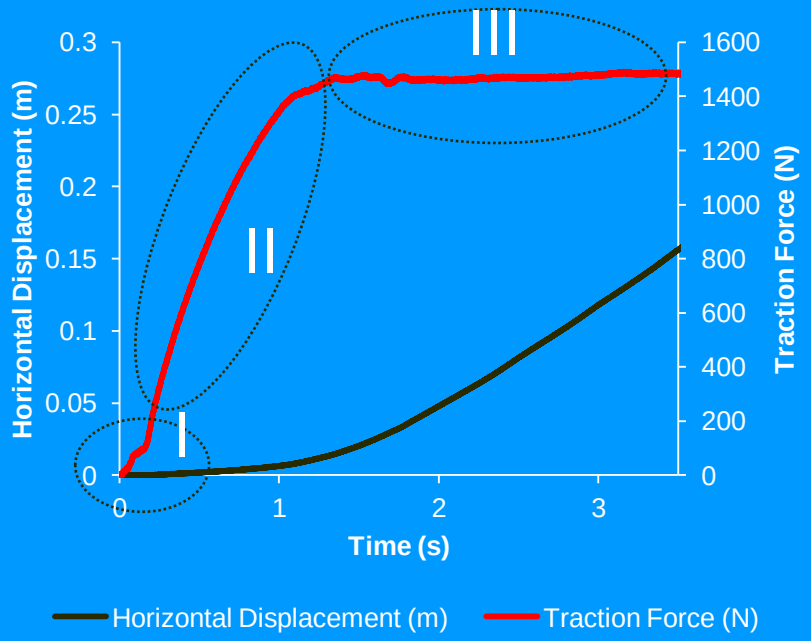
Initial Testing (UoS2)

Typical Traces:

Wet Artificial Clay



Dry Acrylic Hard Court



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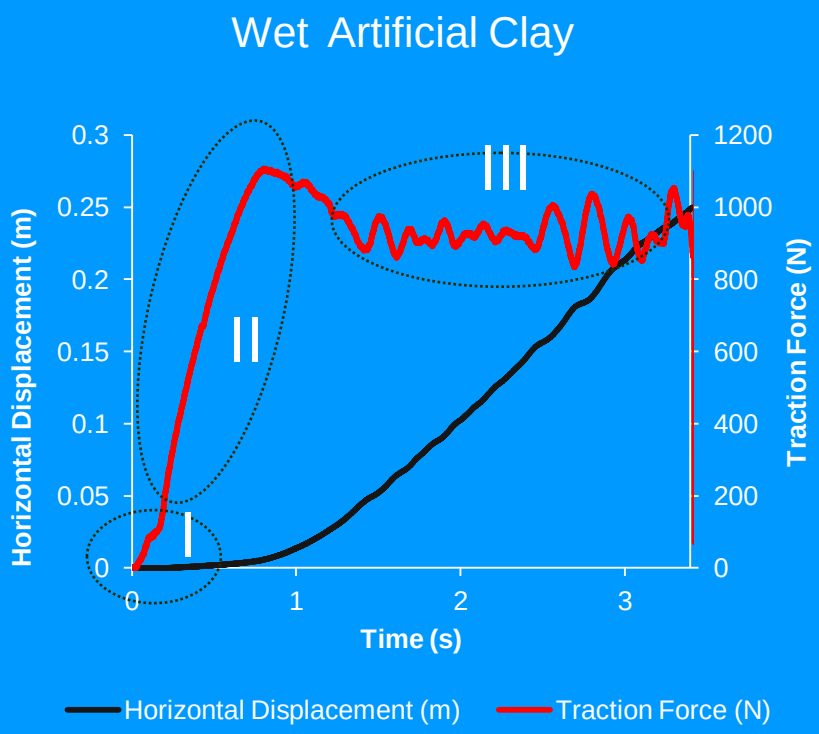
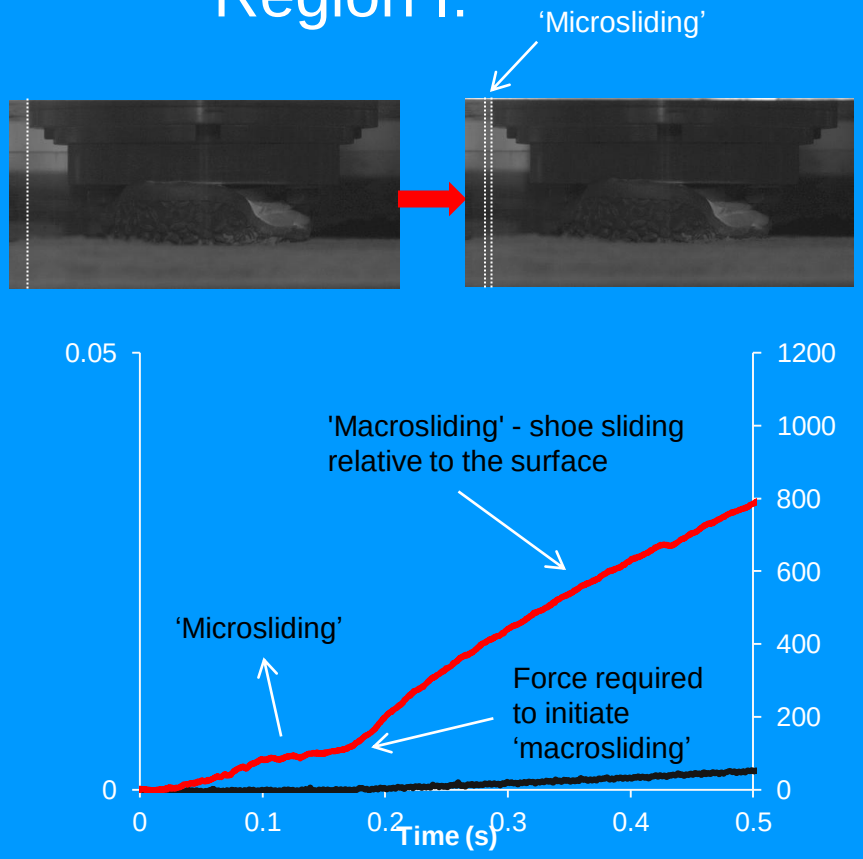
Initial Testing (UoS2)

Typical Traces:



Region I:



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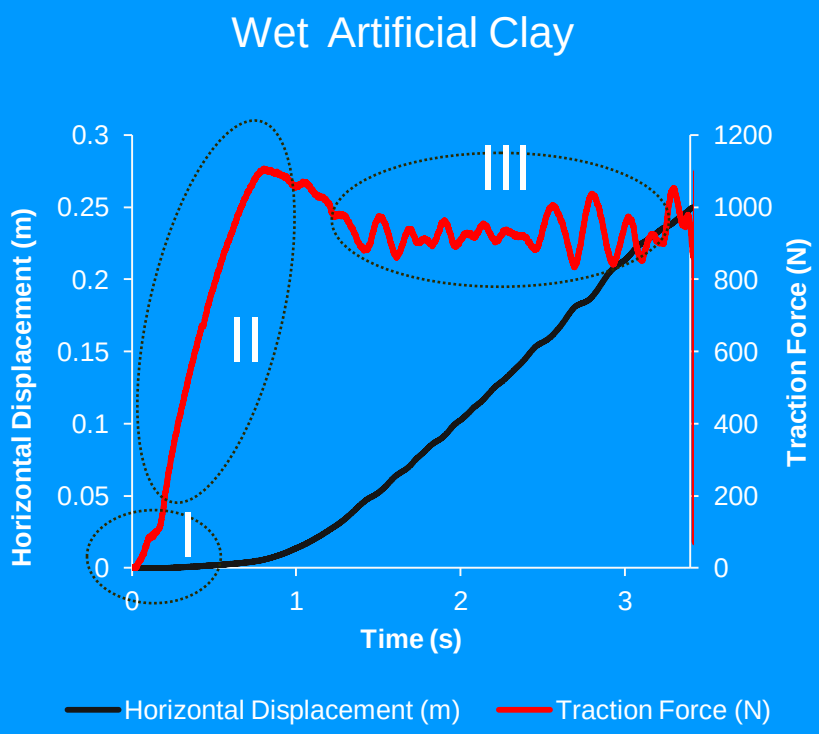
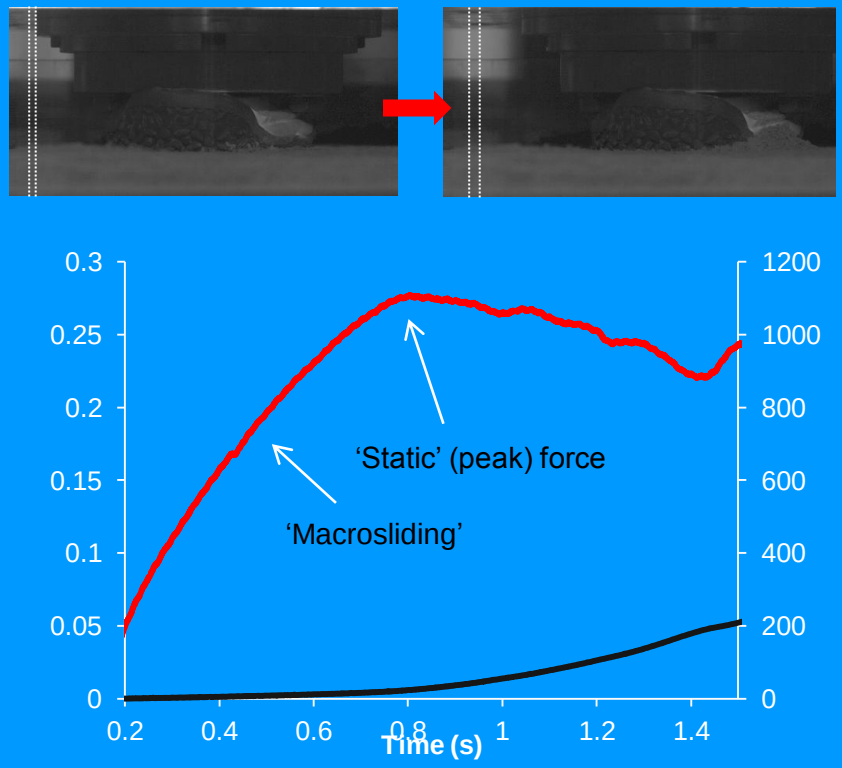
Initial Testing (UoS2)

Typical Traces:

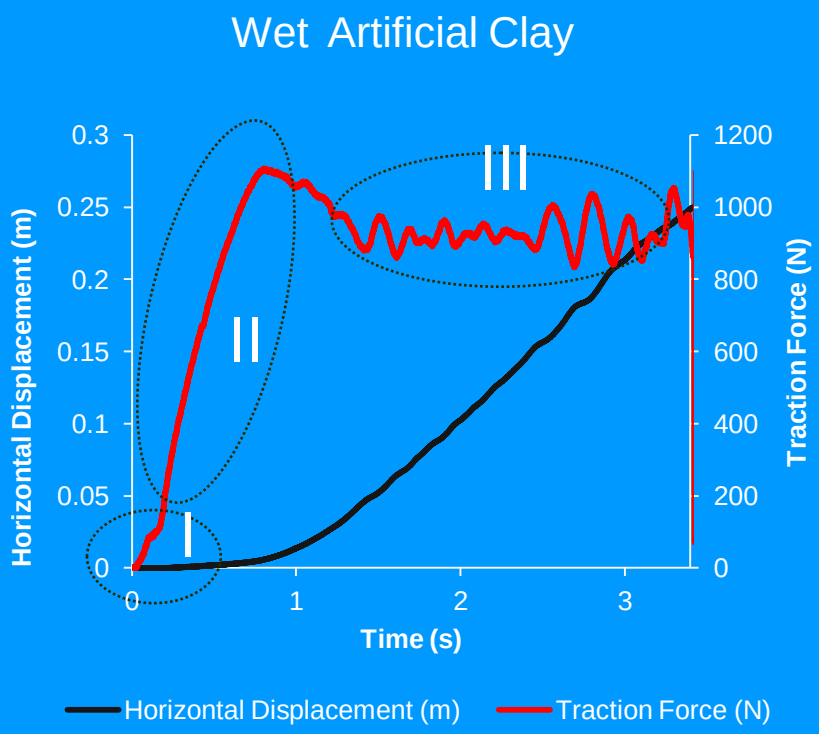


Region II:

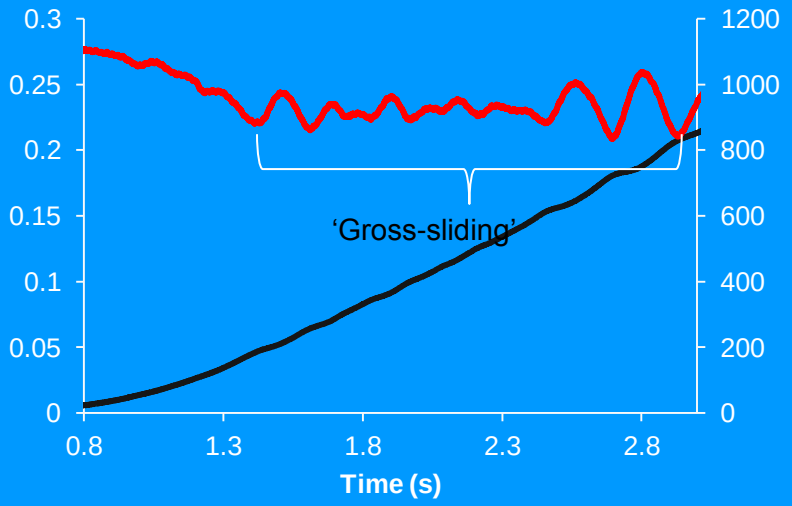


Initial Testing (UoS2)

Typical Traces:



Region III:



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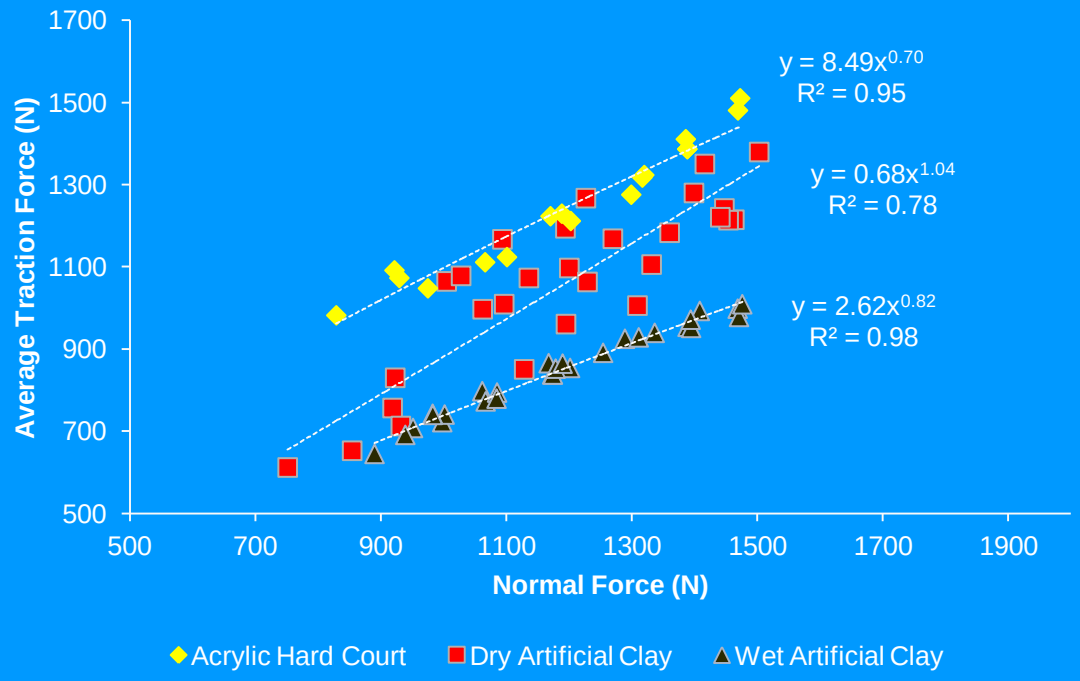
Results Example (UoS2)

Comparison of surface: Average Dynamic Traction



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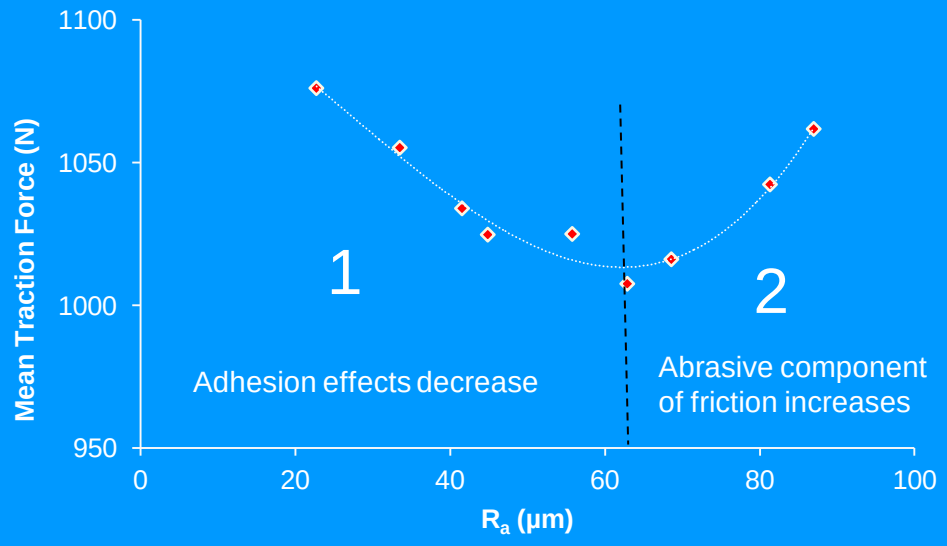
Results Example (UoS2)

Influence of Hard Court Roughness: Peak Traction Force



Future Work

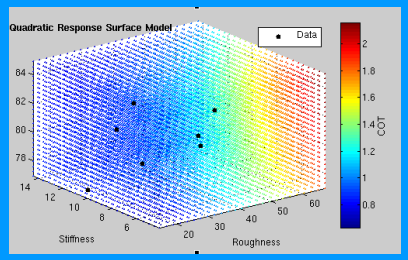
Biomechanical Testing at Exeter

Generate boundary conditions

Mechanical Testing

Parametric study

Develop predictive model



Validate

Acknowledgements:

The University Of Sheffield.

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UNIVERSITY OF EXETER

ITF International Tennis Federation

adidas

EPSRC Pioneering research and skills

Biomechanics Research Team

Dr Matt Carré
Dr Andrea Richardson
Zhijun Yang
Dr Sharon Dixon
Dr Loic Damm

