Sensitivity and Relevance of Current Test Methods

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(Thanks to Kathryn Severn and Dr Colin Young)

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Talk Outline

Brief Introduction - Why Test?

Measuring Performance and Safety

Tests methods and some data

Summary of Findings and Research Needs?

- provoke some thought/discussion!

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Introduction – Why Test?

1. Users – Safety, comfort, skill level…IGB guidance, biomechanical validity, injury studies
2. Construction Quality Assurance: product compliance, build quality, client confidence…
3. Monitoring and Evaluation… Initial Conditions, long-term behaviour, maintenance effects, (simple tests?)
4. Research (& development)…In-house for product development, develop understanding and ‘science’ that can be applied

Testing – Some Issues

Currently the IGB ‘performance’ guidance used to provide some assurance for the ‘user’, and for CQA, Monitoring (some) and R&D to varying levels.

This is appropriate to a degree, but does raise the question of the relevance of the tests and their sensitivity to the important parameters that are being measured…

Important question – what do the (current) tests measure?

User Requirements - Optimise Performance and Safety

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Measuring Performance and Safety

USER aspects:

- Player movements (starting/stopping, running, turning, jumping, landing etc..)
- Player individuality, mass, training & conditioning, motor skills (fatigue), specific footwear..

Forces, velocity, acceleration, direction, area and rates of loading..complex

Measuring Performance and Safety

Surface interaction aspects:

- Hardness, compliance, energy absorption/return
- Friction/traction – linear/rotational
- Materials – stiffness, friction/strength, compressibility, visco-elasticity/non-linearity, fibre/fill interaction, composite layer interaction effects

Measuring Performance and Safety

Test equipment aspects:

- Reliability of the measurement (Repeatability, reproducibility)
- Precision/Accuracy
- Validity – both precise and accurate

Measuring Performance and Safety

Indirect measurements are currently used……

- Validity, accurate relative to the ‘real situation’?
- Sensitivity, precise to a level that is ‘significant’ to the user?
- Player perception vs Data ? Useful for ‘ranking’ pitches and their *relative* performance
- Player safety – hard to quantify ‘risk’ of actual harm, overuse or acute injuries, limits based on experience rather than *mechanisms*…

Measuring Performance and Safety

- Some observations on Performance/Safety, two key areas

- ‘Impact’ and ‘Friction/Traction’

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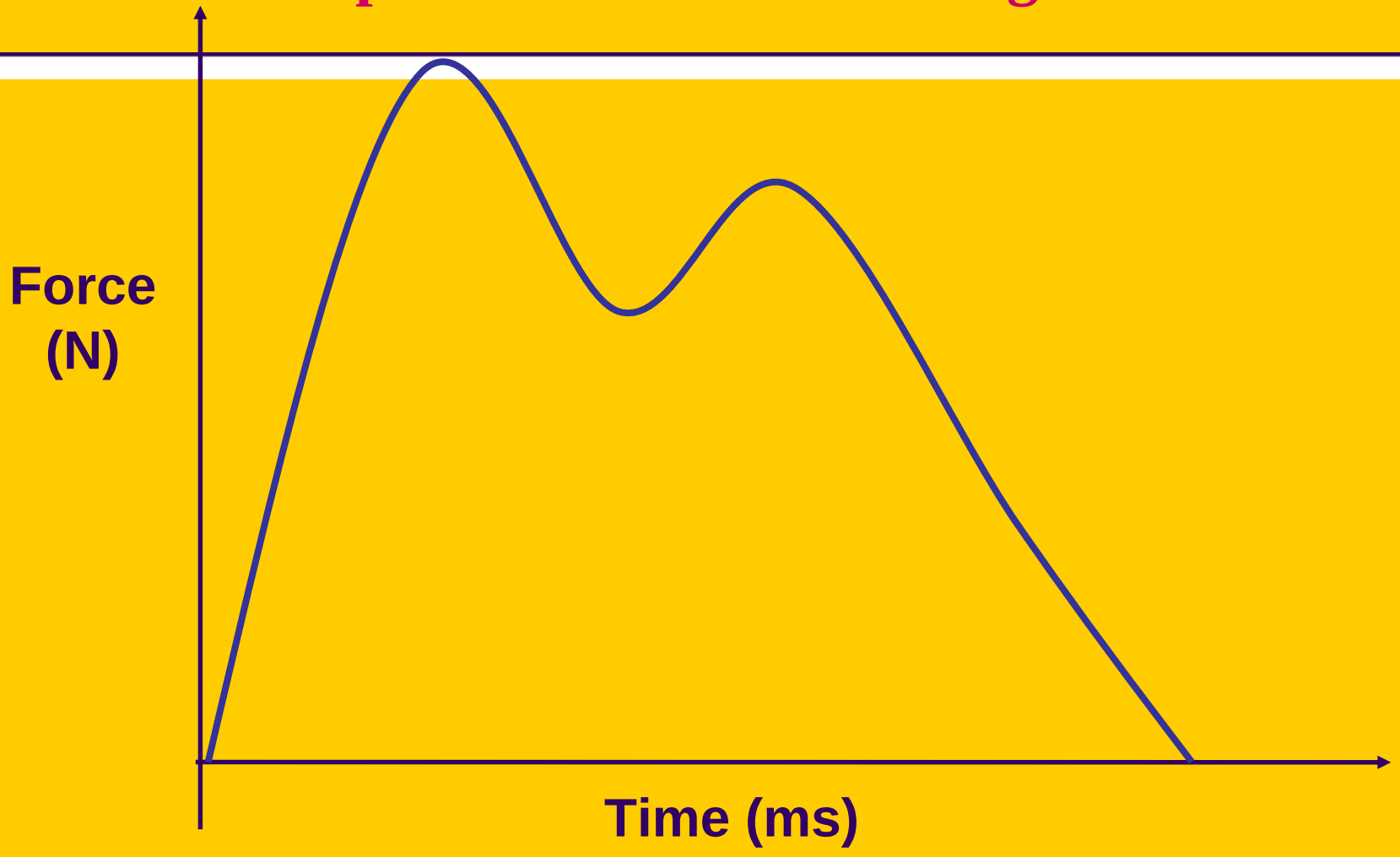
Factors Affecting Impact Testing

- Factors include:
- Test force magnitude and duration (rate)
- Surface contact area
- Plane/Studded footwear - some effect
- Viscous and non-linear strain response of the materials (Carpet, fill, shockpad)
- Composite - layer interactions (zone?)

IMPACT

Simplified Heel-Toe Running - GRF



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Berlin Athlete – Impact Test

Constant Energy Test
Drop height: 55cm
Drop weight: 20 kg
Test Foot: 70mm diameter

Typical Contact Pressures:
Concrete: 1700 kPa (6.5kN)
Acrylic: 1600 kPa
Synthetic Turf: 500-1000 kPa (2-4kN)
Load pulse: ~30 milliseconds

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SPORT REQUIREMENTS
Football, Rugby, Hockey

Testing	Traction	Berlin
	(Nm)	(FRF %)
FA FIFA	30-50 Nm 1 star: 25-50 Nm 2 star: 30 – 45 Nm	≥ 55 % (studded foot) 1 star: 55 – 70 % 2 star: 60 – 70 %
IRB	30 – 50 Nm	60 – 75 %
FIH	None	40-65%

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Generic Surface Types

Unfilled (Water Based)

Filled - Sand filled (dressed)

- Rubber (sand mix)

Industry developing ‘low’ friction unfilled surfaces….

System Components? Many available – 100s of bespoke designs…

Unfilled

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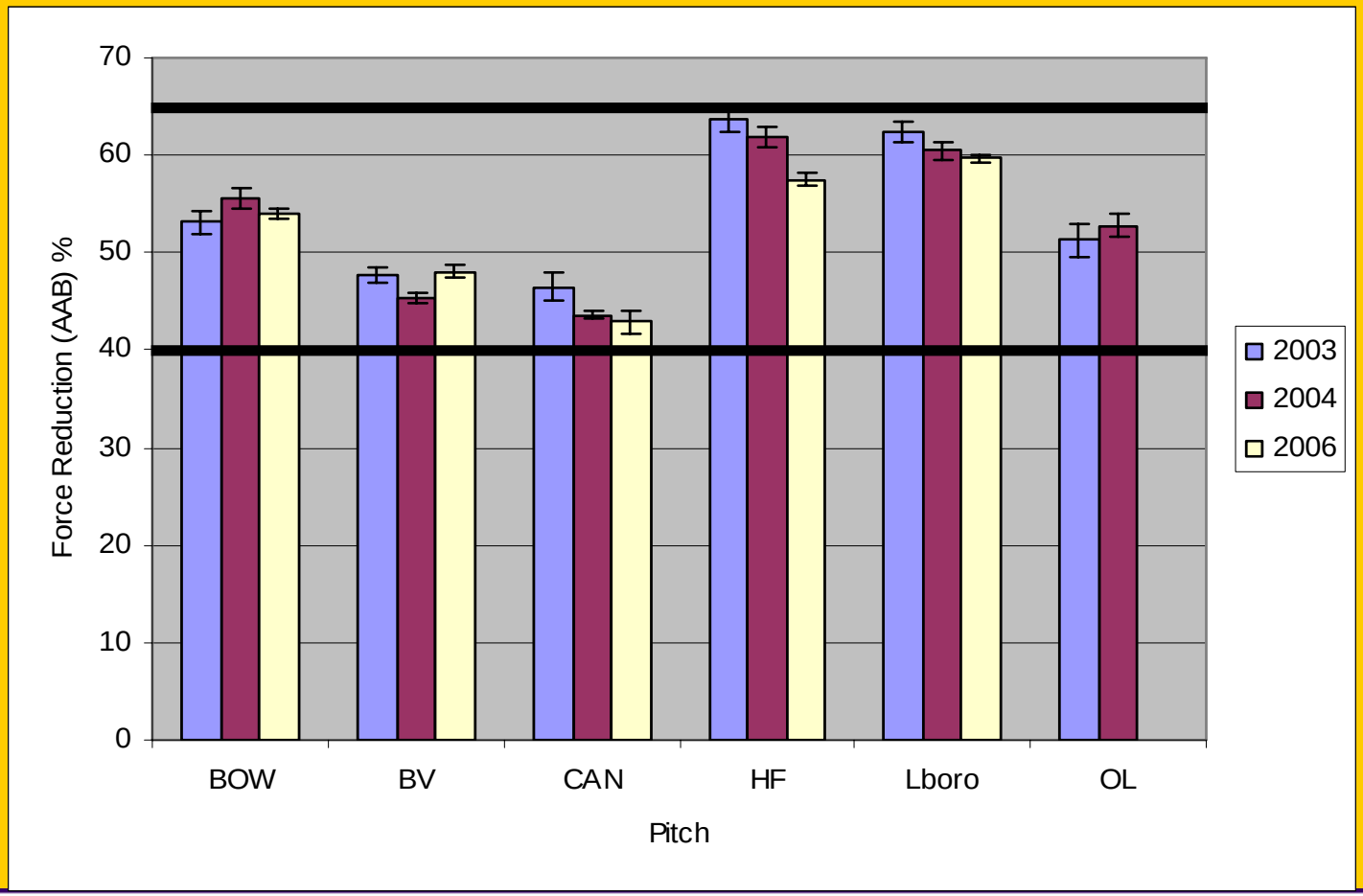
Impact Data

- Use of Impact Devices for Monitoring and Evaluation (Berlin and Clegg)
- Use of Impact Devices for Research and Development (sports hall floors)

Data - IMPACT
Unfilled Hockey Pitches



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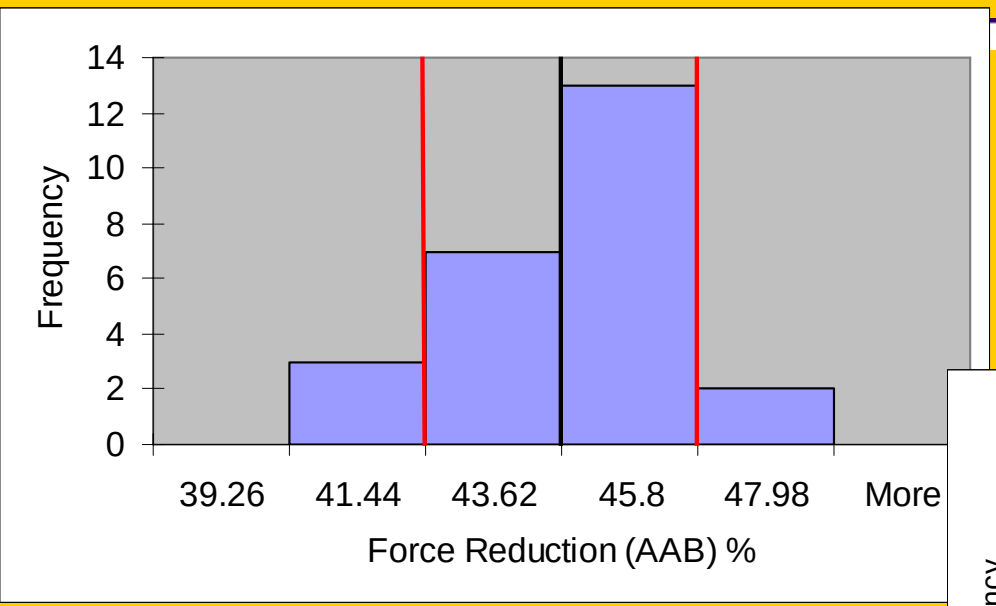
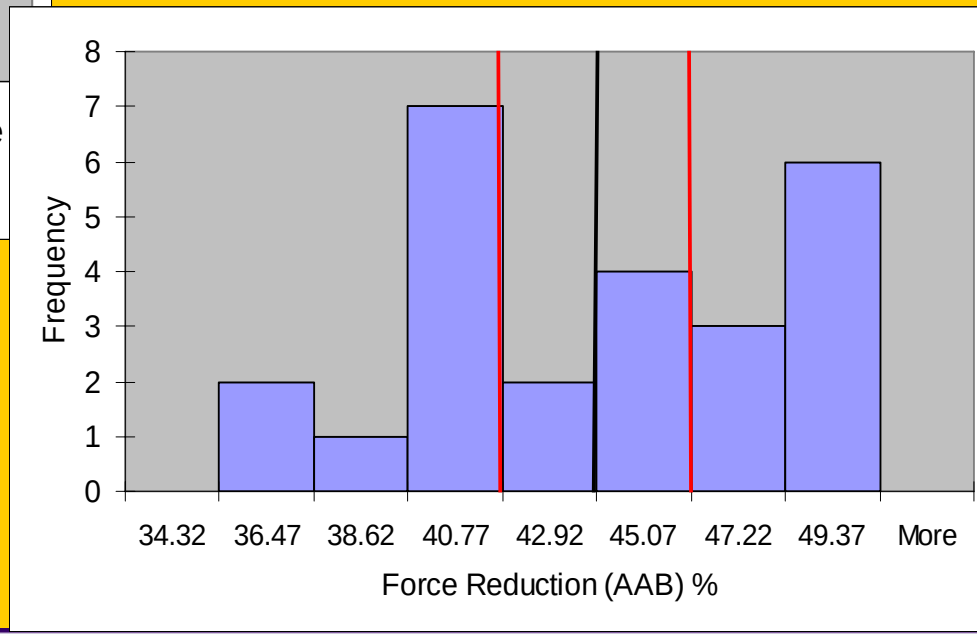
Data – SPATIAL changes
Unfilled Hockey Pitch



2004

2006



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Clegg Hammer – Impact Test

Drop height: 45cm
Drop weight: 2.5 kg (0.5kg)
Test Foot: 50mm diameter

Typical Contact Pressures:
Synthetic Turf: 1000-2000 KPa
Load pulse: ~5-10 millisecs

Useful, simple, sensitive?

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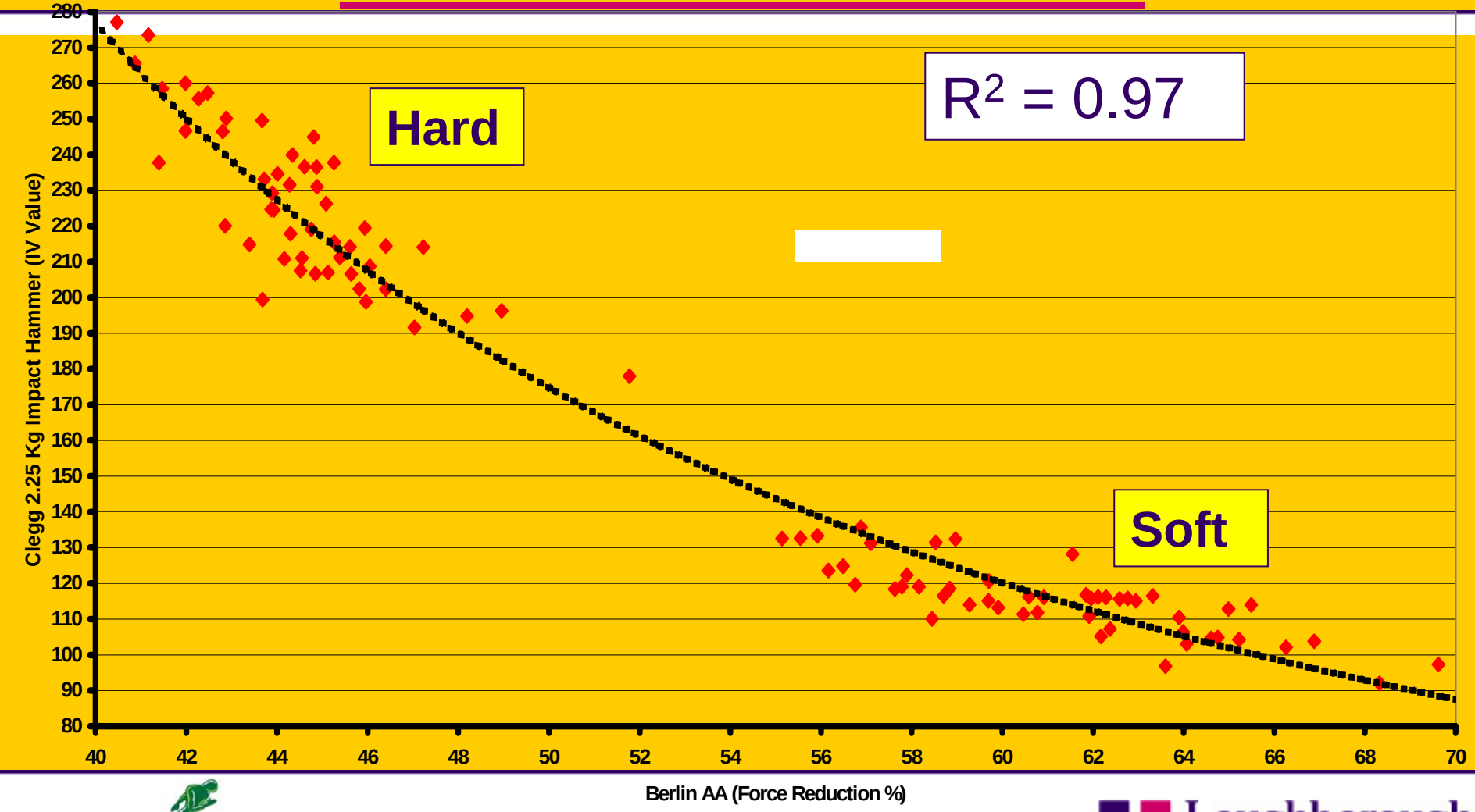
Berlin & 2.5kg Clegg Correlation
6 Water Based Pitches



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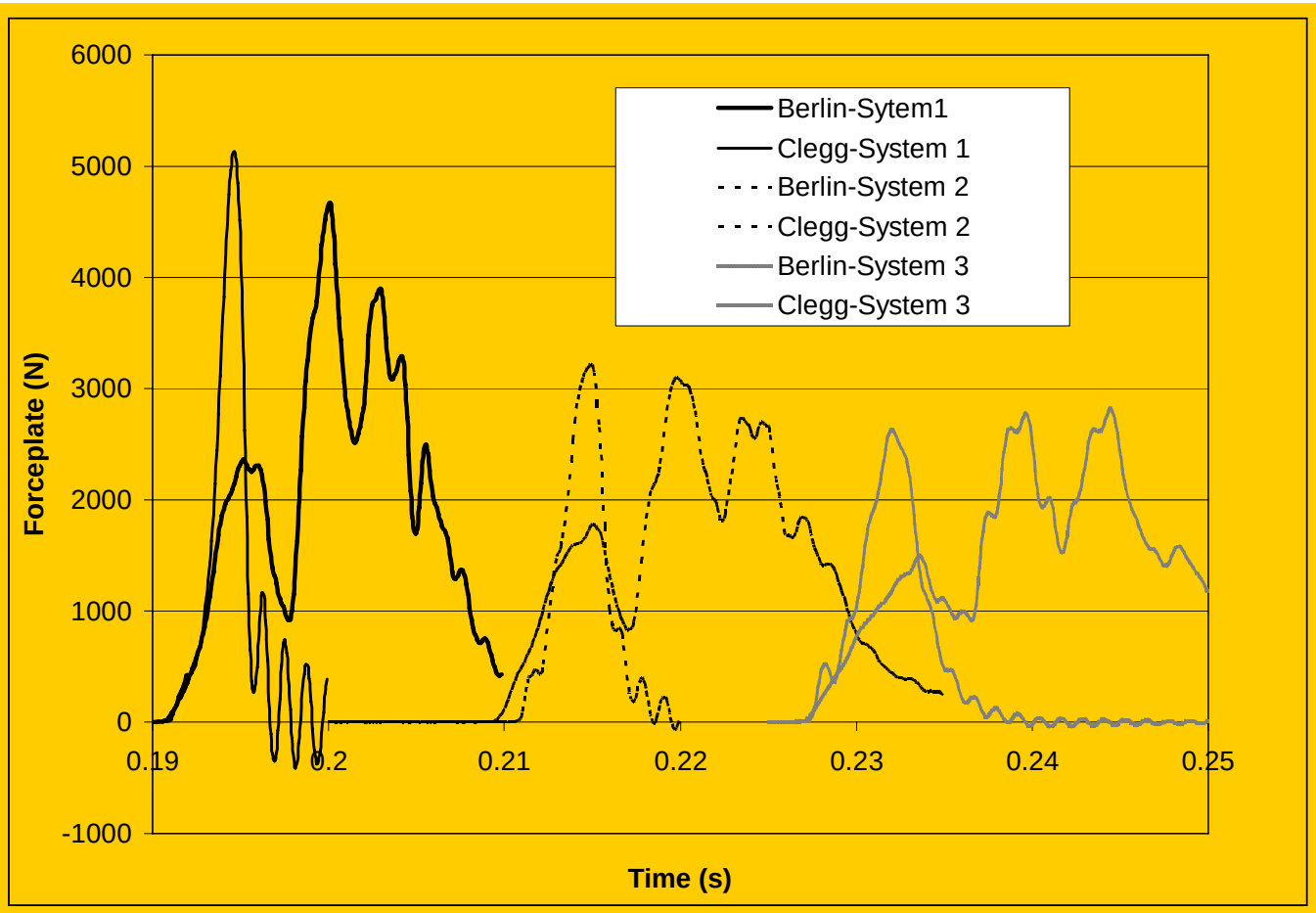
Force Plate Data – Berlin and Clegg
Unfilled Carpets and shockpad combinations



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Long-Pile – rubber filled

3rd generation long pile turf for soccer

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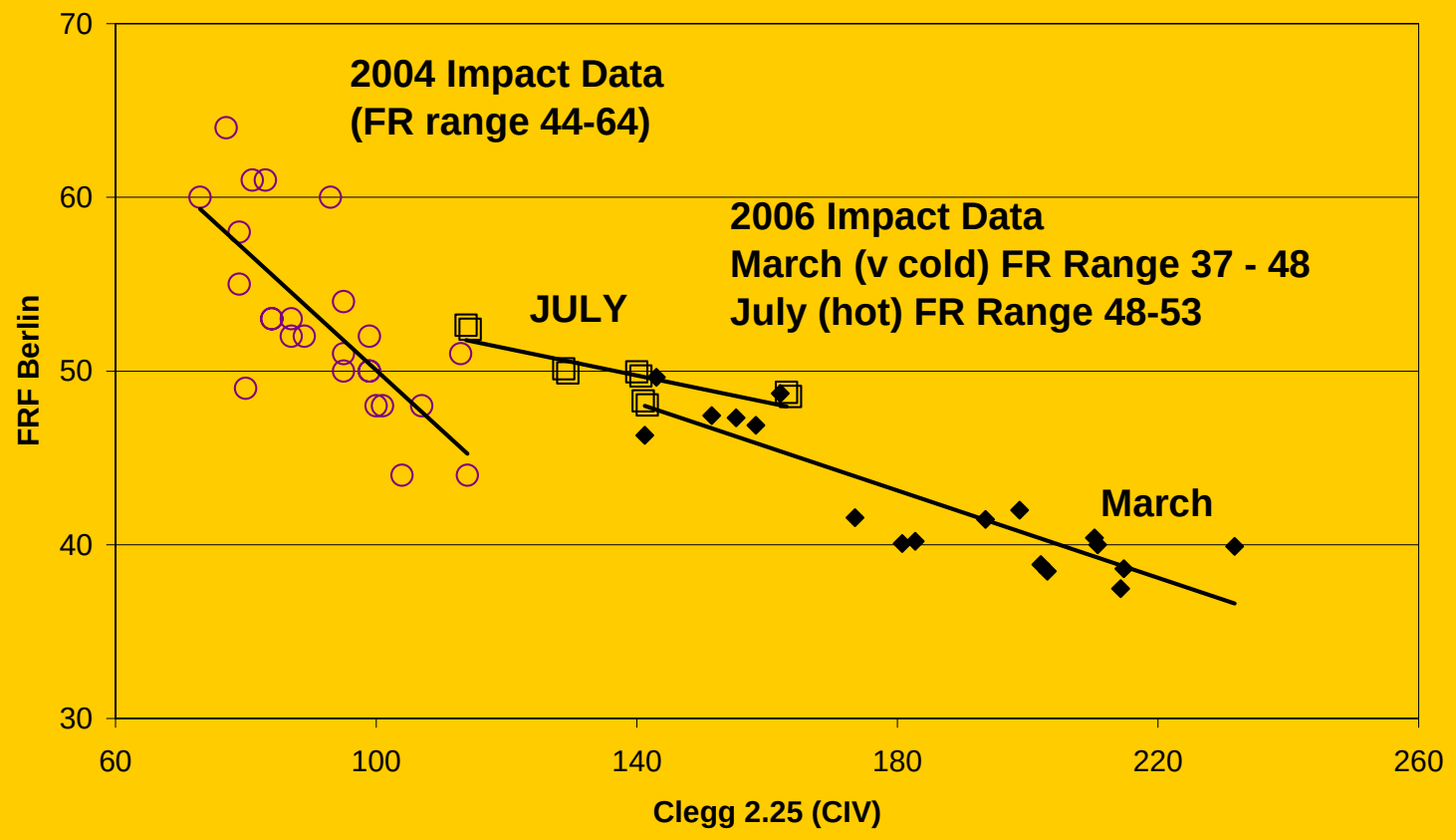
Data
Filled Football Pitches



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Data-Case Study 2
Filled Football Pitches

"Synthetic Surface Heat Studies", *C. Frank Williams and Gilbert E. Pulley, Brigham Young University*

Surface	*Ave Surface Temp between 7AM & 7PM*	
Art' Soccer	*117.38º F (47 ºC)*	*high 157º F (69 ºC)*
Art' Football	*117.04º F*	*high 156º F*
Natural Turf	*78.19º F (26 ºC)*	*high 88.5º F*
Asphalt	*109.62º F*	
Bare Soil	*98.23º F*	

Safety Officer set 120º F (49 ºC) as the maximum temperature that the surface could reach before cooling was required.

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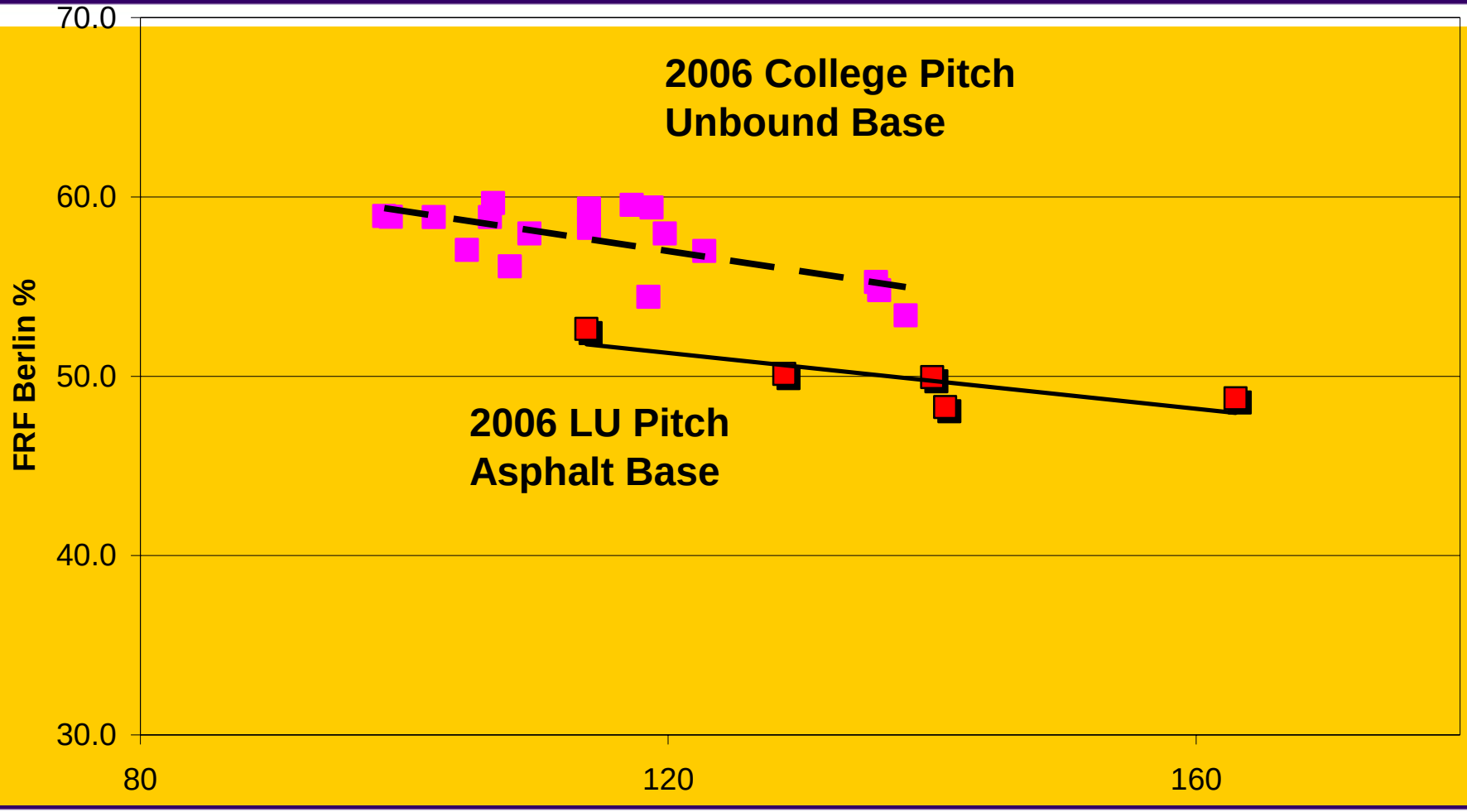
Data
Filled Football Pitches-Base Effect?



Clegg 2.25 (CIV)

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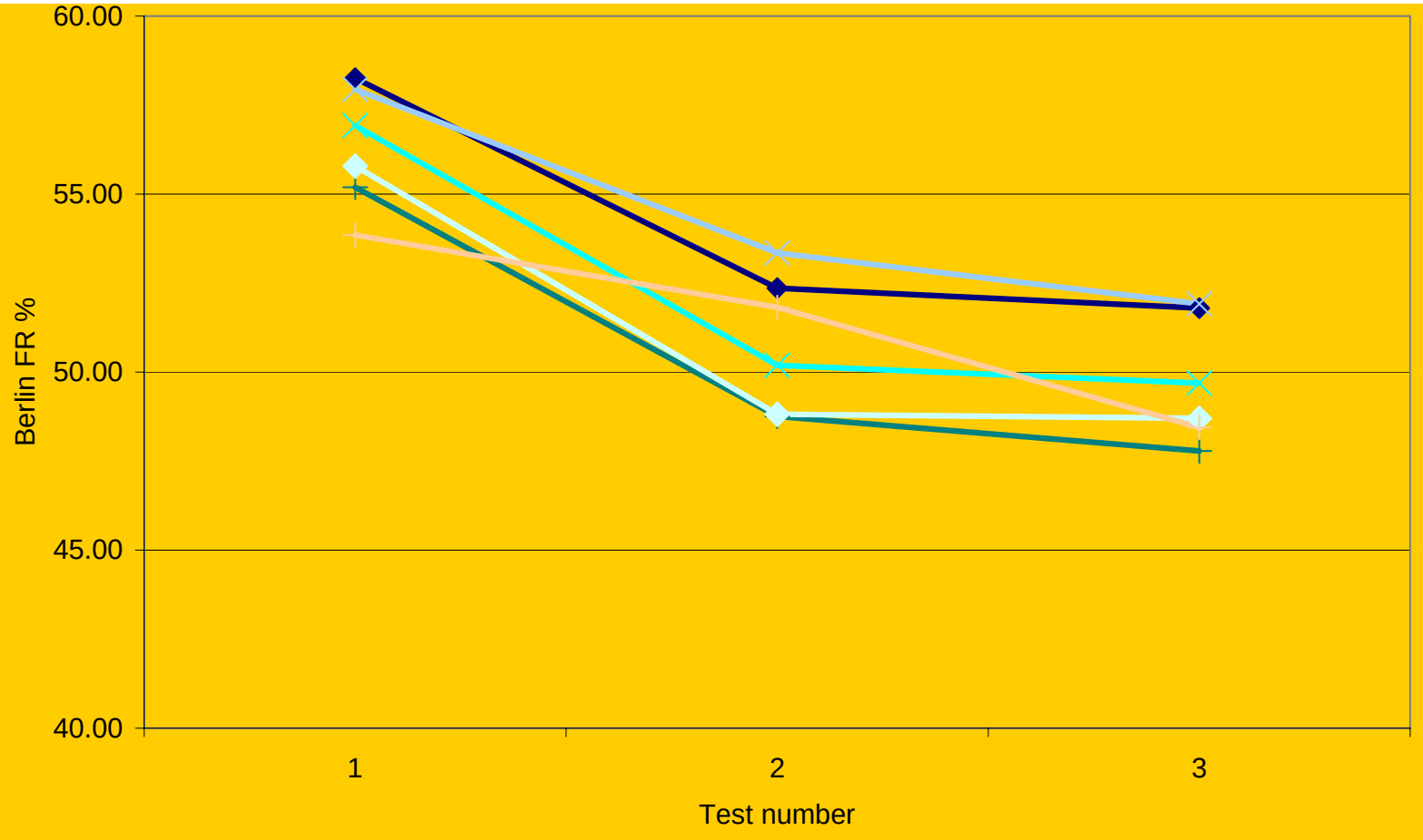
Filled Football Pitch
3 Impacts – Berlin Athlete



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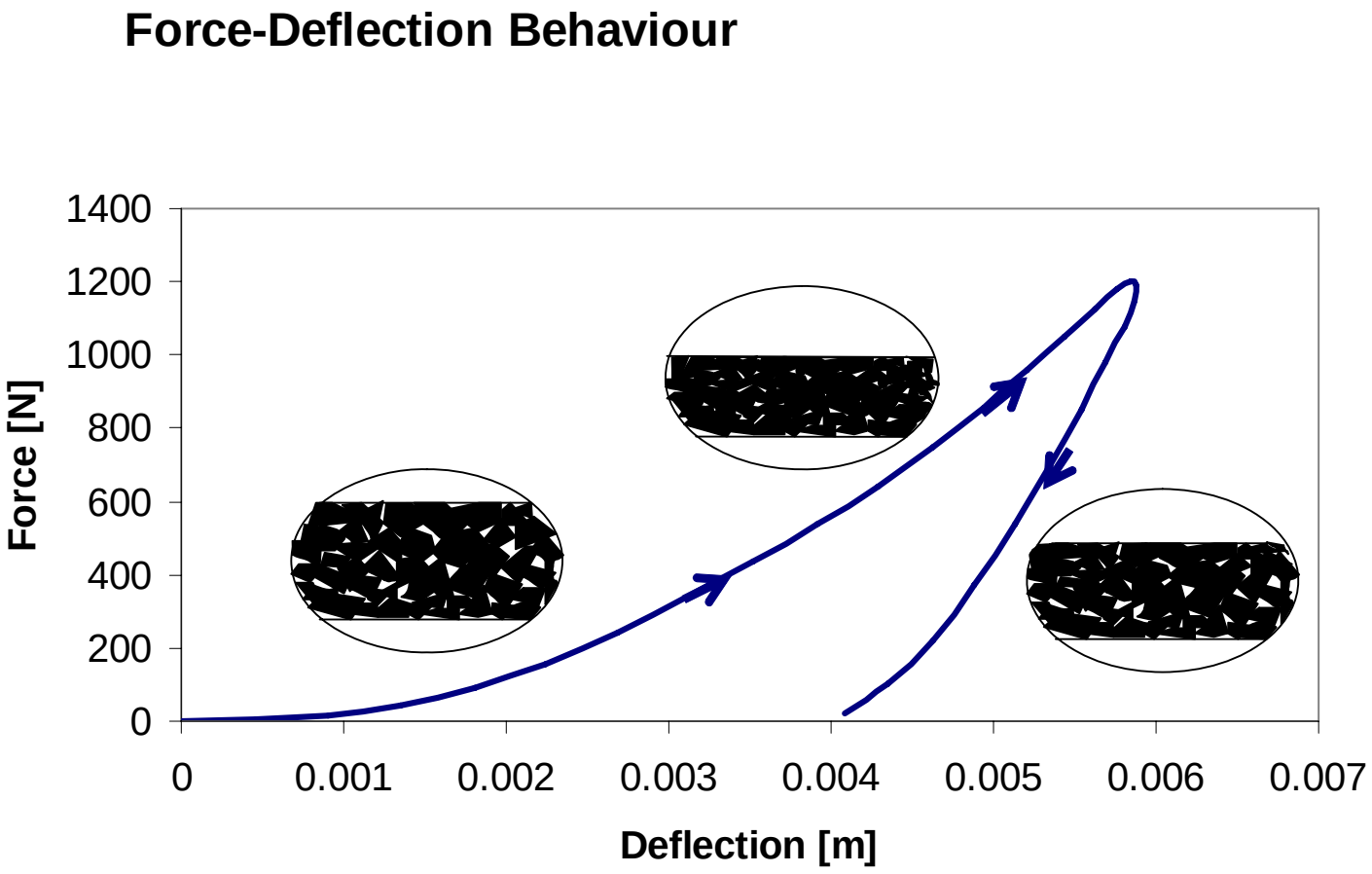
Rubber Fill – Compression Behaviour



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‘R&D’ Testing

Peak ‘G’ impact reaction & Berlin ‘Force Reduction’

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Floor – Pad & Board Effects

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Test Equipment: Prima Plate Test

Controlled Force

Drop height: up to 85 cm

Drop weight: 10 - 20 Kg

Pulse Time: 15 – 30 ms

Plate Size: 100, 200 or 300 mm

Load Range: 0 – 15 kN

Deflection Sensor: 0 - 2200μm

Sample Frequency: 4000 Hz

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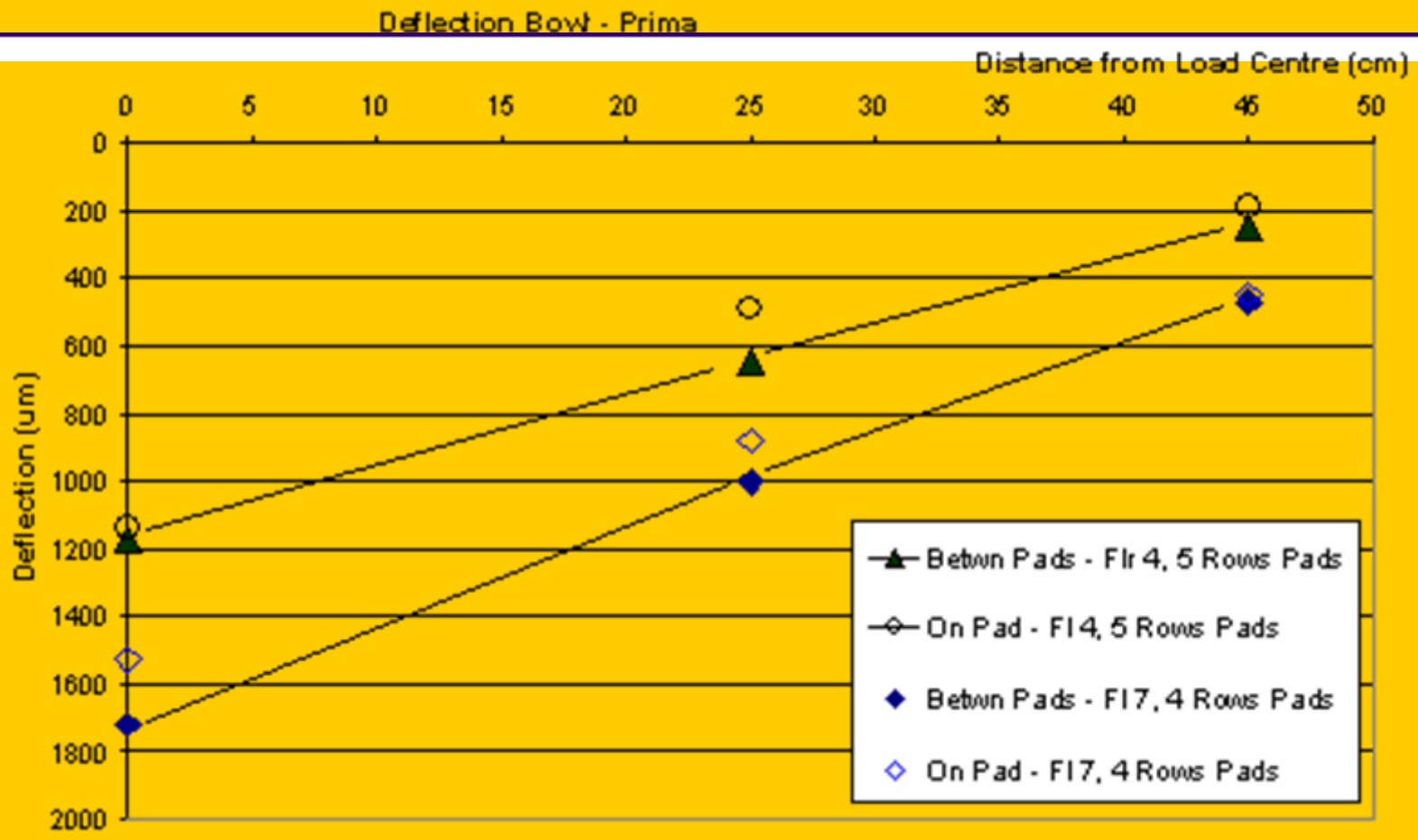
Floor – Bending Behaviour



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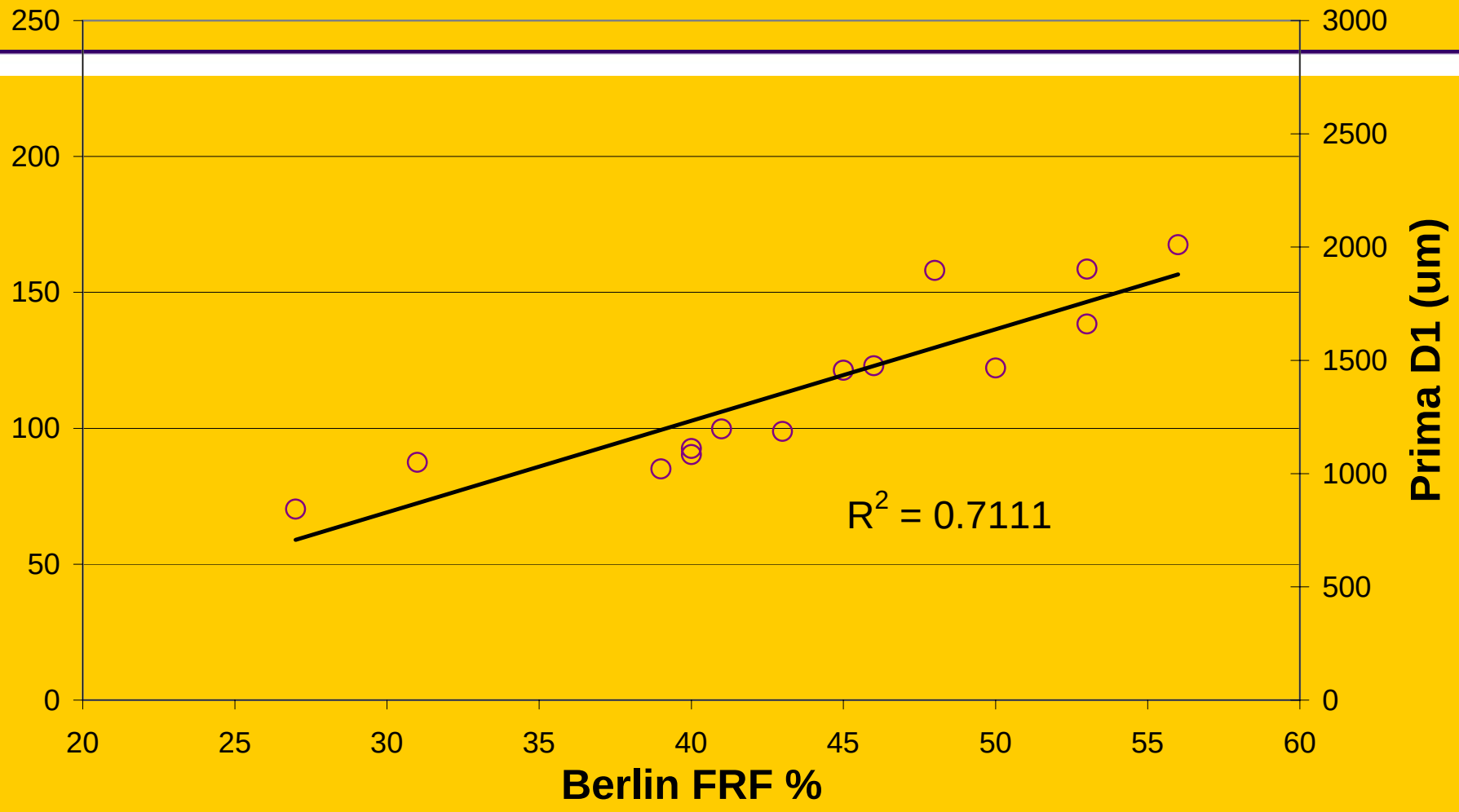
Berlin vs. Prima



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Factors Affecting Friction/Traction

- Not Coulomb friction

- Relative velocity
- Normal force (and shear?) – significant effect..?
- Surface contact area
- Footwear – stud penetration, configuration, length, number etc.
- Material response (carpet, fill etc..) – interface(s) friction, fill shear strength, compression (dilation), fibre reinforcement/entanglement…

Linear Friction/Traction

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Rotational Traction

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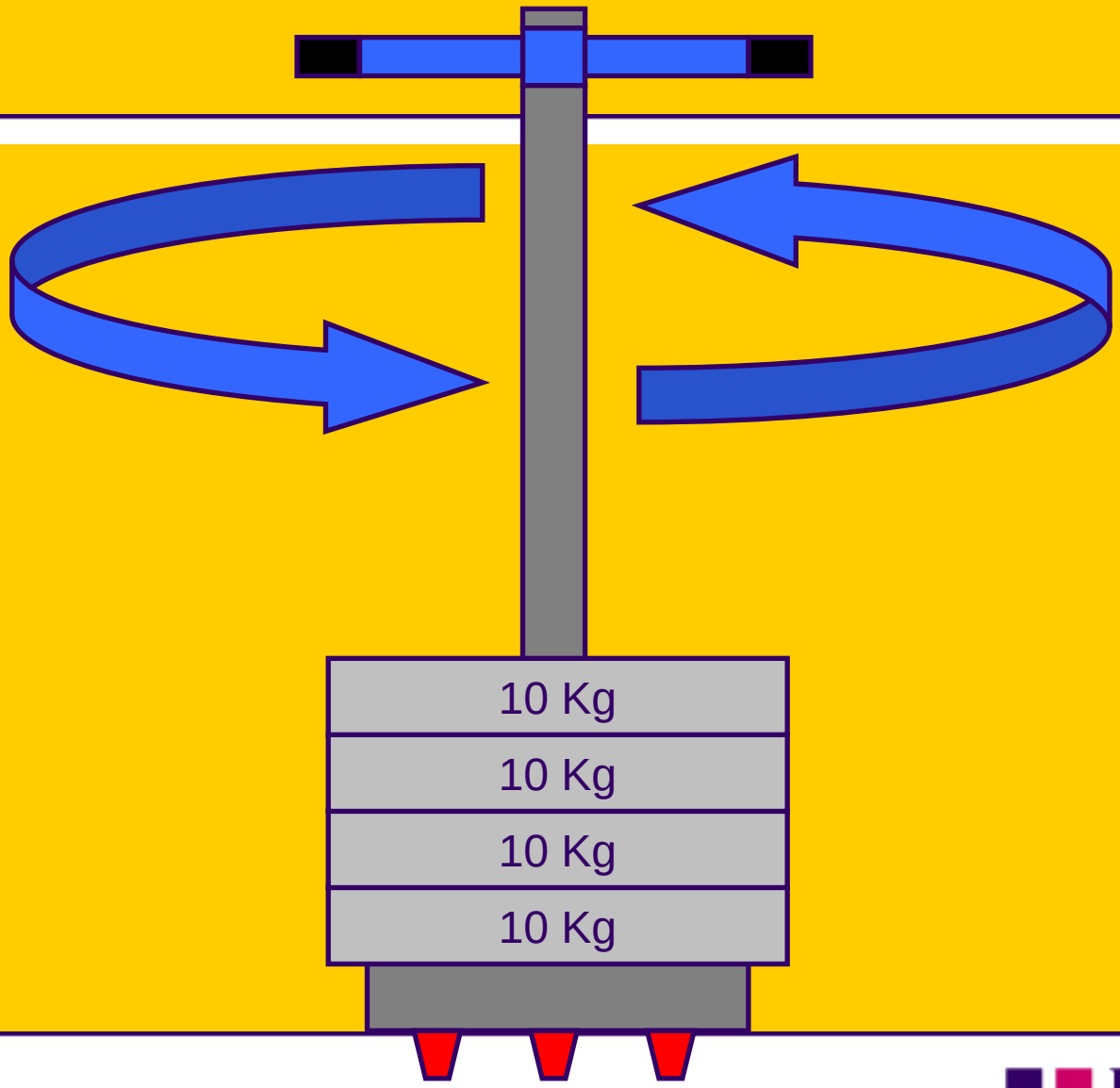
Rotational Traction



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Traction Measurement

- Unfilled systems – Monitoring & Evaluation
- Filled Systems – Monitoring & Evaluation

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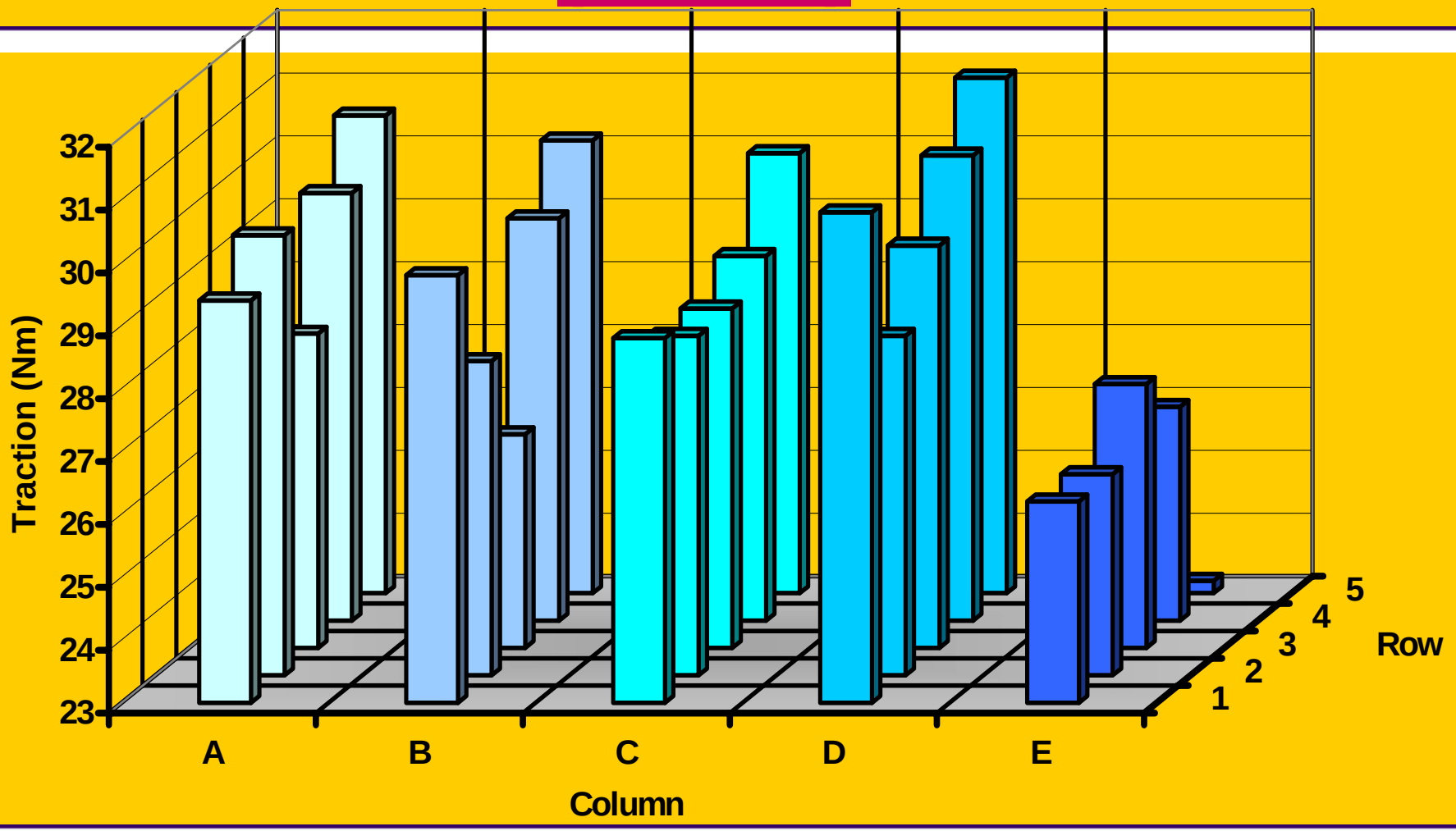
Rotational Traction at Pitch F (Row E)



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Rotational Traction at Pitch F (Row E - Algae)

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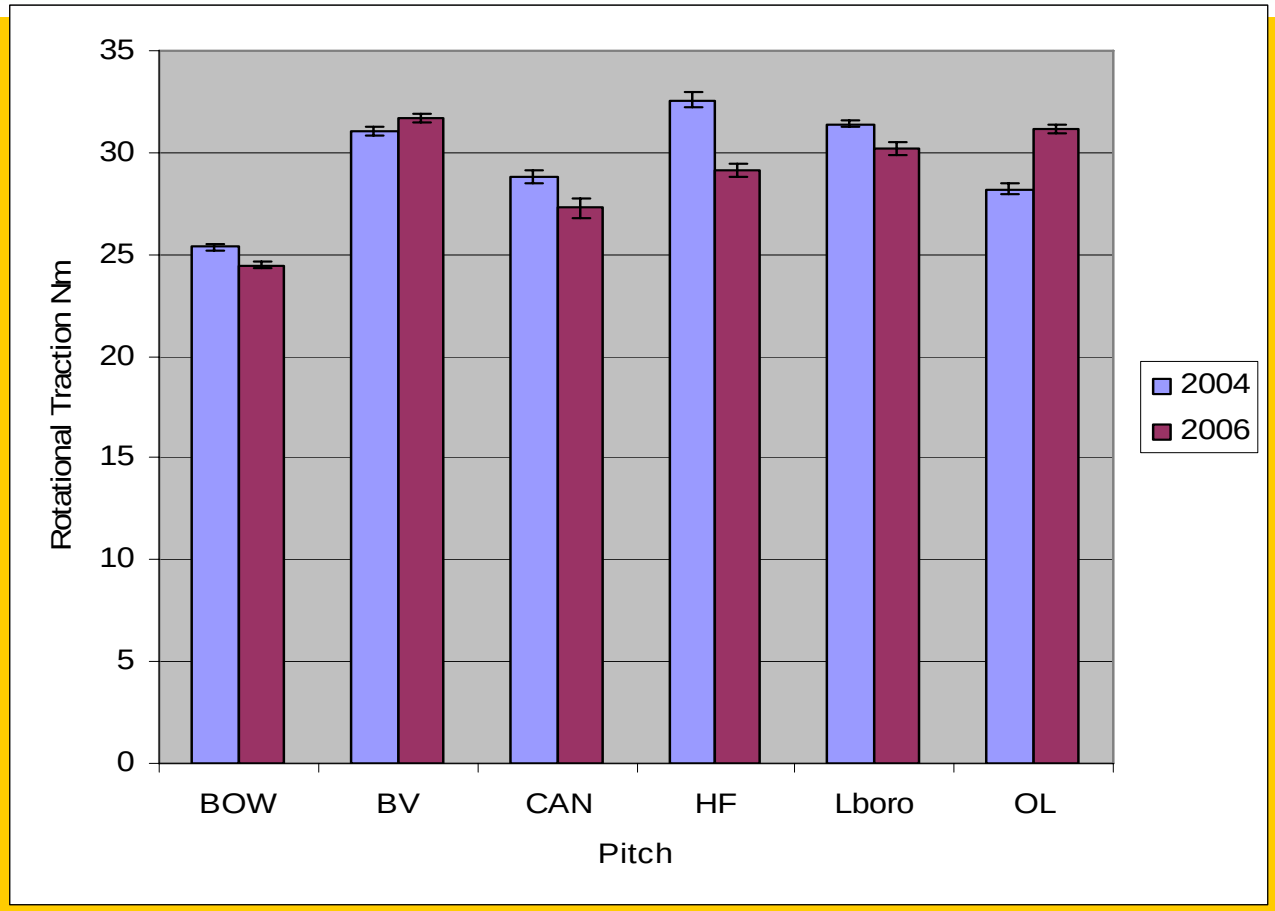
Data- Rotational Traction
Unfilled Hockey Pitches



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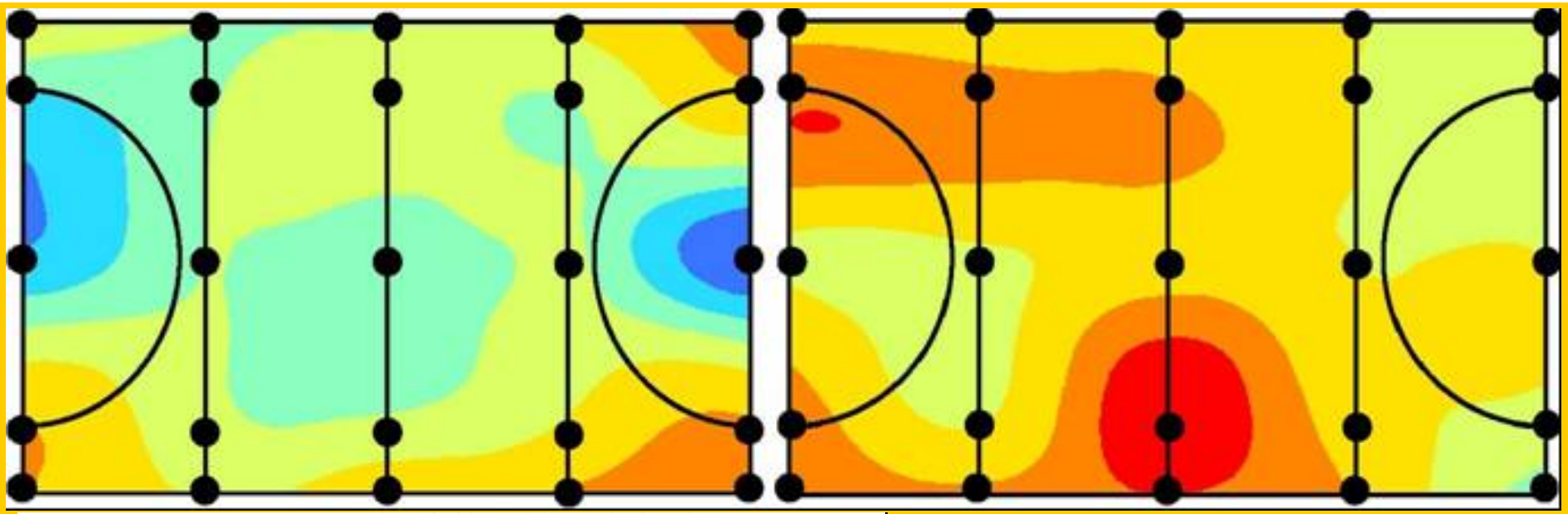
Data - Rotational Traction
Unfilled Hockey Pitches



Key

Sample points

Pitch markings

Rotational Traction Nm

<21	27 - 28
21 - 22	29 - 30
23 - 24	31 - 32
25 - 26	33 - 34

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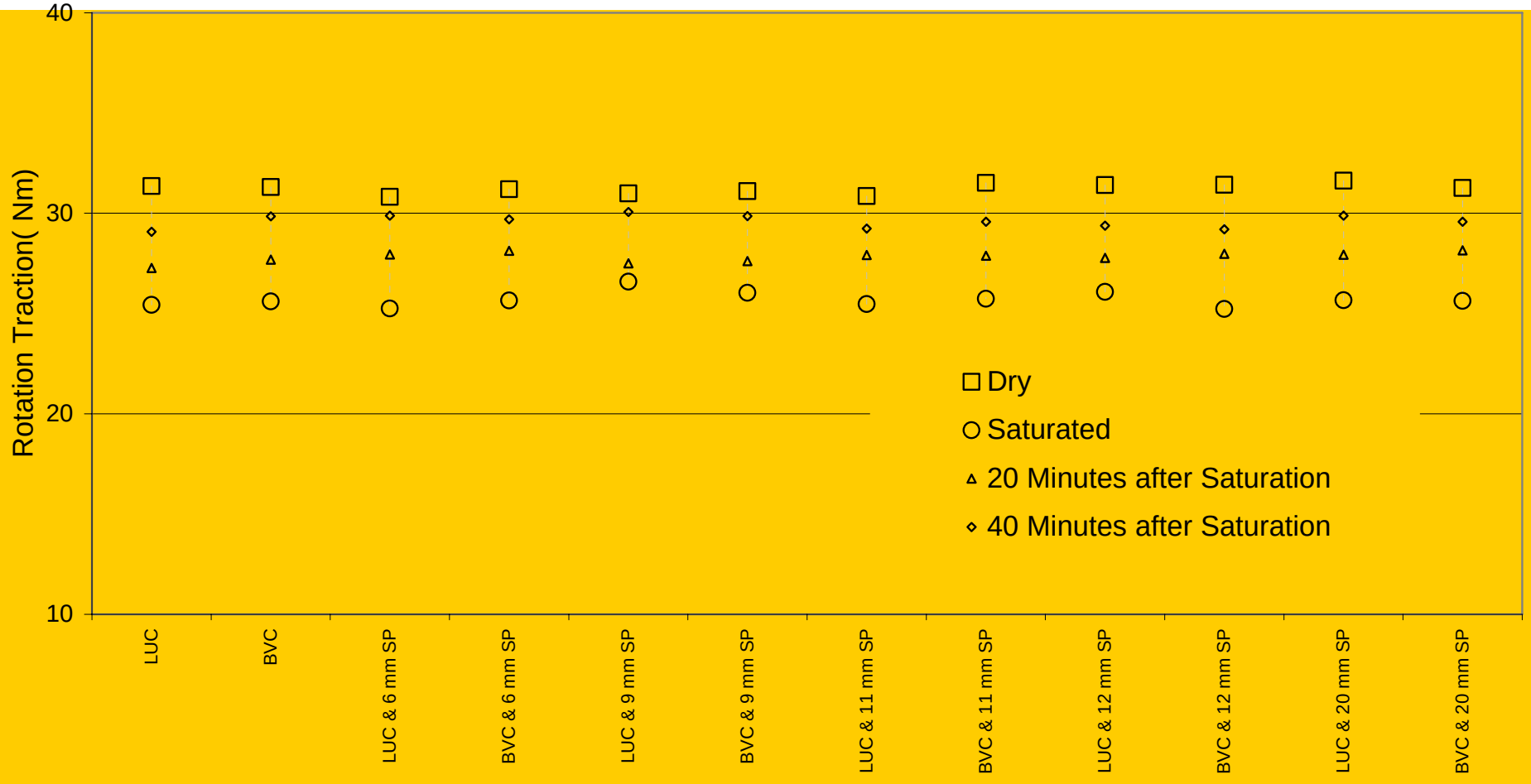
Construction/Design Effects
Rotational Traction vs Shockpad thickness



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Rotational Traction data
Rubber Filled Football Pitches

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Rotational Traction Data
Filled Football Pitches

TRACTION TEST RESULTS (Rotational Resistance)

LU PITCH1

2003 – Test house	28 (Range 27 - 29)
2004 – Project	25-28
2004 – Project	24-32
College Pitch 2	27-30

	Fill density(kg/m^3)		Torque Nm	Berlin FRF %
Laboratory	10	a	22-24	57
	16	b	24-26	62
	22	c	21-23	68

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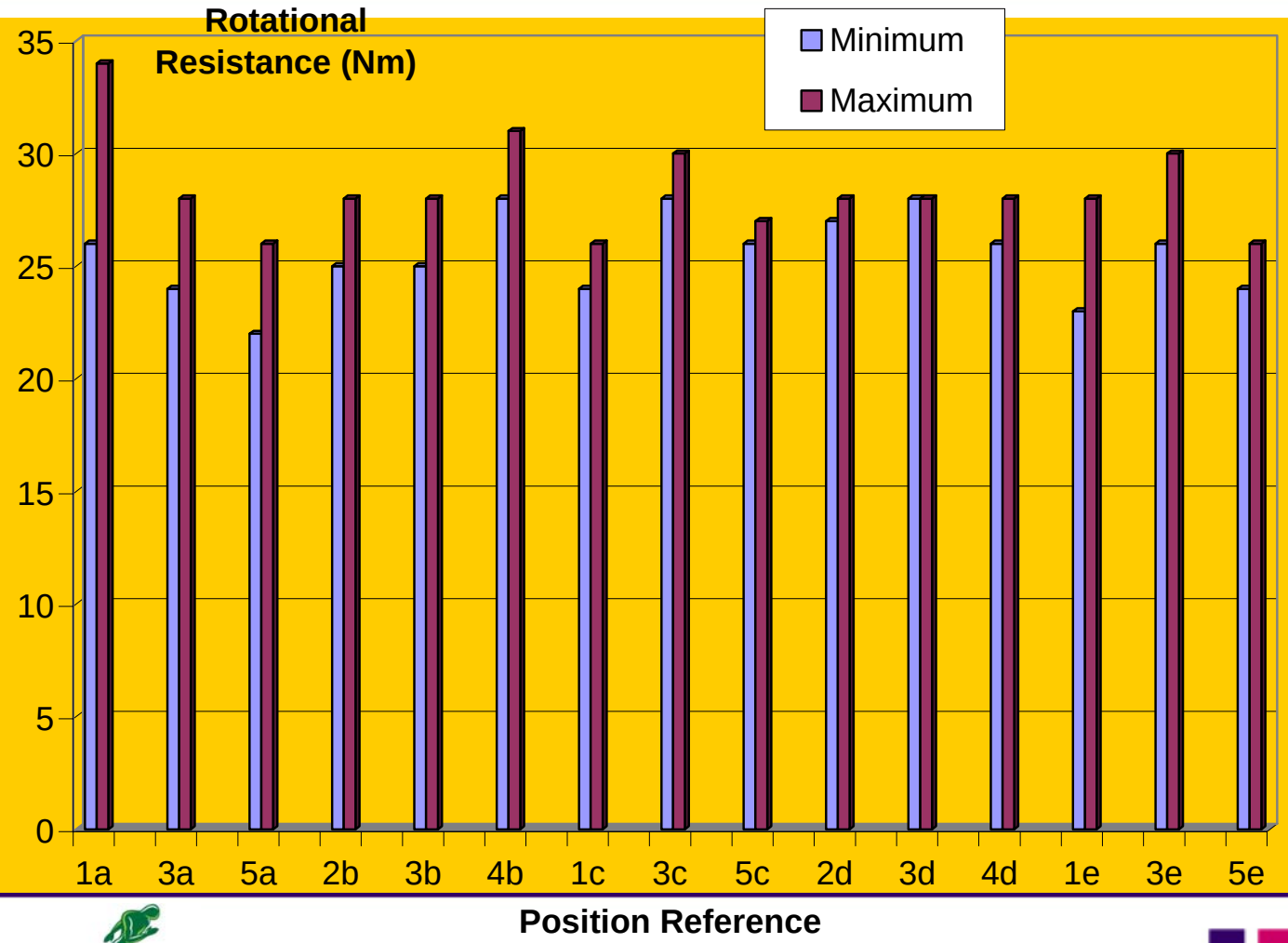
Rotational Traction Data
Filled Football Pitches



LU Pitch 2004

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Other Data – Rotational Traction

- 45-65kg static force increased Torque from 36-49Nm, infilled SBR. (Vachon, 2005)
- IBV (2003) measured 38-47 on Infilled Artificial Turf, 38-68 on Natural turf
- Shorten (2002) – shoe <u>and</u> surface required. Rotational traction should be as *low* as possible - not linked to athletic manoeuvre
- Strathclyde Research has looked at multivariate approach…

Pitch Tester (The ‘Beast’)

Steve Blackburn, Colin Walker, and Sandy Nicol.

Strathclyde University, 2003-2006

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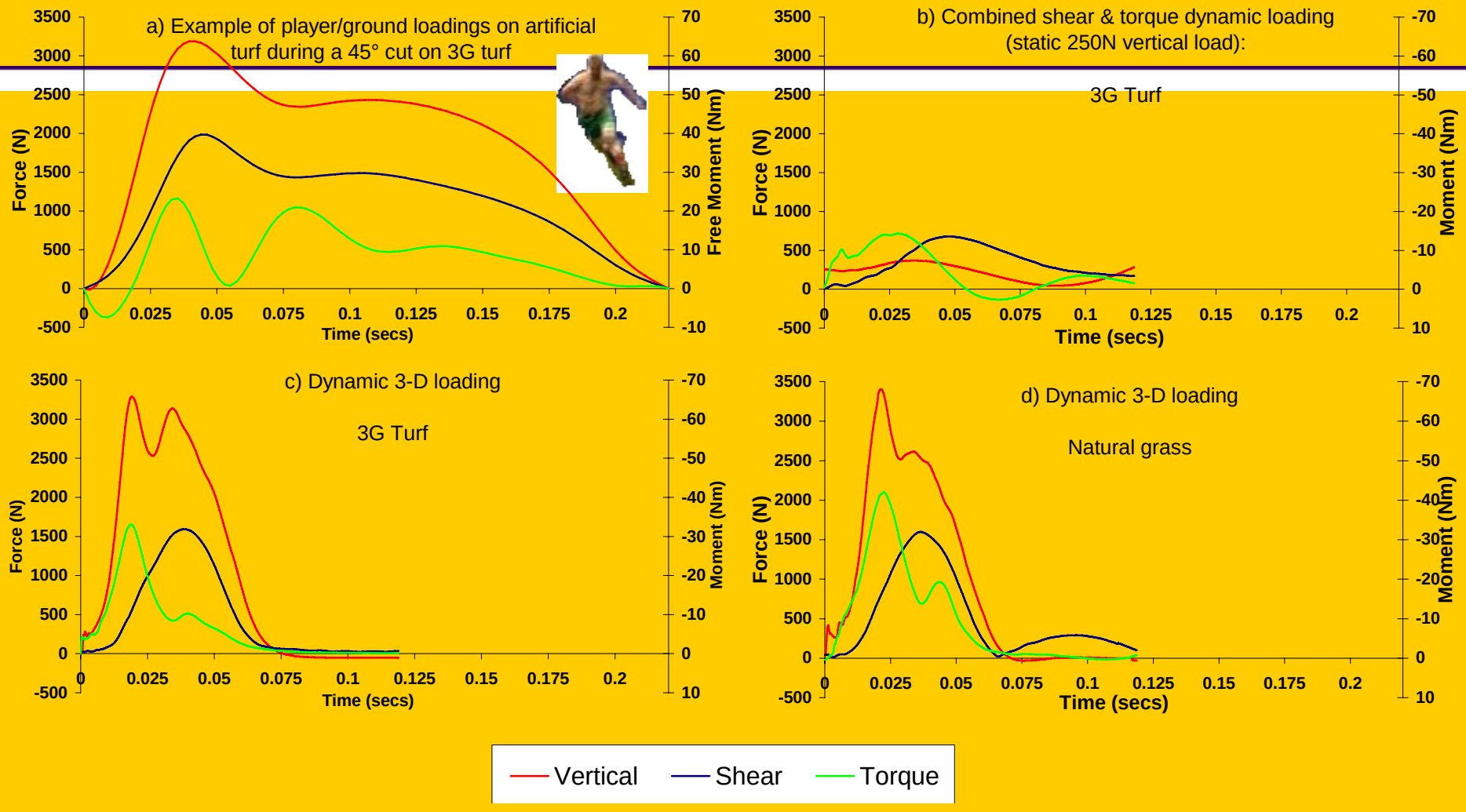
Ground Loadings – a) Player Study, b) c) and d) from Rig



S Blackburn/ C Walker/ S Nicol, Strathclyde University.

Some Findings…1 (Traction)

- Rotational Traction Device - not a very sensitive tool?

  Torque expected to vary with thickness of compressible layers and normal force etc….?
- Current Equipment - wrong level of (static) normal force, and load rate….(operator influence)
- Are the torque levels specified correct for Rotational Traction??

Accuracy and precision look low…

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Some Findings…2 (Impact)

- Impact testing – several tools available, selection should be based on purpose (standards, monitoring, research..)
- Good understanding of *material* stiffness, damping and layer interaction effects is required.
- Berlin is a constant energy test, large experience gained hence continuation..?

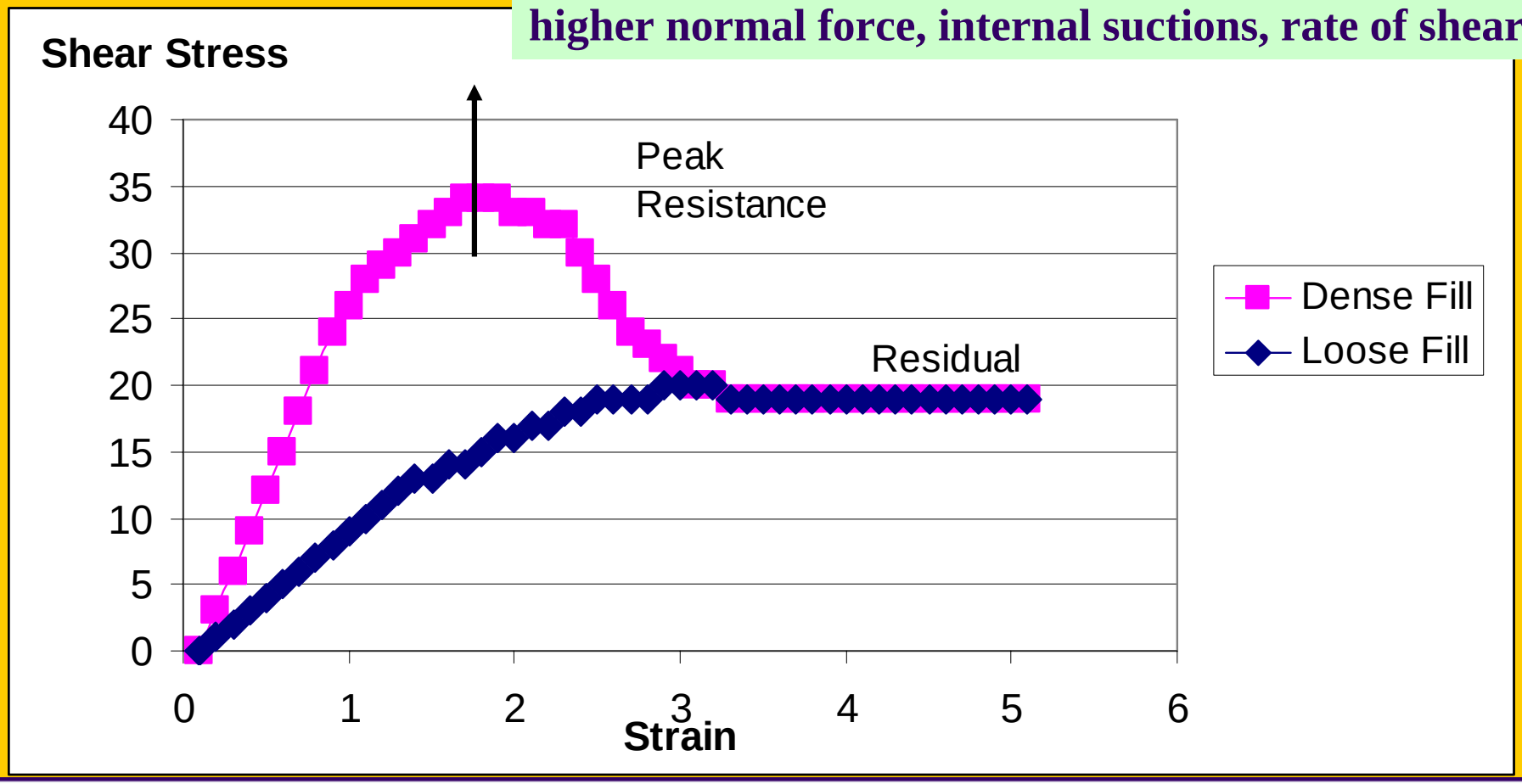
  Controlled force could be more effectively utilised? Fits biomechanical data better…?

FILL ISSUES

- **Fill material type (recycled rubber, EPDM, sand, water, other…**
- **Fill source – size ranges, shape, method of production**
- **Mechanical properties – test methods for particle packing, friction, compressibility/strength? Temperature effects..**
- **Ease of installation – ‘equilibrium’ state..?**
- **Long-term behaviour – degradation, fouling, compaction, drainage effect**

Fill Mechanics - Shear strength (linear)

Increased peak for higher density/compaction, higher normal force, internal suctions, rate of shear



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3G Maintenance – Effects?

Frosty day – reverse compaction effects?

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CARPET ISSUES

- Yarn type
- Yarn properties – strength, stiffness, resilience..
- Yarn source - size ranges, shape, method of production
- Long-term behaviour – degradation through wear, environmental effects
- Mechanical properties – test methods?
- Temperature effects?
- Other – seaming, rucking, colour etc..

General Research Required

- **DEVELOP PITCH SCIENCE**
- Classification of surface systems and ‘state’ – way of comparing between data sets
- Accurate/Sensitive Test Methods

  (based on player loadings, material behaviour aspects)
- Thorough investigation of the factors influencing measurement accuracy & sensitivity

MORE HIGH QUALITY PUBLISHED DATA NEEDED !!!

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THANKYOU

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