Surface Assessment and Modelling of Behaviour

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Assessment requirements…

- Athlete interaction with surfaces
- Ball interaction with surfaces
- The challenge…
  - Produce affordable surfaces with good, consistent performance for athletes (comfort, safety and play) and ball interaction (play)
Mechanical behaviour – Loading due to Athlete…

- Cushioning or Force-reduction  
  - Berlin Athlete and others
- Sliding friction  
  - Pendulum devices, sledges
- Traction  
  - Rotary devices, sledges
Measuring Traction on Turf

- Players seek sufficient traction for performance
  - carry out specific movements

- Injury risk should be minimised
  - reduce high traction forces and moments
Artificial Turf in Football Today

• **Governing bodies allow use at professional level**
  – World Cup 2006 qualifiers
  – UEFA games from 2005-6 season

• **High use at amateur level**
  – Less maintenance (?)
  – Consistency

**Need for physical insight into characteristics of artificial pitches**
Traction Tester

Turf sample
Traction Tester

Studs attached to sled in desired orientation

5 stud pattern used
Traction Tester

Penetration level set on screw gauge
Traction Tester

Low friction rollers maintain penetration level
Traction Tester

Sled pulled by constant speed motor (up to 0.4 m/s)
Traction Measurement
Traction Measurement

Maximum (static) traction

Force (N)

Time (s)
Traction Measurement

Settled (dynamic) traction
Studs Tested

- Circular studs
  - Various sizes
- Other shapes
- Mixed configurations

Cuboid:

Hexagonal:
Dependence on Area

- Mean values with standard error bars for studs A to D
Dependence on Area

- Mean values with standard error bars for studs A to D
- Trend line
Dynamic Traction 0.16 m/s

- Mean values with standard error bars for studs A to D
- Trend line
- Hybrid configurations

Dependence on Area

![Graph showing force (N) vs. stud area (m²) for dynamic traction at 0.16 m/s.](image-url)
Dependence on Area

- Mean values with standard error bars for studs A to D
- Trend line
- Hybrid configurations
- World Cup FF (adidas)
Turf Traction Summary

• *Traction is less dependent on velocity, compared to stud cross-sectional area and geometry*

• *Model to be developed further to include more stud and surface parameters*
Mechanical behaviour – Loading due to ball…

- Ball impacts
  - E.g. tennis, cricket, football
  - Restitution, energy return
  - Sliding, rolling friction
  - Deformation

- Rolling
  - E.g. hockey, football
Types of impact

• Deformable ball / rigid surface
  – e.g. tennis

• Rigid ball / deformable surface
  – e.g. golf

• Deformable ball / deformable surface
  – e.g. cricket
Measuring Impacts…

• Photogrammetry
  – High speed video
  – Strobe photography
• Simulated impacts
  – Light gate systems
Measuring Restitution...

- Ball drops
  - Standard approach
- Impact hammers
  - Generate surface behaviour data
• Design incorporating accelerometer
• Mounted on linear rail
Measuring Friction…

- Pendulums
- Sledges
Modelling Ball Impact Behaviour...

- Newtonian models
  - Simple, can be effective
- Spring-damper models
  - Describe behaviour of ball and surface
- FE models
  - *Potential* to simulate all behaviour for some cases
Newtonian models…

- Used effectively in cricket
  - Combined ball drop and friction info
  - Predicted pace of pitches
Modelling Tennis ball Impact...
Forces during normal impact

![Graph showing forces during normal impact, with labels for Spring, Experimental, Impulsive force, and Damper.]
Forces during normal impact

![Graph showing forces during normal impact. The graph plots force (N) against time (ms). The graph includes lines for Total force, Spring, Experimental, Impulsive force, and Damper, with specific values for each component at different times.](image-url)
Forces during oblique impact
Forces during oblique impact

(a) Smooth (μ=0.51)
Result of Tennis Study…

TennisGUT
Modelling Cricket Ball Impact...

\[
(F)_t = m(\dot{y}_b)_t \\
(F)_t = (k_b)_{t-\Delta t}(y_b - y_p)_t + (c_b)_{t-\Delta t}(\dot{y}_b - \dot{y}_p)_t \\
(F)_t = (k_p)_{t-\Delta t}(y_p)_t + (c_p)_{t-\Delta t}(\dot{y}_p)_t
\]
Determining model parameters...
Model verification…
FE models (Computer Simulations)…

- Used effectively in tennis
  - Surface treated as rigid
  - Applies friction
  - Very complicated for most surfaces
In Summary…

• Athlete / Ball interaction with surfaces
  – Can be assessed
  – Can be modelled (for some situations)

• The challenge…
  – To use this knowledge to improve surfaces
    • By improving collaboration
  – To fill in gaps of knowledge
  – For example…
    • surface consistency
    • effect of construction…
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