Racetrack Surfaces and Technology Integration

10 YEARS OF THE ORONO BIOMECHANICAL SURFACE TESTER
5 YEARS OF THE RACING SURFACES TESTING LAB
Issues in Catastrophic Injury

• Conformation
• Individual predisposition
• Pre-existing disease
• Shoeing
• Training
• Track surfaces
• Multi-factorial risk

No disease no breakdown....

*Tracks did not “cause” the problem, they CAN improve the situation*
Why do Research on Surfaces?

• Well developed work on biomechanics
• Work on tracks was usually done with a regional focus
• Need standard testing
• Testing based on biomechanics
Surface has different function during phases of gait: Impact/loading

**Impact**
Vertical Loading of Soil/Shearing

- Lower vertical modulus reduces strain rate and peak loads
- Shear failure reduces horizontal peak accelerations

Shear and Normal Load from Hoof

High peak load fracture....
Surface has different function: Breakover/Propulsion

- Shear strength to support hoof during propulsion

Break-Over
Unloading with Shear

Low shear strength, bowed tendons....
Surface During Gait

• What the rider feels: 
  *Performance*

• *Musculo-skeletal* loading: 
  *Safety*

• **FIVE FUNCTIONAL PROPERTIES:**
  - firmness
  - cushioning
  - responsiveness
  - grip
  - uniformity

*Can we measure these parameters?*

Surface firmness
Cushioning
Responsiveness
Grip
Cons Uniformity faection

*uniformity*

OF

firmness,
cushioning,
responsiveness,
grip

*Water and Bias*
Surface During Gait

• We need to understand the surface in terms of operational parameters.

• FIVE FUNCTIONAL PROPERTIES:
  – firmness,
  – cushioning,
  – responsiveness,
  – grip
  – uniformity

*How do we measure these parameters?*

We Learn What Matters from the Horse....
Prior literature showing what is important was limited

Initial Funding from AQHA Racing, Started in 2001

Impact
Vertical Loading of Soil/Shearing

Vertical Load & Accelerations
Horizontal Load & Accelerations
Need to Load Like Surface a Horse Track Materials – Synthetic and Natural

- Non-linear
  The more the material is loaded the higher the modulus (stiffness)

- Strain rate dependent
  - Synthetic shows creep deformation
  - Dirt and turf shows dynamic response controlled by moisture content

- Measurement tool length scale consistent with hoof

*If You Race Small Portable Horses You Can Use a Small Portable Tool*
Orono Biomechanical Surface Tester

**Prototype Testing 2004**

- Biomechanical Hoof Tester
  - Started discussion in 1998
  - Comparison of more than 60 tracks, 8 Synthetic Tracks, 5 turf tracks
- During racing (40 min, 24 locations)
- Simultaneously measure shear and hardness
Now the Method has Expanded Beyond Racing
A Decade of OBST Data: **Grip**

6000 tests, 80 Racing & Training Surfaces

Range of slide data on dirt is MUCH larger than on synthetic. Some dirt has less slide (higher Grip) than synthetic.
A Decade of OBST Data: **Cushioning**

6000 tests, 80 Racing & Training Surfaces

Even Cushioning of dirt overlaps synthetic data

Dirt is much more variable

The Important Conclusion: dirt is more variable than a synthetic track
More tools:

Ground Penetrating Radar

- Detect variation in the base and depth of cushion: Holes in the base, Separation of materials, Loss of fines – drainage, cushion depth
- Identify issues before a problem arises.
Ground Penetrating Radar on Oaks Day

Used for base, but can also be windowed for moisture

Do These Changes Really Matter in Racing?
A Decade of Testing: Variability

What factors need to be controlled....

• Synthetic Tracks
  – Spatial
    • Compaction (Cultivator vs. harrow)
    • Grading
    • Segregation of material
  – Temporal
    • Degradation of wax and fiber
    • Loss of rubber
    • Weather and temperature

• Dirt & Turf Tracks
  – Spatial
    • WATER
    • Grading
    • Compaction (tracks with a pad)
    • Segregation of material
  – Temporal
    • WATER
    • Material composition/loss
Maintenance Matters: Rip, Till a Racetrack?

The OBST correlates to actions on track

Effect of track maintenance on mechanical properties of a dirt racetrack: a preliminary study, Peterson and McIlwraith, Equine Veterinary Journal, 40 (6) p 602-605
Not simple!!!!

Three Different Dirt Track “Designs”

- Hoof contacts surface of track during impact.
- During breakover the hoof penetrates the cushion.
- Shear and penetration strength must be sufficient to avoid toe contact with base.

Dynamic Load
2 ½ times Body Weight

Limestone screenings, clay or even concrete
(X-Ray Diffraction) from the Racing Surfaces Lab

Design & maintenance is defined by rainfall & materials

<table>
<thead>
<tr>
<th></th>
<th>Clay content (%)</th>
<th>Organic content (%)</th>
<th>Annual Precipitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow Sand</td>
<td>2.35 (1.02)^*</td>
<td>0.26 (0.25)^*</td>
<td>120.2 (28.3)^*</td>
</tr>
<tr>
<td>False Base</td>
<td>3.57 (1.53)^*</td>
<td>0.47 (0.35)^*</td>
<td>107.7 (45.2)^†</td>
</tr>
<tr>
<td>False Base with</td>
<td>6.76 (3.60)^*</td>
<td>2.49 (2.70)^*</td>
<td>66.0 (25.2)^*†</td>
</tr>
<tr>
<td>Pad</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* ANOVA p<0.05
^ † Tukey-Kramer post-hoc p<0.05

Outcome: Maintenance must match materials

What about Safety of Horse and Rider?

• 3 different racetrack designs, Defined by maintenance, climate and clay mineralogy
• What is safest?
• Data is not statistically significant: This year, may not be the same next year

*Best Dirt Almost as Safe as Synthetic!*
From OBST Data .. **WATER**

The OBST correlates to effects seen on the track.
**Same Effect in the Lab: WATER**

On track it can easily vary from 10-14%

Moisture: 14% to 10%

Shear Strength: 24.6 to 33.7 psi
Synthetic Tracks, Temperature not water

The entire synthetic track is at the same temperature MORE CONSISTENT

To Make Dirt and Turf MORE CONSISTENT

Temperature is a better predictor than other Clegg, Penetrometer etc.

Major Message from Research

• Maintenance, especially water, needs to be controlled

• Different maintenance for different materials
  – Water
  – Harrow
  – Material addition
  – Grading

• Details matter ....
ISO Type Process

• The goal is not to define the maintenance process...
  1. What is going to be done
  2. What has been done
  3. How work is verified

Build a safety critical system every day
Dirt Tracks: Some Years are Bad

- Injury rates on dirt tracks vary between years
  - Same people
  - Same methods
- Weather
- Response to weather
- Synthetic performance depends on temperature; less variation
Understand and Control Track Variation

- Link testing to the outcomes ..
  Performance and safety
- Water is the single biggest input variable on turf
- Proper surface maintenance makes it consistent for turf:
  - Aeration
  - Top dressing
  - Verticutting
How Do Other Industries Do It?

- The goal is not to define maintenance process...
  1. What is going to be done
  2. What has been done
  3. How work is verified
- Approach suited to job: surgical outcomes improve with paper checklist
Close the gap, all dirt tracks as good as best what is the best

• Difference is between good and bad years
  – Same people
  – Weather can vary
  – Respond to weather

• Document process (like aircraft maintenance)
  – Document what you will do
  – Document what you did
  – Document how you inspected it

*u.must not define what is done but focus on the process*
Make Every Dirt Track as Safe as the Safest Dirt Track!!!

- Goals from WSS ....
- Establish daily reporting of maintenance on racetracks
  - Provide information for track management, owners, trainers, jockeys and racing public
  - Institute database of daily maintenance of the main and turf course

### Weather Station Summary

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Track</th>
<th>WX Src</th>
<th>Last Weather</th>
<th>Batt</th>
<th>Links</th>
</tr>
</thead>
<tbody>
<tr>
<td>812</td>
<td>Allen Training Track</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>801</td>
<td>Aqueduct</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>Arlington Park</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>822</td>
<td>Belmont Park</td>
<td>Active</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>105</td>
<td>Calder Race Course</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>102</td>
<td>Churchill Downs</td>
<td>Active</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>813</td>
<td>Darley Stable</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>107</td>
<td>Dal Mar</td>
<td>CHRB</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>108</td>
<td>Emerald Downs</td>
<td>Active</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>303</td>
<td>Evangeline Downs</td>
<td>Active</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>103</td>
<td>Fair Grounds Race Course</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>803</td>
<td>Fair Meadows</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>301</td>
<td>Fairplex</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>307</td>
<td>Golden Gate Fields</td>
<td>CHRB</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>804</td>
<td>Gulfstream Park</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>101</td>
<td>Hollywood Park</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>104</td>
<td>Keeneland</td>
<td>Active</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>306</td>
<td>Los Alamitos</td>
<td>CHRB</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>805</td>
<td>Nizzola Race Club</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>814</td>
<td>Pegasus Training and Equine Rehabilitation Ctr</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>806</td>
<td>Portland Meadows</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>807</td>
<td>Randall Oob James</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>807</td>
<td>Ramapo</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>305</td>
<td>Remington Park</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>304</td>
<td>Santa Anita</td>
<td>CHRB</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>809</td>
<td>Saratoga</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>909</td>
<td>Site Track</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>810</td>
<td>Turfway Park</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>815</td>
<td>WinStar Farm</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>811</td>
<td>Woodbine</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
<tr>
<td>302</td>
<td>Zia Park</td>
<td>WU</td>
<td>2012-10-14 23:55:00</td>
<td>Weather Data Entry Setup Race Sched Change Pxd</td>
<td></td>
</tr>
</tbody>
</table>

Manual Maintenance Tracking System at 8 Racetracks, Automatic Tracking 6 Racetrack, Weather at 12 Racetracks
Critical to Track Data

Maintenance ↔ Weather

• Weather data
  – Station at a standard track location
  – Weather logged to central database

• Water application – irrigation, water truck

• Evaporation model
  – Weather and water truck, estimate moisture content
  – Established methods from precision farming
Enter data for track maintenance

Form for turf

Form for training
Form for water truck use

Historical data

---

### Select Date

<table>
<thead>
<tr>
<th>Date</th>
<th>05/22/2013</th>
</tr>
</thead>
</table>

### Grading

<table>
<thead>
<tr>
<th>Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Race Day #</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Breaks</td>
<td>2</td>
</tr>
<tr>
<td>Races</td>
<td>9</td>
</tr>
</tbody>
</table>

### Enter Maintenance for 05/22/2013

<table>
<thead>
<tr>
<th>Event</th>
<th>Choose ---</th>
<th>Time</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>x 1,000 gals.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments

New Record Option

- Keep Equipment
- Clear All
- Keep Event

Save

### Track Maintenance for 05/22/2013

<table>
<thead>
<tr>
<th>Event</th>
<th>Break/Race #</th>
<th>Time</th>
<th>Equipment</th>
<th>Direction</th>
<th>Rounds</th>
<th>Depth</th>
<th>Speed (s)</th>
<th>Water x 1,000 gals.</th>
<th>Yards</th>
<th>Comments</th>
<th>Entered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Training</td>
<td>04:00AM</td>
<td>Harrow, A-frame</td>
<td>Racing direction</td>
<td>1</td>
<td>10.00</td>
<td>Water x 1,000 gals.</td>
<td></td>
<td></td>
<td></td>
<td>Edit</td>
<td>2013-05-22 04:21:15</td>
</tr>
<tr>
<td>Before Training</td>
<td>04:00AM</td>
<td>Harrow, Double</td>
<td>Racing direction</td>
<td>1</td>
<td>8.00</td>
<td>Water x 1,000 gals.</td>
<td></td>
<td></td>
<td></td>
<td>Edit</td>
<td>2013-05-22 04:21:44</td>
</tr>
</tbody>
</table>
Cushion depth map from probing

Aqueduct Inner Dirt Track
Moisture Test Data: 1/31/12
01-18-2013 16:30:00 AM

9.75

Aqueduct Inner Dirt Track
Daily Inspection Report
Date: 12-31-2012

3½

Comments:
Test set - not real data.

Too

C
Use GPS Tracking to Monitor

GPS Tracking of Critical Maintenance Equipment

Daily report of activity: Precision Farming For Horse Racing
Tracking of Water Truck Depth
Santa Anita

The position of the truck is logged as well as the depth of the water in the tank.
Evapotranspiration Models
Well established for crops including turf

Evaporation Model - Keeneland
How to Inspect the Work

Recall:
The maintenance process...

1. What is going to be done
2. What has been done
3. How work is verified

Surface Tester Used
At Start of Meet and
On the Big Days
Portable Inspection Tools

• Clegg Hammer
  – Does not correlate strongly to race times
  – Does not match biomechanics
    Lower speed and load than hoof strike

• Going Stick
  – Promising, link to biomechanics?
  – Assumes depth of cushion/turf homogeneity

• Penetrometer
  – Most well established, some link to penetration of shoe in breakover
  – “Penetrometer reading bears some relationship to winning times but is not a reliable predictor of such time” (Chivers, 1996, in Neylan & Stubbs 1997)

None are correlated to injury. Weaker correlation to race time than: Synthetic Track Temperature* or moisture in dirt/turf.

* Effect of temperature on 6 furlong times on a synthetic racing surface, M. L. Peterson et. al. Equine Veterinary Journal, to appear
Current Status

• No simple tools measure everything penetrometer, Clegg and Going Stick
• Use the OBST on a periodic basis, multiple machines in North America and Europe
• Variables understood with OBST and controlled between visits
• Periodic inspection and tracking maintenance
  – Like the ISO certification of tracks
  – Using methods from aircraft maintenance

To Make Dirt and Turf MORE CONSISTENT

CONTROL WATER
3rd Step: Inspect What was Done
Map and upload to database

Arlington Park Turf Track
Going Stick Data
08-02-2013 11:00AM
All Data: Central Database

• The goal is to IMPROVE...
  – What is going to be done
  – What has been done
  – How work is verified

• Data can be tied to outcomes
  – Injuries to horses and jockeys
  – Effectiveness of maintenance methods
  – Equipment & labor expenditures
The critical question: Does it Perform Well?

The more critical question: Epidemiology?

What matters is that we protect horses and riders.
Surfaces do not “cause” injuries, they CAN improve the situation

For racing, no disease no breakdown....

Issues in Musculoskeletal Disease

- Conformation
- Individual predisposition
- Pre-existing disease
- Shoeing
- Training
- Track surfaces
- Multi-factorial risk
Everyone Cooperates

- Arlington and Churchill Downs: maintenance tracking and measurement of surfaces
- Santa Anita: Sand Durability, Water Truck Depth tracking
- NYRA: Maintenance Quality System
- Keeneland: Evaporation Model and XRD of candidate sand

Information shared industrywide:

Safer surfaces benefit all horses, riders, fans and owners
Acknowledgements
Kozak, 43, came to NYRA in 2008 ... he has transformed an antiquated system that relied on old-school methods and paper records. Now NYRA maintenance workers are equipped with iPads and BlackBerrys and are entering data from the seats of their tractors. “He’s the future, is what I tell people in track maintenance,” said Mick Peterson, “He’s able to look every day on his phone and see when the equipment went out, what time it went out, what they were doing. This is more like aircraft maintenance ... but ... we’ve got the health and safety of the horses and the riders at stake here”