Performance of Bermudagrass vs. Synthetic Turf for Athletic Fields

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 Youth injuries (<14) cost the US public \$49,192,781,832 in 1997

Emergency room visits (2004)
– 116,000 – baseball
– 186,000 – football





AAP, US CPSC, & National Youth Sports Safety Foundation

• 38 million children & adolescents

(NIH, 2009)

• 3.5 million children under 14 receive medical treatment for sports injuries

(Safe Kids, 2007)

• 50% of these injuries are preventable

(Brenner, 2007; Safe Kids, 2007)



- 5.7% of high school football injuries were definitely related to field conditions, 15.2% were possibly related to field conditions (Harper et al., 1984)
- 10% of lawsuits related to sports injuries claim that the athletic field was inadequately maintained

(Dougherty, 1988)









Athlete-to-surface interactions (Bell, 1985; Nigg et al., 1984)



Surface hardness, consistency & traction







Traction



Why is playing quality so important?



Poor athletic field playing quality negatively impacts player performance & safety

(Cockerham et al., 1993)





University of Tennessee Center for Athletic Field Safety CAFS Facts

- 25 current sports turf research projects
- 5+ acres of athletic turf research
- Cool- and warm-season turf and synthetic surfaces





Comparing Bermudagrass to Synthetic Turf





Root zones

- 1) Sequatchie silt loam
- 2) Sand cap (6 in)
- 3) ASTM F2396
- 4) USGA specification
- 5) Gravel base

USGA			ASTM	
G	0%		G	
FG	≤ 10%		FG	≤ 30%
VCS			VCS	
CS	≥60%		CS	≥60%
MS			MS	
FS	≤ 20%		FS	≤ 10%
VFS	≤ 5%		VFS	≤ 5%
Silt	≤ 5%		Silt	≤ 5%
Clay	≤ 3%		Clay	≤ 3%
Total Fines (VFS+S+C)	≤ 10%		Total Fines (VFS+S+C)	≤ 15%

Surfaces

 Bermudagrass Slit-film Monofilament - Diamond Shape - Horseshoe Shape - Diamond Shape with thatch - Horseshoe Shape with thatch









ASTM F1702; ASTM F355; ASTM F1936; Richardson et al., 2001; Canaway et al., 1990

Digital Image Analysis to Determine Percent Green Cover



Light Box & Digital Camera



SimgaScan Pro 5 Software

























Simulated traffic events to reach 50% Cover: ASTM sand-based root zone: 19 Native soil root zone: 10

Rotational Resistance Comparisons

Synthetic Turf = Bermudagrass



F355 Synthetic Turf Surface Hardness Device



(ASTM 2396)

9.1 kg (20 lbs) missile61 cm (24") drop height



2012 Surface Hardness Values



2013 Surface Hardness Values



Conclusions

• Drainage makes a difference in higher moisture conditions

No differences between rotational resistance

• All surfaces were well below a GMAX 200

Athlete-to-surface interactions
Tennessee Athletic Field Tester







Comparing Bermudagrass to Synthetic Turf







210 lb. foot strike 9 shoes 3 surfaces Natural: bermudagrass Synthetic: monofilament and slit film

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Shoe Brand	Model	
ADIDAS	Malice D	
ADIDAS	Scorch XS	
ADIDAS	Zero Five	
Nike Nike	Alpha Speed	
Nike 🔺 🔢	Alpha Vapor	
Nike	Land Shark	
Nike	Vapor Talon	
Under Armour	Nitro 3 Low	
Under Armour	Saber Mid	

Peak Horizontal Forces



Bermudagrass vs. Monofilament





Bermudagrass vs. Monofilament



Bermudagrass vs. Slit Film



Bermudagrass vs. Slit Film



Horizontal Force Conclusions

- The peak horizontal forces on each surface were Nike shoes:
 - -Bermudagrass x Nike Alpha Speed (338 lbs.)
 - -Monofilament x Nike Land Shark (327 lbs.)
 - -Slit Film x Nike Land Shark (312 lbs.)
 - Several other shoes were not statistically different and were not listed

Horizontal Force Conclusions

- The three lowest horizontal forces on each surface were as follows:
 –Slit Film x ADIDAS Malice D (269 lb.)
 - -Bermudagrass x ADIDAS Malice D (256 lb.)
 - -Monofilament x ADIDAS Zero Five (238 lb.)
 - -Several other shoes were not statistically different and were not listed

Peak Vertical Forces



Bermudagrass vs. Monofilament



Bermudagrass vs. Monofilament



Bermudagrass vs. Slit Film



Bermudagrass vs. Slit Film



Vertical Force Conclusions

- Two of the largest vertical forces were on bermudagrass
 - Nike Alpha Speed (408 lbs.)
 - Under Armour Saber Mid (385 lbs.)

Vertical Force Conclusions

- The three lowest vertical forces were on monofilament turf
 ADIDAS Scorch X (252 lbs.)
 Nike Alpha Vapor (249 lbs.)
 - -ADIDAS Zero Five (218 lbs.)

What does this mean??

It's the shoes not the surface!!!



Temperature on Synthetic Turf

Heat-related Illnesses – USA Today

- 123 high school football players died of heat-related illnesses between 1960 and 2009
- Annual death rate was around 1 per year from 1980 to 1994
- Rose to a yearly average of 2.8 in the next 15 years

Effect on Athletes

 Heat transfer from the surface to the inner soles of shoes could result in heat-related illnesses



Buskirk et al. 1971

A Serious Issue!

 Recognized by the NYC Dept. of Health and Mental Hygiene as the #1 health concern associated with infilled synthetic turf





Denly et al. 2008

Irrigation and Synthetic Turf?

Average High Temp: 42.1° Average Low Temp: 30.1° 7 DAY FORECAST



Synthetic Surfaces Tested

Surface	Fiber Type	Thatch	Pile Height	Infill Ratio (Rubber: Sand)
1	Diamond	Yes	2 inches	2.5 lb. : 1.0 lb.
2	Diamond	No	1.25 inches	N/A
3	Horseshoe	Yes	2 inches	2.5 lb. : 1.0 lb.
4	Diamond	No	2.25 inches	2.8 lb. : 1.0 lb.
5	Horseshoe	Yes	2 inches	2.5 lb. : 1.0 lb.
6	Slit Film	No	2.25 inches	Layers (sand then sand/rubber mixture then rubber) 4 lb. : 3 lb.
7	Horseshoe	No	2.25 inches	2.8 lb. : 1 lb.
8	Horseshoe	No	2.25 inches	2.8 lb. : 1 lb.
9	Horseshoe/Slit Film	Yes	2 inches	2.5 lb. : 1 lb.
10	Slit Film	Yes	2 inches	2.5 lb. : 1 lb.

Experimental Design

•2 Temperature Sensors per Plot -TidbiT v2 Temp Logger

Temperature logged every 10 minutes

•Atmospheric data collected on same interval –HOBO Weather Station & Pyranometer

•Study Duration 22 August 2011 to 22 August 2012

Atmospheric Data

•Air temperature (°C)

•Relative humidity (%)

•Precipitation (mm)

•Solar radiation (W/m²)

Temperature Study

Each 24 hour day was split into six time segments consisting of four hours

- 12:00-4:00 am
- 8:00-12:00 pm
- 4:00-8:00 pm

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Maximum, minimum and mean surface temperature for each time segment

Over 800,000 data points were collected

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Daily Synthetic Turf Models

Synthetic Turf Surface Temperature Model	R ² - value
TurfMax = $-10.25 + (1.622*Max \text{ forecasted} \text{ temperature °C}) + (0.023*Max \text{ forecasted solar radiation W/m2})$	0.87
TurfMean = $0.58 + (0.948 * Mean forecasted temperature °C) + (0.035 * Mean forecasted solar radiation W/m2)$	0.95
TurfMin = -0.73 + (0.98 *Minimum forecasted temperature °C)	0.94
Model Accuracy

Hourly Data	TurfMax	TurfMean	TurfMin
24 hours	+/- 4.41°C	N/A	N/A
48 hours	+/- 5.33°C	+/- 1ºC	+/- 1ºC
72 hours	+/- 4.75°C	+/- 1ºC	+/- 1ºC

Future research needs to include wind speed and irrigation.

Turf & Ornamental Field Day - September 11, 2014

Questions?

