COVER STORY

SAFETY TO THE MAX

In September 1986, WEEDS TREES & TURF exclusively reported the story of a college baseball player's death on a synthetic field. The case raised questions which apply to the natural turf industry. In this issue we examine how to accurately measure the safety of fields. This test, although technical, may help you avoid a lawsuit.

by Heide Aungst, managing editor

Editor's note: Scott Halbrook was a 19-year-old freshman on a baseball scholarship at Oregon State University in Corvallis. On March 2, 1982, Oregon's rainy weather forced the team away from the natural practice field onto the AstroTurf football field at Parker Stadium.

Scott, playing left field, collided with the shortstop while running for a short pop fly. The collision knocked Scott backwards. His head hit the AstroTurf. He never regained consciousness.

Anonymous phone calls about the poor conditions of the field prompted Scott's family to hire attorney Dan Holland of Eugene. The Halbrooks filed suit against AstroTurf manufacturer Monsanto, Sports Install Inc. a subsidiary of Monsanto and Oregon State University. The parties settled out of court in September 1985.

GLOSSARY

The following is a glossary of terms used in the measurement of hardness:

***Acceleration*: The instantaneous time rate of change of velocity which may be positive or negative.**

***G*: The ratio of the magnitude of missile acceleration of gravity, expressed in same units.**

***G-max*: The maximum value of *G* encountered during impact.**

***Severity Index*: An arbitrary parameter equal to the integral of $G^{2.5}$ times distance times time over the total duration of impact.**

The story of Scott Halbrook's death on a college athletic field sent shivers down the spines of field managers throughout the country.

Some natural turf managers shrugged it off since the death occurred on a synthetic surface. Others immediately recognized the ramifications that such a report could have on the natural turf industry.

Natural turf researchers had been looking at making fields safer for several years before the Halbrook case reached the public. But by speaking out, attorney Dan Holland and Scott's father Alan Halbrook got others to recognize that field safety should be a universal concern, not one confined to the artificial turf industry.

This new-found awareness, combined with the liability crisis threatening to doom school athletic programs, has sent scientists in search of practical measurements to set guidelines for field safety.

Setting a standard

The place to start in setting a standard, say researchers, is to look at what already exists. The American Society of Testing Materials (ASTM) has set a test standard (F-355) for measuring the hardness of surfaces. ASTM defines their test method as *the measurement of certain shock-absorbing characteristics, the impact force-time relationships, and the rebound properties of playing surface systems.*

The standard further states, "*this test method is applicable to natural and artificial playing surface systems and to components thereof.*" Although three procedures exist for doing the test, the most common used on sport surfaces is *Procedure A*, which uses a cylindrical 20 lb. missile with a 20-inch circular flat metal face.

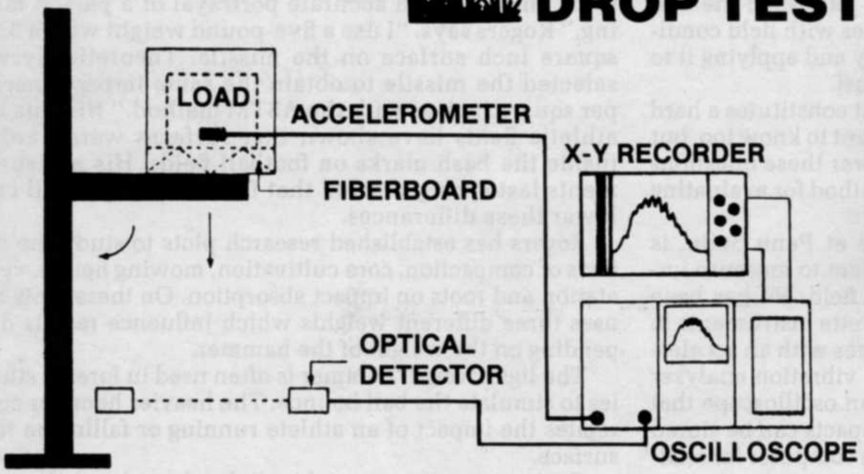
The problem is that most natural field managers have never heard of the test standard or the terminology used in determining hardness levels. Those natural field managers who are aware of the ASTM test may have learned the hard way.

"The only time I've tested a natural field is when there's a lawsuit," says Dick Schefsky, with Northwest Laboratories in Seattle, Wash. "We test artificial turf all the time. We can use the same equipment to test natural turf."

Dissecting the test

Before field managers can truly understand the importance of cultural practices, such as aerating and mowing, they must understand the basic prinicipals of shock absorbancy properties on playing surfaces, and the test which determines this. Schefsky says it's important to know this not just for football players, but for cheerleaders and other sports participants who may fall unprotected onto the surface.

DROP TEST



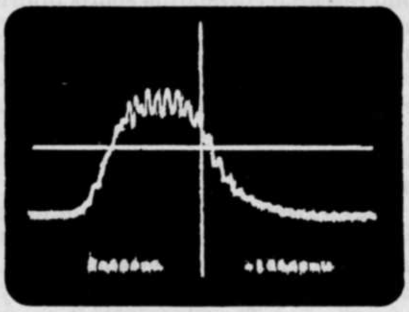


Figure 2: Impact pulse from one drop

Figure 1: An optical detector triggers the scope. The acquired signal is then fed to the floppy disk and an X-Y recorder for permanent storage.

"The deceleration of a falling body that impacts on a surface is one measure of impact absorption," says Don Waddington, Ph.D., soil scientist at Penn State University. "A hard rigid surface would stop the falling body quickly and would absorb little of the energy upon impact. A softer surface has a lower peak deceleration and absorbs more of the energy."

Perhaps a simpler way to understand the test is to imagine holding your arm out stiff and having a baseball thrown at it. If you don't move your arm as the ball hits it, it will sting. But if you move your arm and stop it back by your ear, the hit won't seem as hard because you're actually slowing down the stopping action over a longer period of time.

Not moving your arm simulates a hard surface with a high *G-max*. Moving your arm represents a softer surface, with a lower *G-max*.

The ASTM test is done by impacting the surface at a specified velocity with a missile of given mass and geometry. An accelerometer mounted in the missile monitors the acceleration. An accelerometer is a device which produces a voltage porportional to the acceleration it senses. Northwest uses an accelerometer from Vibro-meter Corp. of Billerica, Mass.

The acceleration of the impact is recorded with the aid of an instrument called an oscilloscope, that is an electronic instrument, like a television screen, which gives a visible trace of the voltage vs. time.

When Northwest Labs perform the test, they drop the missile at three different locations on the field. The drop test instrument includes the missile that has an accelerometer attached to it. An electrical signal emitted from the accelerometer is a measure of the deceleration of a missile when it impacts the surface.

The missile falls past an infra-red photoelectric eye. This optical detector and the accelerometer are hooked into an oscilloscope. A recorder attached to the oscilloscope will record the pulse of the drops (see diagram).

This pulse forms a bell-shaped curve. The points on this curve are Gs (gravities). One G equals the acceleration due to gravity. The peak of this curve is called the *G-max*. The *G-max* is what's looked at as the hardness level.

Another example Schefsky uses to explain the test in simple terms is to drop a ball bearing on a piece of steel. The ball bearing will bounce straight up because the surface won't absorb the shock. But if you drop the ball bearing on a pillow, it won't bounce because the soft surface absorbs the shock. The first example would have a high *G-max* reading. The second would have a lower *G-max* reading.

After taking the readings in the field, Northwest Labs plugs them into a computer program which reads out the actual deceleration rate. The sophisticated digital oscilloscope (Nicolet Instrument Corp, Madison, Wisc., Model 3091) which Northwest uses, allows them to keep the field readings on a "bubble memory cassette" to be re-examined in the lab.

The price of such equipment, approximately $5,300 for a digital oscilloscope and about $500 for an accelerometer, puts it out of the range of most school systems. The cost of purchasing such equipment must also include the guide system, fabrication of a missile, and a recording system. A computer and software program to figure the acceleration is also necessary.

The test and lawsuits

An independent lab can do the testing much cheaper than buying the equipment. Testing fields regularly at a low cost and correcting hardness problems could help school systems avoid major lawsuits and obtain insurance more easily.

"It's desirable to get a third party to do the test," Schefsky says. "I have no stake in the outcome. Third party testing lends credibility for insurance or legal purposes."

Schefsky says Northwest Labs is the only independent lab that he knows of with a portable system. Northwest's specialists will go anywhere in the country for $575 plus travel expenses.

"You have to put it into the budget," Schefsky says. "But if somebody does get injured, at least you will not have been remiss." *continued on page 20*

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Natural turf's impact

Penn State University, which in 1984 published the first solid research correlating sports injuries with field conditions, is taking such known technology and applying it to the special considerations of natural turf.

"Many people are interested in what constitutes a hard or soft field," Waddington says. "We want to know too, but at the same time we are trying to answer these questions we are also trying to develop a good method for evaluating surfaces."

Trey Rogers, a doctoral candidate at Penn State, is working on developing a portable system to measure impact absorption characteristics in the field. He has been using a Clegg impact tester from LaFayette Instruments in Lafayette, Ind. The Clegg impactor comes with an accelerometer. He attaches this to a portable vibration analyzer (Bruel & Kjaer type 2515), which has an oscilloscope that displays the impact curve. Up to 50 impacts can be stored on the analyzer before unloading into a computer for analysis.

Rogers has made some of his own modifications in the instrument. "The Clegg uses a 10 pound weight. I don't think that gives an accurate portrayal of a person falling," Rogers says. "I use a five-pound weight with a 3.14 square inch surface on the missile. Theoretically we selected the missile to obtain the same impact energy per square inch as with the ASTM method." His data on athletic fields have shown that surfaces were harder inside the hash marks on football fields. His measurements last spring showed that frost heaving of soil can lower these differences.

Rogers has established research plots to study the effects of compaction, core cultivation, mowing height, vegetation and roots on impact absorption. On these plots he uses three different weights which influence results depending on the weight of the hammer.

The light-weight hammer is often used in foreign studies to simulate the ball bounce. The heavier hammer correlates the impact of an athlete running or falling on the surface.

Critics argue that natural turf's hardness level changes whether it's wet or dry. "You can still find out what the

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G-MAX TEST*

(Northwest Laboratories, Seattle, Wash.)

Report to: X Stadium
Report On: Artificial Turf

Date: October 29, 1985
Lab No.: E 33859

TEST:

ASTM F355-78
"Shock-Absorbing Properties of Playing Surface Systems and Materials"

Test Site: X Stadium,
Surface: Artificial Turf cemented to resilient pad.
Test Date: September 9, 1985

Test Location Temperature Data	Drop	Time to G max (milliseconds)	Deceleration G's	Severity Index
30-yard line (N.E.)				
Relative Humidity-67%	2	6.0	113	393
Air Temp. 49°F	3	6.0	122	410
Field Temp. 52°F	4	5.5	128	421
Average (Drops 3 & 4)		5.75	125	415.5
50-yard line				
Relative Humidity-57%	2	6.5	116	389
Air Temp. 70°F	3	6.5	104	322
Field Temp. 75°F	4	6.5	108	344
Average (Drops 3 & 4)		6.5	106	333
30-yard line (S.W.)				
Relative Humidity-54%	2	6.5	108	344
Air Temp. 67°F	3	6.5	110	367
Field Temp. 71°F	4	6.0	108	322
Average (Drops 3 & 4)		6.25	109	344.5

INSTRUMENTS:

Manufacturer	Model Number	Serial Number
Oscilloscope:		
Nicolet	3091	84D00624
Accelerometer (Piezoelectric):		
Vibro-meter Corp.	501ER	453

*Although this particular test show G-max levels on a synthetic surface, Northwest Labs will perform tests on natural fields.

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optimal condition should be," Schefsky says. Rogers agrees that his research could lead into sports turf managers knowing what cultural practices to use, such as watering to soften the field.

What's safe?

ASTM has given labs and artificial turf manufacturers a standard to follow in performing tests. But they qualify the test with this statement: *This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

But what does it mean to the turf manager or player safety?

One major synthetic turf manufacturer has determined that *G-max* levels using a 20 lb. missile dropped from 24-inch height of "good grass" is about 75-100, while frozen earth is about 275. This manufacturer aims for the product to have a *G-max* of 200 using the 20 lb., 24-inch test.

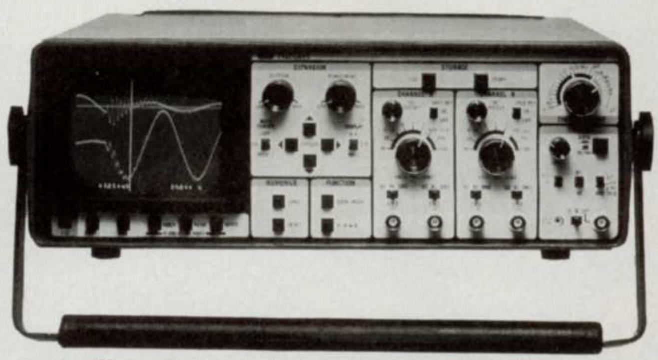
Except for the current work by Rogers and Waddington,

Penn State University uses a Clegg impact tester and vibration analyzer with three different weights for their impact absorption research.

G-MAX VALUES

A major synthetic turf manufacturer has assigned these G-max values using F-355, to the following conditions:

Hard frozen earth/gravel	275
Hand-packed dry earth or "Normal" frozen soil	175-200
P.A.T. system	125-140
"Good" grass	75-100
Soggy, wet grass	70-75



An oscilloscope is an electronic instrument, like a television screen, which gives a visible trace of the voltage vs. time.

no one in the natural turf industry has set *G-max* guidelines for natural fields.

"What are we talking about here?" Holland says. "What's safe? Do you fall from 24 inches or do you fall from your height?"

"It would be nice to write a specification and say 10Gs is safe," says Roger Schmidt, who's in research and development for Uniroyal and on the ASTM sports committee. "But it needs to be technically and logically feasible."

In a new standard which ASTM is proposing for playground surfaces, *G-max* levels will be taken at one foot intervals so that manufacturers can compare the values to the height of the equipment.

Still, Schmidt admits that *G-max* levels alone mean very little.

The severity index can better determine effects on player safety. "Instead of looking at just the maximum force, the severity index looks at a time interval of the force applied," explains Schmidt. "Severity index is more complicated to calculate and more related to head injury."

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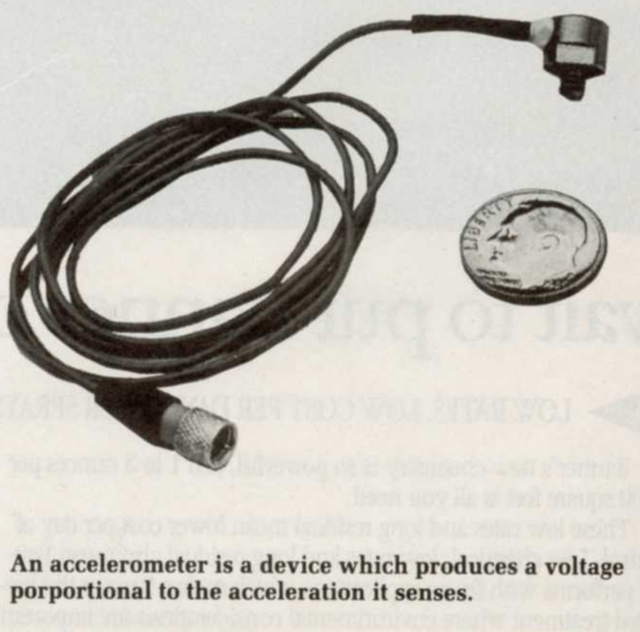

An accelerometer is a device which produces a voltage porportional to the acceleration it senses.

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Severity index

Severity index takes into consideration the Gs as well as the time over which the force is applied.

"Studies show that a person can tolerate a hard surface for a short amount of time. That's usually figured in milliseconds," Schefsky explains. In other words, if the surface absorbs the shock of the impact quickly, then that surface may not be as "hard" to a human body as a surface which absorbs the impact slower. One surface with a *G-max* of 200 may have a higher severity index than another surface which peaks at 200Gs.

Most standards such as ASTM and the severity index are based on head injuries. Original tests in this area dealt with heads hitting automobile dashboards.

Some researchers went as far as dropping animals on surfaces and even cadavers. "What damage occurs in a cadaver's head may be undetectable, while it could produce a concussion in a human being," says Bruce Martin, Ph.D., of the biomechanical engineering department at the University of California at Davis. Martin, along with Dr. Douglas Bowers of West Virginia University Medical Center, completed perhaps the study most critical to the natural turf industry on impact absorption of natural vs. artificial surfaces.

The 1974 test showed that five-year-old synthetic turf was almost as hard as asphalt, while bluegrass sod provided a softer surface. Bowers had planned to re-do the test this year, but the field he had been testing was ripped out. His plans are currently on hold.

The future

Rogers' impact absorption research, along with the work of other turfgrass scientists on turf strength and cultural practices will have profound effect on the future of the athletic turf industry.

"There are many things it could do," Rogers says. "I think we'll start seeing more people in the athletic field service industry. It's cheaper for schools to hire out for services. I think we need this research for athletes and parents of kids at the high school and junior high school level."

"There are many variables to be considered," adds Waddington. "We don't have the resources to do everything at once, but we are making progress." **LM**

PRACTICE MAKES PERFECT

It's an ironic situation, but it happens at schools everywhere: athletes spend more time on practice fields, while turf managers spend more time on game fields.

In 1984, Penn State University researchers published the first study correlating field conditions with player injuries. The researchers found that more injuries happened on practice fields, and that turf managers work less on those fields.

Since the publication of that study, the hardness issue also has come to the forefront of athletic turf management. The two issues combined have given athletic field researchers a new perspective on field management. While natural turf managers need to be aware of "G-max" levels on game and practice fields, the actual turf surface also is a concern.

Matt Leonard and Steve Cockerham look over the traffic simulator they created to produce wear on athletic field research plots.

Rich Henderson, who completed a masters thesis at Penn State in August, looked at the impact absorption properties of various surfaces. "Rich laid the groundwork for my research," says Trey Rogers, a doctoral candidate at Penn State. "He did his research in the lab, while my system is portable."

Henderson's results show that the presence of bluegrass sod on clay and coarse sand soils made the surface softer, but had little effect on a silt loam soil. A turf cover of 60-day-old ryegrass on the silt loam was softer than bare soil. Core cultivation decreased surface hardness of a silt loam soil.

The drop-test instrument used to measure impact absorption is not the only instrument which is important in evaluating turf strength.

Henderson also looked into the use of the pentrameter, a device which is pushed into the soil and measures the force per unit area.

Turf density, soil moisture and bulk density influenced the ease of pushing it into the soil. Turf density influenced a pentrameter with a 1.0 or 2.0 sq. cm. cone, while bulk density influenced a 0.25 or 0.50 sq. cm. cone. The 1.0 sq. cm. cone correlated best with soil moisture.

More research

Another problem researchers face is simulating actual field conditions on research plots. In order to do this for athletic turf, Steve Cockerham, superintendent of ag operations at the University of California-Riverside developed a "traffic simulator."

Cockerham says the invention evolved from "25 to 30 ideas" from other researchers across the country.

"Visualize the center of a football field," Cockerham explains. "It's torn up and compacted. In trying to develop new grasses you have to duplicate the wear of a football player over a plot. You can't tell a turf manager what to do if we're evaluating turf under different conditions than he lives with."

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