

ASTM 1936-10 Test Report

and Deltec Field Tester Results

| Project Information | | | |
|-----------------------------------|---------------------------------------------------------|----------------|-------------------------------------------------|
| Facility Name | Jesuit High School | | |
| Field Use | Football/ Soccer/ Rugby | Test Date | June 29, 2015 |
| Weather Conditions & Observations | Dry | Infill System | Sand, Zeofill |
| Ambient Temperature (°F) | 95F | Date Installed | May 1, 2015 |
| Turf & Base Detail | 1.25" Astroturf Golden Series over Brock SP15 | Test Apparatus | ASTM F355A Triax 2010 Deltec Field Tester |
| Tested By | Edgar Llamas <i>Regional Technical Services Manager</i> | | |

Please Note- Test data herein is confidential information and the property of Brock International. Test data will be provided on a confidential basis to the facility owner of the tested facility. Tests conducted by Brock International are unofficial tests for informational purposes only, and may or may not be conducted in accordance with recognized test standards.

Evaluation Overview:

The purpose of testing the shock attenuation properties of a sports surface is to estimate the probability that an impact on the surface will cause an injury. In order to more accurately assess a surface, both safety and performance must be tested. For this reason, in addition to testing Gmax according to the ASTM 1936-10 specification, the Deltec Field Tester was used to measure the performance criteria of Force Reduction and Vertical Deformation. A complete explanation of the test methods and standards can be found in the Background section of this report.



F355- A missile Results

| ASTM F-355 - Gmax | | |
|-------------------|------|-----------------|
| Drop # | Gmax | Infill depth mm |

| TEST POSITION 1 | | |
|--------------------|-------------|-----------|
| Drop 1 | 87 | 15 |
| Drop 2 | 90 | 14 |
| Drop 3 | 97 | 15 |
| Average 2-3 | 93.5 | 15 |

| TEST POSITION 2 | | |
|--------------------|-------------|-----------|
| Drop 4 | 82 | 17 |
| Drop 5 | 92 | 16 |
| Drop 6 | 98 | 15 |
| Average 5-6 | 95.0 | 16 |

| TEST POSITION 3 | | |
|--------------------|-------------|-----------|
| Drop 7 | 82 | 15 |
| Drop 8 | 87 | 15 |
| Drop 9 | 99 | 15 |
| Average 8-9 | 93.0 | 15 |

| TEST POSITION 4 | | |
|----------------------|-------------|-----------|
| Drop 10 | 83 | 16 |
| Drop 11 | 88 | 15 |
| Drop 12 | 101 | 15 |
| Average 11-12 | 94.5 | 15 |

| TEST POSITION 5 | | |
|----------------------|-------------|-----------|
| Drop 13 | 80 | 14 |
| Drop 14 | 92 | 15 |
| Drop 15 | 99 | 15 |
| Average 14-15 | 95.5 | 15 |

| ASTM F-355 - Gmax | | |
|-------------------|------|-----------------|
| Drop # | Gmax | Infill depth mm |

| TEST POSITION 6 | | |
|----------------------|--------------|-----------|
| Drop 16 | 85 | 15 |
| Drop 17 | 96 | 14 |
| Drop 18 | 105 | 14 |
| Average 17-18 | 100.5 | 14 |

| TEST POSITION 7 | | |
|----------------------|--------------|-----------|
| Drop 19 | 85 | 15 |
| Drop 20 | 99 | 15 |
| Drop 21 | 102 | 15 |
| Average 20-21 | 100.5 | 15 |

| TEST POSITION 8 | | |
|----------------------|--------------|-----------|
| Drop 22 | 89 | 15 |
| Drop 23 | 99 | 16 |
| Drop 24 | 102 | 16 |
| Average 23-24 | 100.5 | 16 |

| TEST POSITION 9 | | |
|----------------------|--------------|-----------|
| Drop 25 | 82 | 15 |
| Drop 26 | 97 | 15 |
| Drop 27 | 105 | 15 |
| Average 26-27 | 101.0 | 15 |

| TEST POSITION 10 | | |
|----------------------|-------------|-----------|
| Drop 28 | 82 | 15 |
| Drop 29 | 93 | 14 |
| Drop 30 | 104 | 14 |
| Average 29-30 | 98.5 | 14 |

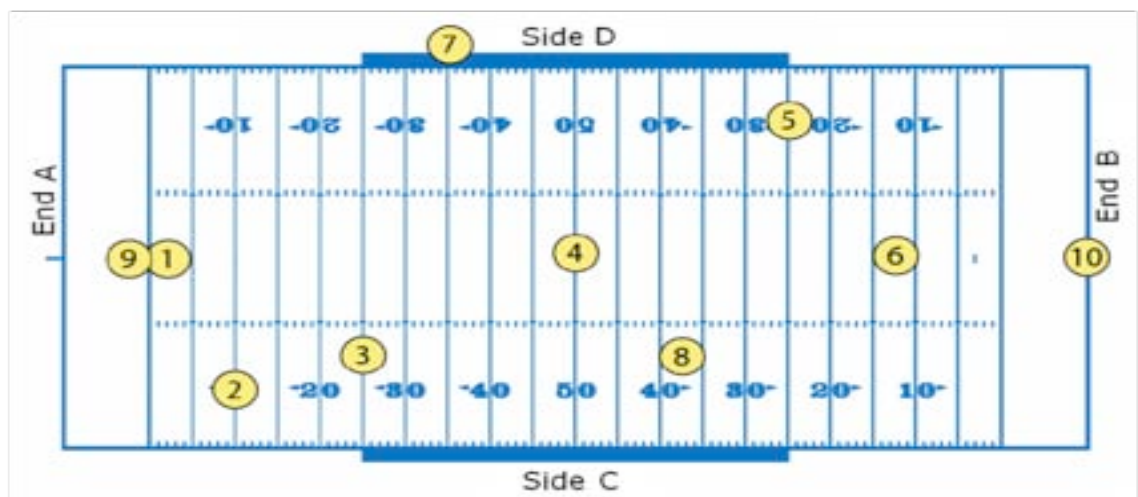
Gmax defined:

The maximum deceleration on impact is called "Gmax" as a multiple of g, the natural constant of gravity. Impact force on the body is proportional to deceleration, so the Gmax test indicates maximum force to the body during impact on the surface.



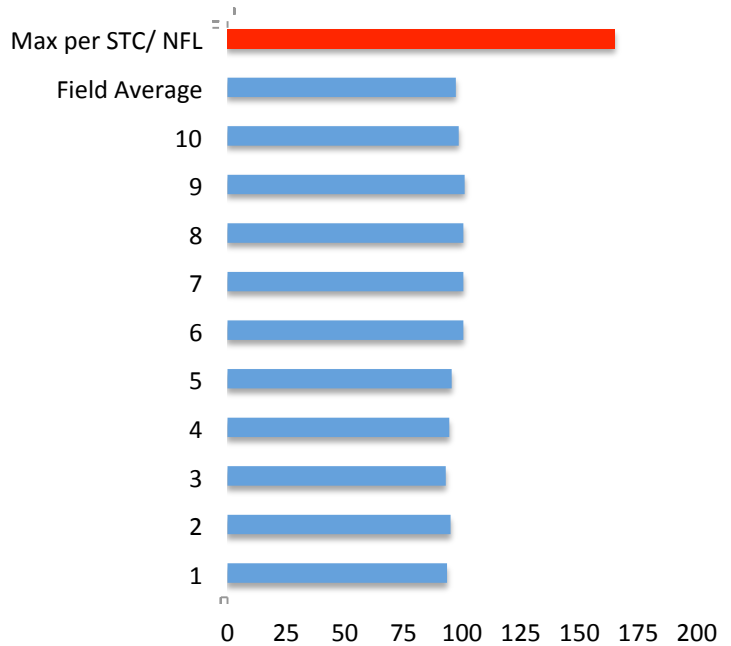
Testing Locations & Results

| Location # | Location Description | Average Gmax | Average Infill Depth (mm) | Surface temp. (°F) |
|-------------------------|------------------------------------------------------------------------------|--------------|---------------------------|--------------------|
| 1 | Goal Line, End A, field centerline | 93.5 | 15 | 157.4 |
| 2 | 10 Yard Line, End A, 63 ft from field centerline to the Side C | 95 | 16 | 150 |
| 3 | 25 Yard Line End A, 40 ft from field centerline to Side C | 93 | 15 | 168 |
| 4 | Field centerline | 94.5 | 15 | 162.2 |
| 5 | 25 Yard Line, East end, 63 ft from field centerline to Side D | 95.5 | 15 | 155 |
| 6 | 12 Yard Line, End B, field centerline | 100.5 | 14 | 161.5 |
| 7 | North Team area, Side D | 100.5 | 15 | 160 |
| 8 | 37 Yard Line, End B, 40 ft from the field centerline to Side C | 100.5 | 16 | 159 |
| 9 | 6 ft from Goal Line to the back of the End Zone, End A, field centerline | 101 | 15 | 150 |
| 10 | 6 ft from the back of the End Zone to the Goal Line, End B, field centerline | 98.5 | 14 | 157.3 |
| Overall Averages | | 97 | 15 | 158.0 |



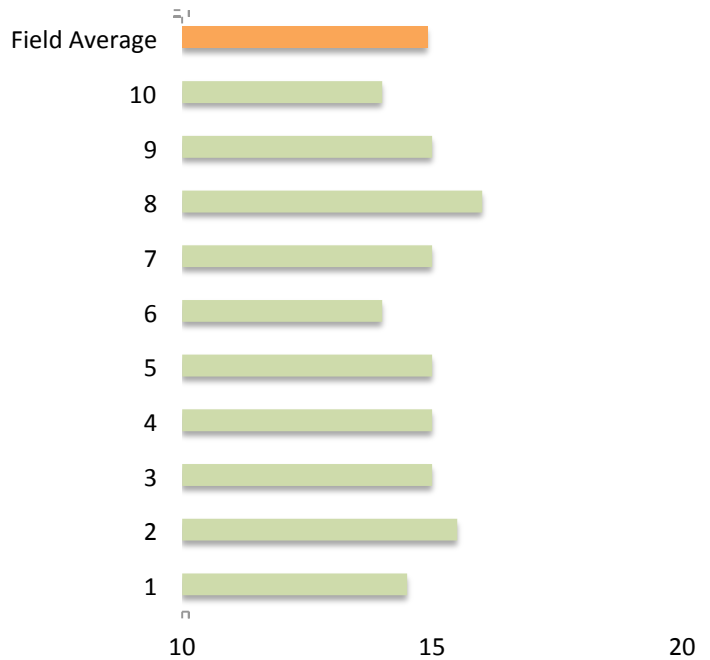
ASTM F355-A Gmax Data

| Location | Average Gmax |
|-----------------|--------------|
| 1 | 93.5 |
| 2 | 95 |
| 3 | 93 |
| 4 | 94.5 |
| 5 | 95.5 |
| 6 | 100.5 |
| 7 | 100.5 |
| 8 | 100.5 |
| 9 | 101 |
| 10 | 98.5 |
| Field Average | 97 |
| Max per STC/NFL | 165 |



Infill Depth Data

| Location | Infill in (mm) |
|---------------|----------------|
| 1 | 15 |
| 2 | 16 |
| 3 | 15 |
| 4 | 15 |
| 5 | 15 |
| 6 | 14 |
| 7 | 15 |
| 8 | 16 |
| 9 | 15 |
| 10 | 14 |
| Field Average | 15 |



Deltec Field Results:

| DELTEC FIELD TESTER | | | |
|---------------------|-----------------|--------------------|---------------------------|
| Test | Force Reduction | Energy Restitution | Vertical Deformation (mm) |

| DELTEC FIELD TESTER | | | |
|---------------------|-----------------|--------------------|---------------------------|
| Test | Force Reduction | Energy Restitution | Vertical Deformation (mm) |

| TEST POSITION 1 | | | |
|--------------------|------------|--|------------|
| Drop 1 | 74% | | 8.6 |
| Drop 2 | 73% | | 8.1 |
| Drop 3 | 70% | | 7.7 |
| Average 2-3 | 72% | | 7.9 |

| TEST POSITION 6 | | | |
|--------------------|------------|--|------------|
| Drop 1 | 74% | | 7.5 |
| Drop 2 | 70% | | 7.3 |
| Drop 3 | 69% | | 6.8 |
| Average 2-3 | 69% | | 7.1 |

| TEST POSITION 2 | | | |
|--------------------|------------|--|------------|
| Drop 1 | 74% | | 8.3 |
| Drop 2 | 70% | | 7.3 |
| Drop 3 | 69% | | 7.3 |
| Average 2-3 | 70% | | 7.3 |

| TEST POSITION 7 | | | |
|--------------------|------------|--|------------|
| Drop 1 | 74% | | 7.7 |
| Drop 2 | 71% | | 6.6 |
| Drop 3 | 70% | | 6.9 |
| Average 2-3 | 70% | | 6.8 |

| TEST POSITION 3 | | | |
|--------------------|------------|--|------------|
| Drop 1 | 75% | | 8.8 |
| Drop 2 | 71% | | 7.8 |
| Drop 3 | 70% | | 7.5 |
| Average 2-3 | 70% | | 7.7 |

| TEST POSITION 8 | | | |
|--------------------|------------|--|------------|
| Drop 1 | 72% | | 8.3 |
| Drop 2 | 69% | | 7.9 |
| Drop 3 | 67% | | 7.8 |
| Average 2-3 | 68% | | 7.9 |

| TEST POSITION 4 | | | |
|--------------------|------------|--|------------|
| Drop 1 | 72% | | 8.6 |
| Drop 2 | 71% | | 8.2 |
| Drop 3 | 68% | | 7.8 |
| Average 2-3 | 69% | | 8.0 |

| TEST POSITION 9 | | | |
|--------------------|------------|--|------------|
| Drop 1 | 74% | | 8.8 |
| Drop 2 | 70% | | 7.6 |
| Drop 3 | 69% | | 7.3 |
| Average 2-3 | 70% | | 7.5 |

| TEST POSITION 5 | | | |
|--------------------|------------|--|------------|
| Drop 1 | 70% | | 8.4 |
| Drop 2 | 69% | | 7.9 |
| Drop 3 | 66% | | 7.6 |
| Average 2-3 | 68% | | 7.8 |

| TEST POSITION 10 | | | |
|--------------------|------------|--|------------|
| Drop 1 | 73% | | 8.8 |
| Drop 2 | 70% | | 8.2 |
| Drop 3 | 69% | | 7.6 |
| Average 2-3 | 69% | | 7.9 |

The Deltec Field Tester (International Standard EN 14808 / 14809) is a flat faced missile impact test to measure surface performance properties under the simulated load of a running adult. A spring connected to the impact missile simulates ankle and knee flexion.



Test Conditions Summary:

The field surface consists of an AstroTurf 1.25" Golden Series synthetic turf infilled with sand and Zeofill installed over Brock SP15. The ASTM F355-A test method was performed in accordance with the ASTM 1936-10 specification. The test was performed in dry conditions at an approx ambient temperature of 95 degrees F. At each test location infill depth was measured and recorded.

Field Test Results

Under the above-mentioned ASTM Specification the F355-A test results indicate that the Jesuit High School Field Gmax range is from 93 G's to 100.5 G's. The average G-max of the points tested on the field was 97 G's.

Reference Standards:

Currently, the ASTM F1936-10 specification requires that the average Gmax of the second and third drops at a single test point shall not exceed 200 average Gmax **. If a turf system is tested in accordance with the Test Method ASTM F355-A, Procedure C, as specified, and the average Gmax of 1 or more of the tested points reported is in excess of 200 average Gmax, the surface system should be brought into compliance, or replaced in full or in part.

The Synthetic Turf Council and NFL specifications require that the average Gmax of the second and third drops at a single test point shall not exceed 165 average Gmax.

*** The ASTM 1936-10 Specification is currently under ballot to revise the maximum allowable Gmax to 165.*

| Quick Reference Results Summary | | | | |
|---------------------------------|------|-------|---------------|------------------------------|
| Test | Min. | Max. | Field Average | Requirements |
| ASTM F355-A (Gmax) | 93 | 100.5 | 97 | STC / NFL - 165, ASTM 200 ** |
| Vertical Deformation | 6.8 | 8.0 | 7.6 | FIFA / WORLD RUGBY 4-11mm |
| Force Reduction | 68% | 72% | 70% | FIFA / WORLD RUGBY 55-70% |

Results based on testing by the University of Tennessee Center for Athletic Safety

| Comparative Reference Results - Natural Sports Turf | | | | |
|-----------------------------------------------------|------|------|----------------------|---------------|
| Test | Min. | Max. | Natural Turf Average | Field Average |
| ASTM F355-A (Gmax) | 70 | 100 | 84 | 97 |
| Vertical Deformation | 7.0 | 11.0 | 9.1 | 7.6 |
| Force Reduction | 65% | 80% | 73% | 70% |



Background

The **ASTM F355-A** (Gmax) test drops a 20lb - 20 in.² flat faced missile from a 24" fall height producing an impact force of 40ft/lb. The method involves dropping the "missile" three times at each location under a controlled consistent height. The first drop conditions the surface. Only the second and third drops are averaged together for the location average. The result is expressed as peak G's or "Gmax". The ASTM F355 A missile is currently the standard test apparatus for the ASTM F1936-10 specification (field testing). A lower Gmax value indicates surface with greater impact attenuation characteristics.

The maximum deceleration is called Gmax as a multiple of g, the natural constant of gravity. Gmax during the impact is an indicator of the surface's resilience. However, this parameter was not derived based on biomechanical considerations but a convention to compare resilience pragmatically.

The development of this 2 ft fall height method can be traced back to the Ford and GM crash dummy tests of the 1960's, medical research papers from the 1960's and 1970's, and a Northwestern University study in which an accelerometer was fixed to the helmet of a middle line backer to measure the impact received during actual play. This study found the impact threshold to be 40 ft/lb that translates to the 20 lb. at a height of 2 ft used in Procedure A of Test Method F 355.

The relevance that the ASTM F355-A Gmax test may have relative to head injury is that a concussion may be caused either by a direct blow to the head, face or neck or a blow elsewhere on the body with an "impulsive" force transmitted to the head. So a harder surface can cause a concussion even if the blow is not directly to the head.

ASTM F1936-10 Specification currently requires that the average Gmax of the second and third drops at a single test point shall not exceed 200 average Gmax **. If a turf system is tested in accordance with the Test Method ASTM F355-A, Procedure C, as specified, and the average Gmax of 1 or more of the tested points reported is in excess of 200 average Gmax, the surface system should be brought into compliance, or replaced. Section 6.3 of the ASTM F1936-10 Specification states: Nothing in this specification is intended to keep an owner, architect, engineer or other specifier from establishing more stringent performance requirements for a turf playing system.



ASTM F355-A

Background

Deltec Field Tester (EN 14808 / 14809) is a flat faced missile impact test to measure surface properties under the simulated load of a running adult . The anticipated body movement is the one of short distance running. A spring connected to the impact missile simulates ankle and knee flexion.

Results Include:

- Vertical Deformation (surface compression)
- Force Reduction (% shock absorption as compared to concrete)

The Deltec test method involves dropping the “missile” three times at each location under a controlled consistent height. The first drop conditions the surface. Only the second and third drops are averaged together for the location average. Our tests were performed at 10 locations on the field according to the ASTM 1936-10 Standard Specification for Impact Attenuation of Turf Playing Systems as Measured in the Field.

Vertical deformation is one of the surface properties that is measured by the Deltec™ Field Tester. Vertical deformation measures the vertical compression of the surface. The result is expressed in millimeters. This result indicates the stiffness and stability of the surface under the impact force of a running athlete.

Force reduction is another surface property that is measured by the Deltec™ Field Tester. Force reduction measures the percentage of shock absorption that the surface provides as compared to concrete (0%).

The Deltec results are related to official test equipment mentioned in the FIFA Quality Concept and have an indicative character.

FIFA and the IRB (International Rugby Board) are sports governing bodies that have directly examined natural sports turf characteristics to establish player-surface interaction parameters for synthetic turf fields. These parameters originally derive from UEFA testing (European Soccer Federation) of natural turf stadiums in the late 90’s in multiple countries and climatic conditions. More recent testing in 2013 by the University of Tennessee’s Center for Athletic Safety produced results that were similar to the UEFA research for force reduction and vertical deformation

| Reference | Vertical Deformation | Force Reduction |
|----------------------------------------------------------------------------------------|----------------------|-----------------|
| FIFA 1-Star | 4-11mm | 55-70% |
| International Rugby Board | 4-11mm | 55-70% |
| University of Tennessee Center for Athletic Safety - Results of Natural Sports Turf | 7-11mm | 65-80% |

