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Synthetic Turf Impact Testing: Part 2 - The Present Current Impact Attenuation Standards and Their Use

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This is the second of a 3-part series on Synthetic turf testing from ASET Services, Inc, and it focuses on the present. This article will focus on some potential avenues for testing and specifying synthetic turf systems, again with a focus on North America. It will focus on some of the common performance limits included in project specifications and in the sales and marketing of today's systems. Once again, this series was started when ASET was asked, "How do the new turf tests apply to a local high school in rural Iowa?" Having taken the time to review the past, we must now consider the present status of impact attenuation testing in synthetic turf fields. Rather than explore these standards in depth, this portion of the paper may have more of the feel of a futurist's view. This paper reflects ASET's opinions and as such there will be those who view the state of today's market differently with regard to what is common in the market and would suggest that different levels should have been discussed in this paper.

As a reminder, this paper is a continuation of the information presented in a previous paper exploring the history of impact testing of synthetic turf in North America. The paper is available on ASET Services' website library and can be found here. This paper won't include an extensive review of the topics presented on the development of head impact standards at ASTM.

As a reminder, this article series focuses on Impact testing only. There are obviously tests and properties beyond those explored in this paper used to describe and specify synthetic turf systems.

Since ASTM F1936 was introduced to measure the maximum deceleration during an impact, the market has started to take a more holistic approach to impacts. F1936 was originally focused on helmet/turf impacts, the more holistic view guiding impact attenation now has tests more focused on head/turf impacts (no helmets) and lower extremity impacts. Whle tests are currently used, the HIC and Lower Extremity tests are not included in the majority of North American synthetic turf specifications. Here are some of the impact tests and properties that are found in specifications today, but some are not widely used.

G-max - ASTM F1936[1] – Facial Plane Impacts

First, the application of F1936 is very close to, if not, being considered as a 'standard of care in North America. Meaning that owners may be liable to a 3rd party for negligence, if their surface does not comply with the limits presented in F1936. That standard of care extends for the life of the field, not simply when it is new. Many owners in North America ignore this long term safety requirement associated with synthetic turf fields.

F1936, or Gmax testing, is far and away the most common test used to evaluate and specify synthetic turf fields in North America today.

In 1998, ASTM F1936 established the maximum allowable g-max level of 200. Since that time, it has remained unchanged. Meaning F1936 has not advanced with regard to *g-max* since 1998. There have been attempts to lower the *g-max* level allowed in F1936, but nothing has reached consensus levels within ASTM, and it is my opinion that nothing will reach consensus levels at ASTM. Several reasons have been brought forward. The following list is my interpretation of the major reasons that have been brought forward within the last 10 years at ASTM.

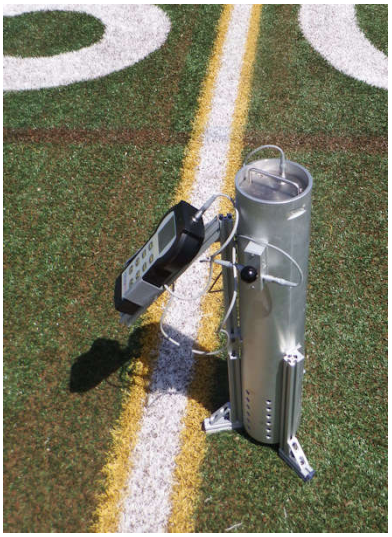

Illustration 1: G-max test equipment on an infilled system with coconut fiber.

- Lowering the maximum level to account for known uncertainties in the measurements. This would effectively guarantee that even with the known errors in measurements the actual g-max did not exceed the 200 level known to be associated with skull fractures and even more serious injuries. ASET believes this argument has merit and should be reconsidered.
- Lowering the maximum level to account for the differences between a flat faced mass and a circular (hemispherical) mass that better represents the shape of a human head. While researchers have presented theoretical relationships, ASET does not believe that there would be a strong relationship that applied to the wide range of system designs currently in the market.
- Lowering the maximum level to account for new research that links lower level impacts to accumulated damage in the brain and brain function. This could also include lowering the maximum level to those now known to be associated with some concussions. Granted, concussion prevention is complex and no single test can assess a surface's ability to prevent them in all impacts.

In the end, all of these attempts to lower *g-max* have met the same fate. They've failed to reach the consensus levels within ASTM required to change F1936. Meaning that a field, or system, that barely passed F1936 in 1998 would still barely pass F1936 today.

g-max changes outside of ASTM

Even though the members of ASTM have been unable to reach a consensus, the members of the Synthetic Turf Council (a leading trade group for synthetic turf) did reach some sort of consensus. The STC has published lower, but non-binding, guidelines[2] with regard to the maximum allowable g-max level throughout the life of the field. In 2011 the STC published recommendations that the g-max level on a synthetic turf field should not exceed 165 during the life of the field. Even the STC's performance requirements have remained unchanged since 2011.

What are manufacturers doing?

The range of performance levels included in product specifications and warranties varies greatly by manufacturer. Some of the manufacturers have systems that provide g-max levels well below the limits established in F1936, and yet others are below the limits within the STC's recommendations. Meanwhile others maintain that the level outlined in F1936 is entirely sufficient, and allow g-max levels up to 200. Some manufacturers have systems in all three categories. The table below contains just a few of the g-max levels that were found in product specifications during an Internet search. No references are given for these values to maintain the anonymity of the manufacturer, and system.

Limits @ Time of Install	Warranty Period Limits
< 110	<145
< 130	<190
<200	<200

So, what does that mean with regard to the current state of g-max testing and specifications and a small school in Indiana or yoru state?

- First, it means that the industry can develop, deliver and guarantee g-max levels far below the maximum levels allowed under F1936. It is up to owners and architects to specify them though.
- It means that the maximum level of 200 has not changed within F1936 in over 20 years.
- It means that the maximum level of 200 is still treated as the absolute 'standard of care' and it is exceeding this level that causes fields to be shut down, or replaced. It is this level that determines if a field is 'unsafe' even though it was theoretically linked to preventing fatalities, not preventing injuries.
- It means that significant portions of the industry see advantages to lowering g-max, as evident by the recommendations made by the STC.
- It means that manufacturers are capable of designing fields that conform to the STC's guidelines that offer significantly better impact attenuation than required by F1936.
- It does not mean that every system sold and promoted by a manufacturer conforms to the STC's recommendations, some may fall back to the levels required in F1936, as evident in the previous warranty examples.
- It means that enough manufacturers and installers are committed to selling systems that do not comply the STC's recommendations that there is no consensus for lowering traditional G-max levels required in ASTM F1936.
- It means that nothing has changed with regard to the maximum allowed g-max within ASTM F1936 since it was introduced in 1998. Fields that barely passed in 1998 still barely pass in 2021.
- It means that owners are architects can specify fields that are considerably safer than required by ASTM F1936, or even the STC's guidelines, but they must make that decision on their own, without guidance from another independent body.

HIC -Cranial Crown Impact Testing F3146

The flat faced missile was originally proposed by Daniel[3] as a way to ensure that structures within an automobile that were likely to impact the face of the occupant did not cause severe or fatal injuries. It was chosen as the original standard specification (F1936) for synthetic turf impact attenuation within ASTM because it produced the most 'reliable' and repeatable results. It is also likely it was chosen over the more anthropomorphic shape that more closely resembles the human head because it did not 'bottom out' on the concrete during testing and it enabled at least some of the fields at that time to pass. The selection of a missile that focuses on the facial plane was viewed as adequate at the time since helmeted players were essentially the sole focus of the standard. However, some now view F1936 as being inadequate to represent forces generated by athletes without helmet such as soccer players.

Illustration 2: HIC Testing of a Natural Turf Field During

As stated previously, the industry is starting to take a more holistic view of the impact properties of synthetic turf fields. The industry has recognized that there are more athletes than ever participating on synthetic turf in sports that do not use or require a helmet. With this view, the hemispherical missile that was developed to simulate head impacts on playground surfacing (ASTM F1292[4]) is beginning to be introduced within product and field specifications.

While the HIC property is a new property with regard to synthetic turf, however it has a history that links it with the method in F1936. The HIC property is far from new, and has it's roots in the same historical data and tests presented in Part 1 of this series and has been used to evaluate playground safety surfacing for nearly 2 decades.

This is the 'E' missile described in ASTM F355[5], and the impact missile used within ASTMF 1292 developed for playground safety surfacing. The geometry and weight is based on the physical traits of 12 year old children. There is not standard specification for synthetic turf regarding this missile. Therefore its application in the industry varies. ASTM F3146[6] is a standard test method developed for rugby surfacing which utilized this impact missile, but it does not establish performance limits.

Owners and architects that view HIC as an important property of a today's synthetic turf systems often include it in their specifications, but it has not reached the level of a 'standard of care.' The primary reason is that there is no unified view of how this property should be measured, presented or what the limits should be.

For those looking for this property to become an ASTM standard specification, I am not optimistic of it becoming part of a standard specification in the next 15 years unless user groups or lawsuits bring pressure on the industry to adopt it. The reason is that there are a number of synthetic turf fields that have been installed, and that are marketed that will not achieve even modest levels of protection under this standard. There is also no agreement on what the minimum reasonable requirement for this property is.

Lower Extremity Ground Reaction Forces – via FIFA rules.

ASTM F1936, driven by safety associated with American Football, focuses solely on head impact attenuation. Meanwhile, FIFA rules were driven by soccer and focused solely on tests to simulate ground reaction forces generated by lower extremities. Within North America there is a slight trend to apply a more holistic view to impact attenuation and include more than just head-surface impacts.

While far from reaching mainstream within North American specifications, architects and owners are starting to require some of the impact attenuation levels outlined under FIFA rules. All of the impact related properties measured in the FIFA rules are obtained using an AAA, or Advanced Artificial Athlete developed in an attempt to simulate the loading properties of athlete's lower extremities.

FIFA rule 04a[7] is used to determine the shock absorption of the surface. This value compares the impact forces on the field to those generated on concrete, or similar 'rigid' surfaces. It presents the shock absorption as a percent that the impact force is reduced. It is one part of the FIFA impact attenuation standard.

FIFA rule 05a[7] is used to determine the vertical deformation of the sports surface under the athlete. It measures the maximum deformation of the surface under the impact generated by the AAA in rule 04a testing. It does not involve another test.

The primary goal of FIFA Rules 04a and 05a is to attempt to make synthetic turf feel and play more like natural turf. While the property is often presented as a safety feature there is no study clearly shows a relationship between injuries and shock abortion or vertical deformation levels. These properties are likely more closely related to athlete comfort than injury prevention.

Application In Today's Specifications:

Bid and Submital Requirements:

ASTM F1936 will be included in every synthetic turf field specification today. It's maximum allowed level of 200 g's is generally accepted as the minimum standard of care in the industry. No turf fields are sold that do not adhere to this limit.

Owners and architects also often include ASTM F1936, with lower limits such as 165 from the STC guidelines or perhaps even lower limits are also common in current specifications. This provides a greater factor of safety that the field will not exceed the 200 g limit from F1936 both when the field is new and as it ages.

HIC testing per ASTM F3146 is present in a relatively small but growing number of specifications. The main issue with HIC testing within specifications is that the industry has no guidance on what the minimum acceptable level of protection is, or how it should be measured and presented. The industry will need to unify behind this property for it to gain truly widespread acceptance.

Ground Reaction Force Testing per FIFA rules is present in an even smaller percentage of specification in North America. From discussions within the industry this property is currently being used as much to weed out contractors and systems as it is to protect the athlete. A growing number of fields, even though still a small percentage of the market, are specifying FIFA certified designs. Due to the cost of becoming a member of FIFA and the cost of certifying a project to all of the FIFA rules, this effectively reduces the number of systems that can be submitted and the number of contractors that can install them.

Verified Performance Requirements:

It is ASET Services' opinion that if a property is important enough to specify then it's important enough to verify. The frequency and use of the previous tests to verify the actual performance of a synthetic turf field varies widely in North America.

The traditional g-max property is verified on virtually every synthetic turf field in North America after it is installed. Most specifications are clear that the g-max performance required must be delivered to the jobsite and maintained through the life of the field.

When HIC testing is specified, it appears to be commonly verified after the field is installed. Utilizing this property during maintenance testing is less uniformly applied than F1936 testing. This is likely due to the fact that it has not yet been established as a 'Standard of Care' through injury lawsuits.

The majority of fields that utilize the FIFA approval within North America do so only in the bid & submittal phase and verification testing is often not required. Specifications are generally more concerned that the field has met one of FIFA's required performance levels in the lab

than in the field. The verification of FIFA methods 04a and 05a is generally limited to fields seeking to be FIFA certified fields where a number of other field tests are also required. Only fields that are going to support official FIFA sanctioned events are required to obtain on-site FIFA certification.

Due to the relative limited use within specifications, ASET does not see the FIFA shock absorption methods or requirements as significant within the current North American market, we do feel that it will play a role in the future of synthetic turf testing and specifications within North America. For this reason we will discuss it further in Part 3 of this series.

References:

[1] *ASTM Standard F1936, 2015, Standard Specification for Impact Attenuation of Turf Playing Systems as Measured in the Field, ASTM International, West Conshohocken, PA, 2015.*

[2] *Synthetic Turf Council, Guidelines for Synthetic Turf Performance, https://cdn.ymaws.com/staging-stc.site-ym.com/resource/resmgr/guidelines/STC_Guidelines_for_Synthetic.pdf 2011*

[3] *Daniel R. P. "A Bio Engineering Approach to Crash Padding" Paper No: 68001 Automotive Engineering Congress, Detroit Mi Jan 8-12 1968*

[4] *ASTM Standard F1292, 2018, Standard Specification for Impact Attenuation of Surfacing Materials Within the Use Zone of Playground Equipment, ASTM International, West Conshohocken, PA, 2015.*

[5] *ASTM Standard F355, 2010, Standard Test Method for Shock-Absorbing Properties of Playing Surface Systems and Materials, ASTM International, West Conshohocken, PA, 2010.*

[6] *ASTM Standard F3146, 2018, Standard Test Method for Impact Attenuation of Turf Playing Surfaces Designed for Rugby, ASTM International, West Conshohocken, PA, 2010.*

[7] *FIFA. FIFA Quality Programme for Football Turf, Handbook of Test Methods, 2015*

For more information regarding sport surface testing and inspections, please feel free to contact us. ASET offers commission testing of new surfaces, follow-up testing to guide maintenance and end-of life inspections to determine the condition of existing fields and sports surfaces.

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