





# Report on the performance and safety effects of the Brock base system under a 3G artificial turf over ten years of simulated ageing

For

**Brock International LLC**

REPORT STATUS:	<b>Final</b>	Signature	Date
Report No:	2490/2075		
Prepared By	<b>Eric O'Donnell</b>		17/12/08
Checked By	<b>Richard Nixon</b>		17/12/08

**FOREWORD**

1. This report has been prepared by Sports Labs Limited with all reasonable skill, care and diligence within the terms of the contract with the Client and within the limitations of the resources devoted to it.
2. This report is confidential to the Client and Sports Labs Limited accepts no responsibility whatsoever to third parties to whom this report, or any part thereof, is made known. Any such party relies upon the report at their own risk.
3. This report shall not be used for engineering or contractual purposes unless signed by the Author and the Checker and unless the report status is "Final".



INFORMATION, ADVICE & KNOW-HOW: FROM THE SYNTHETIC SPORTS SURFACE EXPERTS

**SPORTS LABS LTD**

Unit 12b • Nasmyth Court • Houston Ind. Est • Livingston. • EH54 5EG  
 Telephone: +44(0)845 602 6354 • Fax: +44(0)845 602 6356



Tel: 0845 6026354

info@sportslabs.co.uk

### - Executive Summary -

Brock International LLC commissioned a study into the comparison of performance and safety of an artificial turf system when tested with and without the incorporation of the Brock base system. The study involved artificially wearing/ageing the sample using a Lisport device to impart approximately 1, 2, 4, 6, 8 and 10 years typical use on the artificial turf, then using well documented testing protocols to examine the worn/aged sample over the Brock base and over a simulated stone base without the presence of the Brock base.

The results show conclusively that the Brock base system guarantees consistent long-term performance and safety of the artificial pitch including compliance with properties influenced by the Brock base of the artificial turf system with Global Governing Body requirements for Football (Soccer) and Rugby. This against the comparison of the performance of the artificial turf system tested without any kind of shock pad highlighted that systems over simulated stone compacted/hardened and do not accord with the compliance requirements set by Global Governing Bodies of Sport early in the life of the system and certainly prior to the expiration of any warranty period offered.



Tel: 0845 6026354

info@sportslabs.co.uk

## 1.0 Introduction

Sports Labs is a Professional Services Company who are independent of all contractors, suppliers and manufacturers and prides itself in providing excellence in the design, procurement, tendering process and project management of new or refurbished artificial turf sports fields. The Company also operates an internationally accredited sports surfaces testing laboratory in the UK to test artificial turf, natural turf, athletic tracks, sports flooring and products to ASTM, EN and Governing Body requirements for compliance, defect identification and certification.

## 2.0 Background

2.1 A study into the properties of the Brock Performance Base F24 (known as the Powerbase in the U.S.) was carried out at the request of Brock International, the purpose of which was to characterise the influence of a specific base system within an artificial turf field structure. A comparison of the results from this study was carried out between the same artificial turf system where no Brock base was used, tested over a simulated stone base, in this case concrete. The data is given in Technical Report No. 2490/2075 authored by Sports Labs detailing "Laboratory report on simulated wear testing using Brock Performance Base F24" dated 05/12/08.

2.2 A sample of artificial grass was selected which would in the opinion of Brock International best represent an average artificial turf system commonly used in the market place at present. The sample was a typical 63mm 3G monofilament artificial turf.

2.3 In the study it was important to simulate site conditions within the testing environment; care was taken to maintain the integrity of the sample during wear/ageing. The sample was redressed after each 1000 cycles of wear and the sample was wetted periodically to simulate precipitation.

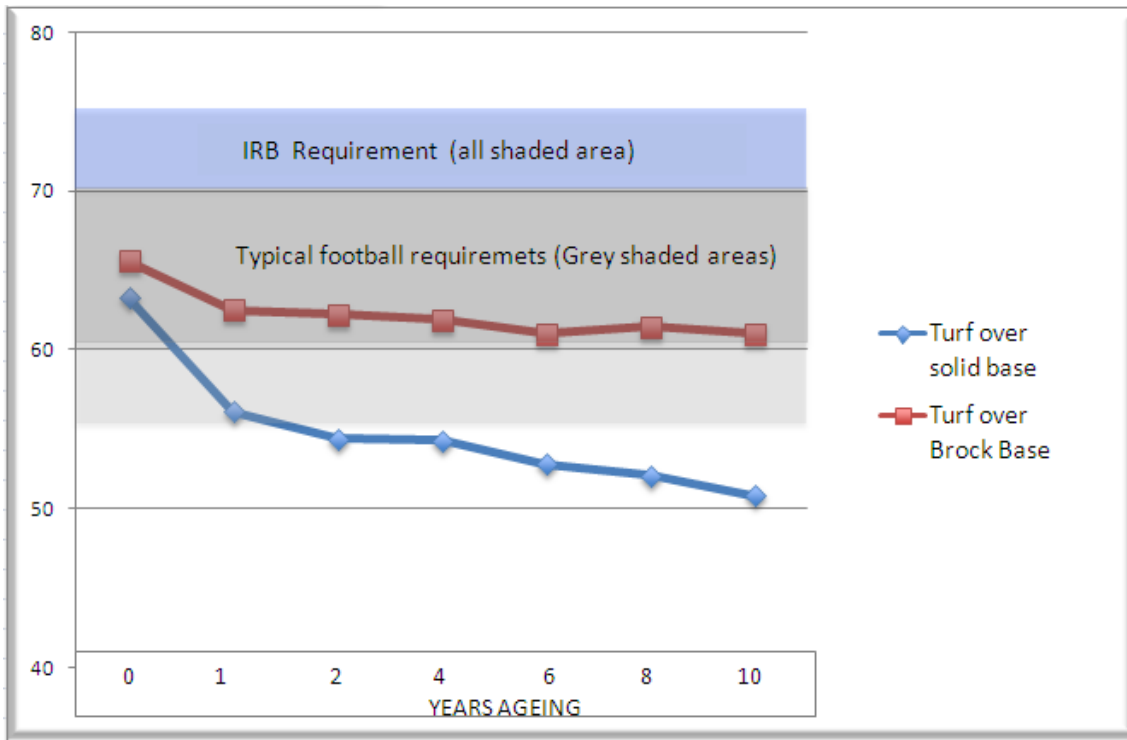
2.4 A Lisport, (see [www.sportslabs.co.uk](http://www.sportslabs.co.uk) for a video of the device), was the apparatus used to age the samples. This device is employed to simulate footfall in terms of years of use. The Lisport device has two studded weighted rollers which traverse the surface of the turf sample in a cyclical manner applying pressure due their weight. The device also applies a shearing force due to the differential speed of the rollers and lateral strain due to the sideways movement of the tray holding the sample during testing. The wear imparted can anecdotally be related to athletic foot traffic in terms of years of use where 1 Lisport cycle equates to 1 hour of use. Wear is built up by applying cycles which over time equates to years of use in the field. For the purposes of this study, an average of 40 hrs use per week x 50 weeks per year for a total of 2,000 hrs per year, was used as a benchmark to equate cycles to years of use.

2.5 The study produced a series of results that highlight how a Brock base influences the physical properties of the artificial turf field when first installed, and year on year thereafter. It is known that artificial surfaces age and that this ageing influences the playing and performance characteristics of the field. Generally, the artificial surface deteriorates with age in terms of shock absorption and ball surface interaction. Maintenance can and does slow the deterioration but cannot prevent it occurring. The study highlights the benefit that the Brock base imparts in terms of safety, compliance and long-term performance.

### 3.0 Shock Absorption (Force Reduction)

3.1 An important property of an artificial turf field is the shock absorption of the surface. This property is measured using a test which compares the artificial turf field with a relatively hard surface such as concrete. The results are expressed as a ratio of hardness between the two surfaces where concrete acts as the bench mark and artificial turf fields would be expressed as a ratio of this value. Artificial turf fields are relatively soft in comparison being designed to simulate natural turf performance.

Fig. 1 - Force Reduction Results (%) – EN 14808



3.2.1 The speed of deterioration in shock absorption against simulated ageing/wear has been characterised;

3.2.1 The difference in the degree of deterioration in shock absorption when an artificial turf field ages or is worn including a Brock base or excluding a Brock base is compared;

3.2.2 The relative amount of compaction occurring in a system when measured with or without a Brock base.



Tel: 0845 6026354

info@sportslabs.co.uk

3.3 The force reduction results (Fig. 1) illustrate the relative shock absorption obtained from the two systems; the initial tests show the sample tested with a Brock base to have slightly higher initial shock absorption than the sample without. A marked and rapid deterioration in shock absorption can be observed in the sample without a Brock base against the stable shock absorption noted in the sample with a Brock base. The reduction in shock absorption from initial to final tests when measured in this manner is 7% with the Brock base. The reduction in shock absorption when measured in this manner is 19% without Brock base.

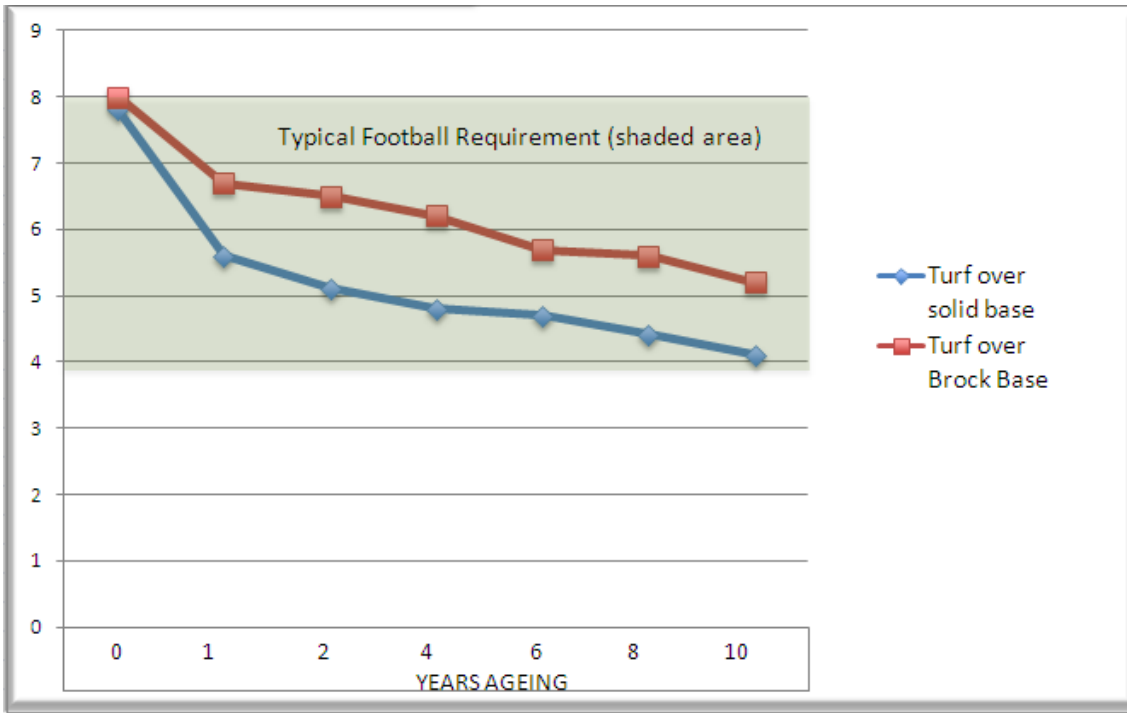
3.4 A significant issue for National Governing Bodies (NGB's), Architects and Proprietors would be the initial and ongoing compliance with prescribed performance and safety limits. Tests show conclusively that where the sample with the Brock base maintains compliance with the NGB's requirements over the life cycle of the artificial turf field (10 years in this case), samples without the Brock base do not comply and in fact fall out with the NGB's requirements within the first 1/3 of the expected life cycle of the artificial turf field (roughly 3 years in a 10 year cycle). Significantly major compaction of the sample without the Brock base occurs in this period with a 37% loss in vertical deformation (19% with the Brock base) and a 15% loss in shock absorption (6% with the Brock base) occurring.

#### **4.0 Vertical Deformation**

4.1 This test is used to measure vertical movement in the artificial turf field as an athlete traverses it during play. The same device as used for Force Reduction, but with a modified spring to collect the vertical movement data. Vertical movement is important as it can influence fatigue in an athlete and also the preponderance of soft tissue injuries to the lower limbs. Surfaces which have high vertical deformation can be perceived as unstable by athletes.

4.2 The results from this test are mentioned in Clause 3.4 however it is worth noting that the fill material compaction has a major influence over the performance of the artificial turf field. Tests show conclusively that where the sample with Brock base maintains compliance with the NGB's specification over the life cycle of the artificial turf field (approximately 10 years), samples without Brock base also stay within NGB's requirements albeit reaches the lower limits in the last 1/3 of the expected life cycle of the artificial turf field (approximately 7 years).

**Fig. 2 - Vertical Deformation Results (mm) – EN 14809**

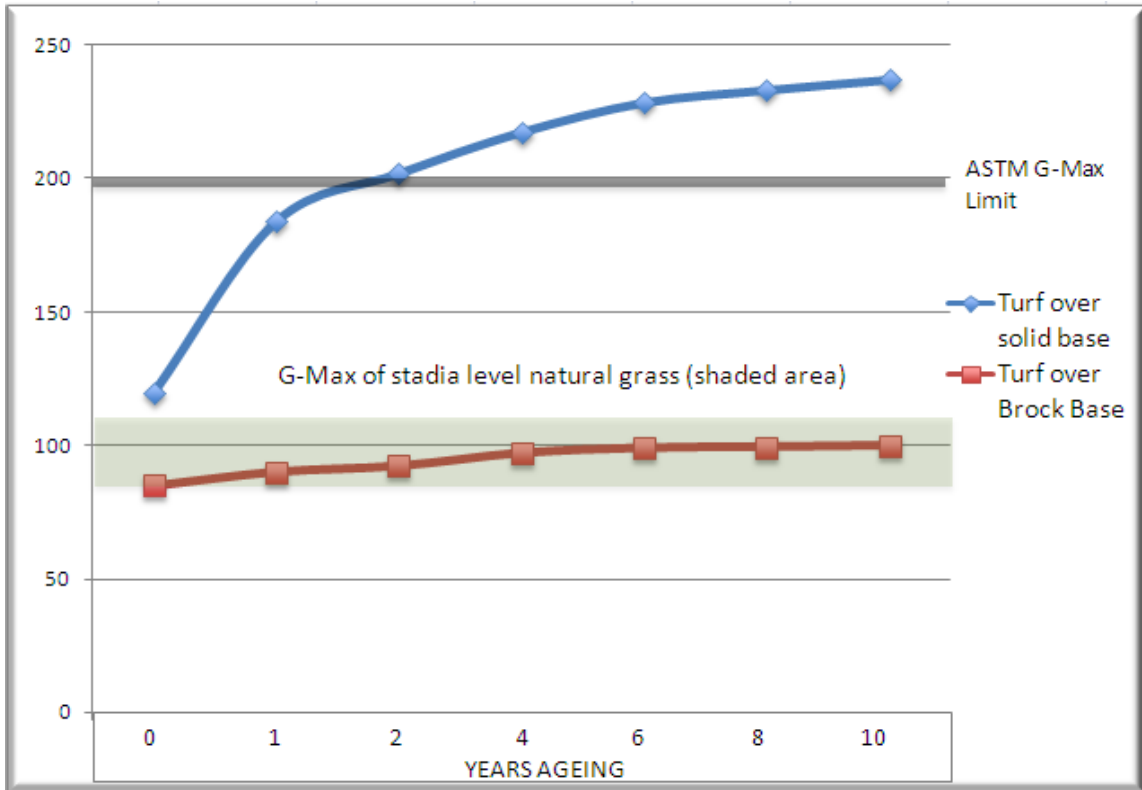


**5.0 Gmax**

5.1 The purpose of testing impact attenuation properties of a sports surface is to estimate the probability that an impact on the surface will cause an injury. The two test methods and references used to describe the degree of safety of a surface are Head Impact Criterion and Gmax.

5.2 Gmax is a measure of the maximum G force experienced as a projectile of a known weight/circumference is dropped from a known height onto the artificial turf field surface; the response is measured in 'G's'. A limit has been set by ASTM as to what is an acceptable Gmax value for third-generation artificial turf fields at 200 G's and the ideal range is generally considered to be between 75 to 105 G's. Gmax is concerned with the safety of the artificial turf field when athletes fall onto the surface as a result of impacts with other athletes or from playing the sport i.e. diving for the goal line, lifting etc. This range accords with what would be described as top quality natural turf fields installed in stadia which are found to be in the range 95 to 105 G's (Shorten, December 2008)

**Fig. 3 - Gmax Results - ASTM F1936-07, F355-01**



5.3 The Gmax results illustrated in Fig. 3 are significant and illustrate a key property of a Brock base within an artificial turf field system. The Brock base maintains Gmax throughout the life of the artificial turf field for the simulated 10 year period in compliance with the standards organisations requirements. The sample without a Brock base fails these requirements at initial testing and throughout. The Gmax value with the Brock base was very consistent only increasing by 15% over the period of simulated wear, whilst the sample without a Brock base increased by 100% demonstrating significant change in properties during ageing.

### 6.0 Head Injury Criterion (HIC)

6.1 Research demonstrates that the Head Impact Criterion (HIC) is the most accurate measure of head injury potential of a surface as it takes into consideration not only the peak force of an impact, but the duration of the impact force.



Tel: 0845 6026354

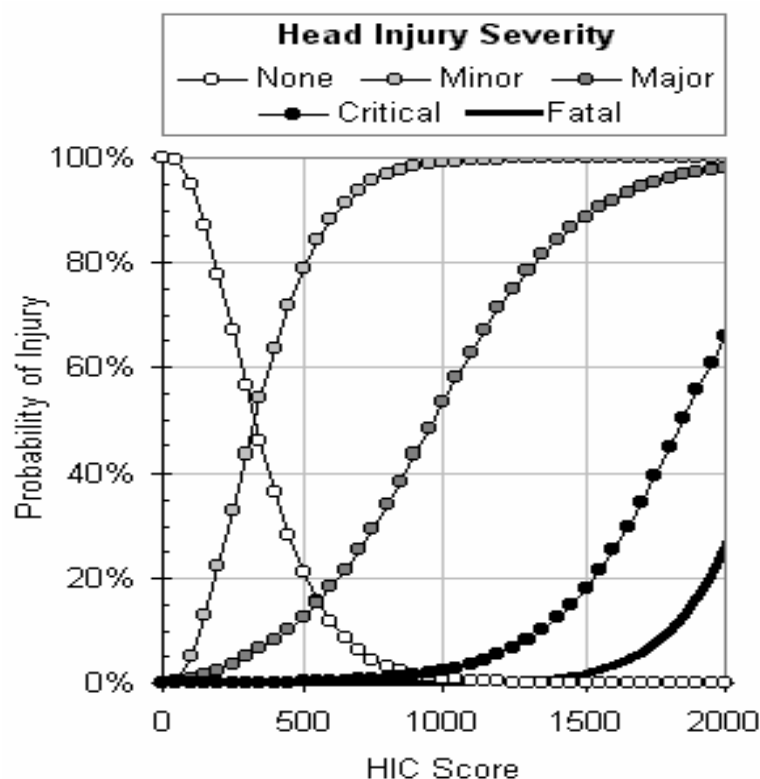
info@sportslabs.co.uk

6.2 An established test in the automotive and play industries, HIC has been a requirement in rugby standards since 2001. The test measures the risk of serious brain injury as a result of an impact with a surface. A head form containing an accelerometer is dropped onto the surface and the impact is measured. The results are expressed as a height at which an HIC value of 1000 is recorded, this being the determined value at which the probability of an injury occurring is 100% from an impact with that surface.

6.3 Understanding the HIC of a surface is to accurately predict the likelihood of a moderate, severe and catastrophic head injury. Empirically determined relationships between HIC scores and the probability of head injury are widely used as a way of estimating head injury risk. (NHTSA, 1997; Prasad and Mertz, 1985)

6.3.1 The graph in Figure 4 shows examples of "Expanded Prasad-Mertz Curves". Each curve estimates a specific level of trauma for a given HIC score.

Fig. 4 - Expanded Prasad-Mertz Curves



6.4 At an HIC score of 1,000, there is a 100% probability of a minor head injury, 55% probability of a major head injury, 5% probability of a critical head injury and the risk of death is no longer non-zero. An HIC score of 1,000 therefore represents the limit of human tolerance,



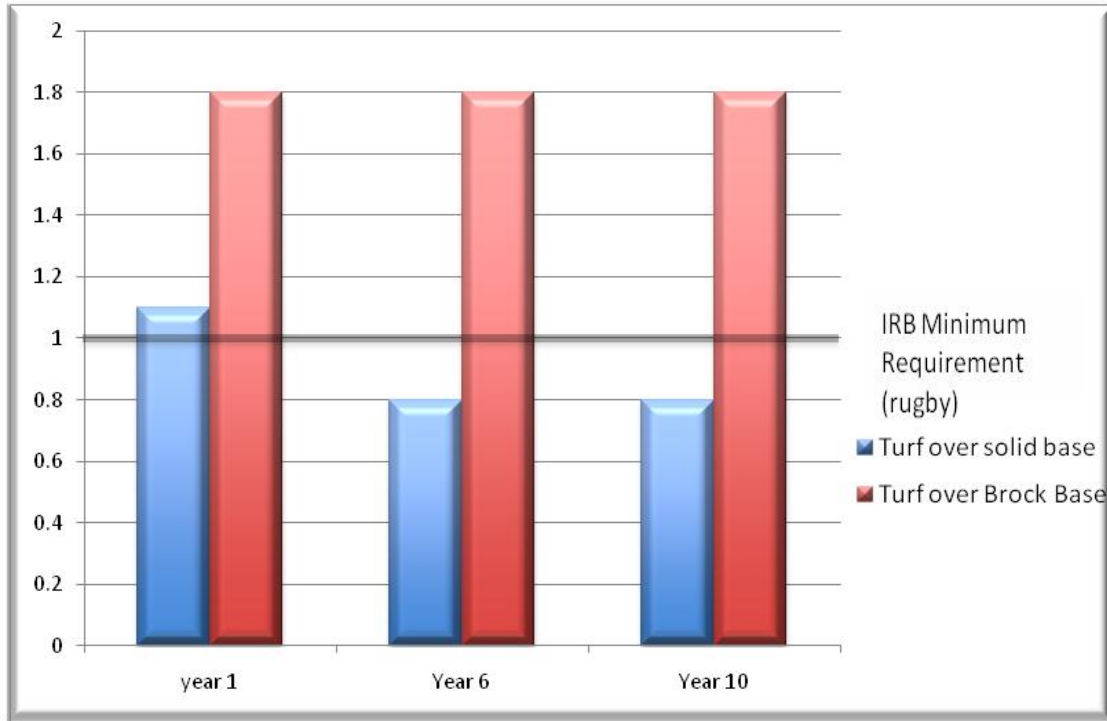
above which the risk of fatal head injury is non-zero. However less severe head injuries with long term effects can be incurred at much lower HIC scores.

6.5 At an HIC score of 500 there is a 79% probability of a minor injury, a skull trauma without loss of consciousness, or that the athlete will incur a minor concussion. At the same HIC value the risk of a major injury (skull fracture, extended period of unconsciousness) is 13%.

6.6 A fall height that produces an HIC score of 1,500 results in a 90% probability of a major head injury (skull fracture, extended period of unconsciousness), a 20% probability of a critical injury and a 3% chance of a fatal head injury. At a fall height that produces an HIC score of 2,000 exists a 100% probability of a major head injury, a 65% probability of a critical injury and a 25% probability of a fatal head injury.

6.7 The chart in Figure 6 compares the HIC results of the artificial turf system tested over a simulated stone base vs. those scores recorded of the artificial turf system over the Brock base.

**Fig. 6 - HIC Results (metres) – EN 1177**





Tel: 0845 6026354

info@sportslabs.co.uk

6.8 Table 1 illustrates the probability of minor to fatal injury occurring when the turf system under test is examined on a solid base or on a Brock base. The assessment indicated that after 6 years of simulated wear the following conclusions can be reached;

6.8.1 The results show that there is a 100% likelihood of a head injury occurring on the turf system over a solid base at a fall height of 0.8m (2.6ft). Whilst to achieve the same degree of probability of injury with the turf system tested over the Brock base the fall height is increased to 1.8m (6ft).

6.8.2 Significantly, there is a 100% likelihood of a major head injury occurring and a 25% likelihood of a fatal injury occurring on the turf system over a solid base at a fall height of 1.2m (4ft). Whilst to achieve the same degree of probability of injury with the turf system tested over the Brock base the fall height is increased to 3.1m (10ft).

**Table 1 – Results and Probability of Injury at HIC Values from 500 to 2000**

Turf tested after 12,200 cycles simulated wear (6 years simulated wear)						Height at Which Probability of Injury Will Occur	
Nature of Injury	HIC Value	Fatal Head Injury	Critical Head Injury	Major Head Injury	Minor Head Injury	Turf over solid base	Turf over Brock base
Probability of Injury at;	2000	25%	65%	100%		1.2m	3.0m
Probability of Injury at;	1500	3%	20%	90%		1.0m	2.4m
Probability of Injury at;	1000		5%	55%	100%	0.8m	1.8m
Probability of Injury at;	500			13%	79%	0.5m	1.0m

6.9 In average climatic conditions, research has shown that the HIC of a Stadia quality natural grass field will range between 1.6 and 2.0m. The results show that an artificial turf field containing a Brock base maintains HIC values at a consistent level throughout the simulated wear period there is no significant change in HIC during wear/ageing, and that protection offered by the Brock base is excellent, comparative to a high quality natural turf surface. These results would be well above minimum requirements for HIC on artificial turf fields. The sample tested without a Brock base is significantly below acceptable levels following wear/ageing and would be considered unsafe for certain sports as the value would fail the NGB requirement.



Tel: 0845 6026354

info@sportslabs.co.uk

## 7.0 Conclusions

7.1 Results show that the artificial turf sample placed on the Brock base maintained compliance with internationally recognized performance and safety standards for various sports well beyond the normal duration of the artificial turf warranty. The sample tested over a simulated stone base fell outside compliance with the same international standards after a relatively short period into the testing programme.

7.2 The shock absorption, deformation and safety of the sample of artificial turf over the Brock base was significantly better initially, and for a sustained period thereafter when compared with an identical sample tested over simulated stone. The latter sample falling out with NGB limits for performance and safety relatively early in the testing programme.

7.3 Critically, the Gmax and HIC results show the presence of a Brock base in the artificial turf field system secures the safety of the surface within accepted limits for the expected life cycle of the artificial turf and well beyond accepted warranty periods normally provided within the industry.

7.4 In addition, discernable differences were noted in the condition of the sample over the Brock base when compared with the sample tested over simulated stone after the testing period – see plates the factual report No.2490/2075.

7.5 The Gmax and HIC of the artificial turf system with a Brock base was found to accord with good quality natural turf fields, even following long term exposure to wear/ageing equivalent to 10 years in-situ wear.

## 8.0 References

8.1 Technical Report No. 2490/2075 authored by Sports Labs detailing “preliminary laboratory report on simulated wear testing using Brock Base systems” dated 05/12/08

8.2 Figure 1 shows examples of “Expanded Prasad-Mertz Curves”. (NHTSA, 1997; Prasad and Mertz, 1985)

8.3 Shorten M.R. & Himmelsbach, J.A. (2003) Sports surfaces and the risk of traumatic brain injury.

8.4 Dr. Martyn Shorten, discussion regarding Gmax values on natural turf fields unreferenced, December 2008.

8.5 Dr. Andrew McNitt, Pennsylvania University, discussion regarding Gmax values on natural turf fields unreferenced, December 2008.



Tel: 0845 6026354

info@sportslabs.co.uk

## Glossary of Terms

**3G (third generation surfaces)** 3G is used to describe an artificial turf filled with specific quantities of sand and elastic particles (normally rubber). The term third generation describes the evolution of synthetic from first generation artificial fibre non filled carpets through to second generation sand based carpets. Third generation describes the next step in the evolution of artificial turf.

**Brock Base Systems;** the Brock base is a modular base system made from pure high grade expanded polypropylene. It is designed to maximize sports performance, safety and drainage as part of a sports field construction. The Brock base is also an effective thermal insulation material and spreads surface loads by 100%. The Brock base system is 100% recyclable.

**Lisport Device;** a device which attempts to simulate in-situ wear of a synthetic carpet under laboratory conditions.

**Standard Concrete Base;** a base which is used in a laboratory which simulates a stone sub-base.

**Standard Pre-Test Conditioning;** the preparation of a sample in a standard fashion so that as far as possible the sample is made ready for the testing the same way every time.

**Shock Absorption;** the test, as detailed in accordance with BS EN 14808:2005 intends to assess the cushioning properties of a surface under the heel strike of users. A 20kg mass is allowed to fall onto a spring of defined properties whose lower end rests, via a force-measuring cell on the surface. The proportion by which the test surface reduces the force applied through the foot is expressed by comparison with a concrete reference sample.

**Vertical Deformation;** the test, as described in accordance with BS EN 14809:2005 intends to assess the movement or deflection of the surface under the heel strike of users. A 20kg mass is allowed to fall onto a spring of defined properties whose lower end rests on a platen. The deformation is measured via linear displacement transducers and a direct measure of the deflection is recorded.

**HIC testing;** was carried out in accordance with BE EN 1177:1998 (loose laid). The test measures the risk of serious brain injury as a result of an impact with a surface. A head form containing an accelerometer is dropped onto the surface and the impact is measured. The results are expressed as a height at which an HIC value of 1000 is recorded, this being the determined value at which the probability of an injury occurring is 100% from an impact with that surface.

**G Max testing** was carried out in accordance with ASTM F1936-07, F355-01. Gmax is a measure of the maximum G force experienced as a projectile of a known weight/circumference is dropped from a known height onto the artificial turf field surface; the response is measured in 'G's'.



**Monofilament Artificial Turf Carpet;** a type of synthetic turf carpet which utilises a monofilament type filament to represent the blades of grass in the pile. Monofilament yarns are normally inherently stronger more durable and less likely to fibrillate than other types of yarn used in the manufacture of synthetic carpets.

**NGB's Specifications;** National Governing Bodies Specifications are standards or codes issued by the National Governing Bodies of football and Rugby to regulate games played on synthetic turf pitches.