Criteria for the Development of Guidelines/Standards for Sports Surfaces

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Why are Guidelines/Standards needed for Sports Surfaces ?

This question would not be asked by those in the engineering field since standards and guidelines are a vital part of technological development, without which technology would not be reliable. But for today, here in the center of Biomechanics in Calgary, it is the topic that I have been asked to present.

In the past biomechanics and engineers have not always seen eye to eye which resulted in occasional negative comments. I feel it is important to take a minute here to contribute a bit to the elimination of the misunderstandings that have developed between the two disciplines. In my view, this was caused mainly through the misunderstanding of the distinctly different approach of the two groups. Understandably it may have seemed arrogant for an engineer-developed test device to be termed an Artificial Athlete. The name implies that a human body form was replicated which was capable of providing data on athlete to surface stress factors. As you all know the Artificial Athlete no more resembles a human body that I do a glass of wine. Also, biomechanics may be irritated when engineers in discussions about the 'right' test device/procedure use terms which seem to indicate that a real imitation of a sportive movement and stress situation is intended. As an engineer I have to clarify that the infringement of / encroachment on the field of biomechanics is only there through perception and is certainly not intended. The naming of the test device for the determination of the ‘give‘ of a surface as Artificial Athlete was strictly done as a piece of public relations. The name was catchy and it helped the general public to understand the concept. Nevertheless, as will be explained later, the Artificial Athlete has a certain relationship with real athletes, but not in a biomechanical sense.

It seems adequate to roughly distinguish those with scientific interest in the relationship of body stress and sport surfaces into two groups: the group of biomechanics and the group of engineers. A separation of science versus technology is not appropriate. It is the targets which distinguish the groups although admittedly the methods of the one group often seem more scientific since they are more sophisticated. In principle, however, each of the disciplines has their scientific background. Each develops, analyzes and critically applies methods of scientific investigation in order to gain knowledge about the interaction and the resulting effects of and to the athlete and the sports surface. The variation is that the biomechanics have more interest in the human component whereas the interest of the engineers is mainly directed to the sports surface component.

Biomechanics deal with an extremely complicated subject, namely human beings which

- occur in an endless number of different types
- are accessible to investigation in a limited way
- cannot be technically reproduced

Within these constraints biomechanics focus their principal studies on kinematic and kinetic movements in order to gain insight into their general function. They work with theoretical models and measurements. Since they cannot specify the athletes, the need for standardization is restricted to the standardization of their investigation procedures. However, this is not what is to be addressed within this presentation, though I hope it has made the compatibility, in fact the companionability of the two groups more clear.

Since the introduction of the modern sports surfaces and the resultant possibility for controlled improvement of the athletic environment, biomechanics and engineers have had little contact. The early roots of the German DIN standards started from the investigative work and reports of Prof. Baumann (Institute of Biomechanics of the Sports University Koeln). However, there was no real communication there and so the test procedures were developed according to more or less technically oriented ideas. To the best of my knowledge, those technical criteria were the only critical factors in the determination of which sports facilities would be used for the Olympic Games held in Munich, in 1972. Also during the time following the Olympic Games a sequence of misunder-standings occured. The attempt to discuss the theoretical analysis of McMahon-Greene (see lit. 20) between biomechanics and engineers failed (ISSS Seminar in Dublin). Also, the theoretical analysis of Pratt (MIT), which would have clarified much of the question over how the visco-elastic properties of sports surfaces affect the performance of runners was not disseminated. Instead, the erroneous presumption that the harder the surface the better the performance of the runners, was perpetuated.

The situation has changed considerably since Juan Dura (IBV, Valencia) has been dealing with the subject from a biomechanical perspective with the additional understanding of engineering methods, especially the practical needs of Athletes and players (see lit. 16 + 17). Also, at the Stadia Turf Summit in Amsterdam this year some quite interesting alternatives and amendments to the established procedures for biomechanically oriented investigations of sports surfaces were presented (see lit 21). Along with this, the contribution of the University of Montreal should also be mentioned.

Actually, I have a rather theoretical subject to talk about. To make it bit more interesting I will introduce the criteria while reporting the history of how certain guidelines were created or developed. I am most familiar with the development in Germany, therefore I will present the German story. However, similar considerations and efforts have been undertaken in other countries (lit. 10).

Standards based on Existing Products Approach : Synthetic Track Surfacing

The original task of the engineers was to consider and specify sports surfaces from a technical point of view. This work started in Germany around 1960 with mineral sports surfaces. These activities gained momentum when the first synthetic track surface was installed in the Olympic Stadium of Mexico City in 1968. Then for the first time, a surface covering was available that had been produced with a new type of synthetic material, different in all respects from any previously known materials used for sports surfaces. Since this was not an imitation of a known material, it resulted in a completely different path of standards evolution than that of synthetic turf which I will be addressing later.

Although the Tartan product used for the new synthetic surface was developed by the Minnesota Mining and Manufacturing Company (3M), it was clear that variations would soon follow. By 1969, just a year later, there were already about 20 alternative products on the German market. This variety was welcomed, however an unprecedented and uncontrolled development of sports facilities followed about the same time.

It was therefore in the public interest to establish a set of rules for the properties of the new surfaces. The goal was two-fold; first, to help avoid costly selection errors of owners by providing them with some criteria for comparison (the price of synthetic surfaces then was about US$ 100.00 per m^2), and second, to provide the manufacturers with a framework for future product development and guide for installed system properties. In Germany, this task was undertaken by the Institute of Sport Facilities Design (Institut für Sportstättenbau ISB) of the German Sports Federation (DSB). The actual developmental work was assigned to the Otto-Graf-Institute (OGI/FMPA) of the University of Stuttgart. Fortunately, the upcoming Olympic Games in Munich (1972) helped to assure the financial allocation needed for this project.

The project was laid out as follows:

First of all, a test site was selected near the Sports University of Cologne where the various companies could install 70m long runways of their products. There were 15 different products involved, which covered the full range of existing products.

The Sports University Cologne together with the ISB developed a questionnaire and used it to poll the physical education students and elite athletes regarding use-relevant properties of the surfaces.

The test house was initially assigned to provide technical test procedures and to apply them to the various surfaces at the test site.

Following an evaluation the results were transferred by the test house to a form of rules for the future manufacturing and installation of synthetic surfaces. The resulting rules were technical in nature since their intended use was for control of the site work.

In 1973, the Federal Institute of Sports Sciences (BISp = successor of the ISB) published an extensive report on this evaluation which it translated into 3 languages (lit. 1).

Following this initial work, a decisive step in the transformation of these rules into practical application was their publication as a DIN standard: DIN 18035-6 'Sports Grounds; Synthetic Surfaced Areas; Requirements, Testing, Maintenance'. As many of you may know, in Germany, most sports facilities are built by Public Authorities with as much as a 2/3's Federal and State subsidy (Golden Plan during the 60ies through 80ies). The subsidies were conditional on the surface meeting the requirements of the DIN. This was very effective in achieving a high level of quality throughout the country.

Simply stated the task was to determine the critical technical properties to be tested; evaluate existing test methods for suitability of application; when necessary develop new tests, test equipment and criteria, and then to enact this as a comprehensive standard.

Critical Technical Properties

As a basis for the technical task (i.e. development of rules (criteria) for the technical properties) the following classes of functions and properties were specified:

- Sports Function
  This specifies the physical conditions provided to the athletes by the sports surface in order to perform their sport effectively. The sports function is regulated through the limiting of excessive stress (i.e. fixation of the foot), the need to provide stabile footing (i.e. by too much resilience in conjunction with too much flexibility), and the goal of limiting premature fatigue (i.e. by too much resilience). With other types of surfaces, Ball Rebound, Ball Roll, and Ball Pace also fall under this classification. In the CEN, FIFA and UEFA documents the terms player-surface-interaction and ball-surface-interaction are used.

- Protection Function
  This addresses the ability or need to protect the athletes against avoidable over stressing during the regular performance of their sports (i.e. by setting a minimum Force Reduction or limitation of Sliding Resistance). It is also to limit the risk of injuries from hard impacts of the non-cushioned body. Actually, sports and protection function are correlated. The challenge is to determine the limit where performance is improved without creating unacceptable risks This threshold will differ for long vs.

short distance runners as well as for elite athletes vs. school or leisure persons. Thus, the determination of this point must be based on consensus and cannot be decided by an exact scientific method.

- (Material-) Technical Function
  This class covers all technical properties that create the long-term preservation of the use of the sports surface. Of special note here are Abrasion and Aging Behavior as well as Spike Resistance. Additional properties are Burning Behavior and Strength.

  An additional class of properties is known as

- Site Technical Properties
  They include Evenness, Drainage / Water Permeability, Thickness and Strength. In each case, both the average and range of variation are relevant to the assessment of uniformity.

This concept of specific functions forms the base of all German standards for sports surfaces.

Evaluation of Existing Test Methods & New Test Development

When selecting the test procedures, we had the option to refer to existing material test standards or to develop new ones. The existing tests were fine when a narrow focus of single properties was desired. The problem was that an evaluation based on a single narrow focus did not recognize a relationship between the properties. Since it was determined that each of the functions of the surface, Sports, Protective and Technical were relevant, it followed that the test procedures would have to focus on all of these properties and not make an assessment based on a single, arbitrary property such as strength (strength does not contribute to sports or protection function and only indirectly to the technical function).

As the first sports related test procedure, a dynamic test apparatus having a certain relationship to the athletic reality was developed for the determination of 'give'. Since the contact between the athlete's foot and the surface is clearly a mechanical affair, one of the first biomechanical platforms was developed and built into a runway. This was used to determine the mechanical reactions at foot contact of various light athletic movements. From the force-time recordings it was determined that the vertical reactions could be understood as sinosoidal waves. Therefore, the dynamic test apparatus named Artificial Athlete was designed to simulate this reaction as closely as possible. Several design modifications have resulted in the much simpler model of today. The important point being that the test apparatus not only provided realistic and relevant test results but also could be used both in the lab and on site under a wide range of weather conditions.

Using this mechanical apparatus it was possible to gain **reproducible** and **comparable** results. Reproducibility means: test results are within a specified range of accuracy if the test is repeated with the same apparatus in the same lab. Comparability refers to the commonality of results which are gained from like test devices (i.e. identical by design or similar) in different labs. Thus on site, the properties of a sports surface can be determined and controlled. This is a significant aspect, which is very difficult to be met by biomechanical methods due to the variability of the test individuals.

Other test procedures were developed or selected following the same concept. This was more successful with some parameters and less successful with others. This work is not at an end and there are certainly other parameters still to be developed. However, in the building/site practice it is not always important to comprehensively control all properties, if at least the critical ones are under good control through a program of accurate testing with proven testing methods and equipment. The issue of comparability of a test method is vital for the validity of test results, especially when they are subject to legal concerns/consequences (whether an installed surface meets the job specifications or not).

Simplicity of test procedures was also an important aspect as it promoted ease in attaining usable comparability data and helped to find inter-lab agreements on common specifications of the test procedures.

Another criterion for a usable test procedure is whether it has **selective or distinguishing power**. If a test measures a product parameter which does not allow recognition of acceptable versus unacceptable products, or distinguish levels of quality between products, it is of little value. A good example of such a test with limited value is the aging test of artificial turf as specified in DIN 18035-7. The opposite is true for the aging test according to the Austrian guideline.

Last, but not least, a test procedure must be **methodologically consistent or sound**. This means that a test procedure must meet mathematical and physical principles and should be free - as much as possible - of arbitrary elements. Thus, whenever possible, details of a test - although being a rough approximation of a real action only - should not be based on majority conclusions of a committee.

Products always vary in their properties. Since performance characteristics are valid only for the specific product sample tested, it is vital to require **identification paramaters** which precisely and comprehensively describe the components and the design of the product.. This way a test of an installed product can not only verify the performance characteristics but also can verify that the product installed is the same as the product selected for a site installation. Thus, standards and guidelines covering requirements must have a set of effective identification parameters.Excellent examples of this can be seen in the UEFA and FIFA documents.

Setting of Criteria

This is where the ISB tests and athlete questionnaires were considered.

Following the examination of existing test methods and the development of new ones, the evaluation of the athletes was added into the mix. The objective was to find a range for the criteria where the manufacturers would have the technological requirements and ability to produce a surface that the athletes would enjoy using.

The data from the test site and from the lab tests on site samples at various temperatures, were plotted and compared. By further comparison with the data of the athletes' questionnaires the range of resilience/give required of the synthetic surfaces was empirically delimited.

In general, this same procedure was followed in the development of all of the DIN standards: the acceptable range of the various characteristics was empirically determined based on the technical results of the current products, the results of the athlete questionnaires and the building codes.

There is an important term which needs special attention: **performance concept**.

Performance Concept is the common view that requirements in standards as well as in bidding specifications shall not address any proprietary property. Performance characteristics are restricted to those properties of a product which are related to its use as opposed to its design. Thus, there is no requirement covering the composition of a surface. Also, there is no requirement that Polyurethane should be used or stating which installation technique shall be followed. So innovations in this field were not stifled. Consequently, products based on Polyurethane, Neoprene, Acrylic, EPDM, synthetic or natural rubber, and Latex were developed and installed. There are surfaces which are cast from liquid or mushy mixtures as well as those which are glued down as prefabricated rolls or tiles (molded or peeled). The performance concept is intended to allow for creativity and development of products over as wide a range as is possible. Practical experience will then serve to sort out which products are usable and will succeed in the marketplace.

Different from the performance concept is the **design oriented product specification**. In the latter case, the design professional would describe the product to be installed by specifying the thickness of fibers, the type of backing or the type of synthetic material. This method should be avoided although sometimes such design details are helpfull to keep the possible products on a certain minimum quality level.

Unfortunately, there is not much room for specific design innovation of synthetic surfaces due to the technical necessities. Therefore, the types of surfaces used for athletic tracks have been rather unchanged for about 25 years now. Current surface products are still - in respect to their performance characteristics - not far from the prototype Tartan product of the 3M company. However, advancements have been made in the manufacturing of synthetic surfaces, especially the materials. One of the most impressive innovations was the development of water-based PUR coating systems.

Application of the Standard

Given the timing of this process, inclusion as part of the work undertaken as part of the European harmonization process: CEN TC 217 'Sports Surfaces' (TC = technical committee) could have provided the opportunity for simplification of international consensus process. However, unexpected factors within the CEN technical committee have delayed that process. Fortunately, there has been substantial success in the adoption of this work through voluntary adaptation by various international sports federations (IAAF, FIH, FIFA, UEFA, ITF) and at ASTM.

The governing body in the field of athletics, the IAAF (International Association of Athletic Federations) has followed this concept in principle and adopted the DIN Standard in the form of its *Performance Specifications for Synthetic Surfaced Athletics Tracks (Outdoor)* (lit. 11 + 12). This guideline refers to the sports performance only. Its aim is to ensure that the performance characteristics of the surface are satisfactory for athletics at the venue and **at the time of an IAAF controlled event** such as World Championship, Olympic Games, Asian Games, Universiades etc. Over and above that, it is to inform the public about what IAAF regards a regular condition of an athletic surface. However, compliance with these requirements is not critical to the determination of whether or not athletic sport can be performed on an athletic surface.

In order to avoid any abuse of this statement, I must ask that you not take it out of context and to emphasize that the very fact that the IAAF Specifications exist demonstrates the necessity of the application of Accepted Engineering Rules. Thus, whomever - owner, design professional, or other party – elects to deviate from these rules must in principle justify the deviation. This aspect may be very important in legal respect.

Standards Based on Ideal Surface Approach: Synthetic/Artificial Turf/Grass

A completely different situation came up when synthetic/artificial turf/grass products were developed - especially those for the use of soccer. In this case, there was a natural model which could be and was to be imitated, that of natural turf. In the 70's the first attempt was made to introduce synthetic turf for soccer and American football. After an extensive testing program in the early 80's (Winterbottom Report lit. 10) and practical tests with top league competitions these synthetic surfaces were rejected for soccer. The primary reason was the lack of a close resemblance to a natural turf in respect to appearance and sports function. Therefore, synthetic turf products were used for training facilities only.

It was the initiative of the Field Turf company in the US through vigorous promotion of the new type of synthetic turf that brought this to the forefront again. Its product was constructed of double length pile fibres in wide standing tufts with an in-fill of sand and rubber granules. This is well known now and does not need any further explanation. This type of synthetic turf caused incredible excitement for the soccer players. The governing bodies of the sport of soccer, FIFA and UEFA took the initiative in establishing guidelines for soccer surfaces, which were published in 2001 and 2002 (lit. 13 + 14). Actually, It is surprising that it took so long for this type of surface to be discovered for soccer application. I remember a site inspection in about 1990 at James Madison University in the Shenandoah Valley of Virginia and another one at the University of Winston-Salem (NC) where the turf was a rather similar: residential like soft pile with a slight sand in-fill on top of an elastic layer. At that point the realization of this as a new type of surface especially suitable for football and soccer had not yet occurred.

Since I was involved in the development of the UEFA guideline, I will use this as an example to explain which criteria were used.

In this case, most of the test procedures were already available (synthetic surfaces; DIN, IAAF, FIH, Winterbottom Report). A test site with the available products was provided at the Nyon Stadium in Switzerland, across the street from the UEFA headquarters. The individual products were installed as 5 x 5 m samples of the systems. They were inspected and assessed by professional soccer players called in by UEFA.

Since the new type of surface closely imitates the primary surface in use for soccer pitches, that of natural grass, it (natural grass) was used as a model. The process of developing suitable requirements was undertaken by measuring the properties of natural turf and comparing them with those of the new synthetic turf surfaces. Most of the existing test procedures were used on various natural grass pitches. As a model of a well-maintained natural turf in optimal condition the Nyon Stadium competition pitch in Switzerland was used. Additional natural turf pitches in Northern and Southern Europe in various conditions were also tested to assure a good cross section of data.

By comparing the data from the various natural grass pitches with the results from the synthetic turf surfaces preferred by the soccer players, the requirements for synthetic turf pitches were derived. Although there was much less estimation/arbitrariness involved than with the athletic surfaces, the limiting figures were selected for what is believed to characterize an ideal soccer surface in good condition (maintenance + seasonal conditions). These figures were set with a rather tight tolerance making it difficult for most products to meet them. As a possible compromise to this the ISSS has proposed that the UEFA guidelines be used as a benchmark against which to categorize surfaces. This would provide the owners of lower level league facilities to select a product according to their preferences independently of the UEFA requirements but still be aware of how the product compares to the UEFA specified range. This idea has not been accepted by UEFA yet though.

One reservation often voiced to these new standards that is that UEFA did not take into account, that even under optimal condition, natural turfs differ in the various countries: pile cut is longer in Norway and shorter in Spain; soil is rather hard in Spain due to weather conditions and rather soft and muddy during long periods in Central Europe. The acceptance of play on natural turf in all of these varying conditions shows that soccer as a game tolerates a wide range of surface conditions. The obvious question that arises then is why were the requirements set at levels which are so much closer than those for natural turf disregarding the obvious advantages of synthetic turfs - holding their consistency throughout the year, throughout the world and with little need for frequency limitations. The probable answer was that the approach in setting the requirements was the reverse of that used in setting the synthetic track requirements. Here the ultimate goal and not the available products provided the model.

Since UEFA is still in the evaluation process of the initial standards UEFA has started a pilot program to gain more information about suitability of synthetic turf. This includes subsidies of € 195'000 for 5 pitches for top league competitions around Europe. The local associations are free to pick the surface product their players prefer without enforcing compliance with the UEFA requirements. However, the local associations are required to keep comprehensive minutes for 2 years of everything occurring on and with the pitch (maintenance, accidents + injuries, players interviews and repeated technical testing). The pitches have to be regularly played on for top league competition.

After the trial period the data will be collected by UEFA and the requirements will be modified as necessary. Then one can be sure that the requirements are consistent. In my view this procedure is reasonable and the best way to develop realistic and reliable and effective requirements.

In the meantime, there is still the problem that too many products do not meet the today's UEFA requirements. UEFA's position on this is that it does not need products complying with these requirements before the year 2005. By that time products may have been developed which will be compliant. Unfortunately, UEFA does not express this view in a public statement. Thus, companies try in every way possible to meet the requirements while not knowing if they will still be valid in 2005.

In addition: although owners may not need a UEFA recognized synthetic turf pitch they naturally believe that only products meeting the UEFA requirements are suitable for soccer or feel that the products should be compliant with the UEFA requirements to be suitable for soccer. This makes the selection of a soccer turf in building projects difficult. On one hand the number of bidders is reduced and on the other hand it is uncertain if the selected product will still be 'suitable' in a few years time. This uncertainty may also paralyze the efforts of the companies to modify their products for best suitability (which may not be guaranteed by compliance with the today's requirements).

While both FIFA and UEFA seek to set requirements on synthetic turf for the betterment of the game of soccer, they have not arrived at the same conclusions. This is especially evident in the differing test methodology specified by each group. While seeking to specify the same property they have provided the same test name but differ on how to perform it. At present the ISSS is following the UEFA guidelines, but hopes that the two organizations will find an agreement soon and thus help to end the current confusion.

One aspect is still missing in the UEFA concept. It covers sports functional performance characteristics, but no technical characteristics (aside of identification parameters). There are hints but no requirements. FIFA addresses this gap. However, the specifications of the test procedures are not clear enough. Therefore, results of products being tested in different labs can be compared on a limited basis only.

So, the method of approach to standards developments is a tug-of-war that must be waged anew with every set of standards developed – do the requirements lead and the products follow as in the case of synthetic turf or the other way around as in the case of synthetic track surfacing?

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