Maintenance best practice and recent research

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Maintenance Best Practice and Recent Research

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Abstract

This paper sets out to capture the recent discussions on maintenance best practice for artificial turf surfaces, from a SportSURF workshop in 2009, supplemented with a case study from Loughborough University. This is enhanced with recent research findings from two studies investigating damage to artificial carpet fibres caused by power brushing, and the usefulness of simple portable tools in monitoring pitch degradation and the alleviating effects of maintenance interventions.

The outcomes of the maintenance seminar showed good consensus for frequency and type of maintenance practice, with a useful rule of thumb of one hour of maintenance for every 10 hours of use of the surface system. Maintenance costs of artificial turf should be expected to be similar to natural turf however, but expressed as ‘per hour of use’ are much lower.

Damage caused by power brushing, from a laboratory study, was found to be minimal in terms of fibre splits or breaks, for three different standard brush systems and three different carpet systems.

Portable monitoring tools, such as the Clegg hammer and rotational traction devices may be suited to monitoring two important pitch properties over time. These relatively low cost tools are potentially useful to manage aspects regarding infill depth and mobility, frozen ground and advice on intervention maintenance.

INTRODUCTION

Maintenance of artificial (also termed synthetic) turf surfaces has for some time been under-resourced, though it has been the topic of much discussion within the industry in recent years. However, controlled experimental studies into the effectiveness of maintenance and development of understanding of the decline in performance of artificial turf systems are few and far between in the available literature. One valuable exception to this is a recent research project, primarily investigating sand-filled systems, within the sport surfaces group at Cranfield University (McCleod, 2008).

A SportSURF organised seminar, in March 2009, brought together parties to share maintenance 'best practice' and included presentations from researchers and practitioners. The key outcomes of the seminar are highlighted in the later section 'what maintenance and when?' It was made very clear at the seminar that 'know your surface' should be a key axiom of all owner/operators to effectively manage their valuable asset, and that artificial turf surfaces are not *low* maintenance.

In addition, Loughborough University has been carrying out research within its sport surface research group evaluating tools for monitoring pitch system properties, and some of these show promise in helping evaluate the effects of maintenance. A recent laboratory experimental study was also completed on the 'damage' caused to new synthetic fibre carpets by repeated brushing, and these topics are explored further in the section 'recent research studies'.

The aim of this paper is to capture the recent discussions on maintenance best practice, and enhance and update these with recent research findings.

How much does/should maintenance cost?

It is clear that artificial pitch systems are expected to be *lower* maintenance than natural turf, but are not maintenance free and nor is minimal maintenance acceptable. The limited number of scientific studies (McLeod, 2008; Cranfield, 2008), support the general information and codes of practice available on maintenance (SAPCA, 2008, FIFA 2009), and also recent presentations by practitioners (e.g. Harris, 2009). Furthermore, a review of the costs attributed to maintenance and comparison of artificial turf to natural turf (See Table 1, after James, 2009) shows clearly that whilst the total cost of resources required per annum may be similar between artificial and natural turf systems, that an artificial turf pitch may be expected to be utilised up to ten times more than a natural turf system per annum. As a consequence, it is the 'costs per hour of use' that are a better measure to show the distinction between relative costs that need to be met.

Table 1. Average annual maintenance expenditure (After James et al, 2009)

	Natural Turf	**Synthetic Turf**
Average Annual Expenditure (£)	7500	8000
Average Weekly Usage (hours)	4.1	44
Average maintenance expenditure per hour of use (£)	35	3.5

Note: In a presentation by Young (Young, 2009) reviewing industry reported spend, his figures suggested a likely cost range of £2000-£6000/annum for synthetic turf pitches, and a cost of up to £20000 for a natural turf pitch hosting soccer at a semi-professional level.

To further compare the ‘real’ costs of artificial turf pitch systems to natural turf, then the collective costs of construction and maintenance need to be collated. One such example is set out in Table 2, utilising detailed data from the Loughborough University archive of pitch tenders, the Facilities Management database of ground-staff hours, materials utilised, and external contracts etc. The expectation of the pitches lasting 10 years is an assumption that clearly affects these total ‘whole-life’ costs, however. Experience suggests products may last longer or shorter dependent primarily on intensity of use and initial quality of materials and build. In this study the intensity of use was estimated based upon booking records retrieved from the University’s records. Casual play (without booking) cannot be included but may be expected to add to the actual hours of use as these facilities are not supervised.

Table 2 Estimated total costs per hour of use for different Artificial Turf surfaces for National Competition level play (Phillips, 2004)

	Water-based	Sand-filled	Rubber-crumb	Natural turf*
Estimated average Use (hours per annum)	2000	2220	2220	150
Cost per hour (£)	50	42	28	210

Notes: * The natural turf pitch is used for matches only, around 70 games per year in this instance. A more moderate standard of play level on the natural turf may be expected to double the use and halve the cost per hour. These figures include the initial capital costs, annual maintenance costs and surface repairs/refurbishments based on a common 20 year life cycle (artificial surface replacements after 10 years) and have been adjusted from 2004 to 2009 costs.

This extra capacity of artificial systems can, in most cases, be used to bring in more income to offset the capital and replacement costs and make artificial turf a viable business solution for many clubs or facility operators. The figures here, and other cost related information (Young, 2009; FIFA, 2009) for income from the hire of the pitch facility alone, suggest a good quality synthetic turf pitch could pay for itself in approximately 5-7 years. However, the cost of resurfacing is clearly a significant investment hence effective maintenance can be crucial in realising the full potential of these potentially profitable assets.

However, the ‘increased capacity’ of artificial pitch systems can be exploited too much, it is argued, shortening the useful life of the system and leading to issues over customer satisfaction, and warranties. It was suggested (Young, 2009) that weekly hours use totals of more than 60 hours are considered excessive, and may shorten a pitch’s life to 5 years or less in comparison to 9 years if used for around 40 hours per week or less.

Despite the lack of coherent quantitative data on this subject, the system is expected to ‘wear’ and that higher usage will lead to accelerated wear.

However, recognising that maintenance is needed is only part of the issue, with several questions remaining. The key ones are ‘what maintenance and when?’, and ‘is the maintenance working effectively?’ It is apparent that if the pitch system is poorly maintained the rate of degradation and associated loss of performance will accelerate. The cost benefit and balance between effective maintenance and a pitch’s longevity at a suitable playing standard has yet to be fully researched, however. In addition, it is logical that any such studies would require a large dataset of pitches as the multitude of carpet products, and their manufacturing processes, the quality of the raw materials used, the consistency of workmanship quality at installation, and the environmental stresses endured are all expected to contribute to the longevity of performance and provide scatter in measured data.

‘What maintenance and when?’

In an interesting and perhaps unique study, 50 artificial turf fields in Holland are currently being monitored. Data from these were presented (Jan-Kieft, 2009) for the period 2001/02-2008, summarising the use, maintenance and play performance related test results for these fields. In general, the findings showed that the pitches had become harder (average -10% Force Reduction, 19% change), less compressible (-5mm, 45% change), increased ball roll (+3.5m, 35% change) and also increased ball rebound (+0.15m, 17%). Rotational traction, however, was similar over the period – perhaps surprisingly in light of the other data. Comparing the lower performing fields to their usage and maintenance did suggest a trend of higher use and lower maintenance promoted poorer performance across a range of the play performance tests. It was pointed out, however, that during this period of testing the performance limits in the standards for soccer had changed and so had the product designs to meet new more stringent criteria. If the level of degradation can be predicted or estimated, then it appears sensible to ensure the initial installed pitch design is as far from ‘failure’ as permitted to maximise longevity at safe levels of play.

In a recent presentation, Fleming (Fleming and Freeman, 2009) drew together information and evidence from the maintenance practices of ground staff at Loughborough University. This data presented the evolution of best practice on the campus for three artificial turf systems: a water-based hockey surface, and two different designs of rubber infilled soccer (3G) systems (one long-pile and one medium pile). Loughborough experiences very high pitch use demand, especially during term-time, for playing levels from its elite (national level) teams down to student inter-hall competition.

The Loughborough ground staff relies upon several feedback routes for planning and monitoring maintenance, and regular pitch inspections is key and is carried out by senior staff. Inspections can observe: play performance aspects, damage to seams, infill level issues, infiltration and drainage problems, surface behaviour under brushing such as fibre loss, and so on. If appropriate the staff can also carry out measurements such as carpet pile height to monitor wear, approximate infill depth, the bounce height of a ball in a simple ad-hoc test. However, mainly due to time/cost limitations rarely do detailed measurements other than ball bounce across the surface get carried out.

Feedback from the users is often sought, but rarely are consultants called in or test houses unless there are major issues (such as plans for refurbishment or issues with damage/wear on newer surfaces). Loughborough sub-contracts a company to provide specialist maintenance on a monthly programme to all of its pitches/surfaces, in addition to its own resourced programme as set out below.

Generic Maintenance Practice at Loughborough University

1. WEEKLY - litter pick 2-3 times, 1-2 safety checks (nets & posts), drag brush 1 or 2 times – utilise different bushes for different surfaces (see later for more detail)
2. MONTHLY - rotary (power) brush of the surface (external contractor) – very near surface affected, fill penetration 2-3mm.
3. ANNUAL – 'revitalisation', takes out top 5-10 mm of infill out, separates out 'contamination' and replaces the infill (external contractor).
4. 5 YEARLY – will consider 'rejuvenation', with deeper fill removal than revitalisation. The decision is based on a pitch specific cost-benefit basis.

In addition to the regular maintenance set out above, Table 3 sets out the more detailed maintenance regime and the type of surface systems in place at Loughborough on a pitch specific basis.

Table 3. Detailed summary of the maintenance regime for three pitch types at Loughborough University, (updated from Fleming & Freeman, 2009)

Pitch type/main sport and design detail	**Usage (weekly hours) and age**	**Maintenance regime**
Water based – hockey exclusively 11mm pile, nylon carpet, 15mm shockpad Bound base	67 (term time) 9 years old	* regular brushing; algal treatment 3 monthly (light) and annual (full), with deep clean to remove dead algae. Twice yearly, rain gun and pump/tank Note, 2009 carpet seams wearing, and algal problem worsening.
Rubber crumb Soccer/Rugby training 61mm pile, polypropylene fibrillated no shockpad bound base	64 (term time) 8 years old	Infill kept topped up high, weekly brush with flexi-comb to move infill & increase shock absorbency. However, deeper brushing is avoided over concerns re increased fibre wear.
Rubber crumb Soccer/hockey 35mm polypropylene Monofilament Pile.	55 (term time) Surface 3 years old. Was a sand based, replaced in 2007	Light zig-zag brushing to maintain flat surface, prevent infill interlocking. Infill maintained level to provide good hockey ball roll (disturbance reduces ball roll). Some seam damage

25mm Shockpad (reused) Bound base.		encountered in high wear areas, in 2009.

Note: * means over and above basic regular brushing

The flexi comb system is a set of long brush strands, and the height of strand (see Plate 1a) can be set to change the stiffness of the brush. This is used to ‘fluff’ the top of the carpet pile and infill regularly on the long pile soccer/rugby pitch aimed to keep it softer (higher shock absorbency). The observation on this pitch, now ten years old, is that the fibres have fully defibrillated into thin strands, and that a lot of fibre is seen in the debris after sweeping. The infill is kept well topped up as there is no shockpad. The ‘zig zag’ brush (see Plate 1b), used on the medium pile length pitch, is also towed behind a vehicle and is used to provide an even fill level especially to help the roll of hockey balls. The height of brushing is set by the operator of the vehicle.

The experience at Loughborough is that the surface’s ‘playability’ can be altered by choice of brush, depth of agitation of infill, and speed of brushing. In addition infill is regularly topped up to avoid any large changes in level that can affect the performance of the system as a whole. This is particularly crucial where a shockpad is missing from the system components.

In general, a rule of thumb that emerged as a consensus from the SportSURF seminar on maintenance practice (e.g. Harris, 2009; James, 2009), is that for every 10 hours of use there should be an expectation of one hour of maintenance.

It is interesting to speculate on the comparison between sand infills and rubber infills, and the maintenance necessary on these systems. The presentation by James (James 2009) briefly summarised much of the work done by his team (McLeod 2008, Cranfield 2008) largely aimed at sand-based surface systems. The findings of this study, carried out in the period 2003-2008 revealed that degradation and loss of performance were due primarily to contamination of the sand infill reducing the infiltration capability of the system, and the effect of fibres laying over the top of the sand infill causing ‘capping’, i.e. trapping the fill and reducing its mobility and increasing pitch hardness. This is one of the few scientific studies that appears to have been carried out aimed at exploring the ‘science’ of maintenance and the mechanisms by which the sport surface may be expected to degrade and the effects of this on playability.

From the presentations and discussions, it is clear that there are many invaluable observations made by ground staff regarding degradation and wear. However, the terminology used by the sport surface industry practitioners to communicate their observations and opinions may not always be consistent or clear to other parties. These term used include ‘infill locking’ - meaning a more compact surface; ‘compaction’ of the rubber infill – usually associated with issues such as increased hardness and higher traction; and pile flattening - whereby the fibres do not recover into an upright position and lay over the infill. However, to enhance the skill and effectiveness of ground staff and specialist maintenance companies, it is clear that some more ‘tools’ are required.

This issue is particularly topical as the governing bodies introduce regular play performance testing to enable a pitch to maintain its licence for competition (e.g. FIFA 2* system). A form of direct pitch assessment would assist programming maintenance works between the periods of independent surface testing (in the FIFA 2* example two yearly) to address any possible problems and avoid costly failures or disputes. Monitoring of surface changes in performance would also be valuable research for input back into system designs for increased durability. Further science concerning pitch materials and behaviour is needed, and the transfer of suitable applied research to enhance maintenance practice. Two recent studies are presented below, aimed to assist in this process.

RECENT RESEARCH STUDIES AT LOUGHBOROUGH

Two studies are presented, one aimed at evaluating damage caused by power brushing the other the efficacy of simple tools to show changes in surface performance.

<u>Study 1. Power brushing and carpet pile damage</u>

In addition to the need for regular maintenance, commonly a form of brushing, concerns are often expressed regarding ‘too much maintenance’ can affect the life of the synthetic fibres in an artificial turf system. At the request of a Leicestershire based sport surface maintenance company, Technical Surfaces Ltd., a programme of work was undertaken in the Sports Technology Institute at Loughborough to evaluate the possible ‘damage’ by power brushing.

Field trials were considered fraught with issues over adequate control, so it was decided to develop a laboratory based (affordable) experimental research programme. The key objectives of the study were: To develop a suitable test method to replicate the power brushing techniques used in practice, for use in a controlled laboratory environment and applicable to a range of brushes; and to measure the wear/damage over a number of cycles of application of the brushes on a range of infilled carpet systems.

The project tasks were:

1. Develop a suitable laboratory test method, comprising a motorised unit to affix the brush to for spinning on a mechanical system capable of tracking up and down a surface sample. The specifics were: achieve a balanced rotation speed up to 3000rpm, with control, a brush size of up to 450mm wide and 600mm diameter, and a ground speed of up to 5mph, controllable and constant brushing depth. The Fanuc robot arm was utilised, in the STI laboratory - see Plate 2).

2. Make up samples of artificial turf surface system samples to an acceptable repeatable standard simulating field conditions (at new). Prior to testing carry out initial measurements on these samples of pile length and infill height, as the starting benchmark, and check visually for any damaged fibres.

4. Carry out the appropriate number of cycles of brush application (1 cycle = return traverse) to the carpet sample – to promote mechanical wear of the system, with a

precise set brush rotation speed, ground travel speed and depth of penetration into the infill. The number of cycles used was 0, 10, 50, 150, 250, 500, 1000 representing a maximum of 20 years-for the weekly brush types. A more severe harder brush is used monthly, and the cycles were set at 0, 9, 18, 36, 72, 135 and 180 also representing 20 years.

5. During the brush cycles, stop the test at the intervals set out and measure observable wear/fibre damage induced by the brushing.

6. At the end of a test take detailed measurements of the change of state of the fibres (i.e. breaks, splits and bends). Photographs were also taken to show visually the damage incurred.

Three carpet systems were evaluated, a sand dressed product suited to hockey (18mm texturised/curled monofilament polyethylene), a multi-use sand filled product (24mm pile, fibrillated polyethylene tape), and a sand/rubber filled long pile soccer system (65mm pile length, polyethylene profiled monofilament).

The carpet sample prepared and tested was 1m long and 1m wide. However the test zone was the width of brushing, i.e. 450mm, and approximately 900m in length. The visual assessment of fibre damage utilised a simple 4 quadrant frame (see Plate 3), to separate specific areas for the researcher to visually count the number of fibres that became damaged, i.e. were bent over, were fractured/broken (across the fibre) or were split (i.e. length ways).

The infill was installed into the samples dry, to the manufacturers recommended weight per unit area and conditioned with a studded roller. The infill moved during brushing, as expected, and at the inspection intervals infill was returned to the sample to 'top up' the level similar to the field maintenance process.

The findings are summarised in Table 4. The accumulation of wear was observed to be gradual, and in general linear. Operator error was reduced by using the same operator for all measurements, and from a period of training and independent verification. However, no automated process of counting damaged fibres was considered warranted (e.g. image analysis or similar), and some error in estimating total numbers observed was deemed acceptable – specifically after initial trials showed the numbers to be low.

Table 4: Summary of damage caused by brushing at end of testing

Carpet/System type	Brush type	Total Brush Passes	No. fibres affected by brush wear (total)	Damage/Wear extent (%)
3rd Generation	Soft	2000	103	1.11
Sand dressed	Soft	2000	46	0.10
Sand Filled	Soft	2000	49	0.29
3rd Generation	Hard	2000	115	1.24

Sand dressed	Hard	2000	118	0.26
Sand Filled	Hard	2000	135	0.79
3rd Generation	Deep	720	145	1.57
Sand dressed	Deep	720	195	0.43
Sand Filled	Deep	720	98	0.57

Note: Brushing with the soft/hard brushes was at 2mm penetration depth into the infill, and deep brushing (with a stiffer brush) was at 7mm penetration depth. The wear was expressed as the sum of splits and breaks (not bends). The total number of fibres per unit area was estimated from the manufacturer's data: the product of the number of tufts per sq metre and the number of fibres per tuft.

A key element of the methodology was to set the brush penetration appropriately and ensure this was controlled across the whole sample length. This was a challenge initially, and included careful measurement of the floor planarity (surprisingly it had a lengthways fall of approximately 1-2mm over the 1m length of carpet. The Fanuc robot arm programme of relative movements was adjusted to allow for the floor unevenness. Furthermore, the most effective way to set the 'brush depth' was experimented with and finalised as: lay a flat metal board on the carpet surface, providing some compression of the carpet fibres and resting upon the infill, and set the brush tips to just touch the metal board surface (a piece of paper was added and the motor spun to show the paper was effectively flicked off the surface). The thickness of board and the desired 'infill penetration depth' were then added to the vertical elevation of its position. In this way, the length of fibre affected by the brushing was much greater than the 'penetration depth'. Observations during testing confirmed the effectiveness of this approach, with infill being brushed out in significant volumes. A brush guard was manufactured to reduce the scatter of infill, and collect it to be returned to the surface.

Discussion of Wear Test Results

The results showed specific types of damage to fibres from these controlled tests, but little total damage. Considering the large number of brush cycles applied the findings show that very little direct damage to fibres is likely to be caused by the weekly (or yearly) brushing. Considering the stiff nature of the brush fibres and their ragged ends, more damage was anticipated. This highlights the benefits of 'soft' fibres that can bend and then recover.

The fibre damage classification was set as 'splits' or 'breaks' (see plate 4 for examples of these) but the damaged fibres are not then redundant in the system. Depending on where the split or break occurs, mostly observed at the depth of brushing, these fibres can still provide some stability and interact with the infill. As no performance related testing was possible no further comment can be made on changes in performance caused by fibre damage, but it is clear from the small amount of damage observed that the power brushing alone would not be expected to adversely affect the system performance for player-surface or ball-surface interaction.

Two key limitations of this work are that: 1) there was no concurrent mechanical wear applied to the carpets, similar to the action of studded boots; 2) nor was their any environmental ageing by UV or potential for natural ageing. If it is supposed that in a real carpet system in use for 10 or more years the fibre properties were to change and become weaker, and more brittle, then vigorous brushing may be expected to expose these weaknesses and produce more damage potentially. The brushing and vacuuming applied would be expected to remove the bits of broken fibre, however, which is clearly helpful in avoiding build up of contamination that may affect the play properties or drainage. In practice, the durability of licensed synthetic surface systems is measured indirectly by the Lisport wear test and other environmental type tests such as UV exposure (e.g. for soccer see FIFA QC Handbook, 2009).

Study 2. Pitch/Maintenance Monitoring Tools

This area of research has been evolving organically alongside other research work at Loughborough aimed at measuring the characteristics of performance of artificial surface systems (for a range of sports). The research projects have, over recent years, focussed on player-surface and ball-surface interaction and player feedback in hockey (Young, 2006), shockpad design and evaluation (Anderson 2008), and more recently traction behaviour of 3rd generation soccer systems (Severn, 2008 & 2010). Additional small projects have gathered field data on the Loughborough University facilities, over a period of time. Rapid testing techniques, however, have permitted usually 25 measurement points per pitch on a grid, to improve the reliability of the data.

The time related data show, in general, for two long-pile surfaces in use since 2002/3, that the average traction measured by the simple rotational traction device (FIFA, 2009) and average hardness measured by the 2.25kg Clegg hammer, have both gradually increased with age/use. The increase in Clegg hardness, of 20-30g, has been observed over a period of several years but is considered a relatively small change. These data suggest the surfaces are well maintained, and are of good quality considering their intensity of use and current age. The research at Loughborough has correlated the Clegg hammer with the industry standard impact test the Artificial Athlete (which measures ‘force reduction’ and is included in FIFA, IRB and FIH standards) and from this relationship a change of around +/- 20g with the Clegg represents around a +/-5% change in force reduction. Over a period of several years whilst this change is considered relatively minor clearly the initial start point of the pitch performance is important, so a system installed at the ‘harder’ end of the scale is expected to potentially *fail* more quickly. In addition, testing before and after deep (annual) brushing has shown the Clegg hardness values to reduce by up to 10-20g on the day. Further more frequent testing is required, however, to better delineate this trend of hardening and the alleviating effects of maintenance. The peak rotational traction data for these two surfaces has in general increased by approximately 5-10Nm over the same period of several years, but from relatively low initial values of 25-30Nm. These increases again have been periodically affected by the deep brushing, in general reducing the peak rotational traction by 2-3Nm which is considered to be a relatively small effect. Careful measurement of infill depth showed the effect of the deep brushing to increase the depth of infill by between 2 and 4mm, from decompaction and an increase of the void ratio (volume of voids to the volume of solids). However, it is unclear as to how long this change lasts once the surface is put back into use.

This data, infrequently measured is also potentially affected by many factors, such as temperature, moisture, changes in fill level and local effects such as shockpad thickness. The effect of frosty February weather on one occasion increased the average Clegg hardness by 60g over the shady part of the pitch. A few hours later thawing was apparent and could be monitored and compared between the areas quickly with the portable Clegg tool. On another occasion, it was clear that high hardness readings (near the corner kick area) related to a lower level of infill which was brought to the attention of ground staff. Infill can and does move around, and in many instances on real pitches may not be adequately topped up, perhaps for cost reasons also. The testing for before and after deep brushing also showed a better uniformity of Clegg hardness readings afterward across the pitch as a whole.

To explore the aspect of infill depth further, Figure 1 shows the Clegg hammer hardness readings versus rubber crumb infill depth for a long pile artificial turf carpet, and with two differing thickness shockpads (15mm is more typical in hockey/soccer, 30mm more typical for rugby) from recent work by Severn (Severn, 2010).

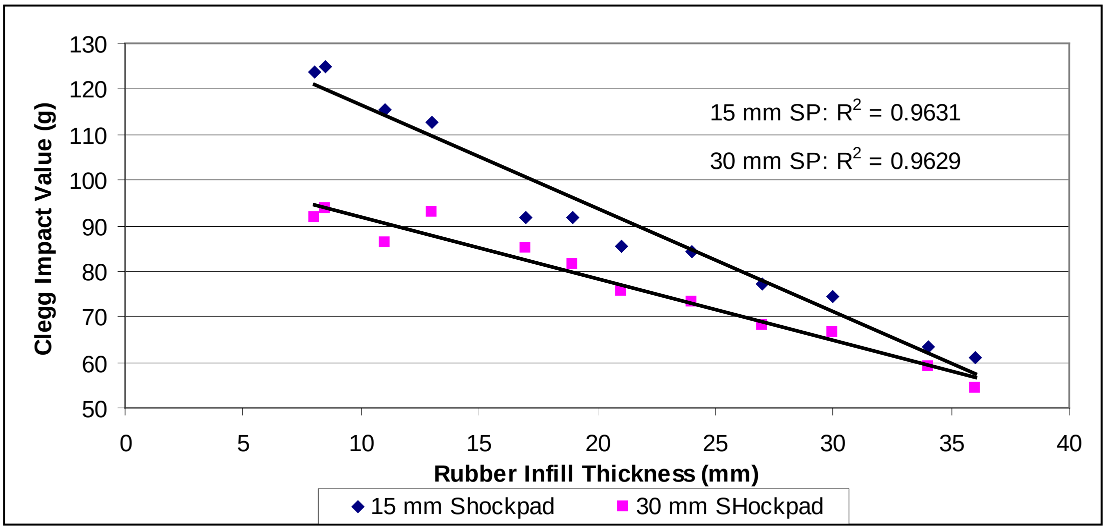

Figure 1. The effect of Rubber infill depth on the Clegg Impact Value of a third generation synthetic long pile turf surface, and for two thickness shockpads. The linear regression lines show a good fit between rubber infill thickness and Clegg Impact Value.

The shockpad effect clearly dominates at lower infill thickness. This relationship compares well with the Artificial Athlete results on the same samples, shown in Figure 2.

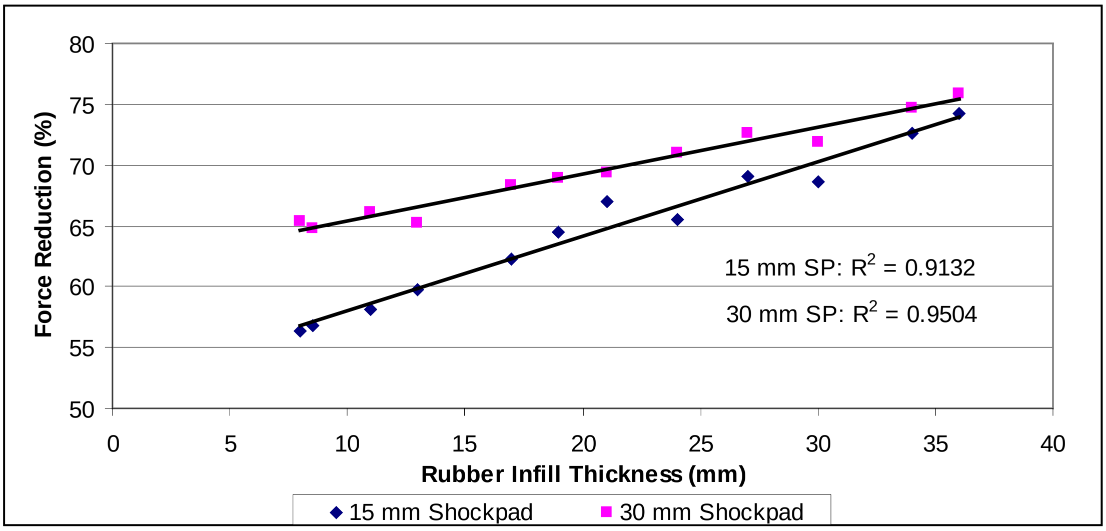

Figure 2. The effect of Rubber infill depth on the Artificial Athlete Force Reduction Value of a third generation synthetic long pile turf surface, and for two thickness shockpads. The linear regression lines show a good fit between rubber infill thickness and Force Reduction.

What is also interesting to note from Figure 2 in particular, is that the acceptable limits for Force Reduction for soccer are approximately covered by the range shown. This might suggest that 'passing' the requirement of say 50-70% FR is no guarantee of acceptable quality. Infill depths should be monitored in addition. Current testing at Loughborough is also showing useful trends with regard to the effects of infill density on the Clegg and Artificial Athlete, suggesting the Clegg is a little more sensitive to the near surface effects (due to its more rapid impact period it is suggested).

It is clear that it would be of great benefit to the groundsman or maintenance operator to monitor the surface regularly for issues such as hardness, and traction, and to measure across many positions on the surface/pitch to ensure a good set of representative values and delineate high wear or problem areas.

CONCLUSIONS

The review of maintenance practices, and across the range of surfaces at Loughborough University, and the work done on sand-based surfaces, has shown that maintenance should be expected to be appropriately resourced and carried out regularly, ideally with some form of monitoring. The most basic monitoring which should be considered is visual inspection by a suitably experienced person.

Studies regarding long-term changes have, in general shown that pitches may be expected to harden with time and become faster, though rotational traction data suggest little change (and that maintenance will reduce this effect but for how long a period is as yet unknown).

Monitoring hardness and traction using simple and portable apparatus is warranted, and considered very relevant to ground staff and maintenance operators. It is worthy of further investigation on a site specific basis, however. Research has shown that the shockpad will influence hardness/shock absorbency measures, but may be suitably sensitive to infill levels to be useful in advising the maintenance of system behaviour.

Maintenance by brushing, soft and hard, is not expected to accelerate the damage caused by environmental ageing or mechanical wear from users.

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Plate 1: a) Flexi-comb brush b) Zig zag brush

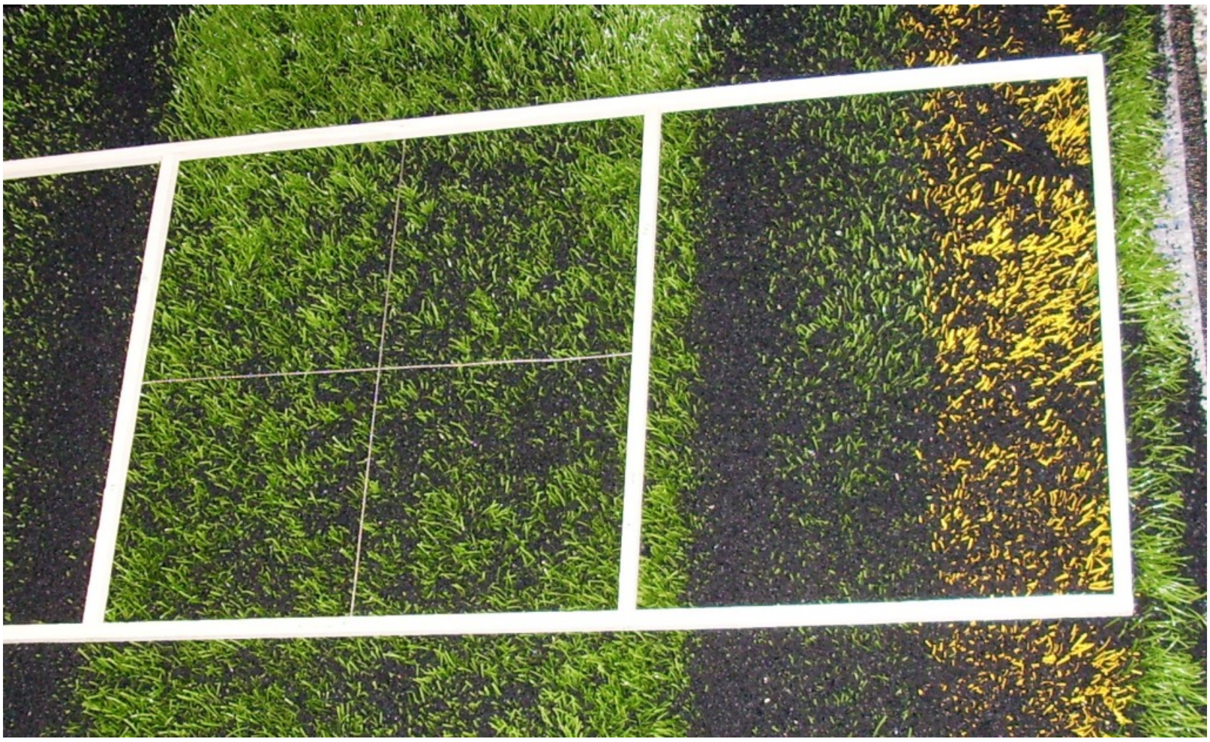

Plate 2 – Measuring quadrangle frame, set on a rubber crumb infilled system – the central portion showing loss of fill highlights the channel tracked by the power brush.

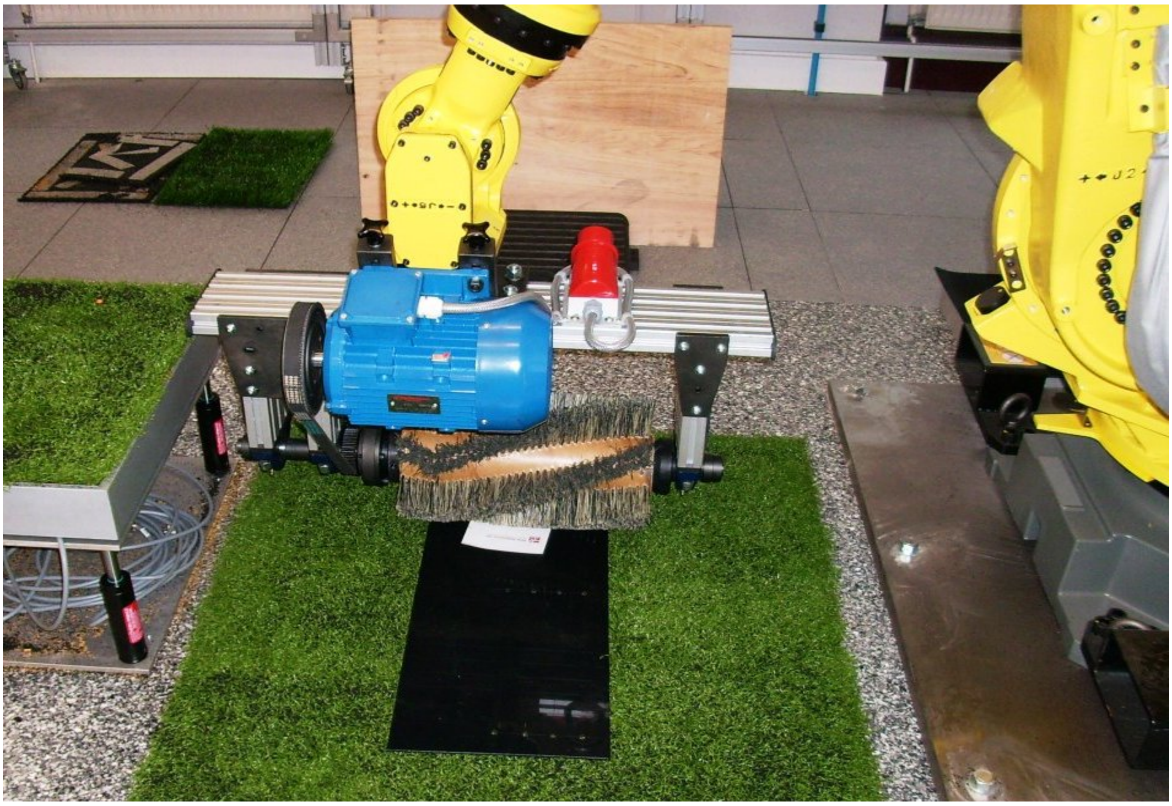

Plate 3 – Fanuc robot arm with power brush mounting (guard removed). The board and paper is to set the penetration depth (see page 9).

Plate 4 – Examples of fibre a) splits and b) breaks from brushing

Note: a) is from 180 cycles of deep brushing, b) is from 500 cycles with a soft brush