Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 72 (2014) 871 – 876

Procedia Engineering

www.elsevier.com/locate/procedia

The 2014 conference of the International Sports Engineering Association

Artificial grass: A longitudinal study on ball roll and free pile height

McLaren, N.J.[a], Fleming, P.R.[a] and Forrester, S.[b]

[a]*Loughborough University, School of Civil and Building Engineering, Loughborough, LE11 3TU, UK*
[b]*Loughborough University, School of Mechanical and Manufacturing Engineering, Loughborough LE11 3TU, UK*

Abstract

Ball roll is seen as one of the first criterion which cause artificial grass pitches to fail performance standards. Previous research has demonstrated that the ball roll distance increased after a seven-year period. However, there is a lack of understanding in the mechanisms causing the ball roll distance to increase with time. During this study, the ball roll distance and free pile height were measured over a twelve-month period on an indoor pitch. The aim was to evaluate the early-life pitch performance and to determine if a correlation existed between ball roll distance and free pile height. The indoor environment protected the measurements from the confounding effects of wind and precipitation, providing a controlled environment in which to assess the effects of mechanical wear from player usage on both ball roll and free pile height.

There was a general trend for the ball roll distance to increase and the free pile height to reduce with time. There was a strong, negative correlation (R= -0.967) between ball roll distance and free pile height. The ball roll distance increased above the FIFA 2* limit within the first twelve months of pitch life, however intervening drag brushing the surface was found to reduce ball roll distance to within the requirements, signifying the importance of regular drag brushing. Significant spatial variation (P<0.001) existed in ball roll and free pile height between high use and low use areas of the pitch. The study provides strong evidence on the effects of free pile height on the ball roll distance, indicating that pitch owners need effective maintenance to ensure the carpet pile remains upright to maintain ball roll distance to meet performance standards.

Selection and peer-review under responsibility of the Centre for Sports Engineering Research, Sheffield Hallam University

Keywords: Artificial grass; ball roll; maintenance; free pile height.

Selection and peer-review under responsibility of the Centre for Sports Engineering Research, Sheffield Hallam University
doi:10.1016/j.proeng.2014.06.146

1. Introduction

The demand for third generation (3G) artificial grass pitches (AGPs) with rubber and sand infill has increased at both professional and community levels. AGPs are often required to meet certain play performance standards on an ongoing basis to maintain certification, of which FIFA (2012) is the most widespread. However, pitch performance degrades with time and usage and ball roll is often a cause for a pitch failing the performance standards. There is a lack of academic research investigating the factors which cause ball roll distance (BRD) to increase. Jan-Kieft (2009) found that the BRD increased over a seven year period on 50 3G AGPs however only general usage and maintenance information was recorded and no investigation into the state of the system was undertaken to explain the change in ball roll data. Verhelst et el (2007) found that the ball roll velocity, and therefore BRD, decreased for systems that were brushed following artificial wearing in the laboratory, compared to unbrushed samples. Although on a different type of artificial turf, McLeod (2008) found that fibre direction affected the rolling resistance of a hockey ball. There exists a standard method, adopted by the sporting governing bodies, to artificially wear AGP samples in a laboratory environment. The Lisport method wears artificial grass samples by way of weighted studded rollers passing over the surface, commonly 5200 or 20,200 cycles depending on the type of testing. However, this testing is only combined with spot tests: force reduction; vertical deformation; vertical ball rebound and rotational resistance and negates the effects that mechanically wearing a surface can have on the ball roll. The standard Lisport method is limited in size, therefore correlating BRD and free pile height (FPH) can be advantageous for carpet manufacturers in designing new systems.

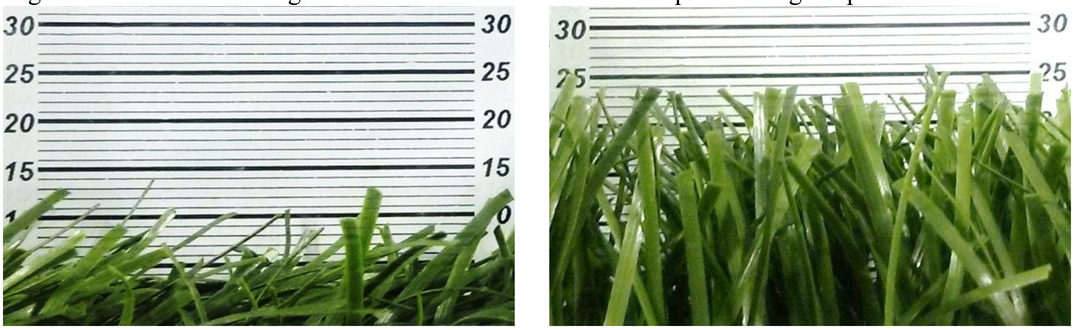

Figure 1 - Free pile height photos from different areas of the same pitch. Photo on the left from location E and photo on the right from location F. The twenty tallest fibres in each photo are averaged to calculate the free pile height measurement.

The purpose of this study was to measure the BRD and FPH (Figure 1) of an indoor 3G AGP to identify if a correlation existed between BRD and FPH and to determine the amount of change, in both, with actual usage of a pitch. In addition, spatial variation was also assessed. Fleming (2011) noted that pitch maintenance is generally thought to increase longevity of the pitch and ability to meet performance standards, but the effects have undergone little academic research. Industry maintenance guidelines, FIFA (2013) and SAPCA (2005) are generalised and provide only an overview of the main processes that can be undertaken. The frequency and intensity of maintenance is dependent upon the amount and type of usage, quality of AGP materials and environmental weathering. The outcome of this research will increase knowledge within the artificial grass market: to demonstrate to owners / operators and manufacturers that play performance declines with time and usage, particularly in early life.

2. Methodology

The indoor location provided a testing site where the primary wearing of the pitch was due to mechanical degradation from player use (thought to be a key mechanism affecting FPH) and reduced any influence from environmental weathering. The test measurements were also unaffected by the confounding factors of wind and precipitation, common in outdoor locations. The AGP was built in May 2012 and was of standard design to meet

FIFA 2* requirements, with a 50 mm monofilament carpet, sand and rubber infill, 15 mm rubber insitu shockpad laid on an asphalt sub-base. Since installation, the pitch received on average 28 hours of use per week. The Football Foundation (2009) adopted an equivalent usage formula, which takes into account the size of the pitch and the number of players, to represent the intensity of usage, rather than simply the hours of use. The formula is to be used for AGPs that were installed under the framework, however could be adopted elsewhere owing to the lack of alternatives. The formula is based on 22 players on 6,500m^2 playing area. The average equivalent usage of this

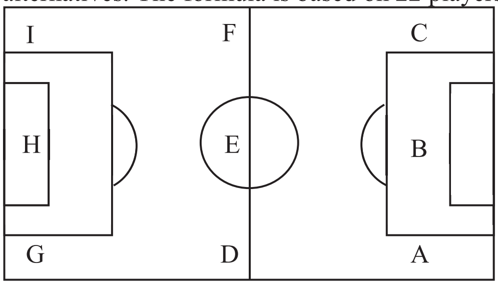

Figure 2 - Testing locations across the pitch. D, E and H are high use areas on this pitch. C, F and I see little use. Usage at location B began to increase as use was rotated across the pitch. Location G is near the entrance.

pitch would be 25.8 hours per week as the pitch is larger than 6,500m^2. The pitch was considered well maintained, with the grounds man maintaining the surface for one in every ten hours of use. This figure increased to one in every five hours of use, as it was noted the ball roll distance was increasing throughout the study. Maintenance consisted of regularly grooming the surface with drag brushes in a variety of directions, while decompacting and cleaning the infill every three months.

Eight data collection sessions were performed over the twelve month period in January, February, May, June, July, September, October and December 2013 (Figure 2). The nine testing locations were split into high (B, D, E & H), medium (A & G) and low (C, F & I) use areas following discussions with the grounds man. Location D would not traditionally be a high use area, however it is near where the players store bags, and the whiteboards are positioned for analysing play, and therefore involve the players huddled in the area regularly. Similarly A and G were considered medium use as were near the entrances to the facility and received increased foot traffic.

A football was released from a standard inclined ramp from a height of 1.0m, where the distance the ball rolled was recorded using a measuring wheel. Within each location, the measurements were taken in four directions at 90° to reduce the influence of pile orientation. Three BRD measurements were made in each direction. FPH measurements were made by averaging the twenty highest fibres using an angled prism (Figure 1). FPH is a measure of the average height of fibres above the infill material in their current state. Therefore a 50 mm carpet pile with 30 mm infill depth has a capacity for a FPH of 20 mm. However if the fibres are not in a vertical orientation the FPH will be less than 20 mm. The FPH test method was adapted from the Rugby Football League standard (2011), where the ten highest fibres are averaged. However it was felt that by only including the average of ten fibres, outliers would have a bigger influence of the FPH measurements; particularly relevant for flattened samples where a few fibres may be upright but the majority are flattened. Four measurements were made in each ball roll direction, one at the start of the ramp, two in the middle of the ball roll, and one near where the ball came to rest. Infill depth measurements were made in the same position as the FPH measurements.

Means and standard deviations for BRD and FPH were determined for: each of the nine test locations; data collection sessions; and high use and low use areas. Significance testing was completed to determine if the BRD and FPH was different with the significance set at $p \leq 0.05$. Independent samples t-test analysis was undertaken between the high and low use areas, while dependent samples t-test analysis was completed between the first and last data collection session. Pearson product moment correlation coefficient analysis was undertaken to determine if a correlation existed between BRD and FPH.

3. Results

There was a general trend for the BRD to increase and the FPH to decrease with time (Figure 3). The average BRD increased from 7.1±1.2 m in January 2013 to 10.2±1.8 m in December 2013. Following the pitch installation in May 2012, the average BRD was 5.0±0.2 m in six locations across the pitch. Thus, the average BRD increased by 104.0% over an eighteen month period and by 43.7% during this twelve month study. The FPH decreased from 23.2±4.6 mm in January 2013 to 15.1±5.0 mm in December 2013, equating to a decrease of 34.9% during this study. There was little variation in the infill depth measurements, other than a 1.3mm average increase in May 2013, due to a ten tonne rubber top-up which occurred prior to the May testing date. The change in BRD between January 2013 and December 2013 was significant at P=<0.001 and FPH at P=<0. 01. The individual BRD and FPH measurements from each location and test session showed a strong negative correlation R= -0.967 (Figure 4).

Spatial variation existed across the pitch for BRD (Figure 5) and FPH (Figure 6). The average ball roll in the high use areas was 10.0±1.4 m and 6.7±0.8 m in the low use areas over the twelve-month period. The average FPH in the high use areas was 14.9±4.1 mm and 24.1±2.7 mm in the low use areas. The difference in BRD and FPH between the high and low use areas were both found to be significant (P=<0.001).

4. Discussion

The BRD increased significantly (P=<0.001) between January and December 2013, highlighting a change in a relatively short period of time when compared to the expected life of AGPs. The ball roll distance exceeded the 10m requirement of FIFA 2* within the first twelve months of installation, in locations E and H. However, the

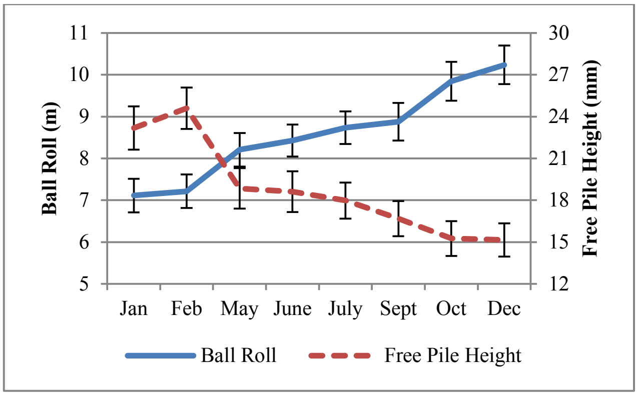

Figure 3 - Averaged monthly ball roll and free pile height. Error bars represent standard error.

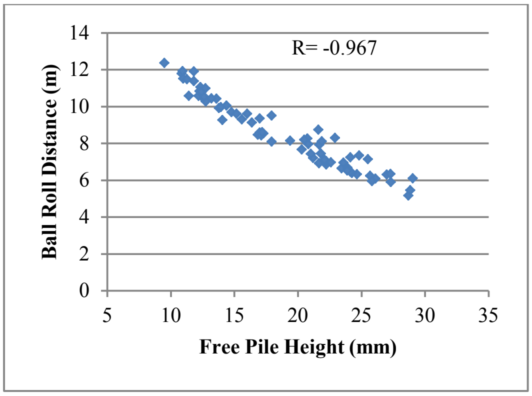

Figure 4 - Ball roll distance and free pile height correlation for a single pitch over a twelve month period.

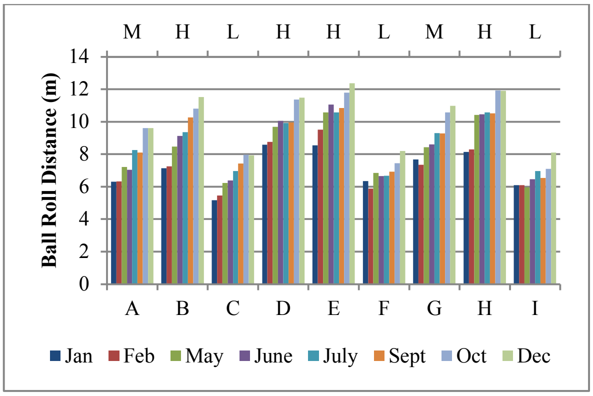

Figure 5 - Average ball roll distance in each location (A-I) over eight test dates. H, M and L refer to high, medium and low use areas.

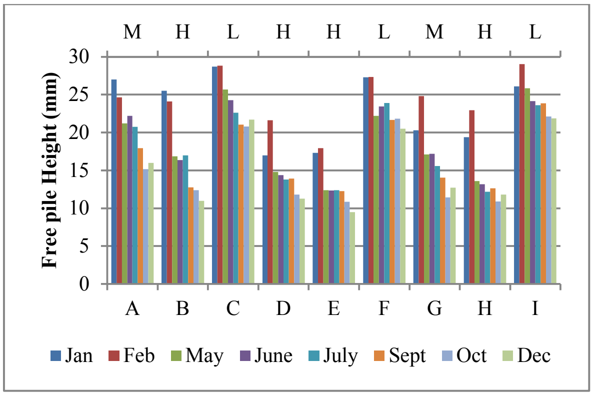

Figure 6 – Average free pile height in each location (A-I). H, M and L refer to high, medium and low use areas.

AGP achieved FIFA 2* certification following maintenance of the surface twelve months after initial testing. Five of the nine test locations exceeded the ten metre requirement within eighteen months of installation, which demonstrates on-going deterioration of the play performance. The significant reduction in FPH during this study indicates that the carpet pile bent and flattened due to interaction with players. The small (1.3mm) increase in infill depth in May 2013 was less than the decrease in FPH between February and May, suggesting some flattening of the carpet pile.

The AGP received on average 28 hours of use per week, however much of this use was concentrated into approximately 3000m^2, until the areas of use began to be rotated around the pitch. Using the Football Foundations (2009) equivalent usage formula, for the reduced area, equates to 68.8 hours of equivalent use per week, with 25 players. The concentration of use in the reduced area coincided with the areas exhibiting greatest reduction in FPH and increase in BRD throughout the study. 28 hours of use would not be considered excessive or insignificant for AGPs, however 68.8 hours would be considered high, particularly for FIFA 2* AGPs. The usage began to be rotated around the pitch from May 2013 onwards however there was slow adoption from users of the pitch.

The BRD and FPH demonstrated a strong negative correlation (R= -0.967). The flattened pile is thought to cause less resistance to the rolling ball and is likely a major contributor to the increase in the average BRD. The strong correlation would suggest that the fibres need to be brushed to a vertical orientation to maintain the ongoing BRD performance.

Pile orientation was thought to affect the BRD based on observation, however it was difficult to quantify the degree of orientation (Figure 1). The BRD was consistently greater in the direction from location F towards location D, compared to the opposite direction (Figure 2). This could have been due to the manufacturing process or storage of the carpet rolls prior to installation, which may cause a tendency for the fibres to lean in a certain direction. This phenomenon existed across the entire surface, however the difference between the BRD in opposite directions was 1.2 m (9.1 m and 10.3 m) in the high use areas and 0.2 m (6.4 m and 6.6 m) in the low use areas. This demonstrates that when the fibres were upright, the pile direction had less impact on ball roll. The February testing data was collected after the surface was brushed, causing an increase in the FPH. However, the BRD also increased, which is opposite the general trend of BRD compared to FPH. The reason for the increase in both BRD and FPH in February is unknown. The bending resilience and density of fibres are also thought to affect the BRD, although did not form part of this study.

There was significant spatial variation across the pitch with increased BRD and decreased FPH in the high use areas compared with low use areas. Strengthening the association of mechanical wear from players flattening the carpet pile. This increases the widely known assertion that player usage should be rotated around the pitch, which highlights the requirement for better management of pitch usage, particularly for those AGPs requiring on-going play performance certification.

5. Conclusion

There was a significant increase in BRD and decrease in FPH with time. The BRD and FPH demonstrated strong correlation (R= -0.967) suggesting that the height of the carpet pile above the infill material, FPH, influences the BRD. The strong correlation between BRD and FPH suggests that FPH could be measured during Lisport wear testing as a method to estimate the likely effect of mechanical wearing on ball roll properties when manufacturers are designing new systems. There was significant ($P<0.001$) spatial variation in ball roll and FPH between high and low use areas across the surface. The significant spatial variation highlights a need to rotate player use which will minimise effects from uneven wear. This is not possible for traditional match play, but can be incorporated into rotating the areas used for training, warm-ups and small-sided games. The ball roll distance in high use areas began to fall outside of the FIFA 2* requirements within twelve months of installation, however maintenance was found to decrease the BRD to within the requirements.

Further analysis needs to be undertaken to assess the effects of drag brushing the surface, including the brushing direction to prolong the life of AGP systems. The regular ball roll and FPH testing should be completed on a range of 3G systems from various manufacturers, in early pitch life, to determine whether similar effects are found to those in this study. The results from this study would suggest further development in yarn technologies and maintenance techniques are required to maintain FPH, and hence ball roll performance for longer.

References

FIFA., 2012. FIFA Quality concept: Handbook of requirements. , http://www.fifa.com/mm/document/footballdevelopment/footballturf/01/13/56/08/fqchandbookofrequirements(january2012).pdf

FIFA., 2013. How to maintain an artificial turf field. Visited online: http://www.fifa.com/mm/document/footballdevelopment/footballturf/01/51/73/34/fifastepguidemaintenance.pdf.

The Football Foundation., 2009. Framework contract for the provision of artificial grass pitches for the rugby football union, the football association and the football foundation.

Fleming, P.R., 2011. Artificial turf systems for sport surfaces: current knowledge and research needs. Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology 225, pp43-64

Jan-Kieft, G., 2009. Quality Monitoring of 50 Artificial Turf Fields. In: SportSurf 7th Workshop 'Maintaining Performance of Synthetic Surfaces'. Loughborough University.

McLeod, A. J., 2008.The management and maintenance of second generation sand-filled synthetic sports pitches. . Cranfield University.

SAPCA,. 2005.The SAPCA code of practice for the construction and maintenance of synthetic turf sports pitches. , 3rd.

Rugby Football League., 2011. Performance and Construction Standards for Synthetic Turf Rugby League Competition and Training Pitches. Online: http://www.rflfacilitiestrust.co.uk/_uploads/RFL%20Performance%20Standard%20for%20synthetic%20turf%20pitches%20(11-10-11).pdf

Verhelst, R., Verleysen,P., Degreieck,J., Rambour,S., Schoukens,G., 2007. Development of a setup for the study of ball roll behaviour in soccer on artificial turf. SportSurf conference. In: The Inaugural SportSURF Conference: Science, Technology and Research into Sport Surfaces (STARSS). Loughborough University Enterprises Limited