Pitch Properties and Performance

ECB

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Introduction

This report presents a summary of the major findings from recent work carried out by the England and Wales Cricket Board's Pitches Research Group. The findings are comprised from three major studies which are briefly outlined below:

Pitch coring programme

Soil cores were taken from pitches by groundsmen at the start of County Championship matches over the period 1996 to 2002. Cores were sent to either the Sports Turf Research Institute (STRI), Bingley or the University of Wales, Aberystwyth where their soil composition was ascertained through a detailed analysis.

Detailed pitch monitoring programme

Detailed measurements of pitch condition and surface performance were recorded at the end of 69 County Championship cricket matches from 1998 to 2003. The information recorded included; ball bounce, hardness, grass cover and condition, cracking and surface damage. Surface friction was determined on some pitches from 2000.

High speed video analysis of pitch performance

Objective measurements of pitch pace, bounce and consistency were achieved using a high speed video system. These measurements were carried out during 40 match visits when 100 ball impacts were filmed on the third day of each match.

Pitch performance criteria

The four key playing characteristics of pitches are bounce, pace, consistency and turn. Most pitches change in one or more of these characteristics over time with the main changes taking place during the first three days of County Championship matches. When either bounce or pace change this may involve either an increase or decrease with a similar proportion of pitches changing in either direction. When consistency changes, pitches always become less consistent in either bounce, or pace, or both. The response of pitches to spin bowling usually increases over time, however, a pitch that is moist at the start of a match will show some early turn until it dries out.

Assessment of playing characteristics

Umpires assessments of bounce and consistency of bounce correlate quite well with objective assessments by high speed video and with either the vertical rebound height of a ball dropped from 3 metres or hardness measurements taken using a 2.25 kg Clegg impact hammer. Also, umpires' comments on the ability of a pitch to take spin are related to the proportion of the soil surface that is damaged on a spin bowlers pitching area.

Pace is the degree to which a ball is slowed on impact with the pitch and high speed video makes it possible to quantify pace reliably. Bowled balls are slowed to a relatively small extent on well prepared pitches and the difference between pitches is rather small. The approximate range in values for first class pitches is from a ball retaining 93% of its speed on a fast pitch to retaining 85% of its velocity on a slow pitch. Umpires' assessments of pace are not related to objective measurements using high speed video, but they are correlated with their own assessments of bounce. It has been concluded that it is impossible to assess the pace of a pitch visually and that umpires are therefore unable to compare the pace of pitches directly. It has also been shown that umpires' assessments of pace are based primarily on 'ball carry'. This latter conclusion is drawn from the observation that umpires' assessments of bounce and pace are correlated with each other. The angle of lift of a ball after impact with the pitch is determined substantially by the 'bounce' characteristics of the pitch so a ball impacting on a 'bouncy' pitch will have a steeper angle of lift and therefore a better 'carry'.

Objective determinations of pitch playing characteristics

A consensus of players and umpires on the playing characteristics of a pitch has to be accepted, by and large, as reality despite the subjective nature (and possible bias) of the assessments. There is no value in having objective, quantitative values that are unrelated to any component of pitch performance experienced by players and umpires. The main aim of scientific research into pitch behaviour is to understand and explain the reasons for perceived pitch behaviour and to devise measurements that objectively and reliably quantify that behaviour. Such measurements enable grounds staff to rate and predict the performance of their own pitches and to compare their pitches with others in the UK and elsewhere.

Research at Aberystwyth in the late 1960s that identified a correlation between umpires and players' assessments of bounce and the vertical rebound of a cricket ball has been confirmed by more recent research including the use of high speed video. Furthermore, it is now apparent that umpires' assessments of pace are affected by a pitch's bounce characteristics so that bounce measurements provide an estimate of both bounce and perceived pace. The most important recent finding with regard to bounce is that pitch hardness determined using a 2.25 kg Clegg hammer is as good a predictor of bounce during play as the vertical rebound height of a cricket ball.

Sufficient data has been obtained in the pitch monitoring programme to provide predictive values for pitches with good bounce and perceived pace characteristics. A target value for the vertical rebound height from 3 m is 55 cm (18%). This is around knee height from a 10ft ball drop. For a 2.25 kg Clegg hammer dropped from 450 mm, the target value is 360 g.

The three metre ball drop test.

Umpires' reports indicate that consistency of bounce is the most valued characteristic of a pitch. The variability in both measured bounce and Clegg impact hardness are correlated with both high speed video measurements of consistency and umpires' assessment

The Clegg impact hammer.

of consistency. However, it is necessary to carry out a fairly large number of readings to achieve a reliable assessment of variability. In the detailed pitch monitoring programme 36 determinations of bounce were carried out over the ball pitching area. For this number of observations, pitches with a coefficient of variation in rebound height greater than 20% of the mean and/or hardness greater than 15% were usually described as inconsistent. This degree of variation is comparable with a range in measurements from about three quarters of the mean value to one and a quarter times the mean. A minimum number of 20 recordings need to be made of bounce or hardness along the pitch. Where the highest three values are at least double the lowest three recordings the pitch will definitely have inconsistent bounce.

Superimposed high speed video images of the cricket ball trajectory (blurred image of batsman to the left).

The coefficient of friction of a ball on a pitch is about 30% greater on a pitch with very thin grass cover compared with very dense cover so turn might be expected to increase with a decrease in grass cover. However, during the pitch monitoring programme umpires' turn ratings were not significantly correlated with percent grass cover. Umpires' assessments of turn were correlated with the extent of damage to the pitch surface and umpires reported moderate or considerable turn when more than around 15% of the soil surface on a spin bowlers pitching area was damaged.

It is possible to determine the true pace of a pitch using high speed video but not by visual observation. If wet pitches are excluded, variations in true pace between pitches are quite small. Nevertheless the differences have been shown to challenge a batsman's judgement especially when playing across the line of a ball. It has been established that it is possible to predict true pace by combining measurements of vertical rebound height and surface friction. As well as quantifying the difference in true pace between pitches, high speed video analysis has shown pace to exhibit variation at different locations on a single pitch. On a pitch with inconsistent pace, trajectory analysis has shown the range in horizontal positions of a ball bowled by a fast bowler can vary by about 25 cm prior to impact with the bat. Pitches with uniform grass cover and consistent bounce will have consistent pace and it may be that consistency of pace on a pitch is more important than the absolute pace of a pitch to which a batsman rapidly becomes adjusted.

Soil and turf factors affecting playing characteristics

With few exceptions, topsoils on county cricket squares have clay contents in the range 27-33%. It has been long established that soils with clay contents less than about 24% have insufficient binding strength. They are liable to break up during play to produce a dangerously inconsistent playing surface. Whilst many cricket squares throughout the world have very clay-rich soils, in the UK climate, soil drying is often difficult. Increasing clay content tends to increase the time required to dry out the topsoil. Furthermore, there is no evidence that clay contents greater than 33% are needed to achieve the highest pitch quality. In essence, provided a square has around 150 mm depth of uniform topsoil with a clay content of around 30% supported on a solid base it has the potential for excellent pitches.

Organic matter content is also important and soils used for construction or topdressing should have an organic matter content no greater than 8% otherwise organic matter will have a large effect on physical behaviour including water retention and soil strength. At the same time organic matter content usually reflects a soil's biological activity so soils with less than 3% organic matter should not be used as a topsoil in pitch construction although soils with a slightly lower organic matter content can be used for topdressing.

Statements made in the previous paragraph need to be explained further because they relate to pitch usage, geographical location of the ground and pitch construction. Although it is undesirable to use soils with clay contents less than 26% (ASSB strength less than 50 kg) on county squares and others that may host three or four day matches, soils at the lighter end of the acceptable range are easier to handle, exhibit less shrinkage (and therefore less cracking) and can be dried out more easily. Construction trials at the STRI showed that soils at the lower end of the acceptable clay content range produced a better performance than more clay rich soils when adverse weather made drying difficult.

Many cricket squares are on native subsoil and this applies to several county headquarter grounds. In the midlands and south/south east of Britain this is rarely a problem to the drying out of pitches unless there is a shallow water table that persists into the playing season. If a shallow water table exists it can be lowered by installing a ring drain around the square plus, on large squares, additional drains between blocks of four pitches connected to the ring drain. The ring drain should be no shallower than 760 mm and backfilled over the plastic drainage tube with clean angular gravel to 150 mm from the surface. A suitable outfall for drainage with a sufficiently deep invert level must be located or engineered.

For newly constructed pitches, soil drying and subsoil drainage can be improved by installing a subsoil drainage layer of angular gravel with linked pipe drains. The gravel drainage layer should be not less than 150 mm thick. This layer will create a suspended water table at its interface with the overlying soil so the total soil depth must be at least 300 mm to create sufficient hydraulic head for drainage. The top 150 mm (100 mm minimum) of topsoil must be uniform and have a constitution suitable for producing pitches. The lower soil can be lighter in texture but no lighter than a loam. Very sandy soils or sand do not provide an adequately stable base to produce pitches with good bounce and in any case the major difference in swell/shrink behaviour is liable to induce a break at the junction with the topsoil.

Umpires' reports suggest that consistency of bounce is the most valued characteristic in a pitch. Other properties that influence umpires' ratings are: uniformity of grass cover, high bounce and carry, pitch dryness and the development of turn later in the match. With the desirable pitch characteristics identified it is possible to examine the soil and turf factors that affect them and assess what control a groundsman can exercise in the short or long term to produce pitches with good characteristics.

Of the five properties, uniformity of grass cover is clearly a maintenance issue determined by the quality of turf culture. Timeliness in pitch repair and renovation after use is very important. The cultivars of perennial ryegrass now available germinate and establish rapidly given good soil preparation. It should be appreciated that uniform grass cover doesn't necessarily imply uniformly dense grass cover and there are pros and cons for this which are discussed later.

Adequate drying out of the soil is essential to achieve a pitch's potential bounce. Furthermore, no excessively moist pitches examined in the ECB monitoring programme were reported by umpires as having better than moderate pace. Whilst in the past it was acceptable to use visual assessment of cricket pitch soils, pitch maintenance and preparation now requires quantitative data on key factors such as organic matter content and distribution, moisture content and the quality of consolidation. Cores taken from pitches, typically 100 mm deep and 15 mm in diameter, can provide important information for cricket groundsmen and results from these should form part of a routine monitoring programme. The table below provides a guideline for target gravimetric moisture contents of prepared pitches. It should be noted that these are related to soil organic matter content. The data refer to pitches that have received good consolidation by rolling.

Recommended maximum gravimetric moisture content in the 0-60 mm depth of prepared pitches (clay 27-33%)

% Organic matter	Less than 6%	6-10%	More than 10%
Max moisture (%)	18	20	22

Having dealt with the two most straight forward desirable pitch properties the more difficult characteristics can be considered, firstly ‘good bounce and pace’. In this case soil constitution, pitch preparation and turf character are all involved. With regard to soil constitution, the earlier statement that it should be homogeneous in particle size distribution over the top 150 mm applies. Clearly the soil organic matter content will decrease over this depth typically from about 10% to 6%. Assuming that a suitable soil is used for the pitch it has to be consolidated by rolling and dried out to achieve its potential bounce and pace. For a soil with a specific particle size distribution and known organic matter content, soil bulk density provides a target value for the adequacy of consolidation. For soils with 27-33% clay the following table provides guidelines on the bulk density of prepared pitches

Target bulk density for any 20 mm deep section in the top 80mm of prepared pitches

% Organic matter	4	6	8	10	12
Bulk density (g/cm^3)	1.75	1.65	1.55	1.45	1.35

An important factor influencing bounce and pace is the percentage cover of green (living) grass. Most of the grass on well prepared pitches is desiccated and yellow/brown. The cover of green grass is more important than total grass cover but it is quite difficult to assess visually or by any other method. As an illustration a pitch with 60% total grass cover with 20% green grass (12% green grass cover) would have less bounce and perceived pace than a pitch with 40% total grass cover and 50% green grass (20% green grass cover). There are several methods a groundsman can use to control the amount of green leaf tissue on a prepared pitch. Clearly the greater the total grass cover the more likely will be a greater amount of green leaf but it is also possible to increase or decrease the proportion of green leaf in the total grass cover by modifying mowing strategy during pitch preparation.

We are uncertain whether or not fibre at the pitch surface is advantageous to bounce and pace although tight grass cover is generally beneficial. In any case there are potential hazards in allowing organic matter to accumulate. If a thatchy surface is allowed to develop the surface may break up in play and it may prove impossible to remove sufficient plant material to enable topdressings to be integrated with the surface soil. Routine pitch coring of county pitches has enabled guidelines to be drawn up on acceptable organic matter contents.

In principle, provided the organic matter content of surface 20 mm is controlled there will be no problems at greater depth. The target for maximum organic matter in the 0-20 mm depth section is 10%. If the organic matter content of this section exceeds 12% there is serious cause for concern because thatch is accumulating and remedial measures to remove it should be put in place immediately.

It is desirable that pitches should begin to take spin as matches progress because it increases the range of bowling talents that can be exploited. A bare or lightly grassed pitch surface has a greater friction with the ball than a tightly grassed surface but the difference is not large. A similar degree of difference has been demonstrated in laboratory trials using bare soils of similar clay content but different proportions and sizes of sand fractions. Tightness of grass cover is probably not of direct importance to turn but the surface of pitches with light cover is more likely to become damaged by wear so there is an indirect effect. Superficial surface damage is the key to increasing turn but care must be exercised in designing pitches that develop favourable spin characteristics. Groundsmen have been known to topdress pitches with sand or sandy soil to increase turn. This can be successful in the short term but serious problems in pitch maintenance develop with time because a build up of sandy soil results in a weak binding soil that may break up and become dangerous. Furthermore, topdressing a pitch with a clay rich soil on a sand dressed pitch will inevitably lead to crusting and surface break-up. Choosing soils for pitches with adequate but not excessive binding strengths is probably the best solution so that wear during play causes sufficient surface damage to favour spin.

Inconsistent bounce is often attributed to a cracking of the soil and many players assume that a pitch with visible cracks will have inconsistent bounce. Whilst pitches with visible cracks may have inconsistent bounce, the cracks themselves are not the cause of the problem. In virtually all cases on well maintained and well prepared pitches inconsistency in bounce is due to the occurrence of one or more horizontal breaks in the soil which prevent cohesion with depth. In these situations the topsoil comprises a series of slices or layers rather than a coherent block. Whilst the problem has been recognised since the 1970s there is still some uncertainty about all the potential causes. From the 1950s to the 1980s the most common causes were:

1. Inadequate scarification prior to topdressing so that grass residues become sandwiched between topdressing and topsoil.
2. Use of different soil topdressings with different binding strength and swell/shrink characteristics.
3. Use of different soils within the top 150 mm to construct pitches.

In recent years with developments in maintenance equipment and a wider understanding of soil technology some of the earlier causes have decreased in importance and poor integration of soils in pitch construction and possibly unsuitable rolling practices have come to attention. Of critical importance is that a single year of incompetence in topdressing practice (incorrect soil or inadequate surface preparation) can be the cause of serious pitch problems more than a decade later.

There are four important aspects concerning pitches with discontinuities or breaks in pitch profiles:

1. Retaining more moisture during pitch preparation sustains consistency of bounce because water films help to hold discontinuous layers together. The inconsistency of bounce increases markedly as the pitch dries out.

2. When a potential break is at a shallow depth, root binding across the break helps maintain consistent bounce. Roots cease to bind across breaks that are deeper than about 40 mm.
3. Pitches that develop extensive cracks and also have discontinuities with depth show the most dramatic inconsistencies in bounce.
4. Once discontinuities have developed they recur each season and no known soil cultural technique can eliminate them.

Lack of soil cohesion with depth is the most widespread and important problem causing inconsistent bounce and failure of pitches to achieve potential bounce and pace. There are however some examples of pitches where playing quality has been sustained for around fifteen years from construction with no development of discontinuities in the profile. It remains uncertain whether playing quality can be sustained indefinitely given good groundsmanship.