International Turfgrass Society
Research Journal Volume 8, 1997.

AN INVESTIGATION OF THE PACE AND BOUNCE OF CRICKET PITCHES IN NEW ZEALAND

K.W. McAuliffe and R.J. Gibbs

New Zealand Sports Turf Institute, P.O. Box 347, Palmerston North, New Zealand

ABSTRACT

A study was initiated to advance the science of cricket pitch pace and bounce assessment by utilising technology available in other spheres of science (e.g. electronics and engineering) for the construction of a pace and bounce test apparatus. The apparatus used a high-powered crossbow to deliver a cricket ball onto a pitch at 25 m/s and a series of light sensors to measure the ball's speed on to and coming off the pitch. The apparatus also measured the height of bounce by using a series of light sensors arranged in an arc of 30° radius. For each measurement it was possible to calculate the percentage of speed reduction (loss of pace) from the delivery and rebound speed, the rebound bounce height as well as the variation associated with replicate measurements.

Trials of the apparatus were carried out during the 1994/95 and 1995/96 seasons at five first class venues around the country. The overall percentage reduction in speed at these venues ranged from 9.6% to 14.8%. Variation in speed reduction ranged from 7.3% to 16.4%, whereas variation in bounce height ranged from 0.0% to 16.3%. The results highlighted the extent to which pitch construction and management could influence pace and bounce. There was generally a poor comparison of measured values with umpire and captain reports, although in general the above results represented pitches of a slow to medium category of pace.

A series of mini-trials was also conducted to look at the effect of a range of factors on speed reduction and bounce height. The results showed that ball age, presence or absence of grass and selected artificial surface amendments (beeswax and graphite) had a significant effect on speed reduction, but less of an effect on bounce height. Implications of these results are discussed.

The apparatus has the potential to be developed further, but in its current state is considered best suited to replicated, scientific trials where the detail of the above interactions (and others) can be determined under controlled conditions.

INTRODUCTION

First class cricket in New Zealand is a high profile, popular sport which has a requirement for both quantity and quality of playing surfaces (McDermott 1994). The game of cricket is arguably more dependent on the quality of the playing surface (notably the pitch) than perhaps any other sport. Good cricket can only be played if a pitch provides consistent ball bounce of an acceptable height, with the ball coming off the pitch on to the bat at a fast enough pace to make a lively and entertaining game. A second component is that pitches must be safe, i.e. that the bounce is not irregular and dangerous.

With the advent of television coverage and the high public profile of cricket, the pitch has become a major focal point for criticism. Attention is frequently drawn to the interpreted quality of the pitch at the very start of every game, or indeed any innings. This subjective judgement can be unreliable, with conflicting assessments often given for the same pitch at any one time. An objective method of assessing pitch pace and bounce would therefore not only help the turf manager, but also give more credibility and accuracy to reports on pitch performance.

Adams and Gibbs (1994) have summarised previous research carried out overseas and in New Zealand that has helped understand the key factors affecting the performance of cricket pitch soils. The first efforts to quantify the playing characteristics of cricket pitches were reported by Stewart and Adams (1969). These researchers examined the effect of various soil properties on ball rebound behaviour and concluded that there was a general relationship between vertical ball rebound height and pace as perceived by players. Dury (1985) used a series of tests, including a bounce test, but no attempts were made to measure pitch pace directly. Dury suggested that pace could be inferred from the vertical bounce height.

Reported attempts to directly measure cricket pitch pace have been published by McAuliffe and Tuohy (1987). As part of a research program to investigate a range of potentially suitable cricket pitch soils, a video analysis method was developed involving a modified clay pigeon shoot to deliver a standard cricket ball. A video camera placed perpendicular to the delivery was able to record the trajectory of the ball against a back screen. Slow motion replay and analysis of the trajectory was able to give the speed of the ball, both before and after contact with the pitch.

As part of a broader study into NZ cricket pitches, Murphy and Field (1991) adopted a sled device to give a gauge of pitch pace through surface friction measurement. It was however considered that the device in question did not accurately reflect a cricket ball striking the surface of a pitch. Surface friction measurement devices have also been developed overseas to quantify the playing qualities of synthetic surfaces (Holmes and Bell 1987). These devices have generally sought to measure the surface/player interaction, rather than the surface/ball interaction.

One recent innovation to televised cricket in New Zealand has been the reporting of bowler delivery speeds. Delivery speed is now able to be accurately measured using radar technology. Whilst this technology measures ball speed at the time of delivery, it currently cannot provide information on the performance of the ball after it strikes the pitch.

Murphy and Field (1991) undertook a study into pitch pace of New Zealand cricket pitches. Using match reports to subjectively access pitch pace they were able to identify a number of soil properties which were deemed to determine pace. However, they were unable to directly measure pitch pace and concluded that not only was there a requirement for such a method, but also there was a need for further research into how fast pace pitches should be prepared. It would be a significant step forward if a new pace/bounce tester could be developed to validate Murphy and Field's model.

Thus it can be seen that most research carried out to date has had to rely on indirect assessments of pitch performance, such as soil density and moisture content or surface hardness (McAuliffe and Gibbs 1993). Such indirect assessments are a useful starting point to give turf managers comparative information on pitch characteristics, but they are limited in that none of them monitor pitch behaviour in any *direct* way. This paper describes the development of an apparatus that directly records the delivery and rebound speed of a cricket ball delivery and its height of bounce, and the results of its subsequent trial during the 1994/95 and 1995/96 cricket seasons.

MATERIALS AND METHODS

Design of pitch pace and bounce tester

Firing side

The prototype apparatus used a high-powered crossbow to propel a cricket ball without spin down a firing barrel made from PVC tube of internal diameter 76 mm. Within the tube was a firing rod connected to the string of the crossbow. The firing rod imparted its energy onto the cricket ball by means of a machined aluminium padded cup attached to the end of the rod. Firing speed was measured by mounting two sets of laser diodes and diode detectors at the end of the firing barrel a distance of 10 cm apart. These sensors were linked to a high frequency circuit which counted the number of waves that passed through the circuit between the time taken for the ball to travel the 10 cm separating the sets of sensors. By knowing the frequency of the current (10 MHz), it was possible to convert the number of waves counted to a time in seconds. The firing speed of the cricket ball was calculated by dividing the distance travelled by the time taken.

Calculations using the dimensions of a bowler at the point of delivery were used to determine the angle at which the ball should be fired onto the pitch. Angles of 16 and 20 degrees were selected, with the facility to use either being provided by a hinged construction on the frame (Wilkins 1995). Results in this paper refer to an angle of 16 degrees only.

Target side

The target side of the apparatus involved measuring the speed of the ball after impact with the pitch surface and the angle at which the ball left the pitch. Because the ball could leave the pitch surface along a range of slightly different pathways due to deformation during contact, two sensors, rather than one, were used to pick up the ball at the first timing point after it had left the pitch.

The second set of sensors beyond the point of impact were arranged on an arc of 30° radius. This arc was located at a 900 mm radius from the mid point of the line between the two sensors near the point of impact. Twelve sensors were arranged around the arc, with each of the eleven spaces separating the sensors representing 2.4° of the arc. The separation of the sensors was such that the ball passing across them could break one beam or two beams. If two beams were broken, the line of passage was presumed to be exactly half way between the two. A 23 point scale resulted whereby the angle of bounce and its relation to stump height (as intersected by a ball landing 1.83 m in front of the batting crease) corresponded to the various possible sensor activations. The speed of the ball after impact was calculated in the same way as with the firing side. A schematic diagram of the apparatus is shown in Fig. 1.

Operation of apparatus and calculation of results

The apparatus provided four types of information: the speed and angle (fixed initially at 16°) of the ball fired onto the pitch, and the speed and angle of the ball bouncing off the pitch. By the nature of the design, the firing speed was relatively constant (approx. 25 m/s). Speed was displayed as the number of cycles of high frequency current that passed through the circuits during the time interval between the ball breaking one laser beam and breaking the next beam. The angle of bounce was shown on a scale alongside an array of lights and noting which light or pair of lights was illuminated. The angle of bounce was subsequently converted to the equivalent fraction of stump height.

Each firing used a standard two-piece Kookaburra cricket ball. Standard firings positioned the ball with the smooth side down to avoid potential variation caused by the seam (although the position of the seam was also investigated as a variable in its own right). A new or relatively new ball was used for each group of firings such that each contact with the pitch was made on an area of the ball with a good shine remaining.

For each firing, the firing speed, rebound speed and equivalent stump height (of bounce) were calculated. A total of 10 firings were normally made per pitch, with five firings being made at each end of the pitch within an area approximately 2 m in front of the batting crease in line with the stumps. The apparatus was moved 10-15 cm between each firing. For each measurement, the percentage retention in speed was expressed as the ratio of the rebound speed over the firing speed. The percentage reduction in speed was simply calculated by subtracting the percentage retention from 100.

For each group of ten measurements of percentage speed reduction and bounce height, the mean and standard deviation (σ, n-1) was calculated. The percentage variation in speed reduction and variation in bounce height was defined as the standard deviation expressed as a percentage of the mean (the coefficient of variation).

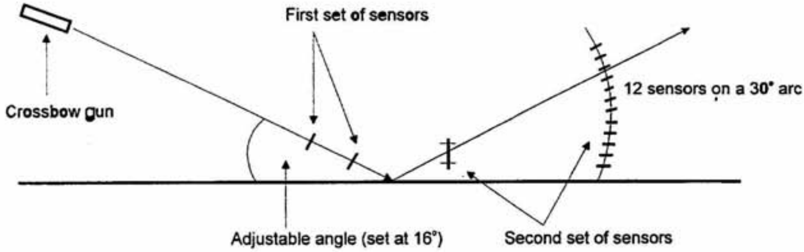

Figure 1. Schematic diagram of pitch pace and bounce tester

Trial program

Two types of trials are reported here. During the second half of the 1994/95 cricket season when the apparatus first became available, it was transported around the country for quantifying pitch performance at first class or international cricket fixtures. A total of 10 pitch assessments were made to gauge the reliability of the apparatus and the range of values likely to be recorded on different soil types and pitches. During this trial, 10 firings were normally made per pitch (five at each end) using a new or near-new cricket ball firing smooth side down. At the end of the cricket season, the speed and bounce results were compared alongside NZ Cricket's own match reports of the performance of the pitch.

During the 1994/95 cricket season it became apparent that the speed reduction results were affected by factors relating to the ball/surface interaction. Thus small-scale trials were initiated during the end of the 1994/95 season and during the 1995/96 season to examine these factors in more detail at selected venues. Factors investigated were:

(i) The effect of different grass density (eg. bare versus well-grassed locations).
(ii) The effect of a new ball versus an old ball.
(iii) The effect of contact with the pitch by the smooth surface of the ball compared with contact by the seam of the ball.
(iv) The effect of artificial amendments applied to the pitch surface (graphite spray, beeswax cream and domestic spray polish).

During this part of the study, five replicate firings were normally made for each treatment being investigated. The Student's T-test (variance assumed to be equal) was used to determine if differences between pairs of treatments were significant. Unless otherwise stated, the smooth ball side was used on a grassed part of the pitch.

RESULTS

Performance assessment

The apparatus was considered to have advantages in several respects. Firstly, the advanced electronics enabled precise measurement of speed (both delivery and rebound speed) such that variation in recorded speed could be attributed directly to external factors. Secondly, the apparatus allowed precision targeting of the tested delivery such that the delivery could be located at specific points on a pitch (e.g. a crack, clump of turf or bare spot). However, several improvements would be required to develop the apparatus to a fully robust piece of testing equipment. These include improving portability of the device, strengthening the ball delivery unit (especially the crossbow strings, which usually snapped after approx. 50 firings) and developing a delivery mechanism that provided a greater firing speed (e.g. up to 33 m/s). Furthermore, substantial modification would be required if the bowler's action was to be studied in detail (e.g. the effect of spin on pace and bounce).

Range of recorded speed and bounce measurements

During the 1994/95 season the average speed reduction ranged from 9.6% at Eden Park, Auckland to 14.8% at Fitzherbert Park, Palmerston North (Table 1). The average percentage variation in speed reduction (coefficient of variation) ranged from 7.3% at Eden Park to 16.4% at the same venue on a different date. The average bounce height, expressed as a fraction of stump height, ranged from 0.79 at Eden Park to 0.90 at the same venue on a different date (Table 1). The average variation of bounce height (coefficient of variation) ranged from 0.0%, also at Eden Park, to 16.3% at The Basin Reserve, Wellington.

There was no significant relationship between percentage speed reduction and bounce height. Pitches with the largest percentage speed reduction (i.e. the slowest paced) were not necessarily associated with the largest variation in speed reduction and pitches with the largest variation in speed reduction were not necessarily associated with the largest variation in bounce height.

Efforts to relate recorded speed and bounce values with umpire and captain assessments yielded relatively limited information (Table 1). Some games did not have registered returns and in other cases there were conflicting pitch assessments made by the officials (e.g. Eden Park on 17/1/95). In addition, most of the pitches measured were considered to fall within a narrow performance band, generally in the medium or slow-paced category.

Effect of surface condition on speed and bounce

The presence of grass was shown to have the potential to significantly reduce energy losses of a cricket ball striking the surface and alter the bounce height compared with a drier and rougher bare soil surface (Table 2). This result has implications in terms of pitch preparation techniques.

Table 1. Summary of pitch pace and bounce results 1994/95 using the standard testing method (smooth side, new ball)

Venue	Date of visit and no. of firings	Average % speed reduction	Variation in speed (%)[a]	Average bounce height (fraction of stump height)	Variation in bounce (%)[a]	Bounce assessment[b]	Pace assessment[b]
Eden Park	3.1.95 (5)	11.4	7.3	0.79	10.1	E,E,E	M,MS,MF
Eden Park	17.1.95 (10)	14.8	16.4	0.82	7.6	E,V,V	S,M,S
Eden Park	22.2.95 (10)	13.5	12.1	0.90	5.7	E,E,E	M,M,M
Lancaster Park	28.1.95 (10)	10.2	11.5	0.90	12.2	E,E	M,M
Basin Reserve	9.2.95 (10)	12.9	10.8	0.85	9.6	V	S
Basin Reserve	11.2.95 (10)	11.6	9.9	0.81	16.3	V	S
McLean Park	16.2.95 (10)	12.6	7.5	0.88	6.8	E	VS
Eden Park	20.2.95 (5)	13.7	14.2	0.86	0.0	V,E	M,MF
Eden Park	26.2.95 (9)	9.6	15.8	0.83	7.7	-	-
Fitzherbert Park	7.3.95 (10)	14.6	10.8	0.88	11.0	V,V,V	MS,S, VS

[a] the standard deviation expressed as a percentage of the mean (coefficient of variation).
[b] as judged by captains and umpires on match days (where available). V = variable; E = even; VS = very slow; S = slow; MS = medium slow; M = medium; MF = medium fast.

Table 2. Percentage speed reduction and bounce height of a pitch with or without grass (Fitzherbert Park, 20/3/95)

	Grass	Bare	T-test
% speed reduction (n=5)	13.9 (s.d. ± 1.9)	20.6 (s.d. ± 1.8)	P = 0.001
bounce height (fraction of stump height) (n=5)	0.88 (s.d. ± 0.04)	0.79 (s.d. ± 0.08)	P = 0.05

Effect of condition of the ball and point of ball contact on speed and bounce

Testing was carried out on two occasions to identify how the age and positioning of the ball (i.e. contact with the smooth side or seam side) affected speed reduction and bounce height. Table 3 shows that at both venues tested the percentage speed reduction was significantly reduced when a new ball was used compared with an old ball (the latter defined as one used for more than 50 overs). In contrast there was no significant difference between old and new ball in terms of bounce height. The measured difference in speed reduction is consistent with anecdotal observations made by players that a new ball tends to come through more quickly on to the bat.

Table 3. Percentage speed reduction and bounce height of two pitches using a new ball and an old* ball

	Eden Park (20/2/95) Old pitch, rough surface, rapid ball wear			Fitzherbert Park (8/2/96) New pitch, minimal ball wear		
	Old	New	T-test	Old	New	T-test
% speed reduction (n=5)	18.2 (s.d. ± 1.6)	13.7 (s.d. ± 1.9)	P=0.01	13.6 (s.d. ± 2.7)	9.6 (s.d. ± 0.9)	P=0.05
bounce height (fraction of stump height) (n=5)	0.92 (s.d. ±0.09)	0.86 (s.d. ± 0.00)	N.S.	0.82 (s.d. ± 0.08)	0.81 (s.d. ± 0.08)	N.S.

* defined as a ball that has been used for more than 50 overs (300 deliveries)

Table 4 shows that the exact point of contact with the pitch (i.e. smooth versus across the seam) had either no significant effect or only a marginally significant (P=0.1) effect on speed reduction on the two pitches measured. Similarly, the bounce height was not significantly affected by the positioning of the ball as it struck the pitch surface. However, other non-replicated firings under different circumstances showed that contrasting results were possible, suggesting that further investigation is required on the interaction of the seam with the pitch surface.

Effect of amendments on speed and bounce

Two separate small-scale trials were carried out to identify if surface-applied amendments could significantly change the percentage speed reduction and bounce height. Each amendment was applied over part of the grassed pitch surface. The results demonstrated that the percentage speed reduction could be significantly affected by applied amendments (Table 5). Products such as graphite spray lubricant or beeswax cream had the potential to increase pace (i.e.

reduce energy losses), although domestic spray polish showed no effect on speed reduction compared with the grass control. In contrast, the bounce height was either unaffected by the amendments, or in the case of the domestic spray polish, was actually significantly reduced.

Table 4. Percentage speed reduction and bounce height of two pitches with contact by the ball either on the smooth or on the seam

	Lancaster Park (28/1/95)			Eden Park (22/1/95)		
	Smooth	Seam	T-test	Smooth	Seam	T-test
% speed reduction (n=10)	10.2 (s.d. ± 1.2)	10.7 (s.d. ± 2.1)	N.S.	13.6 (s.d. ± 1.6)	15.6 (s.d. ± 2.8)	P=0.1
bounce height (fraction of stump height) (n=10)	0.90 (s.d. ±0.11)	0.88 (s.d. ± 0.07)	N.S.	0.90 (s.d. ± 0.05)	0.97 (s.d. ± 0.14)	N.S.

Table 5. Percentage speed reduction and bounce height as affected by applying different artificial surface amendments

	Fitzherbert Park (21/3/96)				Fitzherbert Park (8/3/95)		
	Grass	Spray polish	Spray graphite	T-test	Grass	Beeswax cream	T-test
% speed reductio n (n=5)	12.8 (s.d. ± 0.7)	12.7 (s.d. ± 0.7)	9.5 (s.d. ±0.9	N.S. (grass vs. polish); P=0.001 (grass vs. graphite)	13.9 (s.d. ± 1.8)	10.7 (s.d. ± 1.2) [5.4]*	P=0.0 5
bounce height (fraction of stump height) (n=5)	0.92 (s.d. ± 0.09)	0.77 (s.d. ± 0.09)	0.84 (s.d. ± 0.14)	P=0.05 (grass vs. polish); N.S. (grass vs. graphite)	0.86 (s.d. ± 0.00)	0.86 (s.d. ± 0.08)	N.S.

* mean % speed reduction obtained from two replicates using beeswax cream on bare soil

DISCUSSION

Despite being only a very preliminary study (in terms of field work), the results reported here have shown that there is a complex array of variables affecting pitch pace and bounce. Of importance is not only the absolute values of pace and bounce, but also the variability associated with these characteristics. In this study, most of the variables studied had more of an effect on pace (speed reduction) rather than bounce, but this result may be a reflection of the comparatively high quality of pitches studied. Lower grade pitches may well demonstrate a greater range of bounce variability. Grass reduced energy losses compared with a bare soil surface, presumably because of its lubricating effect, similar to what was being mimicked by some of the artificial amendments. It will therefore be important to learn the extent to which grass should be prepared prior to a match in order to maximise pace.

The condition of the ball was just as important. A ball used for more than 50 overs (300 deliveries) resulted in a significantly slower pace than a new ball. For pitches where ball wear is rapid (e.g. pitches with minimal grass cover and/or an abrasive soil texture), players and spectators often notice a change in the quality of the game as the pace decreases and they tend to relate this deterioration to the pitch itself. Current results suggest that a change in the properties of the ball, not the pitch, is just as likely to be a reason for pace reduction during a match.

The positioning of the ball on impact with the surface (smooth versus seam) was not found to change pace significantly. However, in this preliminary research there is evidence to suggest that in other circumstances, for example when the pitch surface is soft, a ball hitting with the seam is likely to come off slower and rise to a greater height as a result of the ball 'digging in' (Turner [former NZ Cricket Coach], pers. Comm.).

In this study, the percentage speed reduction varied significantly between matches played at a single venue and between pitches at different venues. This result demonstrates that the method of pitch preparation has a major influence on pace. For example, Eden Park No.1 pitch recorded a speed reduction of 9.6% on 26/2/95, compared with a value of 13.7% only one week previous. Turf managers therefore have the opportunity to influence pitch pace by the way in which they manage and prepare a pitch.

It is unfortunate that no truly fast-paced pitches (as judged by officials) were measured in this study. It can be speculated that a fast-paced pitch would have a percentage speed reduction of less than 10% on the basis of the range of values measured here. In this trial, amendments were used in an attempt to artificially generate a fast-paced pitch. The potential for amendments to increase pace was demonstrated (in particular the percentage speed reduction of 5.4% using beeswax cream on bare soil in Table 5) and could be useful for venues which traditionally suffer from slow-paced pitches. Such action of course would have to be sanctioned by the governing bodies of the game.

Finally, the application of the apparatus developed here needs careful consideration. Playing performance research is currently pre-occupied with the development of standards. The game of cricket has some way to go before pace and bounce standards can be introduced in an objective sense. The effect of the variables studied here needs to be quantified under more controlled conditions before further work examines how pitch preparation techniques (in particular soil type and management of soil moisture and density) can be exploited for optimum results. Further work will be best carried out on a replicated trials basis especially with the current apparatus because of its limited capacity for safe transport and absence of malfunctioning at actual venues.

ACKNOWLEDGMENTS

The financial assistance of Sport Science New Zealand is gratefully acknowledged along with the continuing support of NZ Cricket Inc. Special thanks are given to cricket enthusiast, Dr Brian Wilkins, and to his colleagues John Hawkins of Victoria University and Matthew Armstrong of Wellington for developing and constructing the pace/bounce tester. Bill Walmsley, Peter Munro, Alex Glasgow, and Catherine Andrews of the NZ Sports Turf Institute and the ground staff of the venues visited are also thanked for helping with the collection of data.

REFERENCES

Adams, W.A. and Gibbs, R.J. (1994). 'Natural Turf for Sports and Amenity: Science and Practice'. (CAB International: Wallingford).

Dury, P.L.K. (1985). 'Cricket Pitch Research'. (Nottinghamshire County Council: Nottingham).

Holmes, G. and Bell, M.J. (1987). 'Standards of playing quality for natural turf'. (The Sports Turf Research Institute: Bingley).

McAuliffe, K.W. and Gibbs, R.J. (1993). A national approach to the performance testing of cricket grounds and lawn bowling greens. *International Turfgrass Society Research Journal* **7**, 222-230.

McAuliffe, K.W. and Tuohy M.P. (1987). Cricket wicket research carried out by Massey University during the 1986/87 season. *New Zealand Turf Management Journal* **1(5)**, 3-9.

McDermott, P. (1994). Cricket playing surfaces: where to from here? In 'Proc. 5th NZ Sports Turf Convention, Palmerston North' (Eds. R.J. Gibbs and M.P. Wrigley) pp.6-8. (NZ Sports Turf Institute: Palmerston North).

Murphy J.W. and Field T.R.O. (1991). Factors affecting pace on NZ cricket pitches. *New Zealand Turf Management Journal* **5(4)**, 15-19.

Stewart, V.I. and Adams, W.A. (1969). Soil factors affecting the control of pace on cricket pitches. In 'Proceedings 1st International Turfgrass Research Conference' (Ed. The Sports Turf Research Institute: Bingley) pp.533-546.

Wilkins, B. (1995). 'Development of a method for the measurement of cricket pitch pace: user's handbook'. (NZ Sports Turf Institute: Palmerston North, New Zealand).