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Design and Development

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A COMPARISON OF CRICKET BALL CORES

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Abstract

Unlike many sports, cricket balls for use in 1st class matches in the UK must pass a testing regime described in a British Standard. Various work has investigated the aerodynamic ('swing') properties of cricket balls and some has been carried out examining the dynamic properties of balls during impacts with the pitch and bat. However, very little research is known to have been published on the cores of cricket balls, the construction of which can vary widely from traditional wound centres to composite moulded ones.

This paper describes elements of a study carried out to compare certain material properties of the cores of all the balls licensed for use in UK 1st class cricket with those of traditionally manufactured centres. Results show that certain types of construction can lead to 17% variation in hardness along the principal axes. These hardness variations were also apparent when complete balls were tested.

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Introduction

The exact origins of the sport of cricket are uncertain although mentions of a game resembling cricket appear around 1300AD in southern England. Much of cricket's development has been lost or never recorded, but by the second half of the 18^{th} Century crowds of up to 20,000 were watching certain games and high stakes gambling was involved [1]. Initially, the rules varied depending upon in which part of the British Isles the game was being played, but in 1788 the Marylebone Cricket Club (MCC) laid down a code of laws that was adopted throughout the game. The MCC is still the custodian of laws relating to cricket around the world [1, 2].

The ball is covered by Law 5, which specifies the tolerances for circumference (22.4 – 22.9 cm) and mass (155.9 – 163 g), but does not specify any other characteristic [3]. In the late 1970s, the Test and County Cricket Board (TCCB), the Cricket Council and leading ball manufacturers joined forces to develop, along with the British Standards Institute (BSi), a standard for cricket balls used in the British Isles. The latest version of the standard was published in 1995 and consists of a sequence of 8 tests that determine various aspects of the ball such as seam height, hardness and wear resistance [4]. For use in 1^{st} Class Cricket in the UK, a ball must obey both Law 5 and pass the British Standard. Other national cricket boards around the world, such as the Australian Cricket Board (ACB), have their own standards that balls must meet for use in their countries.

In the past, research into cricket balls has concentrated upon the effect of swing that is seen during the deliveries of certain bowlers [5, 6]. Other work has been carried out on the interaction of the ball with the pitch [7]. Much work has also been carried out on the general dynamics of sports balls such as golf balls, baseballs and tennis balls (e.g. [8] and [9]). However, no work is known to have been published on cricket ball cores. This paper describes aspects of work carried out during the summer of 2000 on behalf of the England and Wales Cricket Board (ECB), which was formed in 1997 from a merger of the TCCB and National Cricket Association.

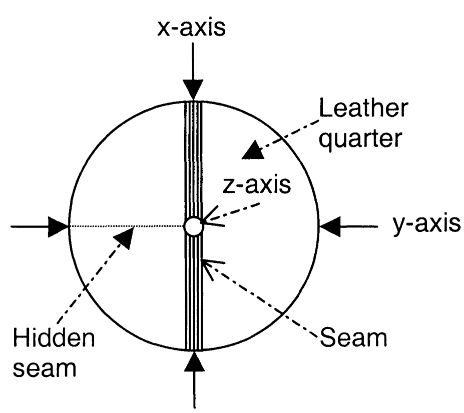


Figure 1: diagram of a cricket ball showing the principal axes and location of the seam.

Traditional cricket balls are produced using a 'quilted' or 'layered' core. A moulded cork centre (approximately 2 cm in diameter) is alternately layered with wool yarn and more cork. The wool is wound wet and under tension to compress each of the layers of cork – as the yarn dries out the compressive force on the cork layers increases. Typically five layers of cork and six of yarn are put down. The leather cover consists of four pieces (or quarters) of hide. On the equator of the ball there is a visible seam (the 'primary seam') that consists of six rows of stitching; all other stitching to join the quarters together (the 'quarter seams') is hidden (see figure 1). Traditionally, the quarter seams are set at right angles to each other.

Cricket balls have many similarities in construction with baseballs and the balls used in the game of Real Tennis. All the balls used in U.S. Major League Baseball are all made by Rawlings Sporting Goods and there has been recent concern expressed about their performance during games [10]. The construction of a baseball core consists of a composite cork/ rubber pill, which is surrounded by two layers of rubber. Around this centre are wound three layers of wool and a finishing layer of cotton string. The construction of Real Tennis balls has been investigated recently at Cambridge University Engineering Department (CUED) [11]. To this day, Real Tennis balls have been made by hand and have changed very little - a core or pill is constructed from cut up cork pieces and then wrapped with cotton webbing before being finished off with a hand stitched felt cover.

At the time of writing, three companies have had balls pass the British Standard and have thus been allowed to supply balls for 1st Class Cricket. None of these manufacturers use a traditionally produced core. They use instead either a composite or rolled core. Composite moulded cores consist of cork and rubber particles mixed together and placed into a mould. Pressure and heat are then used to bond the particles of the composite together. Rolled cores are fabricated by layering up alternate sheets of cork/rubber mix and rubber. The sheets are cut to size, rolled up and then heated in a hydraulic press. Schematic diagrams of all three types of core are shown in figures 2, 3 & 4.

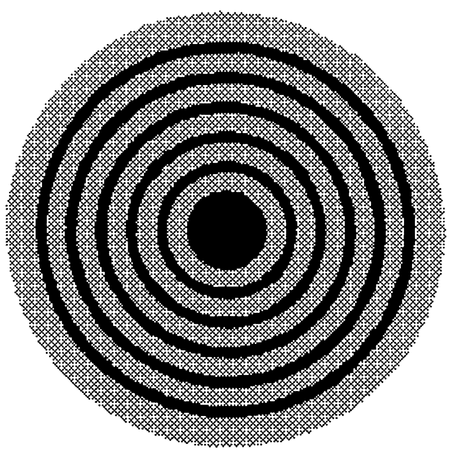


Figure 2: cross section of a traditional core (direction of cut is not important). The black areas represent cork whilst the mottled areas show the layers of wound flax.

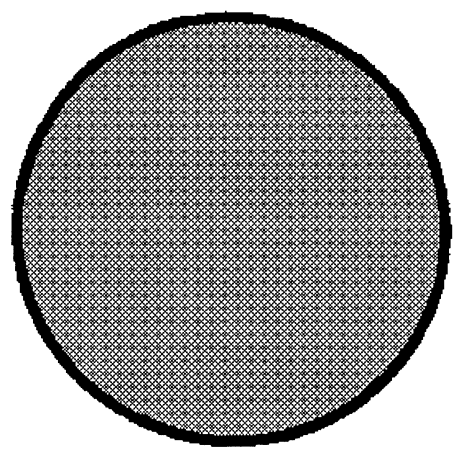
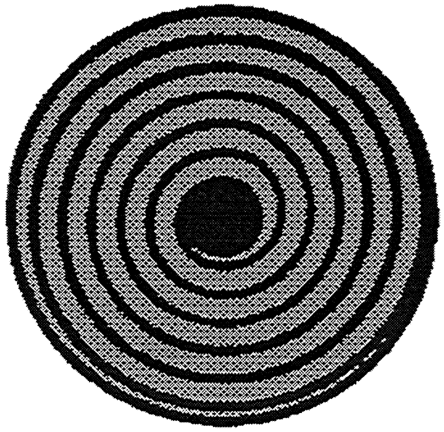


Figure 3: cross section of a composite core (direction of cut is not important). The mottled region represents the cork/ rubber particles bonded together.



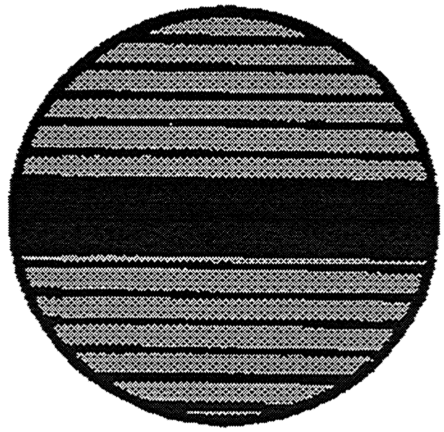


Figure 4a: cross section of rolled core cut in the plane of the seam (x-z plane). The black regions show the rubber sheets and the dark grey regions represent the cork/rubber sheets.

Figure 4b: cross section of a rolled core cut perpendicularly to the plane of the seam (y-x plane). The colours are as described in figure 4a.

Experimental Details

The England and Wales Cricket Board supplied 5 different batches of cores for testing purposes: two were composite, two were rolled and one was produced in the traditional manner. For the purposes of the tests the cores had their principal axes marked and were coded:

- Comp.1 – composite core, coarse cork granules
- Comp.2 – composite core, fine cork granules
- Roll.1 – rolled core type I
- Roll.2 – rolled core type II.
- Trad. – traditional core

Four complete, brand new balls were also supplied: one was made with a composite core, two with rolled cores and one with a traditional core. This paper describes two of the tests carried out on the cores and the whole balls.

<u>Test a: Drop test</u>

This test was based upon that described in BS 5993 Annex G "Method for determination of hardness" [4] although differences between the two make drawing direct comparisons between results not possible. The apparatus consisted of a concrete base (dimensions 840 x 840 x 750 mm) onto which was fixed a load cell. The cell had a concave 'cup' attached to it to support the cores during testing. A steel guided striker of mass 5.280 kg with a flat circular striking surface of diameter 132 mm was situated on vertical guides on either side of the load cell. An accelerometer was attached to the striking surface. The maximum height to which the striker can be raised is approximately 4 m.

An electromagnet and rope pulley system is used to raise the striker to a set height of approximately 1.2 m. This height ensured an impact velocity of 4.66 ms^{-1} (the same value as used in the British Standard test referred to above), which was measured using a light beam velocity meter situated just above the samples. A tolerance of +/- 3% was allowed for the impact velocity. Figure 5 is a schematic diagram of the drop test apparatus.

Data from both the accelerometer and the load cell was displayed on an oscilloscope and recorded on a PC using Dlog software that was sampling at a rate of 20,000 Hz. Figures for the peak deceleration and maximum load were recorded for each run. Three samples of each type of core were tested on each of the three principal axes. The whole cricket balls were also tested in this way along with a baseball for comparative purposes.

Test b: Compression test.

An Instron machine (Model 5500R) was used with each sample being compressed by 10 mm at a speed of 0.5 mms^{-1}. As with the drop test three samples of each type of core were tested on each of the three principal axes. The whole cricket balls were also compared in this way (after having been tested with the drop test) along with a new baseball for comparative purposes.

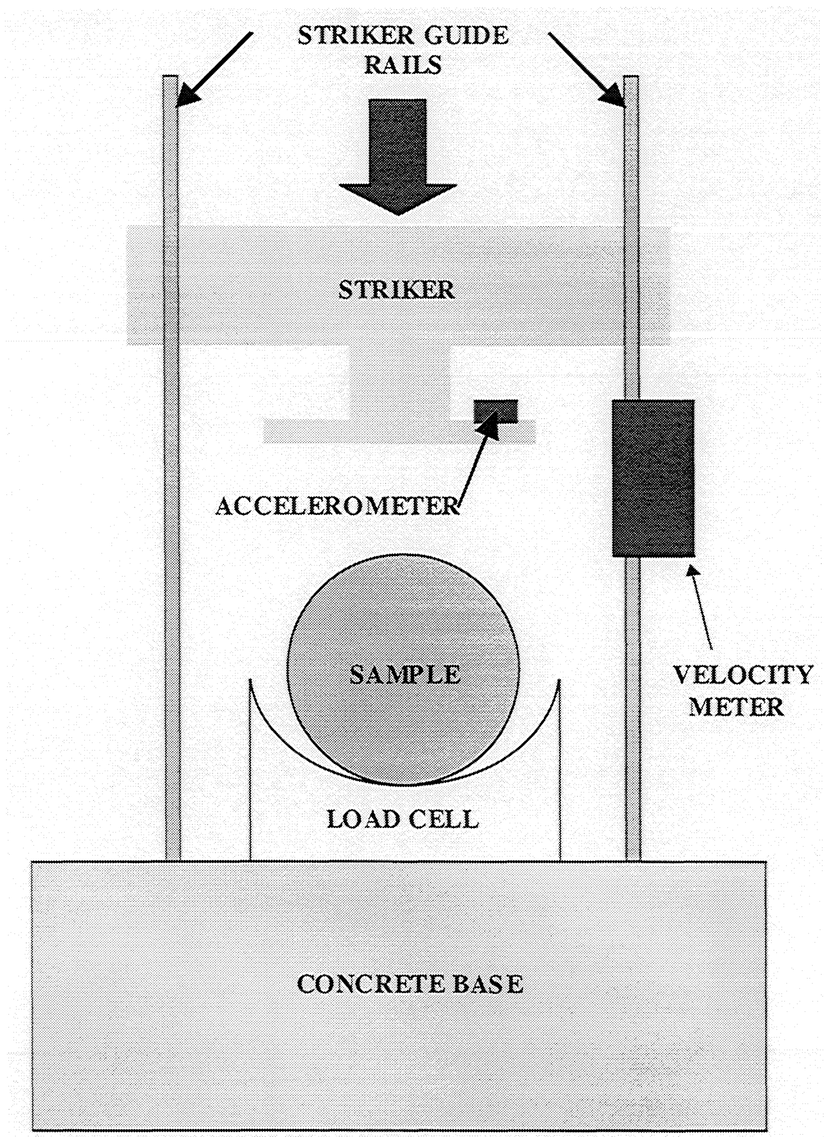


Figure 5: schematic diagram of the drop test.

Results

Drop test

A typical impact trace recorded during the test is shown in figure 6. The peak loads and decelerations were recorded and averaged. Figure 7 shows the peak load values gathered for each sample and axis whilst figure 8 shows the data for peak deceleration. In figures 7 and 8 the data point is the mean recorded value and the error bars show the spread of recorded values.

It must be noted that one of the composite cores (Comp.1) became cracked during the drop test irrespective of the axis being struck. None of the other cores exhibited visible damage after the test. The results of the tests on whole balls (including a baseball) are shown in figure 9.

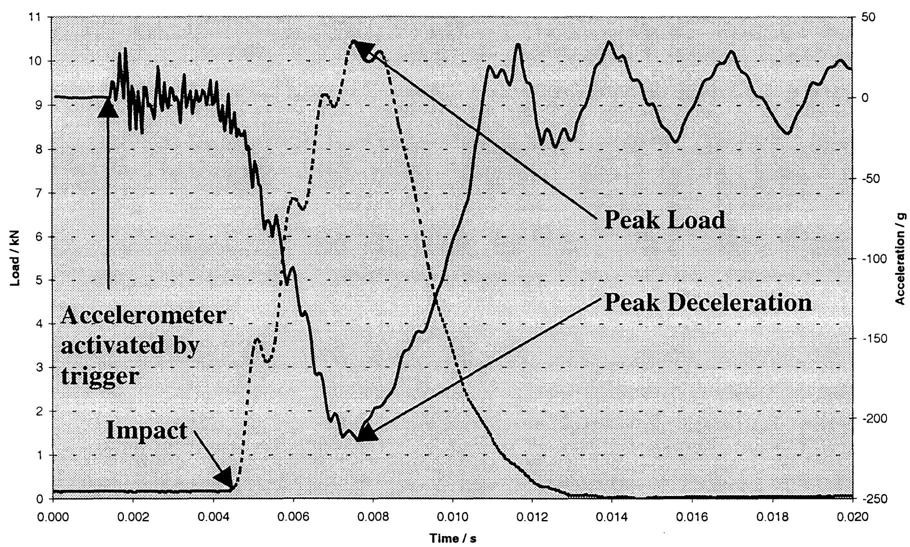


Figure 6: typical impact trace (traditional core: x-axis)

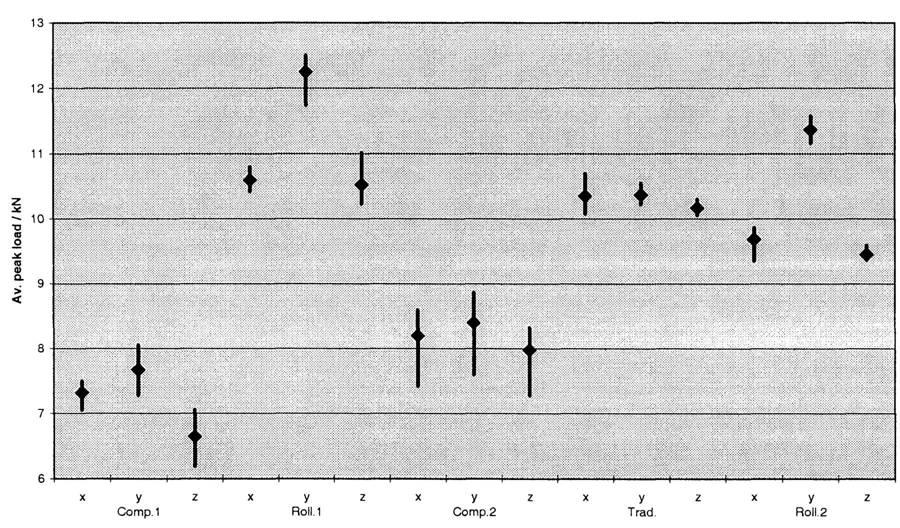


Figure 7: mean peak load by sample and axis

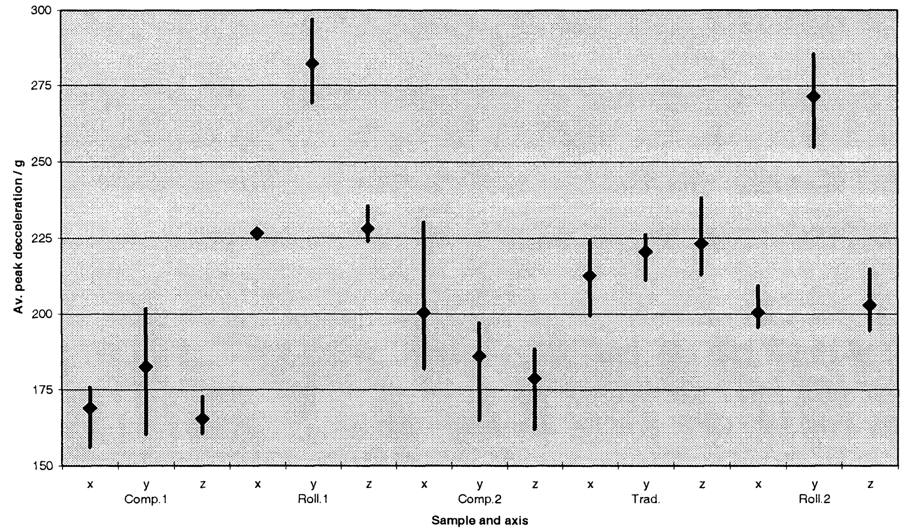


Figure 8: mean peak deceleration by sample and axis

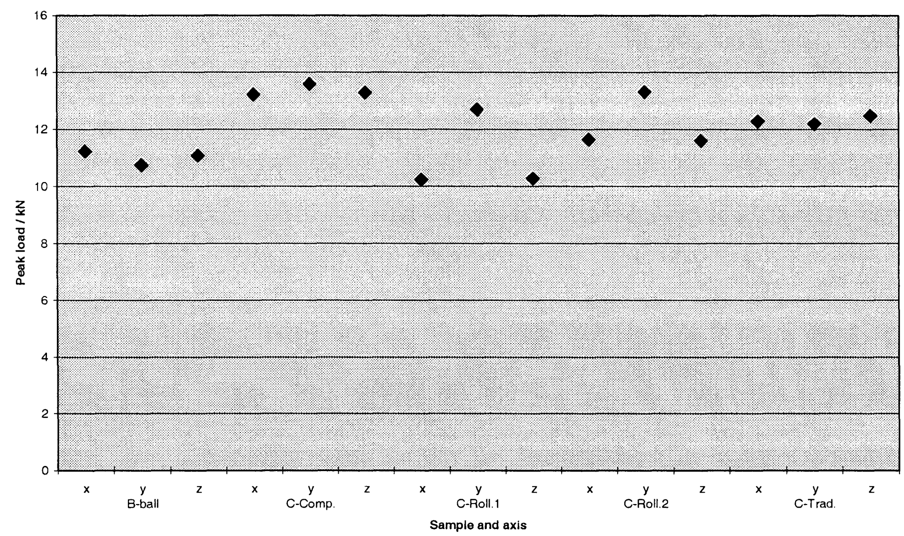


Figure 9: mean peak load comparison for whole balls

Compression test.

The load required to compress each sample by 10 mm was recorded. Figures 10 and 11 display the loads required along each axis to compress the cores and whole balls respectively.

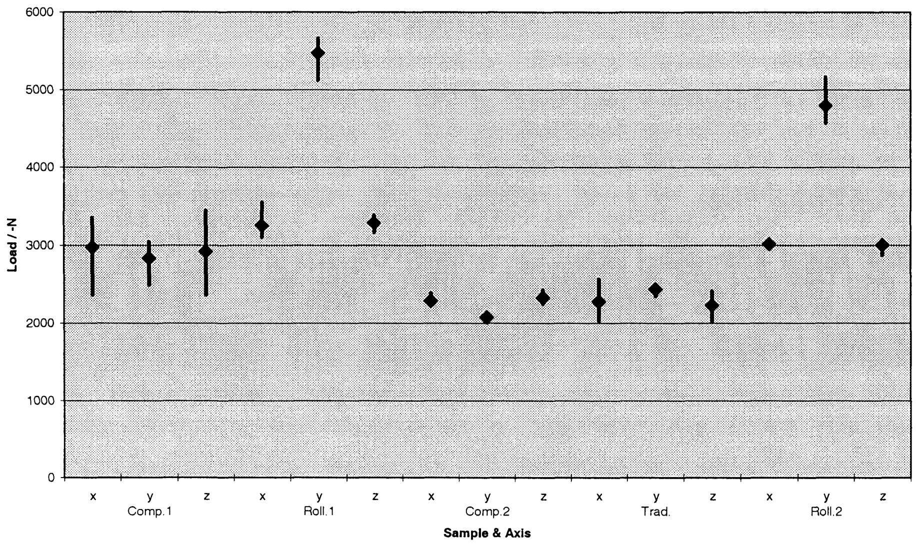


Figure 10: comparison of cores by axis

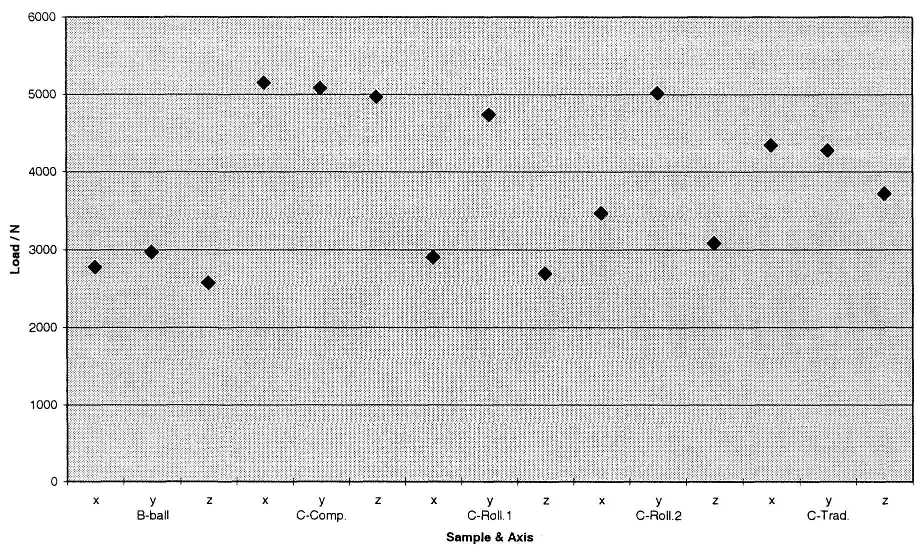


Figure 11 comparison of whole balls by axis

Discussion

Rolled cores are constructed in a way that gives obvious axial variation when the cores are sectioned as shown in figures 2 – 4.

The results of the drop test indicate that the traditional core and the composite core (Comp.1 can be ignored due to all the samples of that type cracking) did not show any marked variation in peak load between the three principal axes. Examining the deceleration data (figure 8) shows that the spread of results for each of the three main axes lie within those of the other two axes for both the traditional core and the second composite core. In the case of the rolled cores the data shows that there is no significant variation between the x- and z-axes. However, the y-axis is significantly different to the x- and z-axes. For 'Roll.1' the y-axis mean peak load is 16% greater than that of the x-axis whilst for 'Roll.2' the difference is 17%.

When figure 9 is examined, it must immediately be pointed out that only one ball of each type was available for testing hence the lack of error bars. The general trend appears to be that the values for peak load recorded on the three principal axes for the baseball, the composite-cored cricket ball and the traditional-cored cricket ball are similar. The values obtained for the two rolled-core balls show an increase in peak load for the y-axis. For 'C-Roll.1' the y-axis value is 24% greater than that for the x-axis and for 'C-Roll.2' the difference is 14%. It appears that the differences measured in the cores are apparent in the whole ball.

The results for the compression test seem to support these observations. In figure 10, the data recorded for the traditional and two composite cores shows that there are no prominent differences between the three axes. The compressive load required for the y-axis for the two rolled cores is significantly greater than that required for the x- and z-axes. In the case of 'Roll.1' the y-axis value is 68% greater than that recorded for the x-axis, whilst for 'Roll.2' the difference is 59%.

When the whole balls were tested using the Instron machine (figure 11) both the balls made with rolled centres required a much higher load to compress the y-axis than the x- and z-axes. For 'C-Roll.1' the y-axis value is 63% greater than that recorded for the x-axis, whilst for 'C-Roll.2' the difference is 45%. The composite centred ball showed no dramatic variation between the three axes, each requiring a load of approximately 5 kN. Both the baseball and traditionally centred cricket ball had z-axis values lower than those for x- and y-axes. The order of testing was x-, y- and then z-axes. When the z-axis was tested, both balls were visibly misshapen (suggesting permanent core damage) and this may be a possible explanation for the lower recorded values, but once again it must be pointed out that only one ball of each type was available for testing.

To examine this issue further, tests on more complete balls are required. In terms of other possible tests, a series of experiments to investigate the coefficient of restitution would show how the different ball types perform at speeds similar to those seen in the actual game (bowling speeds up to 95 mph) - examining the ball/ pitch and ball/ bat interactions.

Concluding Remarks

The tests described in this paper appear to indicate that cricket balls produced with rolled cores exhibit large discrepancies in hardness between the plane of the seam and the axis perpendicular to the seam. This variation will have an effect on many of the main dynamic interactions of the game depending upon which part of the ball is involved: e.g. ball with ground and ball with bat. A further important area of note must be when the ball strikes the body (with associated health risks), which occurs both intentionally and unintentionally throughout the game of cricket. This factor has been studied at some length by sports such as baseball [9].

Cricket is a game that has many areas of natural variation in it ranging from the composition of the pitch to the overhead weather conditions. It is an issue for the ECB to address in conjunction with the manufacturers as to whether there should be noticeable variation between different types of 1st class cricket balls, all of which have passed the British Standard. One possible course of action open to the ECB is to undertake an extensive review of the requirements of the British Standard, a result of which could be the introduction of regulations governing core construction.

Acknowledgements

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