ISSS Technical Meeting 2004, Ball Roll

1. Introduction

The Ball Roll Distance is an important property of synthetic turf surfaces for football (soccer). This test has shown significant differences between some synthetic turfs and natural turf.. The test methods for measuring ball roll behaviour can be split into two different procedures. Either by measuring the total roll distance or by measuring the velocity change over a given distance. The velocity change method was developed in England and described in BS7044.

Test equipment for those two methods includes the following device:

- Ball roll ramp, practically speaking the same design for all methods
- Football
- Steel tape for measuring the distance the ball rolls or a timing gate system
- Vertical scale for measuring the drop height for the ball
- Water level to adjust the ramp (so it stands vertical upon the surface)
- Wind speed sensor (outdoor)

Photo 1; Ball roll ramp

Photo 2: Wind speed sensor, steel tape and levelling device

Photo 3 Timing gate for measuring velocity change

2. Measuring the total roll length

2.1 UEFA manual:

- The pressure in the ball shall be adjusted to give a rebound on concrete, at the temperature the test will be made, of 1,35 ± 0.03 m from drop height 2.0 m measured from bottom side.
- Release Height: 1000 ±5 mm from bottom side
- Measure the roll length from the point were the ball first hit the surface to the point below the centre of the ball at which it is resting on the surface.
- Five readings in each direction
- Move the ramp slightly between each drop to avoid tracking

UEFA requirement: 5 –8 m

When measuring outdoor the wind speed shall not exceed 1 m/s (3,6 km/h)

2.2 FIFA (EN12234):
In this standard only the velocity change is measured, but describes how to calculate roll length based on velocity change.

$\Delta V = - 1.434 \log_{10} DR + 1,87$

Based on this formula, the FIFA requirement 0,4 to 0,75 m/s means that the Ball Roll Distance must be within the range 6.0 – 10,6 m.

2.3 EN 12234:

- The pressure of the ball shall be 0.9 bar ± 0.1 bar
- Release Height, from the bottom side of the ball and surface: 1000 ±5 mm
- Measure the roll length from the point were the ball first hit the surface to the point below the centre of the ball after it comes to a resting position on the surface.
- Five readings in each direction
- Move the ramp slightly between each drop to avoid tracking

When measuring outdoor the wind speed shall not exceed 0,9 m/s (3,2 km/h).

2.4 BS7044:
More or less the same as the EN method

2.5 ASTM:
No test method

Conclusion all methods for measuring Roll Distance:

- The only difference between the test methods is the pressure in the ball.

3. Measuring velocity change:

3.1. UEFA, only in laboratory:

Test procedure:

- The pressure in the ball shall be adjusted to give a rebound on concrete, at the temperature the test will be made, of 1,35 ± 0.03 m from drop height 2.0 m measured from bottom side.
- Drop height: Adjusted so that the initial velocity varies slightly within the range of 2,5 m/s
- Distance between two sets of timing gates: 2.0 m
- Distance between ball ramp and first set of timing gates: 0,5 m
- 12 readings, each time varying slightly the initial velocity of the ball, and move the ramp slightly to avoid tracking.

Calculation and expression of results:

- Calculate the velocity change for each initial and final velocity
- Plot the calculated values of velocity change against the initial velocity
- From the twelve tests, discard the four most extreme results and from the resulting curve, interpolate the velocity change at an initial velocity of 2,5 m/s.

3.2 FIFA (EN12234)

Test procedure:

- Ball pressure: 0.8 bar ± 0,1 bar
- Drop Height: Adjusted so that the initial velocity varies slightly within the range of 2,5 m/s
- Distance between two sets of timing gates: 1.0 m
- Distance between ball ramp and first set of timing gates: At least 1 m.
- 5 readings, move the ramp slightly between each procedure to avoid tracking

Calculation and expression of results:

- Calculate the velocity change for each initial and final velocity
- Plot the calculated values of velocity change against the initial velocity
- From the resulting graph interpolate to obtain the velocity change at an initial velocity of 2,5 m/s

3.3 EN 12234

Test procedure:

- Ball pressure: 0.9 ± 0,1 bar
- Drop Height: Adjusted so that the initial velocity varies slightly within the range of 2,5 m/s
- Distance between two sets of timing gates: 1.0 m
- Distance between ball ramp and first set of timing gates: At least 1 m
- 5 readings, move the ramp slightly between each procedure to avoid tracking

Calculation and expression of results:

- Calculate the velocity change for each initial and final velocity
- Plot the calculated values of velocity change against the initial velocity
- From the resulting graph interpolate to obtain the velocity change at an initial velocity of 2,5 m/s

3.4 BS7044:

More or less the same as the EN method

3.5 ASTM
No test method

Conclusion all methods used for measuring velocity change

Table 3.1. Summery of the methods

	UEFA	FIFA	EN 12234
Drop height	Varying slightly from a height which gives an initial velocity of 2,5 m/s	Varying slightly from a height which gives an initial velocity of 2,5 m/s	Varying slightly from a height which gives an initial velocity of 2,5 m/s
Number of readings	12, where the four most extreme are discarded	5	5
Distance between timing gates	2 m	1 m	1 m
Distance from ramp to timing gate	0,5 m	1 m	1 m

The main differences between the methods are the distance between the two timing gates, and the distance between the ramp and the first set of timing gates.

4. Comments

Measuring Ball Roll Distance (BRD) is a direct method of determination. The main problem with this method is the size of the sample needed when testing in laboratory, and that the results very much will be influenced by wind when testing outdoor. By using the timing gate system it would be much easier to use a tent to protect the ball against the wind. Based on this, many studies haave been undertaken in the hope of finding a reliable way to calculate Ball Roll Distance (BRF) based on measurements of Velocity Change (VC).

4.1. UEFA/NBI project

One of these studies was done by NBI on behalf of UEFA in the autumn 2003. A summary of this report is given in the following:

This program contained the following test objects:

- Six 3rd generation synthetic turf installations, outdoor.
- Three natural grass fields, outdoor
- One type of 3rd generation artificial grass with three different fill heights, measured in laboratory. The free pile height was 25, 20 and 15 mm.

For the outdoor installations the BRD and VC was measured in four directions, two along the pitch in opposite directions at the centre of the field and two in the transverse directions, one with and one against the slope. The laboratory tests were carried out in two opposite directions. For each direction the ball was dropped 10 times. This means a total of 360 measurements of BRD and VC

Input values

Release height: 1 m
Distance between timing gates: 2 m
Distance between ball ramp and first set of timing gate: 0,5 m

RESULTS

The diagram shows the connection between Ball Roll Distance (BRD) and Velocity Change(VC) for all the fields and directions tested in this investigation.

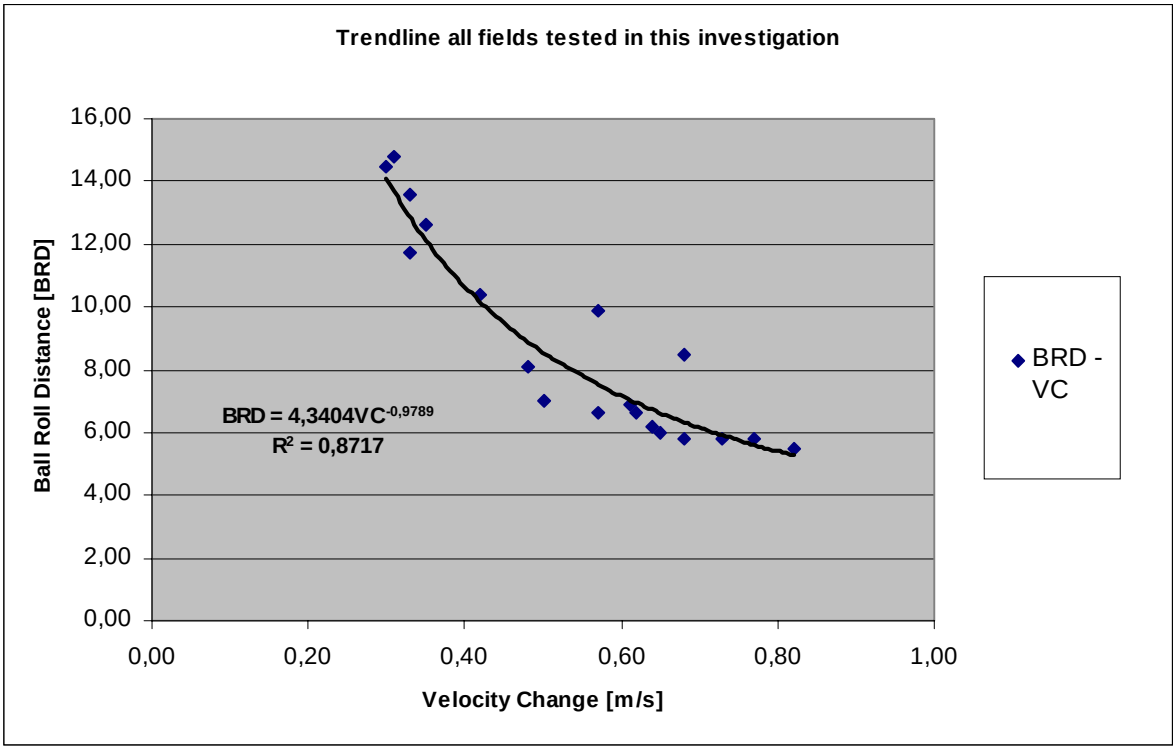

Table 2 shows the correlation between VC and BRD based on the formula in diagram 1.

VC	BRD
0,15	27,8
0,20	21,0
0,25	16,9
0,30	14,1
0,35	12,1
0,40	10,6
0,45	9,5
0,50	8,6
0,55	7,8
0,60	7,2
0,65	6,6
0,70	6,2
0,75	5,8
0,80	5,4
0,85	5,1

Conclusion
Our conclusion was that though the correlation between BRD and VC varies within a series of ten drops, the average values of ten drops could be used to calculate the Ball Roll Distance based on the Velocity Change.

4.2. IST method by Kolitzus. How to calculate the Ball Roll Distance from Timing Gate Measurements

This method takes in account the fact that the deceleration decreases the slower the ball roll.

From a release height of 1 m, mesurements showed that the speed of the ball when striking the surface is 3,2 m/s

To make it easier the rolling process is regarded from its end where the ball comes to rest.

The first step when testing a specific surface is to find the relationship between ball speed and deceleration. This is determined by releasing the ball down from various heights, for example 1,00 m, 0,75 m 0,5 m and 0,25 m. The deceleration for each height can be calculated by using the formula:

$dec = (V_a^2 - V_b^2) / (2 \times dist)$ (m/s^2)

Va = velocity when passing first set of timing gates
Vb = velocity when passing second set of timing gates
dist = distance between the two sets of timing gates

Plotting the *dec* values against the average speed between the timing gates results in a more or less straight line of form:

$dec = a + b * v$

Where a and b is constants taken from the graph.

Based on this curve the Roll Distance can be calculated stepwise from the point where the ball comes to rest to the point where the ball leaves the ramp with a speed of 3,2 m/s.

5. Conclusion

As shown above, several methods have been introduced trying to find a correlation between Ball Roll Distance and Velocity Change. However, another uncertainty is introduced when translating Velocity Change to Ball Roll Distance, either based on theoretic formulas or empiric results.

The Ball Roll method (preferred by UEFA) is a direct method, but it can be difficult to get reliable results in field. Maybe the Velocity Change method (used by FIFA) is to be preferred, simply because it makes it easier to protect the measurements from being influenced by weather conditions such as wind and rain.

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