Ball Roll measurements – slope correction

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FIH (and also UEFA) characterise the ball rolling properties of playing surfaces by prescribing measurement of ball roll - an appropriate ball is rolled down a ramp onto the surface and the roll out distance measured.

In many situations the surface is not level but has a definite slope – up to 1 % for Hockey surfaces. Present procedure is to average the up slope and down slope roll distances.

However, this procedure may significantly overestimate the true roll distance, as a simple analysis of the dynamics of the roll will demonstrate.

For a flat surface the ball roll distance S may be related to the other physical parameters by

$$m\,g\,h = \mu\,S$$

Where m is the mass of the ball, g the gravitation acceleration, h the release height of the ball on the ramp, and μ the rolling resistance (assumed here to be linear with ball speed)

On a down hill roll there will be an additional height term, h', on the left side of the equation - the extra fall due to the slope. The equation then becomes

$$m\,g\,(h + h') = \mu\,S'$$

Where S' is the down hill roll distance.

The slope fall height h' is related to the slope by

$$h' = S' \sin\theta$$

$$\simeq S'\,\theta$$

where θ is the slope angle.

The down hill roll distance may then be equated as

$$S' = m\,g\,h\,/\,(\mu - m\,g\,\theta)$$

Similarly the up hill roll S" is given by

$$S'' = m\,g\,h\,/\,(\mu + m\,g\,\theta)$$

The average of the up and down hill rolls is

$$S_{av} = m\,g\,h\,\mu\,/\,(\mu^2 - \underline{m\,g\,\theta^2})$$

If θ is zero S_{av} reduces to S, but if a slope is present then it will be different from the true roll distance.

These equations may be manipulated in a mathematical package such a Mathematica, Matlab etc. to give corrections that can be applied to the actual roll measurements to give the true roll distances.
A series of curves are shown in Fig 1 and 2. These show the corrections that should be subtracted from the average of the up and down hill measurements when a slope is present. Four different average roll distances are shown – A, 13 m, B 14 m, C 15 m and D 16 m. For the calculations m = 0.16 kg, g = 9.8 m/s/s and h = 1.0 m.

Fig 1

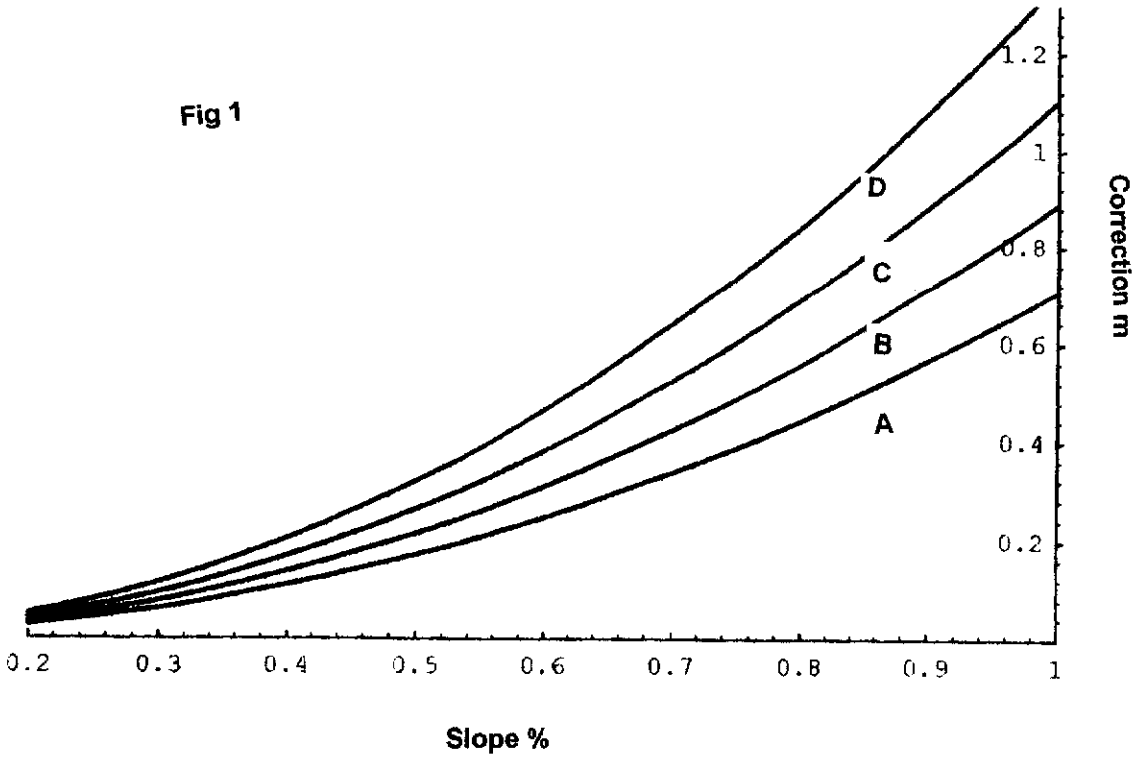
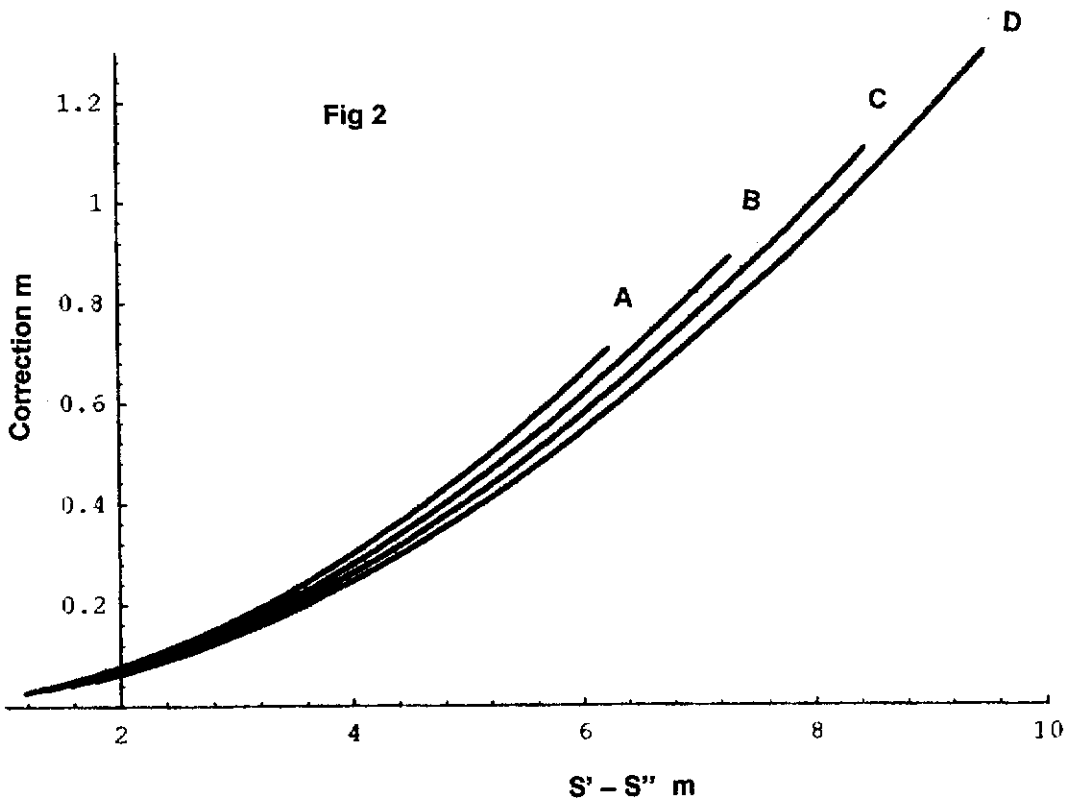

1.2
1
0.8
0.6
0.4
0.2
Correction m
D
C
B
A
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Slope %

Fig 2


D
C
B
A
1.2
1
0.8
0.6
0.4
0.2
Correction m
2
4
6
8
10
S' – S" m