11. FOOTBALL AND SURFACES

O-061 Development of a friction tester for soccer materials

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OBJECTIVE The existing techniques to measure the friction between sports balls and surfaces use methods which do not replicate the true contact conditions and velocities during a game situation. The friction between two materials is largely condition dependent and the data taken from a test machine is only relevant to that setup. The paper describes the development of a soccer materials tribometer. The study was to investigate the surface interactions that occur during a game of soccer with a view to quantifying the frictional properties.

METHODS Deformable material friction is sensitive to normal pressures and sliding velocities. The frictional force has two components: deformation and adhesion. Player studies have been researched to find typical ball velocities and spin rates. A finite element (FE) model then has been used to investigate further the contact conditions. Fig 1a shows the contact pressure variation with duration of impact.

RESULTS The machine design was based on a block-on-ring approach (fig 1b). A pivoted lever arm came into contact with a rotating drum by applying a force from the other end. With the surface in the tray in contact with the drum, the torque change was recorded by the inverter. The change in torque allowed the calculation of the coefficient of friction. Calibration of the load and torque was ongoing.

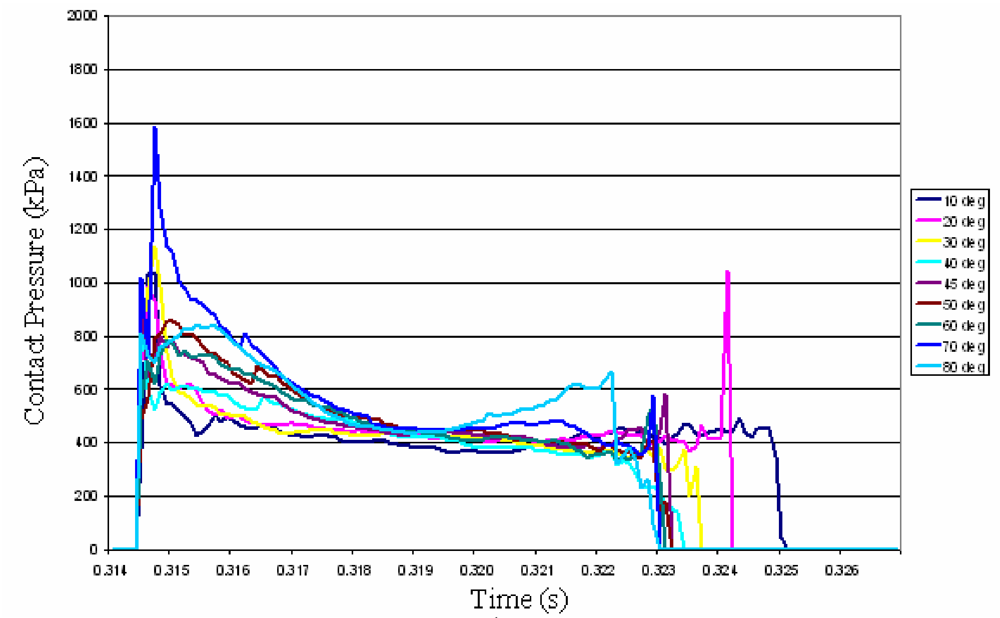

Figure 1a. FE contact pressure for a 25ms^{-1} oblique impact at varying impact angels.

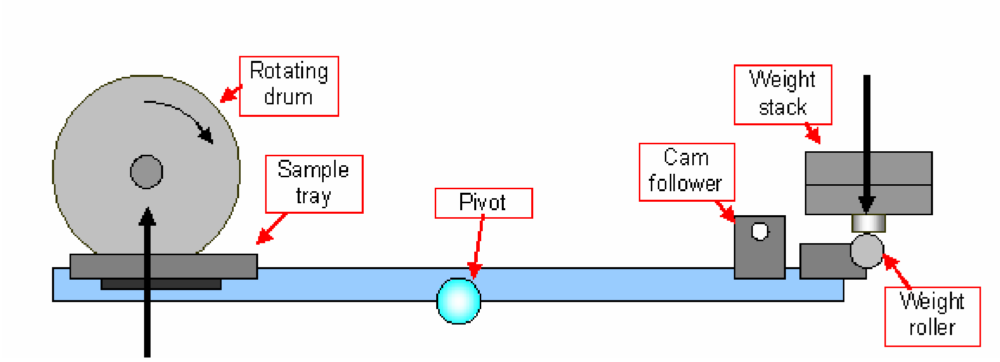

Figure 1b. Diagram showing the main features of the tribometer.

CONCLUSION The soccer materials friction tester has been developed to take in to account the contact conditions. The pressures and velocities can be replicated which in turn should give more representative friction data for soccer materials. However the contact time is difficult to replicate due to the short impact duration. This data is of fundamental importance to manufacturers in designing new equipment

KEY WORDS Tribology, tribometer, football, finite element, impact.

O-062 Identifying knuckle effect in football

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OBJECTIVE When the boundary layer of a sports ball undergoes the transition from laminar to turbulent flow, a drag crisis occurs whereby the drag coefficient (Cd) rapidly decreases. Especially, we can observe the strange swaying on non-spinning type soccer balls by lateral force fluctuations, which can cause the 'knuckle effect'. However, the aerodynamic properties and boundary-layer dynamics of a soccer ball are not well understood. The purpose of this study is to discuss the aerodynamic characteristics of football using computer fluid dynamics (CFD) and visualization of the vortex structure around the real flight football in high Reynolds number.

METHODS An incompressible unsteady analysis was performed using the finite volume method based on fully unstructured meshes. In order to visualize the flow around the soccer ball during flight, a ball was coated as uniformly as possible with titanium tetrachloride. The subject who is top level university soccer player performed an almost non-spinning straight kick towards the middle of a goal from a distance of 15 m.

RESULTS It was observed that a large scale of fluctuation was generated in the lift coefficient. The separation point of a non-spinning football in CFD retreated to ~120° from the front-stagnation point and with the vortex region shrank. The complex vortex structure was observed near the CFD ball model; however, it was difficult to represent the vortex structure from a short distance.

DISCUSSION The results of experiment in this study showed that the Strouhal number of wake near the real flight football was about 1.0 that was similar to the high-mode value of a smooth sphere. It was also observed that the vortex was paired in the wake. Moreover, it is observed that the large-scale of fluctuation in the vortex trail which Strouhal number is estimated for 0.1. It is considered that the large-scale of fluctuation in the vortex might have been due to the 'knuckle effect' of the non-spinning ball.

KEY WORDS Aerodynamics, knuckle effect, football, wind tunnel, visualisation.

O-063 Soccer ball dynamic force measurement and modelling

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OBJECTIVE Equipment manufacturers continually strive to produce technically more advanced soccer balls as it is prerequisite of this game; however the effectiveness of this process requires a detailed understanding of the impact characteristics of soccer balls to ensure that new technologies and designs improve the quality of the game. Unlike previous studies which used force measurements at low impact velocities, this study investigated dynamic forces that occur for soccer balls at velocities of actual playing conditions. A soccer ball finite element (FE) model is developed and validated using the experimental data.

METHODS Normal impact tests were undertaken using a ball typical of that used in elite competition and force measurements were recorded using a Kistler force plate. Impact velocities of 9, 14, 23 and 30 m/s were used throughout experimentation. Simulated impact scenarios were compared with experimental results.

RESULTS Figure 1 shows peak forces increased with impact velocity (from 1494 +58 /-65 N – 6942 +471/-396 N), and depicts high speed video data of deformation, which also increased with impact velocity. The FE model slightly overestimated the peak force for impact velocities 9 and 14 m/s, but generally gave good agreement with both dynamic force and deformation data.

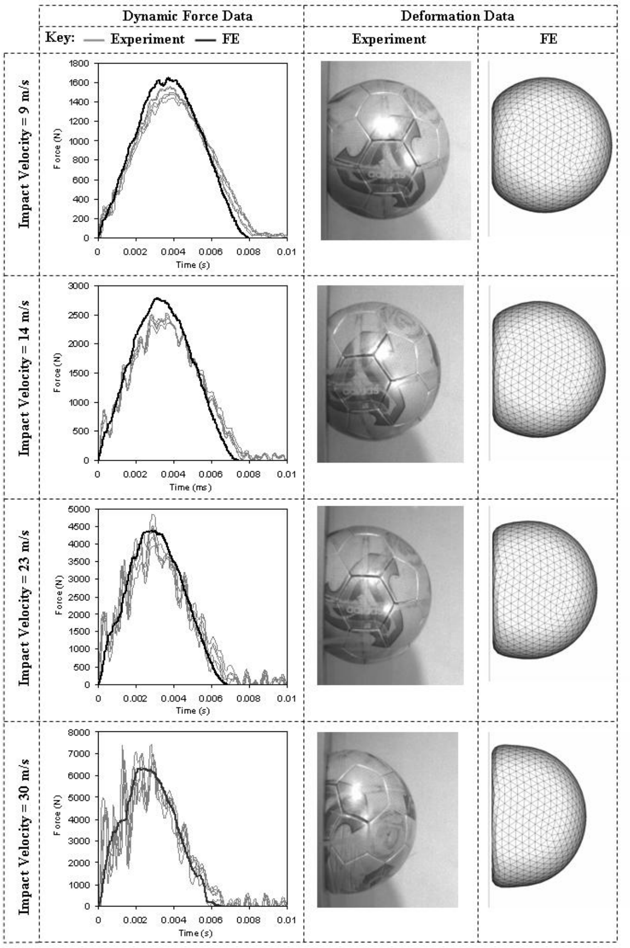

Figure 1. Experimentation and FE model comparisons of force vs time, and deformation data for impact velocities of 9m/s, 14m/s, 23m/s and 30 m/s respectively.

CONCLUSION This study showed that impact velocity had a profound effect on the measurements of dynamic force and deformation. It should be noted that the 30 m/s force data, gave significant variability due to natural frequency limitations of the force plate. The FE model showed good agreement with experimentation which gave confidence in its efficacy in understanding soccer ball impacts and it's use to assist in the development of future soccer ball designs.

KEY WORDS Soccer ball, impact mechanics, finite element modelling, force measurement, deformation.

O-064 Development of a sliding tester

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OBJECTIVE Today, artificial turf is becoming more and more used for soccer. The most inherent problem of this artificial turf are injuries due to sliding. The existing testing devices for sliding used by FIFA and UEFA, focus on the coefficient of friction of the turf and the caused abrasion of the skin. However, a crucial parameter in the process of skin burning, the temperature, cannot be measured. The aim of this study was to develop a new testing device that can assess how well different types of turf are fit to do a sliding on them. This device is a realistic approximation of a soccer sliding, considering realistic values for player speed and mass and measures the increased temperature during the sliding as well as the friction, in order to assess the risk of: burning wounds.

METHODS The new testing device consists of a ramp, from which a sledge is launched onto the field (Figure 1). At the bottom of the sledge, thermocouples in a newly developed artificial skin measure the temperature during the sliding. The speed of the sledge can be varied up to 22km/h, the weight can be varied between 15 and 31kg, leading to comparable contact pressures as in a real sliding.

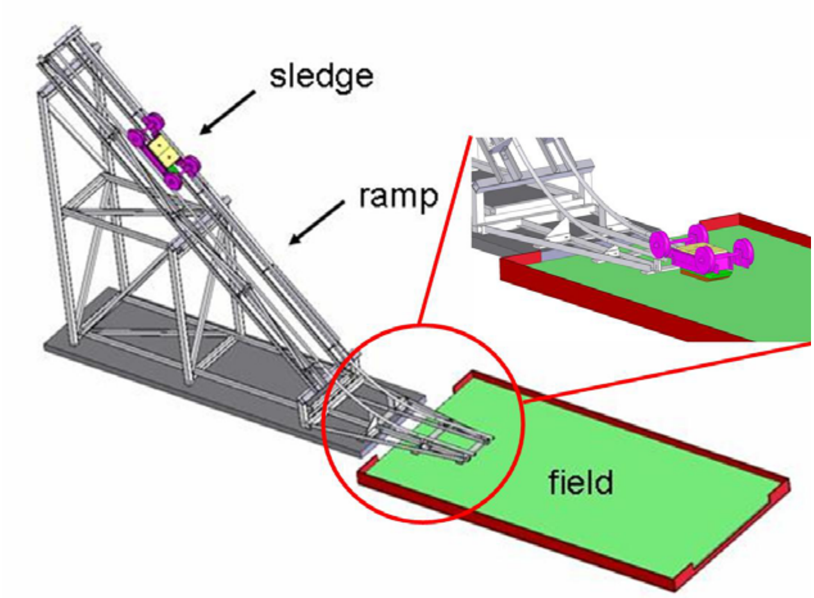

Figure 1. Testing device.

RESULTS The measurements showed that the temperature rises as soon as the sledge enters the field, and gradually decreases after it comes to a standstill. The rise in temperature is higher with increasing speed and mass of the sledge (Table 1). The varying amount of rise in temperature, as well as the sliding distance of the sledge, can be used to compare different fields.

CONCLUSION The developed testing device allows a classification of different fields: the lower the rise in temperature, the better the turf is suited to perform a sliding on it. The testing device can also be used for more fundamental research on the sliding phenomenon, as extensive sliding tests with soccer players are not possible due to the risk of burning injuries.

Table 1. Measured rise in temperature (average and standard deviation) as a function of mass and speed of the sledge.

Mass [Kg]	Speed [M/S]	Av Rise in Temperature [°C]	Stdev Rise in Temperature [°C]
14.8	2.4	4.1	0.4
14.8	3.1	5.6	0.4
14.8	3.7	8.0	0.2
14.8	4.2	8.4	0.6
18.8	3.7	9.5	0.6
22.8	3.7	11.2	0.8
26.8	3.7	12.6	1.3
30.8	3.7	14.0	1.0

KEY WORDS Artificial turf, soccer, sliding, burns, skin.

O-065 Comparison of test performance peculiar to soccer on synthetic and natural grass fields

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OBJECTIVE Soccer fields has great importance on playing soccer. Besides performances of soccer players on different fields is still searched. The goal of this research is the comparison of test performance peculiar to soccer on synthetic and natural grass fields.

METHODS Twenty soccer players participated in this research. 6 different tests were executed to determine performance with ball and without ball on synthetic and natural grass fields. The data which were obtained from the tests executed on synthetic and natural grass fields were compared by using T test.

RESULTS There were significant differences between the performances which were executed on synthetic and natural grass fields in 5 of the tests. On symmetric part of the tests synthetic grass fields provided better results but on asymmetric part of the tests natural grass fields gave better results. (p>0.005).

Table 1. Means and SD of test results.

	Mean (Sn)	(±SD)
30 M Grass	4,28	0,164
30 M Sen.	4,05	0,122
30 M Grs.Ball.	4,72	0,174
30 M Sen. Ball.	4,42	0,115
HÜFA 1 Grass	9,99	0,413
HÜFA 1 Sen.	10,02	0,331
HÜFA 2 Grass	12,12	0,427
HÜFA 2 Sen.	12,19	0,452
41 M Grass	11,47	0,554
41M Sen.	12,60	0,353
41 M Gra. Ball	14,43	0,625
41M Sen. Ball	15,06	0,430

CONCLUSION The results showed that synthetic grass fields were better in test divisions on symmetric structure. On the contrary, the results of natural grass field were better in test division on asymmetric. Moreover, there were meaningful statistical differences. It was concluded that natural grass fields were better for soccer dominated with asymmetric structures in halts, sudden movement and jumps.

KEY WORDS Soccer, tests, natural grass fields, synthetic grass fields.

O-066 Player perceptions of soccer ball performance

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OBJECTIVE The launch of a new soccer ball, especially for a major tournament, often instigates debate about the suitability and performance characteristics of modern balls. The soccer balls are typically criticised for being ‘too light’ or for ‘moving too much in the air’ yet these opinions are based on the subjective perceptions of the players, which often do not correlate with objective, scientific test. The aim of this study was to develop experimental methods to elicit, analyse and better understand players’ perceptions of soccer balls. The objective was to use these methods to compare the playability and performance characteristics of a prototype ball with three tournament balls. In future, these techniques could be used to identify undesirable ball attributes earlier in the design process.

METHODS 38 players from four professional clubs in the UK conducted four skill tests (passing, ball control, heading & shooting) using four different ball types (A-D), After each test, the players rated characteristics of the ball related to that skill using 7-point scaled response questions developed in consultation with players and coaches. The mean ranking for each ball for each characteristic was computed from the players’ ratings.

RESULTS Figure 1 show the mean ball ranks plotted on a scale for each characteristic studied during the shooting test. The bars in Figure 1 indicate the magnitude of Fisher’s Least Significant Difference (LSD). If the bars for two balls do not overlap, then the balls were perceived to be significantly different. Ball D, therefore, was perceived to fly significantly faster and moved/swerved more than Ball C.

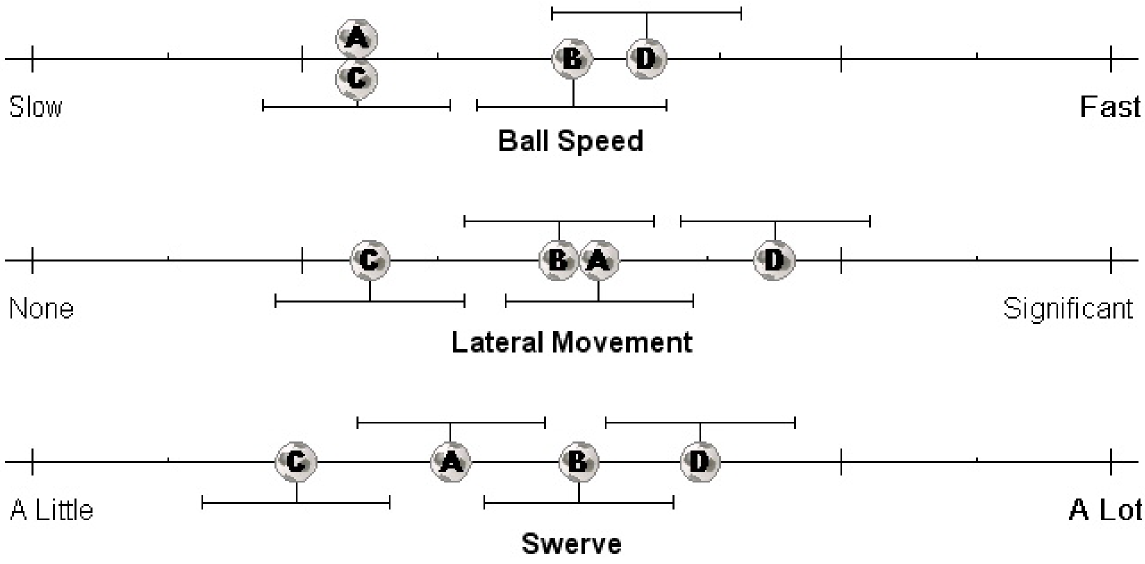

Figure 1. The mean ball ranks plotted on a scale for each characteristic studied during the shooting test.

CONCLUSION The experimental methods developed were successful in measuring players' perceptions of soccer balls. Significant differences in ball characteristics were identified and the suitability of a prototype soccer ball was evaluated against tournament standard balls. In future, the tests could be used to identify differences of opinion between goalkeepers and outfield players or between different football cultures.

KEY WORDS Sensation, perception, football.