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Friction Behavior Of Football Shoe Sole Sliding Against Artificial Grass.

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***Abstract*—The present work discusses the friction coefficient displayed by the sliding of three types of football shoe soles against three types of artificial grass. The effect of applied load on the static friction coefficient displayed by foot wear soles sliding against artificial grass is investigated. Friction tests are carried out at 200 to800 N loads at dry and water wet artificial grass. The tested artificial grass is made of polyethylene fibers of different intensity, length and thickness.**

Based on the experimental results, it was found that sliding of the tested shoes against artificial grass displayed friction coefficient which decreased down to minimum then slightly increased with increasing water content. As the load increased, friction coefficient decreased. The values of friction coefficient were different according to the tested shoe and tested grass. At dry sliding, the second tested shoe displayed drastic friction decrease, while sliding against the artificial grass of thicker fibers displayed relatively higher friction values. The second shoe showed higher values of friction coefficient at water wet sliding compared to the first one. As the contact area increased, the highest values of friction coefficient were displayed at dry sliding. Finally, it is recommended to conduct further experiments to determine the proper football shoe sole as well as the proper artificial grass to provide safe running.

Keywords—Friction coefficient, football shoe soles, artificial grass.

I. INTRODUCTION

The application of artificial grass extensively increases in school and universities although it has potential health and environmental risks. It is used in areas for sport playgrounds and stadiums, [1]. Besides, artificial grass can withstand more use than natural. It is suitable for roof gardens and swimming pool surrounds. It was found that, dry sliding of barefoot against artificial grass displayed friction coefficient which slightly decreased with increasing normal load, [1]. For smooth polyurethane sole, friction coefficient showed very low values, which lead to slipping of the user. Polyurethane flat sole was influenced by the number of fibres, where friction coefficient decreased with decreasing number of fibres. Friction coefficient decreased with decreasing number of fibres. Friction coefficient increased as the fiber length and thickness increased. Sole fitted by studs displayed low friction values due to decrease in the contact area. The thickness of fibers showed significant effect on friction coefficient for bare foot at sliding against water wet artificial grass. For flat sole, friction coefficient showed drastic decrease compared to bare foot sliding due to formation of water film on the contact area. Protrusions in the sole surface allowed the water leakage from the contact area so that friction coefficient increased. The difference in friction coefficient among the tested fibers confirmed the significant effect of the number of fibers.

The disadvantages of artificial grass are that it requires infill such as silicon sand and/or granulated rubber. Some granulated rubber is made from recycled car tires and may carry heavy metals which can leach into the water table, [2, 3]. There is evidence showing higher player injury on artificial turf. Friction between shoe soles and older generations of artificial turf can cause abrasions and/or burns to a much greater extent than natural grass. This is an issue for some sports: for example, football in which sliding maneuvers are common and clothing does not fully cover the limbs. However, some third-generation artificial grasses almost completely eliminate this risk by the use of polyethylene yarn. Friction coefficient is the major scale to quantify floor slipperiness.

Surface roughness is known to be a key factor in determining the slip resistance of floors.

Artificial grass has polyethylene plastic sheets that simulate grass fixed in infill layer. The infill layer includes recycled tires as well as athletic shoes, silica, and virgin rubber material. The recycled rubber contains toxic metals such as zinc, lead, cadmium, aromatic hydrocarbons, and which harmfully influences organs, lungs, kidneys and liver of humans. It was found that a structure of artificial turf football fields should be composed of asphalt sub-base, elastic layer, filling sand composed of round grain silica, recycled rubber, and synthetic fibers, [2 - 5]. It was reported that the natural grass field could be replaced every year, [6], where the worn parts of the field can be repaired at significantly lower cost than installing and maintaining an artificial turf field. Besides, artificial grass field requires water to cool the field to make it playable.

Synthetic turf is extensively used in surfaces of playing fields, [7, 8]. The surface properties have been developed in new brands of wide selection of materials. These fields offer a number of advantages over natural turf. In a recent study, it was found that wet artificial grass gives lower friction than dry one. Players wearing short studded shoe suffer lower friction, [9]. This effect could be cancelled when players wear other common stud shoes. The comparison between natural grass and synthetic grass in combination with different shoes was studied, [10]. The choice of an appropriate shoe for use on a given surface requires acceptable level of slip or foot fixation which depends on temperature and presence of moisture and contaminants, [11]. Good performance and reduction of injury depend on choosing the proper soccer boot, [12 – 14]. By understanding of the biodynamic of soccer, podiatrists can advise and protect those athletes.

It was claimed that higher ground stiffness can influence injuries, [15, 16]. Studies of adaptation of the players to the surface and the effect of the changes between different types of playing surfaces on injury were pursued, [17 – 19]. It is necessary to compare teams training and playing their matches on artificial grass to teams who mainly train and play on natural grass, [20, 21], to record and quantify the risk and severity of overuse injuries, [22]. By this proposal, it can be possible to detect the increased injury risk associated with rapid switches in playing surface. The role of infill material and fiber structure, of the artificial grass on the rotational traction associated with American football shoes, was discussed, [23]. The torque produced at the football shoe–surface interface was measured by mobile testing apparatus. Three infill materials in combination with three fiber structures were tested. It was found that infill material, fiber structure, and shoe design significantly affect rotational traction.

The present work discusses the friction behavior of different types of football shoe soles sliding against three types of dry and water wet artificial grass.

Experimental work

The test rig used in the present work was designed

and manufactured to measure the friction coefficient

displayed by the sliding of the tested shoes against the artificial grass surface through measuring the friction force and applied normal force, Figs. 1 - 3. The artificial grass surface in form of a tile (400 × 400 mm^2) is placed in a base supported by two load cells to measure both the horizontal force (friction force) and vertical force (applied load). Two digital screens were attached to the load cells to detect the friction and vertical forces. Friction coefficient is determined by the ratio between the friction force and the normal load. The artificial grass test specimens were prepared from three type of artificial grass. The tested artificial grass is shown in Fig. 4.

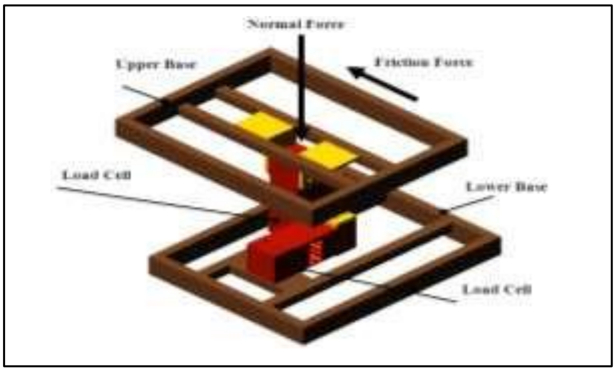
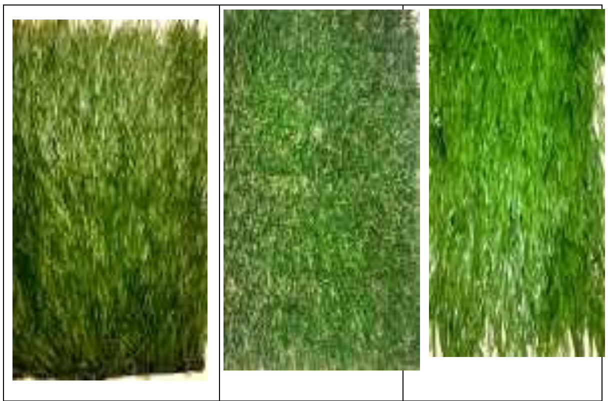


Fig. 1Arrangement of the test rig.

Fig.3 Application of the load.



Artificial grass 1 No. of fibers = 12 Mesh size = 7.5 mm Fiber length = 30 mm Fiber width = 0.7 mm Fiber thickness = 0.13 mm	Artificial grass 2 No. of fiber = 28 Mesh size = 7.5 Fiber length = 30 mm Fiber width = 0.7 mm Fiber thickness = 0.13 mm	Artificial grass 3 No. of fiber = 10 Mesh size = 7.5 Fiber length = 60 mm Fiber width = 1.4 mm Fiber thickness = 0.22 mm

Fig.4 The tested artificial grass.

Friction test was carried out at different forces (loads) ranging from 200 -800 N. Foot wearing football shoe was loaded against counter face (artificial grass) at dry and water wet sliding conditions. Three types of shoe soles (I), (II), and (III) were tested, Fig. 5. Friction values of 400, 600 and 800 N were used in evaluating the performance of the tested shoes and grass. Those load values represent the average values of the weight of children, ladies and gentlemen.

Shoe (I) 135mm² Contact area 77.8 Shore A	Shoe (II) 193 mm² Contact area 78.8 Shore A	Shoe (III) 227 mm² Contact area 61.5 Shore A

Fig. 5The tested football shoes.

RESULTS AND DISCUSSION

Sliding of shoe (I) against artificial grass 1under 400,600,800N loads displayed friction coefficient which decreased down to minimum then slightly increased with water content. As the load increased, friction coefficient decreased. The maximum value of friction coefficient (0.65) was observed at 400 N normal load at dry sliding, while minimum value (0.16) was observed at 800 N normal load for wet grass of 0.5 water content. Under 1 liter water content the higher final value of friction coefficient was (0.41)at 400N load while the lower final value of friction coefficient was (0.28) at 800 N load .

Sliding of shoe (I) against artificial grass 2 displayed friction coefficient which decreased with increasing water content. The values of friction coefficient were relatively lower than that observed for grass 1. It seems that the increase of the fibres intensity caused that behavior. Under 1 liter water content the higher value of friction coefficient was (0.35) at 400N load while the lower value of friction coefficient was (0.18) at 800 N load.

When the length, width and thickness of the fibers of artificial grass 3 increase, friction coefficient shows different trends for varying load and water content, Fig. 8. At relatively lower load (400, 600 N), friction showed relatively higher values especially at 0.5 L water content. This behavior may be from the relatively increase in the grass fiber dimension, where the contact area between shoe sole and grass increases.

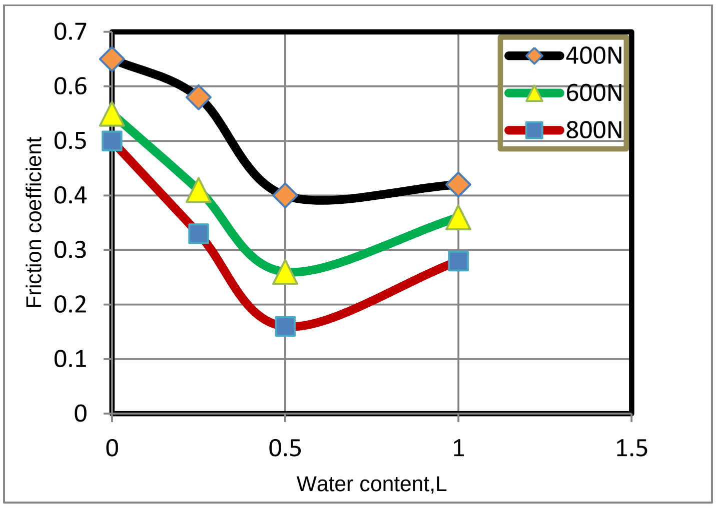


Fig.6 Friction coefficient displayed by shoe (I) sliding against artificial grass 1.

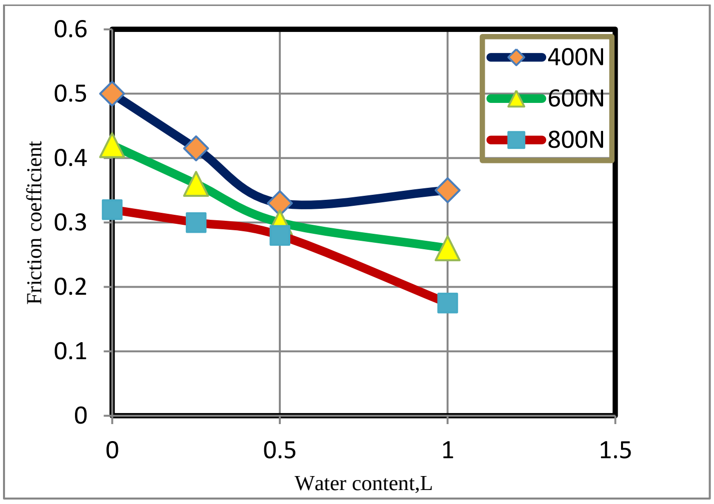


Fig. 7 Friction coefficient displayed by shoe (I) sliding against artificial grass 2.

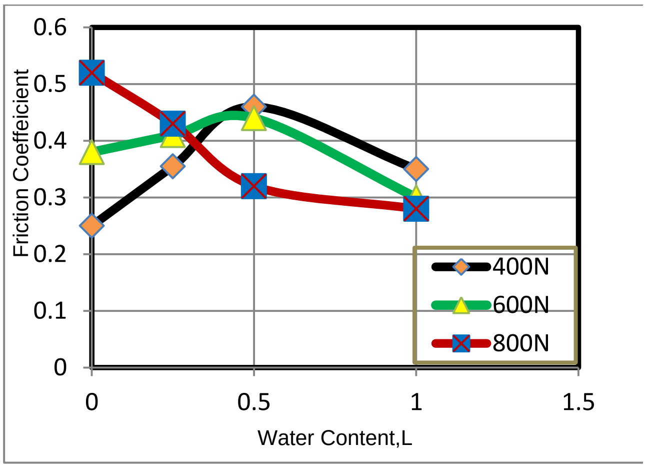


Fig.8 Friction coefficient of shoe (I) sliding against artificial grass 3.

Sliding of shoe (II)soles against artificial grass 1 under 400,600N loads displayed significant friction increase with increasing water, while at 800 N friction coefficient increased up to maximum then decreased, Fig. Comparing the results with that observed for shoe (I), at dry sliding shoe (II) displayed drastic friction decrease. At higher water content (1.0 L) shoe (II) shows slight friction increase. This trend may be attributed to the relative increase of the contact area of the soles, Fig. 9.

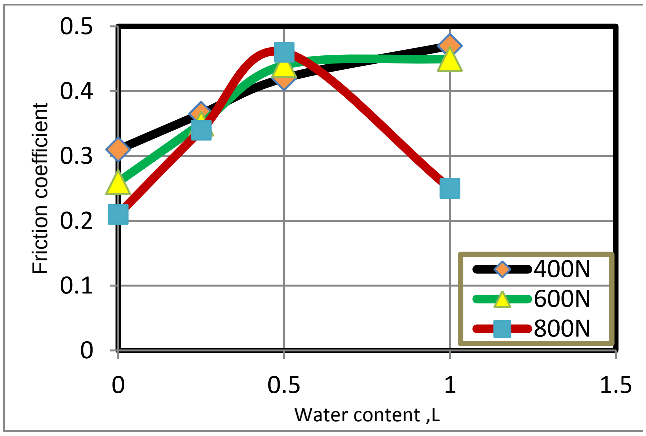


Fig.9 Friction coefficient displayed by shoe (II) sliding against artificial grass 1.

Values of friction coefficient displayed by the sliding of shoe (II) against artificial grass 2shows discrepancy related to the water content, Fig. 10. Higher loads show increasing friction trend with increasing water content, while 400 N load shows slight friction decrease. The maximum value of friction coefficient (0.5) was observed at 800 N normal loads at 1.0 L, while minimum value (0.1) was observed at dry sliding.

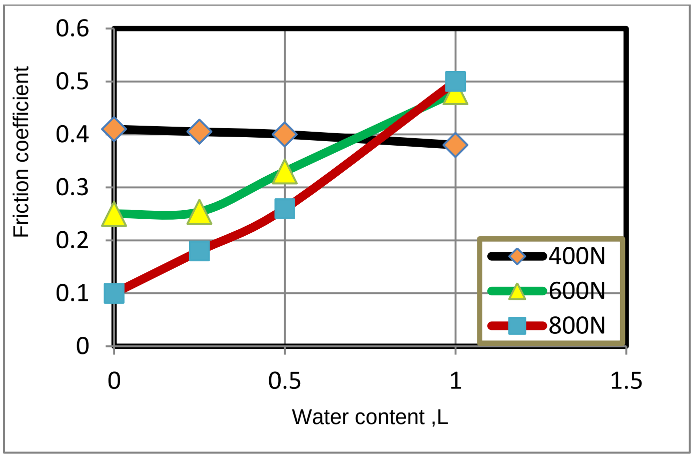


Fig.10 Friction coefficient displayed by shoe (II) sliding against artificial grass2.

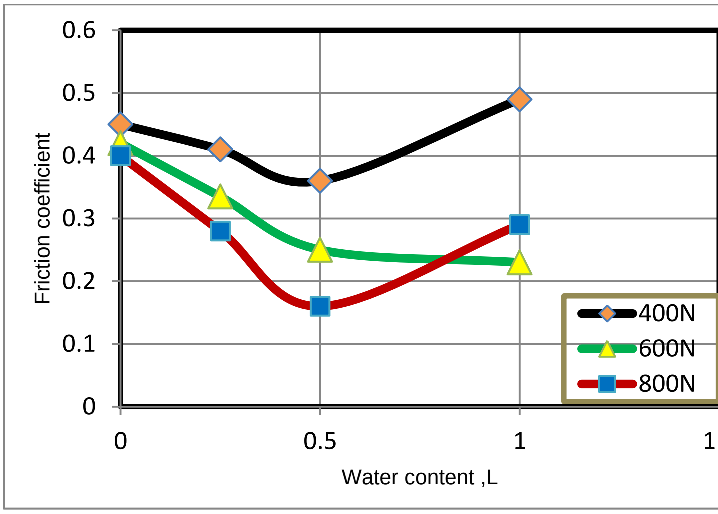


Fig.11 Friction coefficient displayed by shoe (II) sliding against artificial grass3.

Shoe (II)sliding against artificial grass 3 displayed relatively higher friction values at dry sliding, Fig. 11. As the water content increases friction decreases down to minimum then increases. Generally shoe (II) shows higher values of friction coefficient at 1.0 L water content compared to shoe (I). This result may be interpreted on the increase of the area of contact.

Figure 12 shows the relationship between friction coefficient, displayed by shoe (III) sliding against artificial grass 1, and water content. At dry sliding, shoe (III) shows the highest values of friction coefficient. As the water content increases friction decreases down to minimum followed significant increase. The maximum value of friction coefficient (0.69) was observed at 800 N normal load at dry sliding, while minimum value (0.2) was observed at 0.5 L. The relative increase of the contact area of shoe (III) with artificial grass may be responsible for the observed behavior.

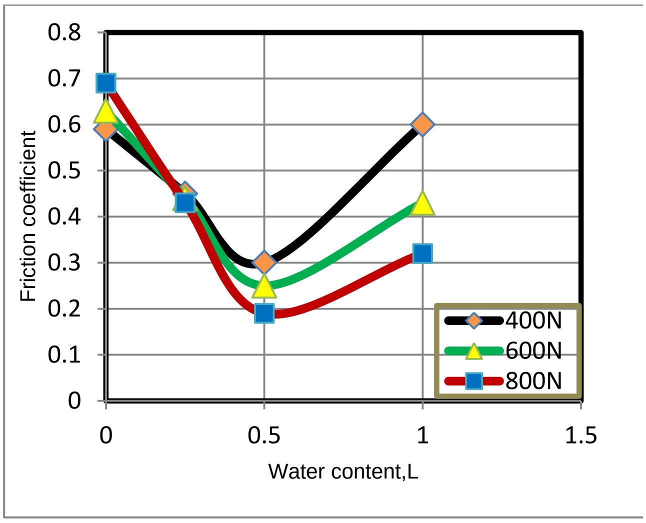


Fig.12 Friction coefficient displayed by shoe (III) sliding against artificial grass 1.

Sliding of shoe (III) against artificial grass 2 displayed lower friction values than that observed for grass 1 at dry sliding. As the load increases, friction coefficient decreases. The big difference in friction coefficient may be one of the major factors in safe running on the tested artificial grass. The lowest friction values were observed at 0.5 L water content. Further increase in water content causes an increase in friction coefficient.

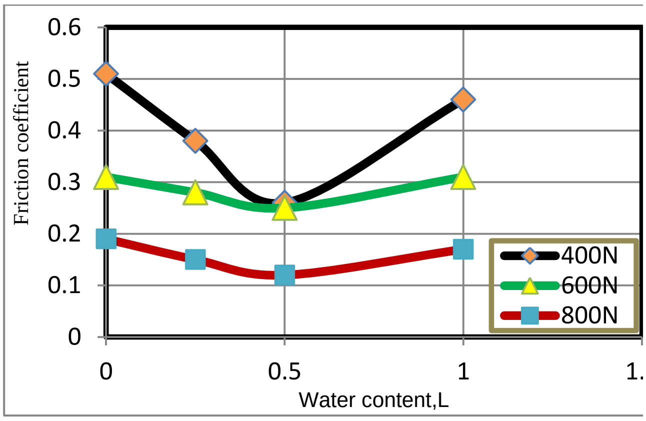


Fig.13Friction coefficient displayed by shoe (III) sliding against artificial grass 2.

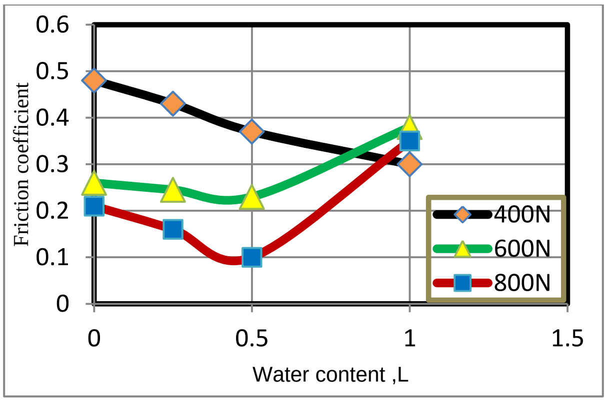


Fig. 14 Friction coefficient displayed by shoe (III) sliding against artificial grass 3.

Further friction decrease is observed for sliding of shoe (III) sole against artificial grass 3. Knowing that Shoe (III) and grass 3 have the biggest contact area, the results indicate the necessity to proper selection of other materials to be used in shoe studs in order to provide higher values of friction to guarantee safe running free of slip.

CONCLUSIONS

1. Sliding of shoe (I) against artificial grass 1 displayed friction coefficient which decreased down to minimum then slightly increased with water content. As the load increased, friction coefficient decreased. Sliding of shoe (I) against artificial grass 2 displayed friction coefficient which decreased with increasing water content. The values of friction coefficient were relatively lower than that observed for grass 1. When the length, width and thickness of the fibers of artificial grass 3 increase, friction coefficient shows different trends for varying load and water content.

2. Comparing the results of shoe (II) with that observed for shoe (I), at dry sliding shoe (II) displayed drastic friction decrease. At higher water content (1.0 L), shoe (II) shows slight friction increase. For the sliding of shoe (II) against artificial grass 2, higher loads show increasing friction trend with increasing water content, while 400 N shows slight friction decrease. Sliding against artificial grass 3 displayed relatively higher friction values at dry sliding. As the water content increases friction decreases down to minimum then increases. Generally shoe (II) shows higher values of friction coefficient at 1.0 L water content compared to shoe (I).

3. At dry sliding, shoe (III) shows the highest values of friction coefficient. As the water content increases friction decreases down to minimum followed significant increase. Sliding against artificial grass 2 displayed lower friction values than that observed for grass 1 at dry sliding. As the load increases, friction coefficient decreases. Further friction decrease is observed for sliding of shoe (III) sole against artificial grass 3.

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