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EFFECT OF THE THICKNESS AND WIDTH OF ARTIFICIAL TURF FIBER ON THE FRICTION AND ELECTROSTATIC CHARGE GENERATED DURING SLIDING

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ABSTRACT

The present work discusses the effect of the fiber thickness and width of the artificial turf on the friction and electrostatic charge (ESC) generated during sliding ofsport and football shoes as well as bare foot on its surface. Friction coefficient and ESC are determined at dry and water wet sliding.

Based on the experiments carried out in the present work, it was observed that as the fiber thickness increased, friction coefficient increased. Bare foot showed the lowest friction due to the leakage of ESC from the contact area through the human body so that the adhesion between bare foot and turf surface decreased. Besides, ESC generated at the sliding surfaces increased with increasing fiber thickness due to the increase of fiber deformation. At water wet sliding, bare foot showed relatively higher friction values due to the squeeze action followed by the sport shoes, while football shoes displayed the lowest values. In addition, turf of smooth surface displayed the highest intensity of electrostatic charge. It is recommended to introduce new materials to be used as artificial turf of lower ESC to reduce its hazards.

KEYWORDS

Artificial turf,fiber, thickness, width, friction coefficient, electrostatic charge.

INTRODUCTION

The application of artificial turf for indoors and sport yards has increased over the use of natural grass, [1, 2], in the regions of limited rainfall. The disadvantages of the natural fibers are high cost of maintenance as well as the severe effect of weather that cause wear and tear. The influence of the artificial turf on artificial skin was discussed and compared to human skin, [3]. This factor is more important than the comfort and quality of the turf and is currently secured by the FIFAs Quality Concept for Football Turf, [4]. The fibers of artificial turf are tested to ensure the quality of the turf and guarantee the safety of football players against the abrasion of the turf. The effect, of infill material of turf on the performance of football players, was discussed, [5]. The friction of artificial turf depends on infill depths and types that affected the skin-turf interaction, [6, 7]. The results showed that turf fibers have strong effect on the friction

behavior of partially-filled turf. This observation can be used in developing skin-friendly turf products.

One of the great concerns of artificial turf is the abrasion of skin. Turf yarn materials based on polypropylene and polysulfobetaine methacrylate were tested when sliding against silicone skin, [8]. It was observed that, hydrophilic polymer brushes succeeded to reduce silicone skin-sample friction effectively. Artificial turfs consisting of polymeric yarn carpetswith rubber and/or sand infill were extensively used, [9, 10]. The surface properties of turf affect player performance and severity of injury. Researches have been performed to investigate the relationship between skin injury and surface properties of artificial turf. It was found that artificial turf causes higher risk of injuries than natural turf due to their higher abrasion on skin, [11 - 13]. Tests were carried out to measure the friction of the tested turf materials sliding against silicone skin.

Artificial turf was tested to investigate the effect of the wear and environmental conditions on its behavior, [14]. It was proved that temperature had no effect on the mechanical behavior of the turf. The structural specifications of the turf such as fiber materials and dimensions, infill materials, sub-layers and sub-base construction types are responsible for the mechanical behavior, [15 – 17]. Skin injuries induced from sliding in football yard were quantified, [18], where they depend on the degree of abrasion of the turf. It was proved that skin irritation depends on the degree of abrasion. Some tests were carried out using silicone and foam to replace skin, [19, 20], to evaluate the abrasiveness of turf. The effect, of natural and artificial turf on the skin of female football players, was investigated, [21].It was found that artificial turf reduced the risk of knee injury compared to natural turf. Recently, the effect of applied load on the static friction coefficient displayed by footwear sliding against artificial turf was investigated, [22, 23]. The tested artificial turf is made of polyethylene fibers of different length and thickness. It was shown that football shoes displayed low friction values due to decrease in the contact area. Flat sole displayed drastic decrease in friction coefficient compared to bare foot sliding due to formation of water film on the contact area.

In the present work, the influence of the thickness and width of the fibers of the artificial turf on both of friction coefficient and electrostatic charge is investigated under dry and water wet sliding.

EXPERIMENTAL

Friction coefficient displayed by the sliding of the tested shoes and bare foot on artificial turfsurface was determined by using test rig designed and manufactured for that purpose through measuring the friction force and applied normal force. The artificial turf surface in form of a tile (400 × 400 mm^2) was placed in a base supported by two load cells to measure both the horizontal force (friction force) and vertical force (applied load). Friction coefficient is determined by the ratio between the friction force and the normal load. The artificial turf test specimens were prepared from two groups of artificial turf fibers. The first one was of 1.5 mm fiber width of 0.14, 0.18, 0.19, 0.21 and 0.25 mm thickness, while the second group was of 0.15 mm fiber thickness and 1.0, 1.4, 1.6, 1.8 and 1.9 mm fiber width. Friction test was carried out at different forces (loads) ranging from 50 to 1200 N. The load values represent the average values of the weight of children, females and males. Bare and foot wearing sport and football shoes were loaded against the tested artificial turf at dry and water wet sliding conditions, Figs. 1 and 2. Besides, three types of fibers of 1.8 mm width were selected, two of them (turf I and II)

have longitudinal protrusions, while the third one (turf III) has smooth surface as shown in Fig. 3. ESC was measured for the three fibers to investigate the effect of the protrusions on the ESC generated during sliding.

Training Shoe
Polyvinyl chloride 75.2 Shore A.

Football Shoe
Polyvinyl chloride 79.4 Shore A.

Fig. 1 The tested shoes.

Fig. 2 Bare foot friction test.

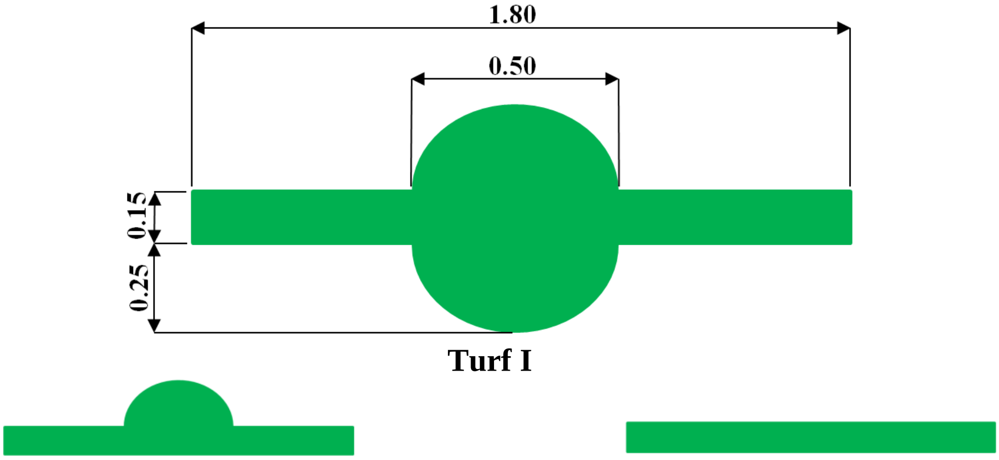

Fig. 3 Photomicrographs of the surfaces of the tested turfs.

RESULTS AND DISCUSSION

Results of experiments carried out to investigate the effect of fiber thickness on the friction coefficient showed significant effect at dry sliding, Fig. 4. As the fiber thickness increased friction coefficient drastically decreased. This behavior can be explained on the fact that as the fiber thickness increases the deformation of the fiber decreases so that the contact area decreases. Sport sole displayed the highest friction coefficient followed by football sole, while bare foot showed the lowest and consistent trend of friction. It seems that the deflection of the turf fibers in the contact area was affected by the fiber thickness. Fiber thickness of 0.14 mm displayed the highest friction values. This observation recommends that type to be used in dry application. Bare foot showed the lowest friction due to leakage of ESC from the contact area through the human body so that the adhesion between bare foot and turf decreased.

Measuring ESC on the turf surface after dry sliding showed that football shoes displayed the highest values followed by sport shoes, where the ESC slightly increased with increasing fiber thickness, Fig. 5. ESC increase with increasing fiber thickness can be explained on the fact that as the fiber thickness increases its deformation increased and consequently the number of free electrons in the external orbits of surface atoms that are responsible for the generation of ESC and separated from the fiber surface increased. That observation can confirm results of friction coefficient shown in Fig. 4.

At water wet sliding, bare foot showed relatively higher friction values followed by sport shoes then football shoes displayed the lowest values, Fig. 6. It seems that presence of water film on the contact area as well as the nature of the surface of the bare foot allow the squeeze action that recorded the highest friction values. Football shoes showed the lowest friction due the decreased contact area of the studs penetrating the tested turf.

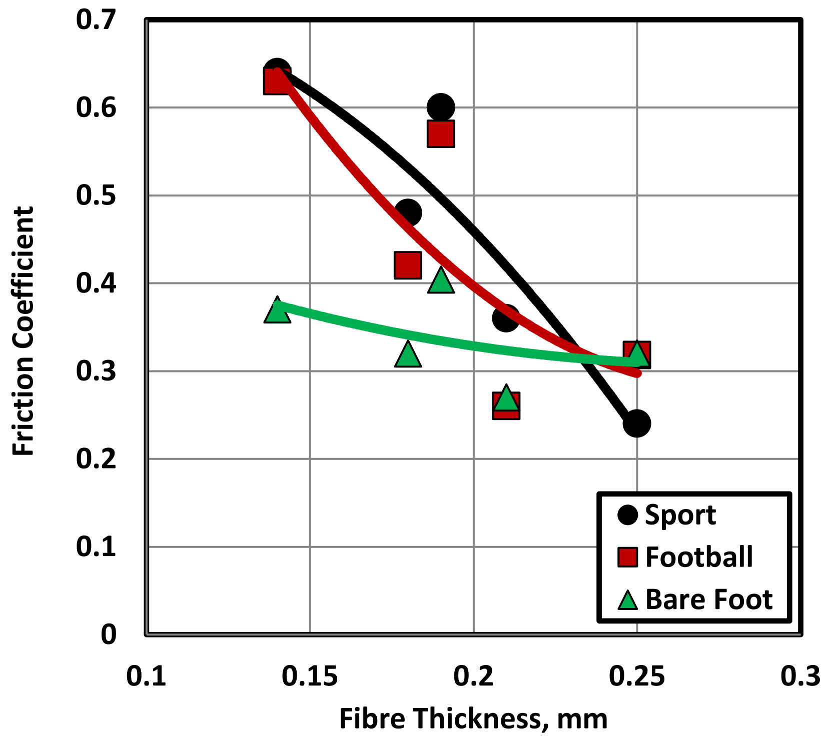

Fig. 4 Effect of fiber thickness on friction coefficient at dry sliding.

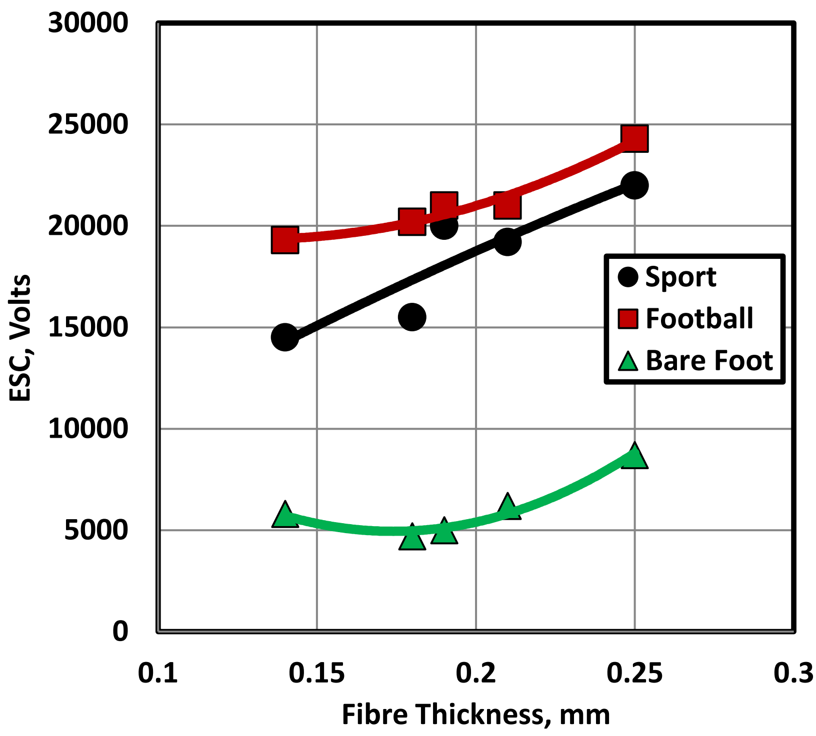

Fig. 5 Effect of fiber thickness on electrostatic charge at dry sliding.

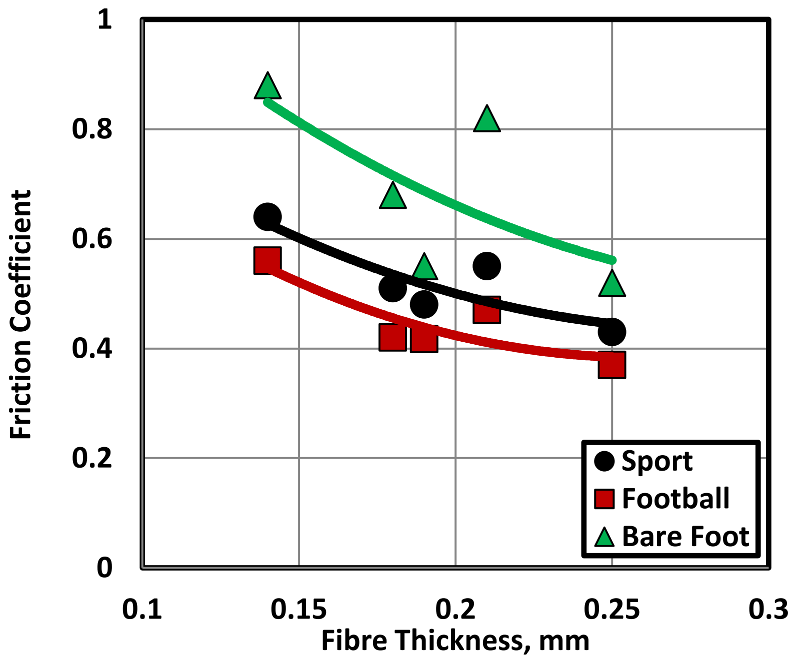

Fig. 6 Effect of fiber thickness on friction coefficient at water wet sliding.

Friction coefficient significantly increased with increasing fiber width at dry sliding, Fig. 7. Sport shoes showed the highest friction, while bare foot gave the lowest one. This observation can be interpretted due to the increase of the fiber contact area subjected to friction. Bare foot showed the lowest friction values. It was interesting that fiber width

had no effect on the ESC generated from the friction of the tested turf and the counterfaces, Fig. 8.

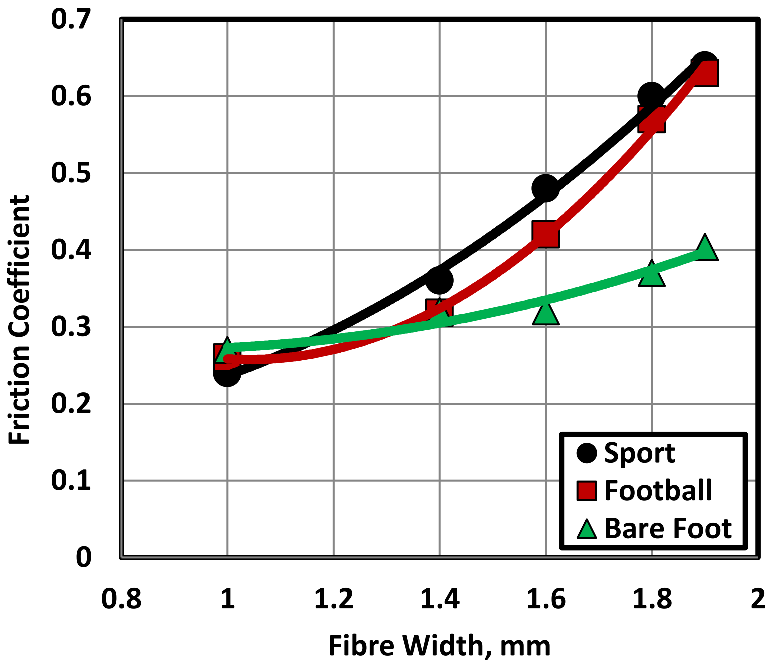

Fig. 7 Effect of fiber width on friction coefficient at dry sliding.

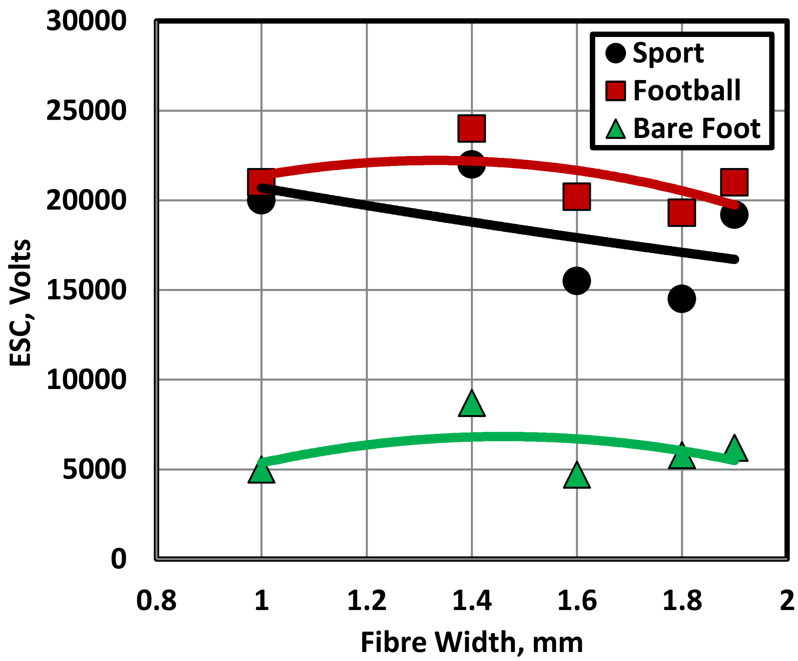

Fig. 8 Effect of fiber width on electrostatic charge at dry sliding.

At water wet sliding, bare foot showed the highest friction values, Fig. 9, where increase of fiber width represented significant increase in friction coefficient. Based on that behavior, it can be recommended to use turf of 1.8 mm fiber width in indoor floor near the swimming pool. Football shoes displayed the lowest friction coefficient due to the presence of the studs that decreased the contact area.

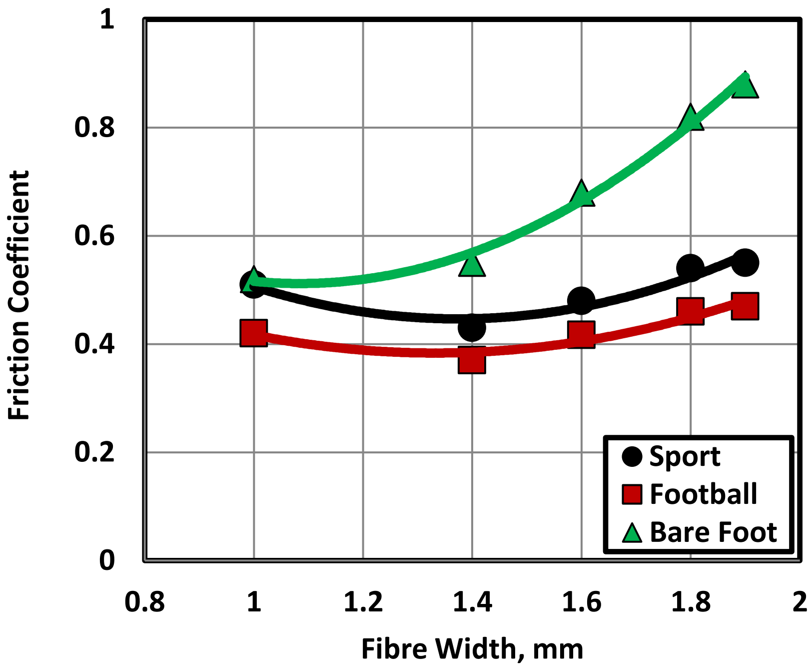

Fig. 9 Effect of fiber width on friction coefficient at water wet sliding.

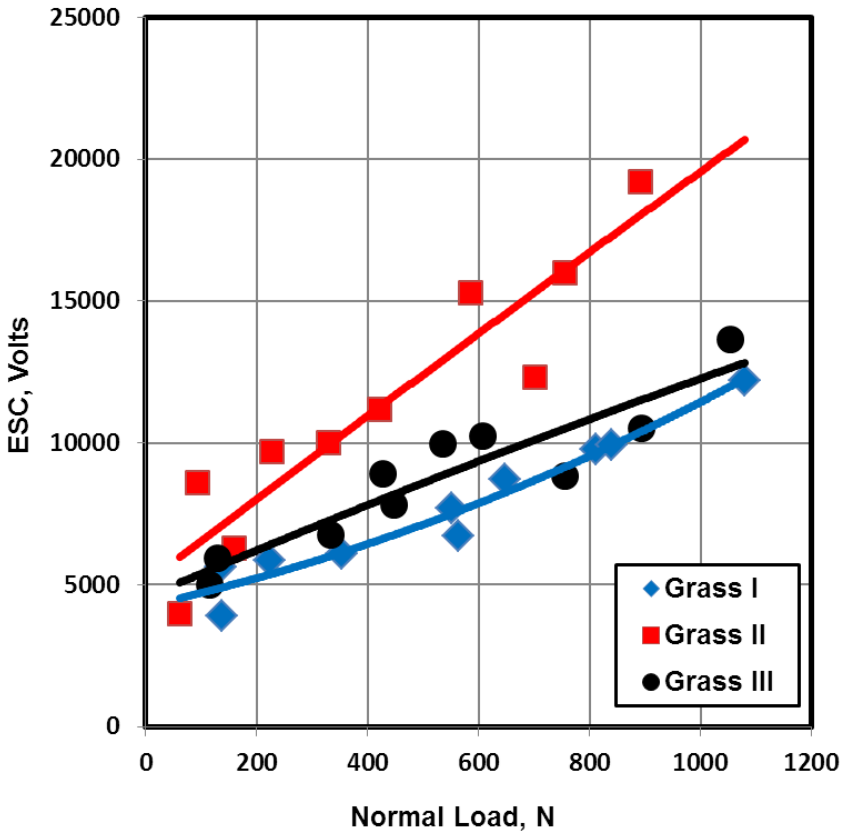

Fig. 10 Electrostatic charge generated from sliding of training shoes on the tested artificial turf.

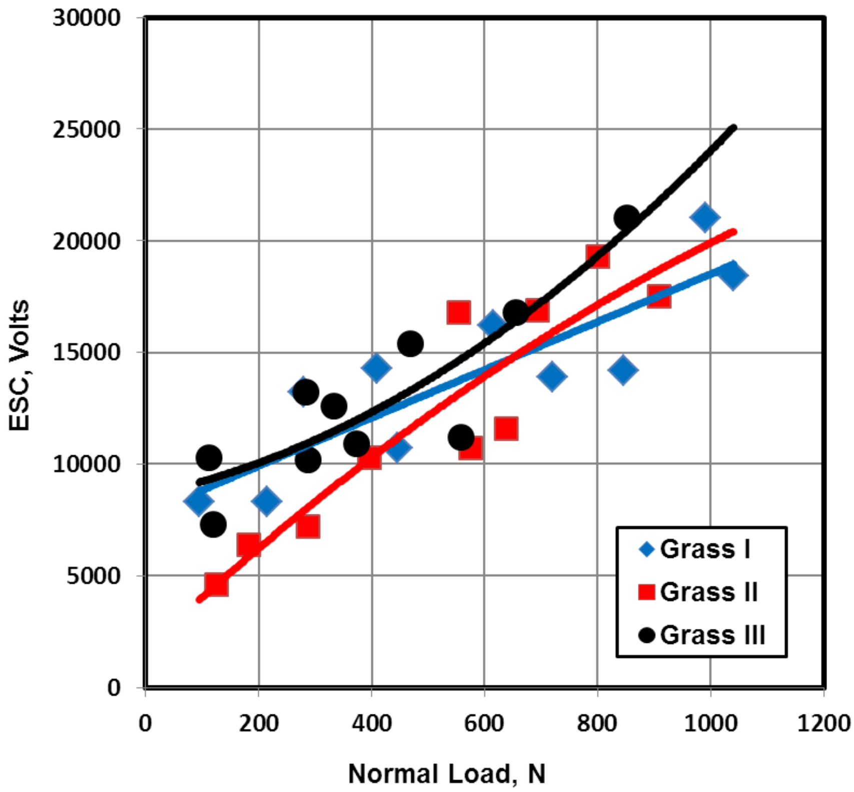

Fig. 11 Electrostatic charge generated from sliding of football shoes on the tested artificial turf.

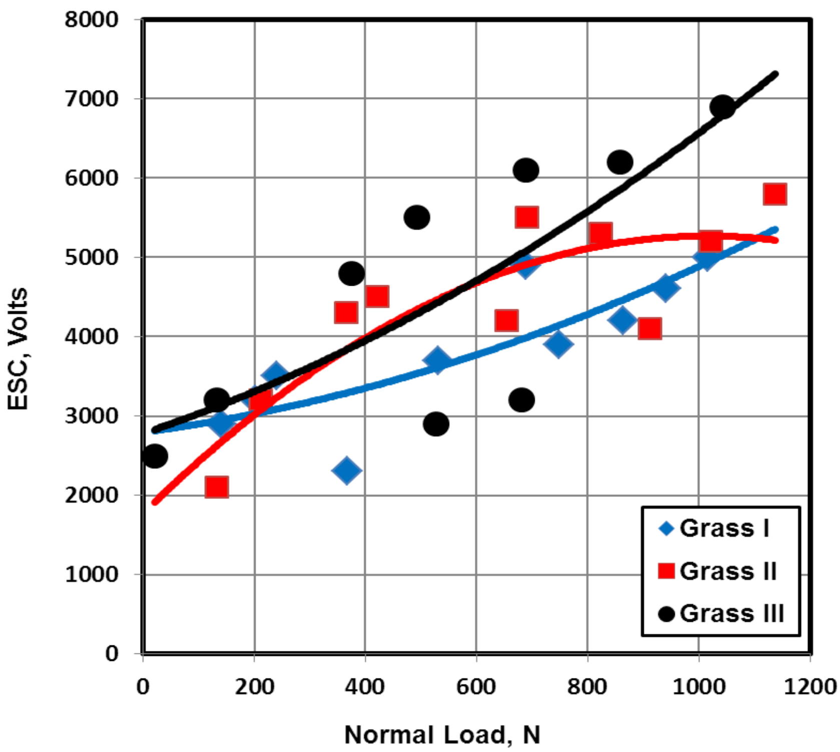

Fig. 12 Electrostatic charge generated from sliding of bare foot on the tested artificial turf.

Stable walking and running on artificial turf is evaluated by the static friction coefficient. It is well known that walking and creeping on floor can generate ESC of intensity depends on the materials of floor and footwear, [24, 25]. Little attention has been devoted to ESC generated from sliding against artificial turf. As polymeric material artificial turf has a tendency to develop ESC when rubbed with dissimilar materials like human skin, polymer and rubber. Due to the high resistance of turf, ESC is not easily dissipated, especially in dry sliding. Running on artificial turf may cause injuries induced by friction between the skin and turf. It was found that earthed textiles with conductive threads did not give ignitions, [26].Further tests were carried out on three types of the tested turf to investigate the effect of the surface protrusions on ESC generated from sliding of training shoes on the surface of the turf. It was observed that turf II that of one sided protrusions displayed the highest ESC values, while double sided and smooth turf s showed lower ESC values, Fig. 10. The difference was significant confirming the effect of the protrusions. Sliding of football shoes on the tested artificial turf showed that smooth surface turf generated the highest values of ESC, Fig. 11. This behavior may be attributed to the increase of the contact area beween the turf and outer surface of the studs of football shoes. The same trend was observed when bare foot slid on the tested artificial turf, Fig. 12. The values of ESC represented lower values than that measured for training and football shoes. It can be recommended to carry out further experiments to introduce new materials to be used as artificial turf of relatively lower ESC to reduce its hazards.

CONCLUSIONS

1. As the fiber thickness increased, friction coefficient drastically decreased. Sport sole displayed the highest friction coefficient followed by football sole and was much affected by fiber thickness, while bare foot showed the lowest and consistent trend of friction. A good correlation was found between friction coefficient and ESC generated on the sliding surfaces.
2. At water wet sliding, bare foot showed the relatively higher friction values followed by sport shoes, while football shoes displayed the lowest values.
3. Friction coefficient significantly increased with increasing fiber width at dry sliding.
4. At water wet sliding, bare foot showed the highest friction values. It can be recommended to use turf of relatively higher fiber width in indoor floor near the swimming pool.
5. As the fiber width increased friction coefficient increased.
6. Turf of smooth surface displayed the highest intensity of electrostatic charge.
7. Great concern should be forwarded towards introducing new materials for artificial turf of low ESC to reduce its hazards.

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