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ARTIFICIAL GRASS TO REPLACE NATURAL GRASS IN GREEN AREAS AND PUBLIC PARKS TO COMBAT WATER SHORTAGE

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ABSTRACT

Water availability is the biggest environmental issue that faces many countries like Egypt in the 21st Century. Water-efficient sustainable landscapes can be responsive to the environment, re-generative, and can actively contribute to the development of livable communities. This paper presents experimental results aiming at improving the walking safety measures on artificial landscape covers. The basic aim is to study future developments that are necessary to deal with the emerging changes in play grounds and public parks. Floor slipperiness is usually monitored by coefficient of friction. Tests are made with 50 to 300 N loads, in dry and wet rubbing conditions for Polyethylene fibers of different length and thickness. The friction decreased with the increase in normal load, which indicates high possibility of slipping for runners. The performance of polyurethane wear is affected by the density of fibers per unit area, whereas the friction decreased with decreasing the number of fibers. On the other hand, the friction increased with increasing the fiber thickness and length.

Keywords: friction coefficient, artificial grass,slips and falls, injury risks, virtual environments, ergonomics.

INTRODUCTION

Artificial grass is a surface of synthetic fibers made to replace natural grass [1]. It is often applied in arenas and sport yards. The difficulty of getting enough sunlight for the grass to stay healthy in domed, covered, and semi covered or tented stadiums introduced the use of artificial grass to become a good substitute. Artificial grass offers a good solution when the environment is hostile for growing green natural grass. Besides, artificial grass is more durable with reasonably longer life and can resist wear more than the natural. It is suitable for the surroundings of swimming pools, roof gardens and landscape green designs. Finally it needs very low maintenance processes and low maintenance cost when compared to natural grass.

The disadvantages of artificial grass however are that it requires filling materials such as silicon dioxide sand and/or granulated rubber. Accordingly, some granulated rubber is produced from crushed recycled tires and usually have heavy metal impurities which leach into the soil and find its way to the water table, [2]. Higher player injury is reported evident on artificial grounds. Falling and sliding on older generations of artificial turf cause abrasions and high friction which generates enough heat to cause burns to a much greater extent than natural grass. This is an issue for sports such as football in which sliding maneuvers are part of the game and clothing shorts do not fully cover the limbs. However, this risk has been completely eliminated by using the polyethylene yarn in the third-generation of artificial grasses.

Floor slipperiness has been always monitored by the coefficient of friction as a prime indicator. Tribo-testing of the coefficient of friction for rubber sliding indoor against polymeric flooring materials having a range of surface roughness is reported, [3]. The coefficient of friction decreased when increasing both the applied normal load and surface texture. The coefficient of friction in water lubricated rubbing however, increased to a maximum and then fall down with increasing surface roughness. Adding detergent in water to lubricated sliding resulted in notable decrease in the coefficient of friction with increasing the surface roughness. Oil lubricated contacts, showed the highest friction values at roughness value of 4.0 µm R_a. In water and oil lubricated rubbing, smooth flooring surface slid on water and oil contaminated surfaces showed lower values of the coefficient of friction (μ = 0.08). This value is close to the values observed for mixed boundary lubrication where the two mating surfaces are separated by a fluid lubricant film. The coefficient of friction of bare foot and polymeric samples in dry sliding conditions, indicated the decrease of its values down to a minimum followed by an increase with increasing the surface roughness, [4]. In water lubricated sliding, textile cotton samples gave the highest friction coefficient. It notably decreased with increasing surface roughness in lubricated sliding with water and detergent. Oil lubricated flooring materials, rubbing against human skin resulted in drastic reduction in the coefficient of friction, while cotton textiles showed the higher values.

In practice, the surface properties and tribological characteristics of the materials changes due to mechanical wear, ageing, soiling and maintenance, [5]. In the sport halls surface changes within the floor are mainly due to wear, fatigue, tearing, cleaning processes and material transfer from shoe (Elastomer abrasions contaminating particles) to the surface. The coefficients of friction on the surfaces of five floor coverings were monitored periodically over 30 months duration in a new sport complex, [6]. Mechanical wear and tear resulted in different surface topography either by smoothing or roughening, [7, 8], depending on the material of the flooring and its surface characteristics.

Slip resistance is usually assessed by the coefficient of friction which is very dependent on surface roughness. The effect of surface texture of ceramic samples, sliding against rubber and leather, on the coefficient of friction, was demonstrated, [9]. In this work, glazed floor tile surfaces with roughness ranging from

VOL. 13, NO. 19, OCTOBER 2018 ISSN 1819-6608
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0.05 and 6.0 µm was investigated. The coefficient of friction showed decreasing values to a minimum followed by increasing values with further increase of the surface roughness.

One of the major factors affecting walking stability during carrying heavy objects and asymmetric materials handling is resistance of flooring materials to slip and skitter. Floor slipperiness is usually evaluated using the static or the dynamic friction, [10]. Specific limiting values are recommended within the slip-resistant standards for unloaded, normal walking conditions, [11, 12]. Obviously, higher values of static and dynamic friction are required for safe walking specially when handling loads.

Published research indicates reasonable correlations between roughness and friction for a given pair of surfaces, [13 - 17]. Abrasion of rubber shoes during walking on rough coarse grit flooring materials gradually increase the interfacial roughness associated with a rise in friction. Dense rubber became ground and polished yielding flat smooth surface when rubbed on common floors or when rubbed in mechanical polishing. Recent Bio-tribological investigations [18-20] focused on skin friendly materials.

In the present research, it is aimed to through some light on the frictional behavior when walking with different types of foot wear against artificial grass.

EXPERIMENTAL

The experimental set up, Figure-1, is basically a designed test stand which was locally manufactured to measure, monitor and assess the coefficient of friction during sliding of the test samples and specimens against the artificial grass surface. This was achieved by measuring the friction force (F) and the applied normal load (N), Figure-2. The artificial grass surface in form of a square tile is mounted in placed on a base. The base itself is supported by two load cells, one to measure the horizontal force (friction force, F) and the other to measure the vertical force (applied load, N). The load cells were connected to two digital screens to read and plot the friction and vertical forces. The coefficient of Friction is calculated as the ratio between the friction force and the normal load (F/N). Four types of artificial grass test specimens were prepared. These artificial grass materials are given in Table-1.

Figure-1. Test set-up.

Figure-2. Normal & Shear load cells.

Friction test were carried out under different loads from 50 -350 N. Test specimens were loaded against the counter face of the rubbing pair (artificial grass) at dry and water wetted sliding conditions. Four types of test samples are used. Namely: smooth (I), sport pattern specimen, quadrilateral studs (II), cross hatched tread (III) and rubber specimen with cylindrical studs (VI), Table-2.

RESULTS AND DISCUSSIONS

Walking with barefoot indoor on flooring is a usual custom and habit. Artificial grass can be used indoor near swimming pools and corridors. Dry sliding of barefoot against artificial grass yields friction coefficient which slightly decrease with increasing the normal load (N). This does not follow Amontons law which declares that the coefficient of friction is independent of the normal load. The maximum value of the coefficient of friction ($\mu = 1.05$) was observed at 100 N normal load for specimen (C), while minimum value ($\mu = 0.59$) was observed at 600 N normal load for specimen (A), Figure-3. Therefore, artificial grass (C) can be used in indoor near by the swimming pool due to the higher value of coefficient of friction. Behaviour of specimen (D) reflectes the dependence of bar foot friction on the cut size or fiber size of the grass.

VOL. 13, NO. 19, OCTOBER 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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Table-1. Artificial grass specimens.

	
Tile Specimen A No. of fibers = 30 Mesh size = 7.5 mm Fiber length = 30 mm Fiber width = 0.7 mm Fiber thickness = 0.13 mm	Tile Specimen B No. of fibers = 34 Mesh size = 7.5 mm Fiber length = 30 mm Fiber width = 0.7 mm Fiber thickness = 0.13 mm
	
Tile Specimen C No. of fiber = 32 Mesh size = 7.5 Fiber length = 30 mm Fiber width = 0.7 mm Fiber thickness = 0.13 mm	Tile Specimen D No. of fiber = 12 Mesh size = 7.5 Fiber length = 60 mm Fiber width = 1.4 mm Fiber thickness = 0.22 mm

Table-2. Surface texture of tested samples.

(I) Flat Polyurethane smooth surface Ra 100 μm	**(II) Quadrilateral sports pattern, 10 mm wide**
(III) Cross hatched walking pattern 8mm width	(IV) Cylindrical studs Ø 6mm, pitch 12 mm

Smooth polyurethane test specimen (I), confirmed that the friction coefficient relatively decrease with increasing the normal load (N), Figure-4. For all specimens, somewhat low coefficient of friction, which normally leads to slipping of a runner or walker, was observed. Tile specimen (D) is the worst one. Values of the coefficient of friction for smooth specimen were less than those obtained by rubbing of skin bare foot. Polyurethane flat specimens showed friction dependency on the number fibers at the rubbing interface, where the coefficient of friction showed lower values by reducing the number of fibers per unit contact area. This observation is confirmed by the highest coefficient of friction obtained for fiber sample (B) of the highest fibre density per unit area followed by fibre sample (C) and finally fibre sample (A).

VOL. 13, NO. 19, OCTOBER 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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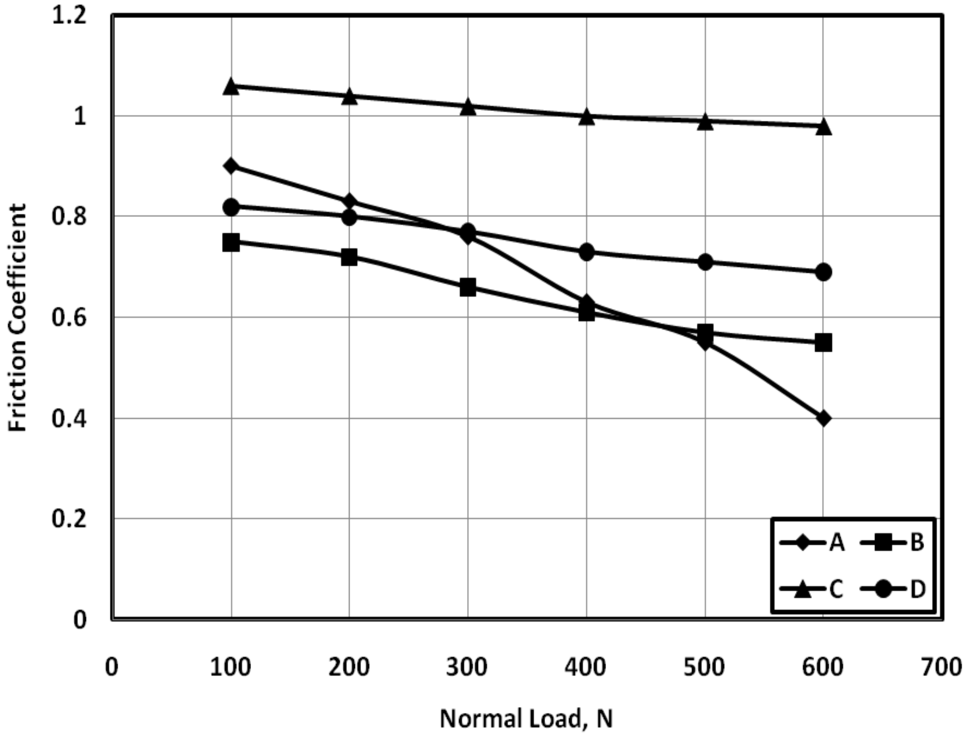

Figure-3. Friction coefficient of bare foot sliding against dry artificial grass.

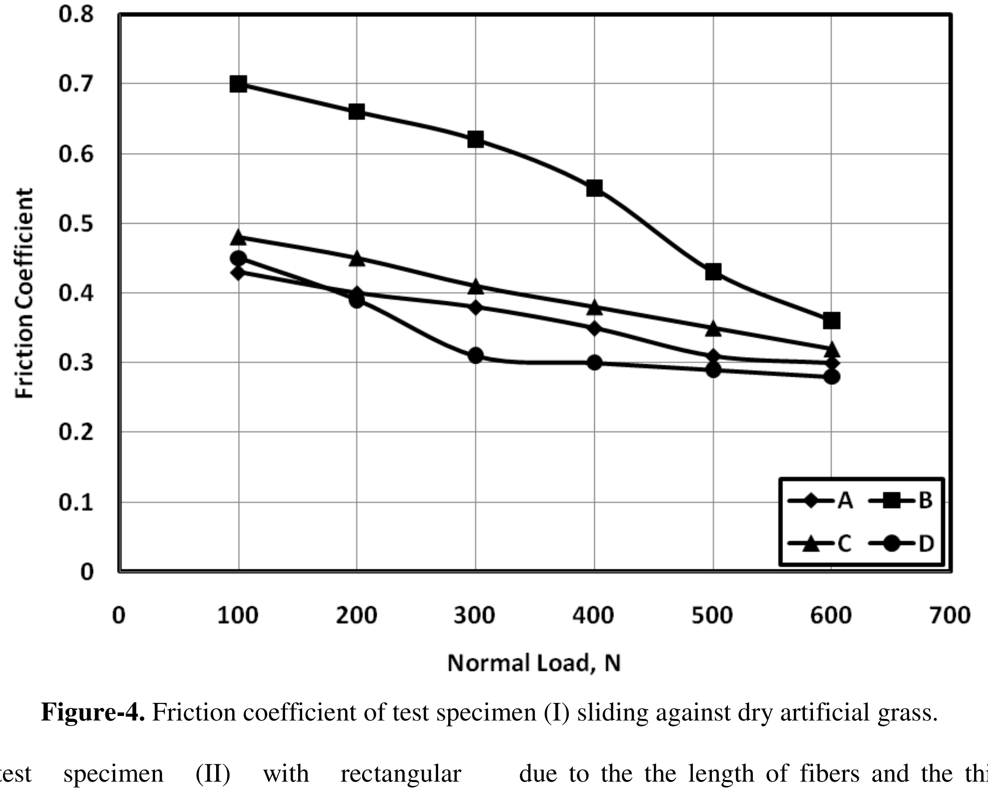

Figure-4. Friction coefficient of test specimen (I) sliding against dry artificial grass.

For test specimen (II) with rectangular protrudents sliding against dry artificial grass, friction coefficient decreased with increasing the normal load (N), Figure-5. The highest value of the coefficient of friction (μ = 1.2) was observed at 100 N load for tile specimen (C), while the lowest value (μ = 0.41) was observed at 600 N normal load for tile specimen (A), which confirms the increase of slip risk. Tile specimen (D) showed higher coefficient of friction as compared with tile specimen (A) due to the the length of fibers and the thicker cut of of fiber .

Test specimen (III) with cross hatched surface pattern showed relatively lower values of the coefficient of friction when slid against dry artificial grass, Figure-6. These values most likely cause slips, with tile specimen (D) giving the worst performance. It is evident that as the number of fibers in the bundle decraeses, the friction coefficient decreases. Tile specimen (B) showed the

ARPN Journal of Engineering and Applied Sciences

highest friction values followed by tile sample (C) and finally tile specimen sample (A).

For test specimen (IV) with cylindrical protruding pattern, sliding against dry artificial grass, friction coefficient decreased with increasing the normal load (N), Figure-7. The highest value of the coefficient of friction (μ = 1.05) observed at 100 N normal load for tile specimen (B), while the lowest value (μ = 0.33) observed at 600 N normal load for tile specimen (D). Although the test specimen (IV) was fitted by six polyamide and five polyethylene protruding studs, friction values were lower than those observed for test specimens (II) and (III) due to the reduced contact area. The contact in this particular case took place between the grass and the studs. This observation should be taken into consideration in further investigations aiming at the proper selection of the materials used in manufacturing of the football studs.

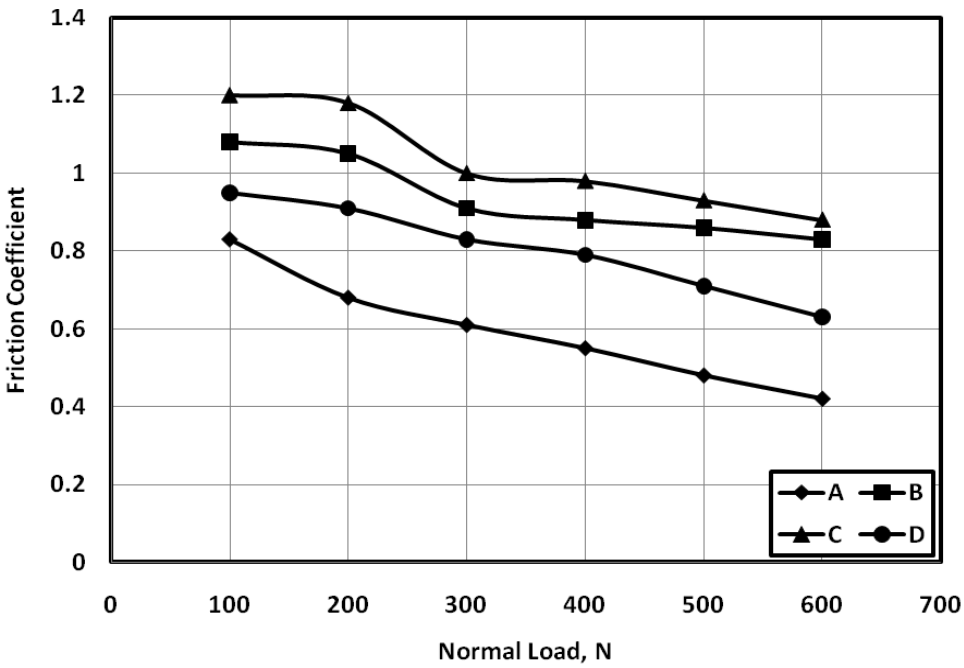

Figure-5. Friction coefficient of test specimen (II) sliding against dry artificial grass.

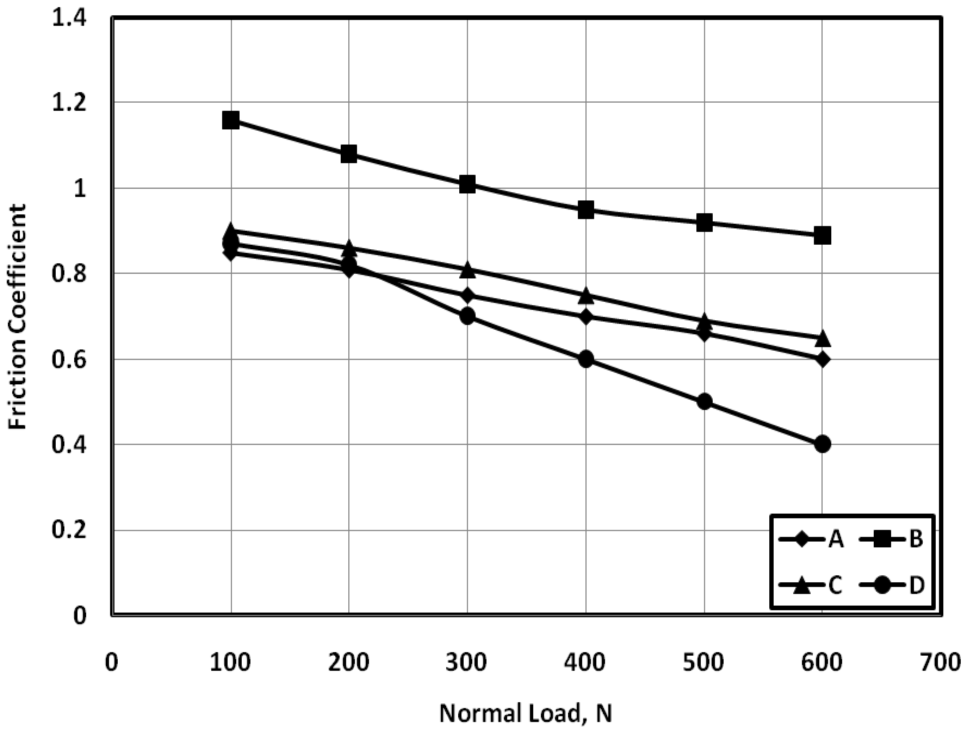

Figure-6. Friction coefficient of test specimen (III) sliding against dry artificial grass.

VOL. 13, NO. 19, OCTOBER 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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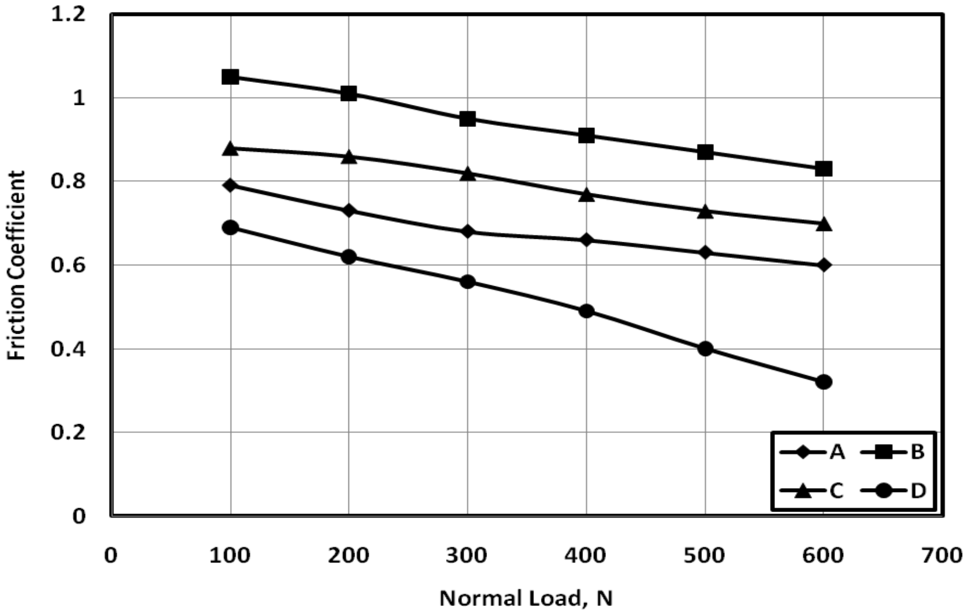

Figure-7. Friction coefficient of test specimen (IV) sliding against dry artificial grass.

When bare foot slid against water wetted artificial grass, friction coefficient decreased with increasing the normal load, Figure-8. The maximum value of friction coefficient (μ = 1.05) was observed at 100 N normal load for tile specimen (B), while minimum value (μ = 0.68) was observed at 600 N normal load for tile specimen (A). Comparing this behavior to the one presented earlier for dry sliding, one can claim insignificant changes in tribological behavior. The thickness of the fibers, however, showed significant effect on the coefficient of friction. It looks like that the deflection of the fibers within the contact area was dependent on the fiber thickness. It is therefore important to investigate the contact deformation for both the test specimen and the tile materials to demonstrate the effect of the fiber thickness on the coefficient of friction.

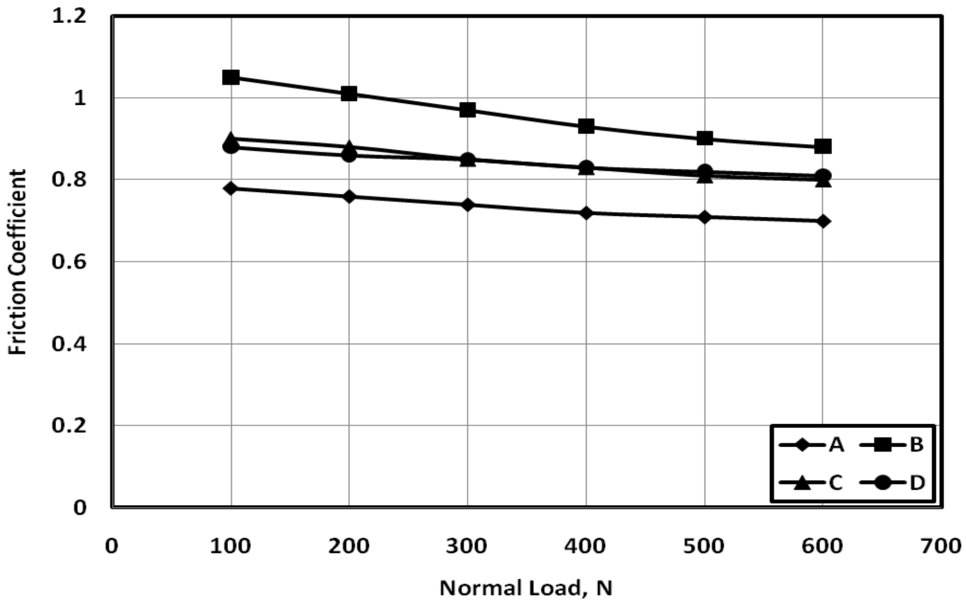

Figure-8. Friction coefficient of bare foot sliding against water wetted artificial grass.

For test specimen (I) sliding against water wetted artificial grass, the friction coefficient showed significant decrease as compared with the bare foot sliding case. The highest friction values were displayed by tile specimen (B), Figure-9. The highest value of friction coefficient (μ = 0.56) was observed at 100 N normal load. A very low friction coefficient which allows slipping was obtained by tile specimen (A). The flat surface of test specimen (I) was responsible for that drop in the friction coefficient, due to water film formation within the contact area.

For test specimen (II), the friction coefficient decreased with increasing normal load, Figure-10,

VOL. 13, NO. 19, OCTOBER 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

showing recorded values higher than those demonstrated by test specimen (I). This behavior is attributed to the water leakage out of the contact area from the gaps between the protrusions in the specimen surface. The water film thickness strongly depends on the height and width of the treads.

For test specimen (III) sliding against water wetted artificial grass, friction coefficient decreased with increasing normal load (N), Figure-11. For all of these test specimens, very low friction coefficient, which favors slipping of the user, was observed. Tile specimen (D) displayed the lowest values of the coefficient of friction. This behavior can be explained on the basis that the number of the fibres was very low as well as the tread groove did not allow the water to escape from the sliding surface.

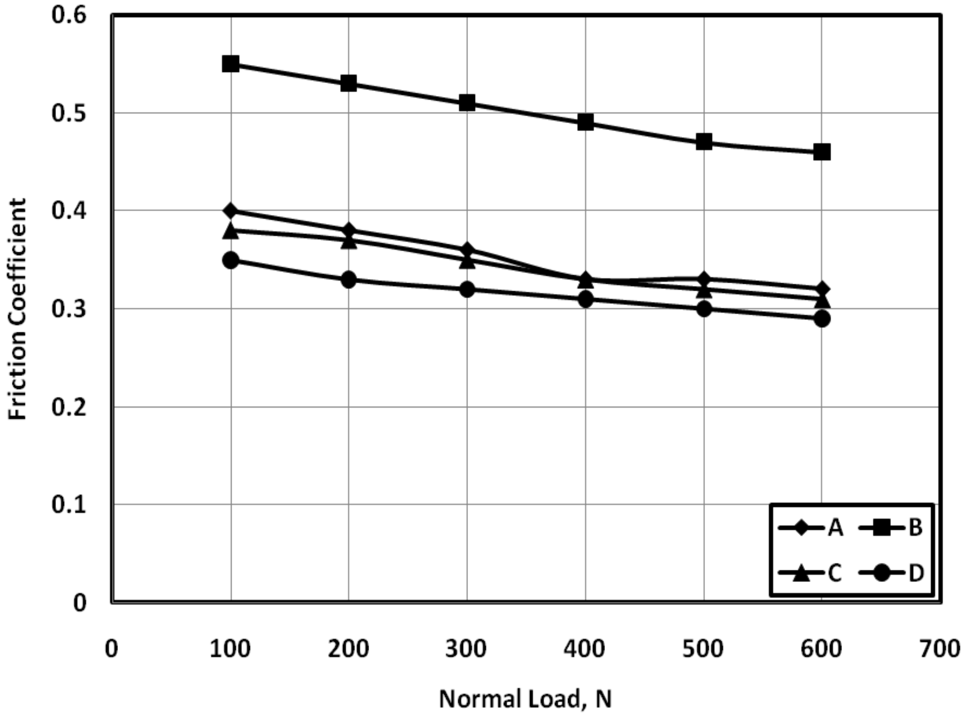

Figure-9. Friction coefficient of test specimen (I) Sliding against water wetted artificial grass.

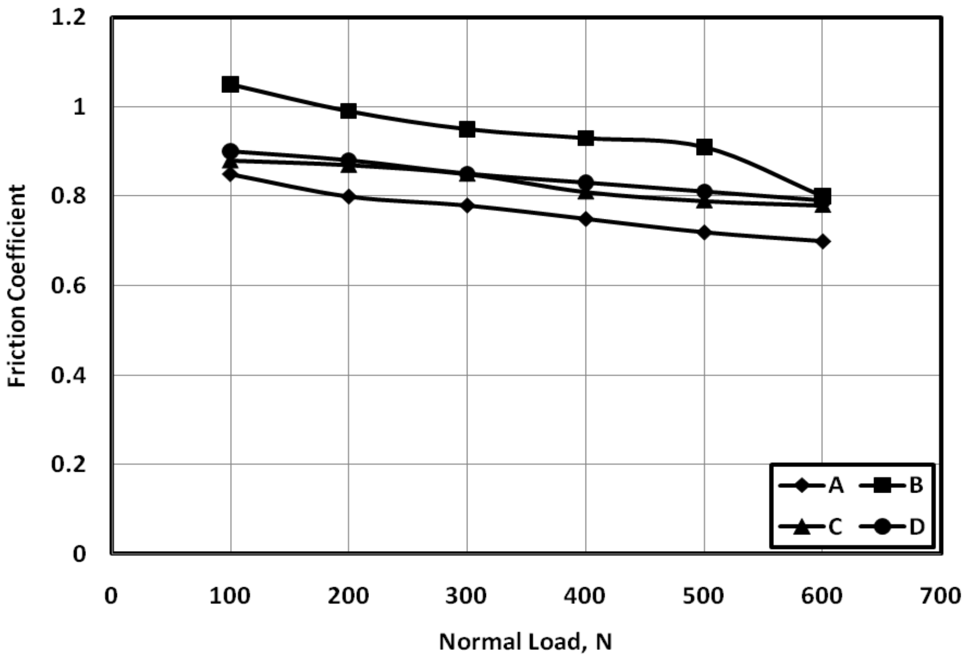

Figure-10. Friction coefficient of test specimen (II) Sliding against water wetted artificial grass.

ARPN Journal of Engineering and Applied Sciences

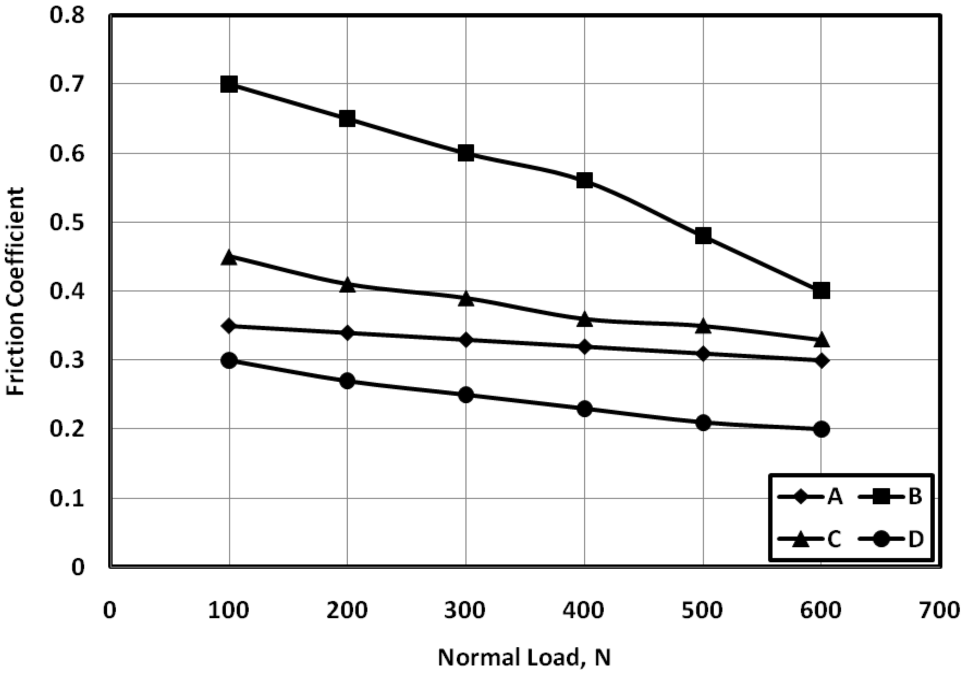

Figure-11. Friction coefficient of test specimen (III) Sliding against water wetted artificial grass.

Test Specimen (IV) showed relatively higher friction values than test specimens (I) and (III), Figure-12. The friction coefficient decreased with increasing normal load. The maximum value of friction coefficient (μ = 0.99) was observed at 100 N normal load for tile specimen (B), while minimum value (μ = 0.40) was observed at 600 N normal load for tile specimen (D). The difference in friction coefficient among the tested fibers confirmed the significant effect of the number of fibres per unit area on the measured friction.

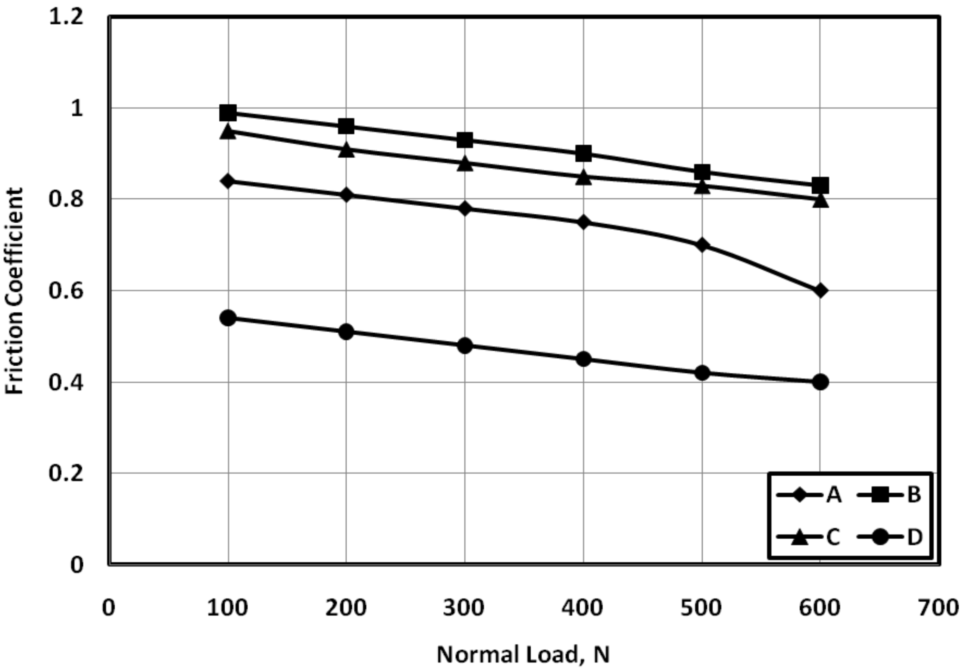

Figure-12. Friction coefficient of test specimen (IV) Sliding against water wetted artificial grass.

CONCLUSIONS

a) Unlike metallic materials, the present combinations bio/ polymeric and polymeric / polymeric pairs do not follow Amontons law. Friction coefficient obtained by sliding against artificial grass decreased with increasing the normal load.

b) Dry sliding of barefoot against artificial grass showed relatively higher values of the friction coefficient.

c) Values of the coefficient of friction for smooth specimens were lower than the measured value for bare foot.

d) The friction coefficient increased with the increase of the fiber length and thickness.

e) Friction values were lower for test specimens fitted by polyamide studs, as compared with those observed for other specimens. This is due to decrease in the contact area, where the contact took place between the grass and the studs.

f) The thickness of the fibers showed significant effect on the friction coefficient for bare foot sliding against water wetted artificial grass.

g) Drastic decrease in friction of smooth test specimens slid against water wetted artificial grass was noticed as compared to bare foot sliding.

h) The presence of protrusions in the test specimen surface increased friction coefficient due to their ability to let the water leakout from the contact area. The water film thickness strongly depends on the height and width of the protrusions of the test specimen treads .

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ARPN Journal of Engineering and Applied Sciences

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