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Frictional Behaviour of Bare Foot and Foot Wearing Socks Sliding Against Marble Flooring Tiles

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Abstract. The present experiments provided quantitative results on the static friction coefficient generated by bare foot and foot wearing socks sliding against the tested tiles. Furthermore, the analysis of the test data gave information about the effectiveness of the tested cleaners and detergent. A better knowledge of the parameters which influence friction coefficient would allow the proper selection of the cleaners, detergents and socks for safe walking.

The static friction coefficients of bare foot and foot wearing socks walking on wet and dry marble floor tiles used in *Tawaf* yard and *Massaa* as well as in halls, entrances and passages areas in *Al-Haram* in Makkah were tested. The tested cleaners (A), (B), (C), (D), (E), (F) and (G) as well as detergent (H) were added into the washing water. The tested tiles were replenished by the solution. Experiments were carried out using a test rig which was designed and manufactured for these tests. Normal loads were applied by foot up to 700 N.

The experimental results showed that for bare foot dry sliding against tiles of *Massaa* displayed the highest friction values, while tiles of the Halls displayed the lowest ones. The highest values of friction coefficient were in tests using cleaner (B), while the lowest values were observed for cleaner (C), (D) and (E). Furthermore, the tested tiles wetted by detergent (H) and cleaner (A) gave the maximum friction coefficient after drying. Tiles of *Massaa* displayed values of friction coefficient up to 0.8. The cleaner (F) displayed friction values which could be considered non-slip for tiles of *Tawaf* and Halls, while tiles of *Massaa* gave slippery sliding. The cleaner (G) experienced non-slip sliding for tiles of *Tawaf* and Halls, while tiles of *Massaa* showed slippery sliding.

For foot wearing cotton socks, at dry sliding, it was noticed that the tiles of *Massaa* displayed the highest friction values followed by the tiles of *Tawaf* and Halls. The sliding condition ranged between very slip-resistant and slip-resistant. In the presence of water, friction coefficient displayed relatively higher friction values than that observed at dry sliding. Friction coefficient displayed higher values in the presence of cleaner (F) than that observed for water sliding. Tiles of *Tawaf* showed higher friction than tiles of *Massaa* and Halls. Furthermore, friction increase was observed for cleaner (G) which provided more safe walking.

Keywords: Friction coefficient, dry friction, water, cleaners, detergents, bare foot, foot wearing cotton socks, marble flooring tiles.

1. Introduction

Reducing slip and fall accidents for older individuals has been a goal for many researchers for several decades. Numerous studies have shown that with advancing age, there is an increasing incidence of falling[1, 2]. The age related changes in the skeletal muscle property, such as muscle fiber types may hinder quick gait adjustments required for successful ambulation over slippery floor surfaces. Slip resistance of flooring materials is one of the major factors affecting bare foot walking. Floor slip-resistance may be quantified using the static coefficient of friction. In the USA, the static coefficient of friction of 0.5 has been recommended as limiting non-slip standard for unloaded, normal walking conditions[3]. Higher static coefficient of friction values may be required for safe walking when handling loads. In Europe[4], it was suggested that the floor is "very slip-resistant" if the coefficient of friction is 0.3 or more. A floor with the coefficient of friction between 0.2 and 0.29 is "slip resistant". A floor is classified as "somewhat slippery" if its coefficient of friction falls between 0.15 and 0.19. The floor is "slippery" and "very slippery" if the coefficient of friction is lower than 0.15 and 0.05, respectively. These classifications were established to quantify the risk associated with slipping and falling. The subjective ranking of floor slipperiness was compared with the static coefficient of friction (μ) and found that the two measures are consistent[5, 6]. Many state laws and building codes have established that a static $\mu \geq 0.50$ represents the minimum slip resistance threshold for safe floor surfaces. Furthermore, the Americans Act Accessibility Guidelines for Disabled[7,8], contain advisory recommendations for static coefficient of friction of $\mu \geq 0.60$ for accessible routes (*e.g.* walkways and elevators) and $\mu \geq 0.80$ for ramps.

The effect of the detergent content on the static friction coefficient of bare foot sliding against wet and dry marble floor tiles used in *Tawaf* yard (A) and *Massaa* (B) as well as in halls and passages (C) in *Al-Haram* in Makkah was tested [9]. It was shown that, at wet sliding of bare foot against (A) type tiles, the highest friction values were displayed at 0.031 vol. % detergent content. After drying, friction coefficient increased up to maximum then decreased with increasing detergent content. The highest values of friction coefficient at 0.25 vol. % detergent content were 0.72, 0.5 and 0.46 at 200, 400 and 600 N respectively. Besides, wet (B) type tiles displayed a decreasing trend in friction coefficient with increasing detergent content. The highest friction values were observed at 0.031 % detergent content. After drying, friction coefficient was higher than that observed for (A) type tiles, where maximum friction value was 0.95 at 200 N load shown with 0.125 vol. % detergent content.

The effect of the cotton content of socks on the frictional behaviour of foot during walking was studied [10]. The static friction coefficient displayed by foot wearing socks of different cotton content under dry, water and water detergent mixture lubricated sliding conditions was investigated. It was found that the friction coefficient increases with increasing the cotton content in socks, where polyamide socks displayed the lowest friction and cotton socks displayed the highest one. The highest friction coefficient was displayed by *Massaa* flooring tiles followed by *Tawaf* and Halls tiles. For foot wearing socks, water lubricated sliding gave relatively higher friction values than dry sliding. It was concluded that appropriate shoes and insoles are not enough and attention must also be paid to socks [11 – 13]. Hosiery helps to remove perspiration from the skin, regulate foot temperature, provide pressure relief, and protect the skin from abrasion. The static and dynamic coefficients of friction between skin and socks and the effect of sock wearing on foot biomechanical response were not studied in terms of their frictional properties [14]. It is estimated that an individual takes about 8000 - 10,000 steps a day. During walking, foot presses and rubs against flooring materials.

It was reported [15, 16] that the friction coefficient between skin and Teflon fabric can be as low as 0.04 while that between skin and cotton fabric is as high as 0.54. Wearing sock can reduce friction and allow the foot to slip on the flooring [17]. To reduce the risk of foot slip, an easy and effective approach is to increase the shear force by selecting and wearing socks with proper friction properties. Wearing sock with low friction against foot skin is effective in reducing shear on the skin than the sock with low friction against the insole [18] hence is able to reduce the risk of developing blisters and ulcers.

Friction between the insole, sock and foot has significant impact on the perception of comfort and the risk of injury of the wearers. Low friction allows the foot to move easily in the shoe. However, excessive movement can result in feeling of insecurity and may generate pressure and rubbing between the top and upper part of the foot and the shoe [19]. Rubbing in shoe includes friction between the foot and the inner surface of sock, and that between the outer surface of sock and shoe. Too low friction in both interfaces may lead to excessive movement of foot in shoe and induces discomfort feeling of insecurity. It was found that the difference in friction coefficient at the different interfaces provide insight into where slip occurs [20]. It was predicted that slip would be expected at the interface of lower friction coefficient rather than the interface of higher friction coefficient. It was recommended to set low friction on one side to allow foot sliding, and high friction on the other side to provide appropriate level of resistance to avoid excessive movement.

It was found that wearing sock of low friction against the insole to allow more relative sliding between the plantar foot and footwear was found to reduce the shear force significantly [21]. Socks are able to change the frictional properties between the foot–shoe interface. Abrasion of the foot skin can be avoided by reducing the shear between the contact interfaces with the use of socks made from textile fibers of low frictional coefficients [22]. The mechanical effect of sock with different frictional properties on foot was investigated by finite element models [23]. Wearing sock can reduce friction and allow the foot to slip on the insole, hence to reduce the shear. In the sock I simulation, lower friction coefficient between the insole and the sock outerside was introduced. Even though the friction coefficient between the sock inside and the foot skin was still high, the foot was able to slide together with the sock on the insole and the shear force was reduced significantly. This is in consistency with the measurements [24], which showed that the shear stresses for subjects wearing nylon hose were significantly lower than the values for hose-free subjects. It was reported that by using the Teflon fiber to the sock soles to impart an extremely low friction value, the socks reduced the occurrences of blister by around 90 vol. % in athletes [25]. Shear is possibly a main mechanical risk factor of blister development. Therefore, reduction of shear is crucial in preventing the foot lesion development.

Slip resistance of flooring materials is one of the major environmental factors affecting walking and materials handling behaviors. Floor slipperiness may be quantified using the static and dynamic friction coefficient [26]. Certain values of friction coefficient were recommended as the slip-resistant standard for unloaded, normal walking conditions [3, 4]. Relatively higher static and dynamic friction coefficient values may be required for safe walking when handling loads.

The surface roughness of flooring materials is likely changed mainly through mechanical wear, periodic cleaning processes and material transfer from shoe soles (elastomer abrasions and dirt particles). Coefficients of friction were measured periodically over a period of 30 months on the surfaces of five types of floor coverings in a new sport complex [27]. The changes in the surface properties and frictional characteristics of floor coverings can be expected in practical use because they are subject to mechanical wear, ageing, soiling and maintenance [28]. Surface changes through mechanical wear range from smoothing to roughening, depending on flooring material and surface characteristics. Surface roughness is known to be a key factor in determining the slip resistance of floors [29, 30].

The effect of surface roughness on the friction coefficient of ceramic when sliding against rubber and leather was investigated [31]. Glazed floor tiles of different roughness ranging from 0.05 and 6.0 μm were tested. The test results showed that, friction coefficient decreased down to minimum then increased with increasing the surface roughness of the ceramic surface. Measurements of the static friction coefficient between rubber specimens and ceramic surfaces were carried out at dry, water lubricated, oil, oil diluted by water and sand contaminating the lubricating fluids [32 – 35]. It was observed that, dry sliding of the rubber test specimens displayed the highest value of friction coefficient. For water lubricated ceramics, the value of the friction coefficient decreased compared to dry sliding. For oil lubricated ceramic, friction coefficient decreased with increasing height of the grooves introduced in the rubber specimens. Besides, diluting oil by water displayed values of friction much lower than that observed for oil lubricated condition. As for ceramic lubricated by water and soap and contaminated by sand, friction coefficient increased significantly as compared to the sliding conditions of water and soap only. In the presence of oil and sand on the sliding surface, the friction slightly increased. This behaviour may be caused by sand embedment in rubber surface and consequently the contact became between ceramic and sand. At lubricated sliding surface by oil and water contaminated by sand, the friction presented higher value than that of oil and sand sliding conditions.

In the present work, the influence of seven types of cleaners as well as one detergent added to the washing water on the static friction coefficient of bare foot and foot wearing socks walking on wet and dry marble floor tiles used in *Tawaf* yard and *Massaa* as well as in halls, entrances and passages areas in *Al-Haram* in Makkah was tested.

2. Experimental

Experiments were carried out using a test rig designed and manufactured to measure the friction coefficient between the foot and the tested flooring tiles through measuring the friction and normal forces. The tested flooring tiles are placed in a base supported by two load cells, the first measures the horizontal force (friction force) and the second measures the vertical force (normal load).

Friction coefficient is determined by the ratio between the friction and the normal forces. The arrangement of the test rig is shown in Fig. 1. Bare foot of a male of 59 years old was loaded against dry, water and water detergent mixture lubricated flooring tiles. Seven types of cleaners and deodorants used in the experiments, (A, B, C, D, E, F and G) were added to water in concentration of 2.0 vol. %, while the detergent was added in concentration varying from 0 – 0.5 vol. %, Table 1. The tested flooring materials of marble tiles were in form of a quadratic sheet of 0.4 m × 0.4 m and 30 mm thickness. The marbles tiles are used as floorings in *Tawaf* yard, *Massaa* and *Al-Haram* Halls such as entrance, corridors as well as indoors areas. Their roughnesses were 2.2, 1.6 and 1.3 μm Ra, (the centre line average of surface heights, CLA), they will be referred in this text as A, B and C respectively. Friction test was carried out at different values of normal load exerted by bare foot and foot wearing cotton socks sliding against dry, water and water detergent mixture lubricated flooring tiles. Tests were carried out at different values of load exerted by foot. In the present work, the results of three selected values of load of 200, 400 and 600 N, which represent the average weights of the children, women and men, are considered.

Table 1. The cleaners and detergents used in the experiments.

Type	*Characteristics*
A	Anti Bacterial Anti Septic Disinfectant
B	Flooring Cleaner
C	Multi Purpose Cleaner
D	Disinfecting Cleaner
E	Multi Purpose Cleaner
F	Disinfectant Pine
G	Highly Perfumed Cleaner
H	Detergent for Fat and Oil Removal

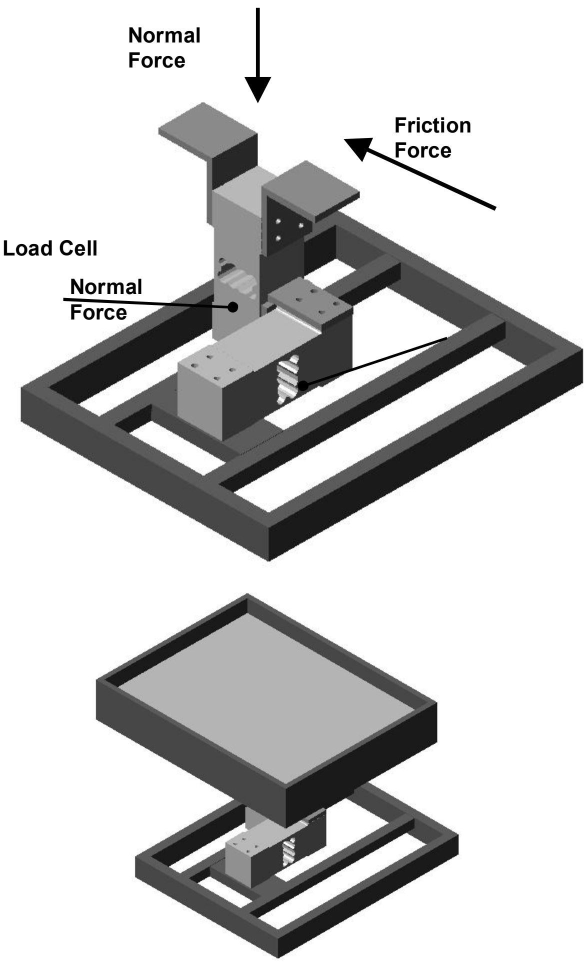

Fig. 1. Arrangement of the test rig.

The testing conditions of the experiment were water–detergent mixture before and after drying. Mixture was replenished on the tested flooring materials, where the amount for each replenishment was 10 ml to form consistent water film covering the sliding surface. After the wet test, the tiles were air dried and the friction test was carried out. After each measurement, all contaminants were removed from the flooring materials using absorbent papers. The flooring materials were then rinsed using water and blown using hair dryer after the cleaning process.

3. Results and Discussion

Friction coefficient of bare foot sliding against the dry tested flooring is shown in Fig. 2. Friction coefficient decreased with increasing load due to the decrease of the hysteric component of friction which was affected by the adhesive junctions to stretch, rupture and relax. Flooring tiles of *Massaa* displayed the highest friction values, while tiles of the Halls displayed the lowest friction. Values of friction coefficient of bare foot sliding against *Massaa* tiles were 0.5, 0.43 and 0.4 at normal loads of 200, 400 and 600 N.

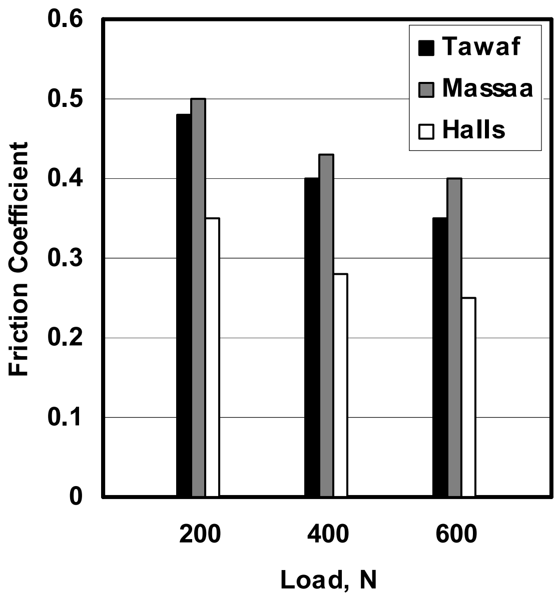

Fig. 2. Friction coefficient of dry sliding of bare foot.

Friction coefficient of wet sliding of bare foot by cleaner (A) gave reasonable friction values (Fig. 3) tiles of *Massaa* displayed friction values ranging between 0.3 and 0.4. Tiles of *Tawaf* and Halls gave relatively lower friction than *Massaa*. Generally, minimum friction coefficient was 0.22. Based on the slip-resistant standard in Europe [4], where the floor was ‘‘very slip-resistant’’ if the friction coefficient was 0.3 or more. A floor with a friction coefficient between 0.2 and 0.29 was ‘‘slip resistant’’, the tested tiles proved to be quite good slip resistant.

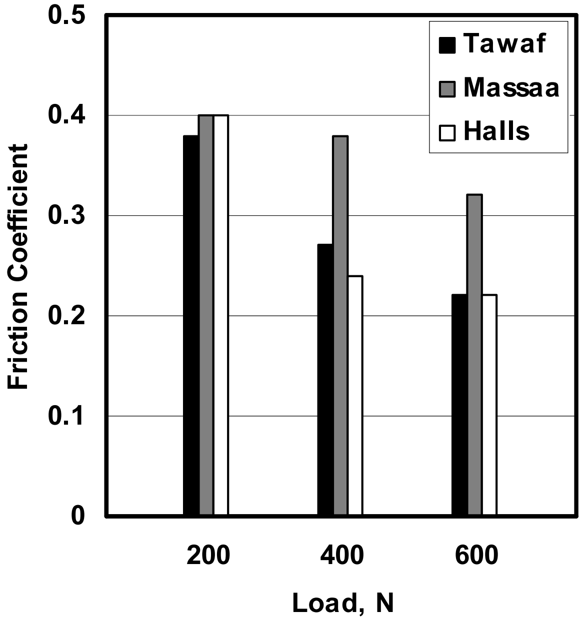

Fig. 3. Friction coefficient of wet sliding of bare foot by cleaner (A).

Friction coefficient of wet sliding of bare foot by cleaner (B) showed relatively higher values approaching to 0.7 for *Massaa* tiles (Fig. 4) which agrees with the American standard for slip resistant materials, where a static friction coefficient of 0.5 has been recommended as the slip-resistant standard for unloaded and normal walking conditions [3]. The minimum friction value for *Massaa* tiles was 0.33. Lower friction values were presented by tiles of *Tawaf*, where the values were 0.38, 0.28 and 0.25 at 200, 400 and 600 N load respectively. The tiles of the Halls showed relatively higher friction values than the tiles of *Tawaf*.

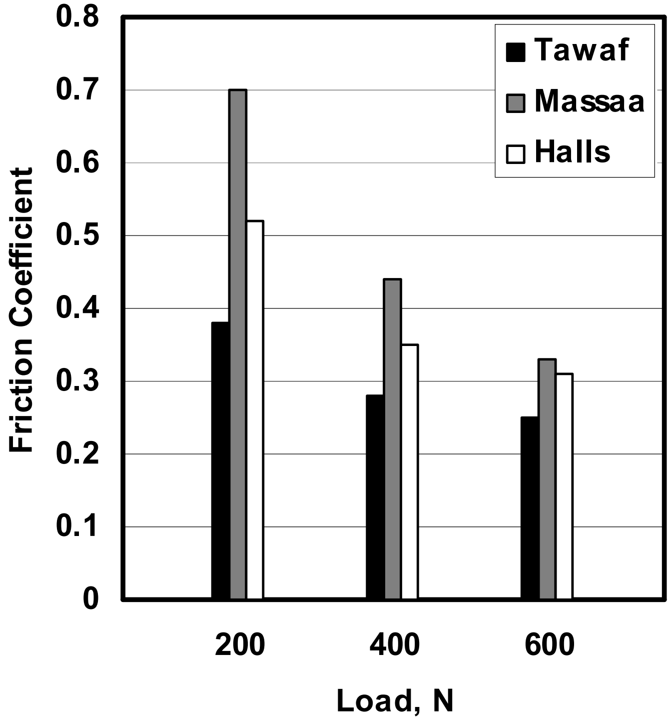

Fig. 4. Friction coefficient of wet sliding of bare foot by cleaner (B).

The sliding of bare foot against the tested tiles wetted by cleaner (C) drastically decreased the friction values, Fig. 5. Values of friction coefficient displayed by tiles of *Massaa* were 0.15, 0.1 and 0.07 at 200, 400 and 600 N respectively.

Although cleaner (D) showed higher friction values than Cleaner (C) (Fig. 6) the values were still lower than that required for safe walking. Tiles of *Massaa* still displayed the relatively highest friction. As the load increased, friction values decreased, where the lowest values (very slippery) were displayed for 600 N load.

Friction coefficient, of sliding of bare foot against the wetted tested tiles by cleaner (E) shown in Fig. 7, slightly increased relative to the cleaners (C) and (D). Tiles of *Massaa* displayed the highest friction values. At loads of 400 and 600 N the sliding was considered slippery.

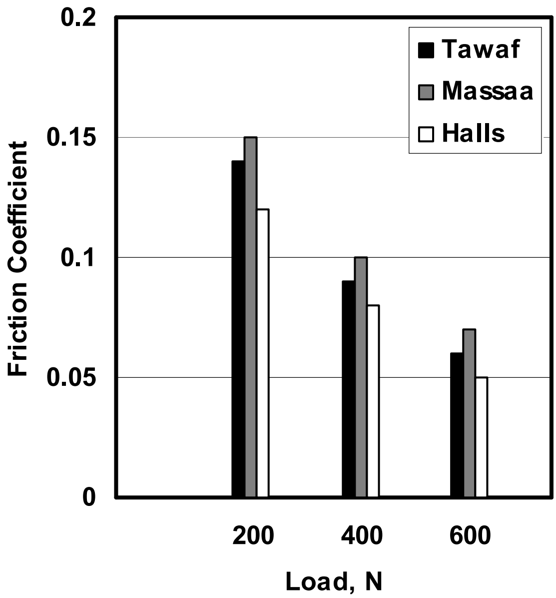

Fig. 5 Friction coefficient of wet sliding of bare foot by cleaner (C).

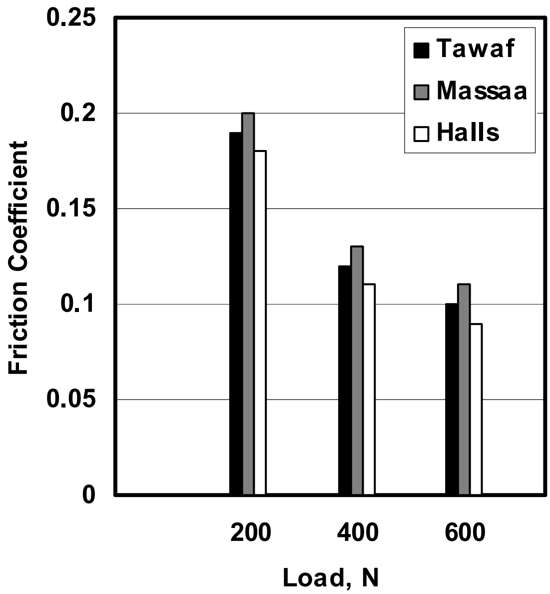

Fig. 6. Friction coefficient of wet sliding of bare foot by cleaner (D).

Cleaner (F) displayed relatively higher friction. For tiles of *Tawaf*, friction coefficient values were 0.38, 0.23 and 0.20 at load of 200, 400 and 600 N respectively. Those values are considered as very slip-resistant to slip-resistant. Tiles of *Massaa* showed the highest friction values, while tiles of Halls gave the lowest ones.

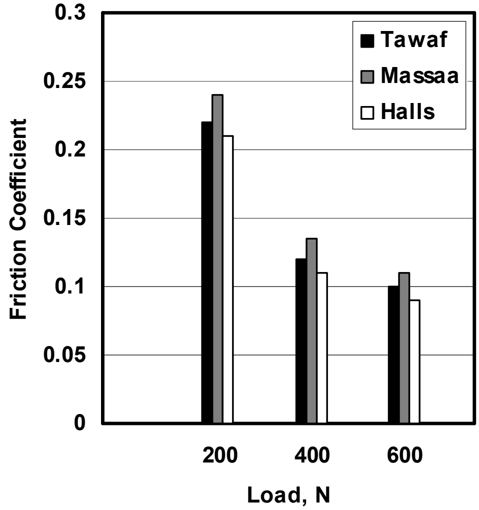

Fig. 7. Friction coefficient of wet sliding of bare foot by cleaner (E).

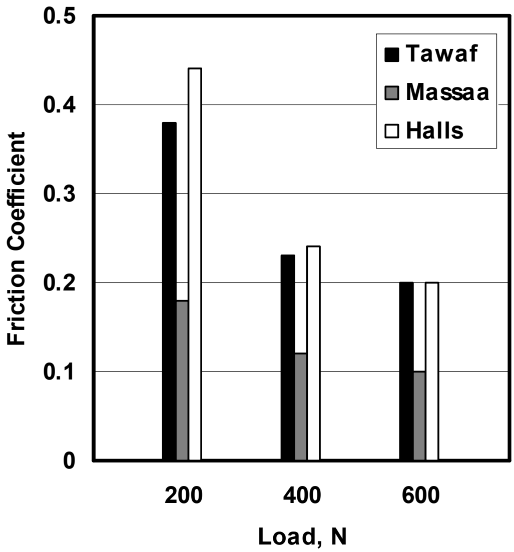

Fig. 8 Friction coefficient of wet sliding of bare foot by cleaner (F).

Friction coefficient of the sliding of bare foot against the tested tiles wetted by cleaner (G) (Fig. 9) displayed lower values than that observed for the cleaner (F). In the *Massaa* area, cleaner (G) led to significant decrease in friction coefficient. Tiles of the halls showed an increasing trend of the coefficients of friction. The heavy traffic of bare foot, soiling through organic deposits (*e.g*., microorganisms and materials abraded or washed from feet), dust, calcification and cleaning might have contributed to the surface wear and changes in the slip resistance of the marble tiles. Based on the above mentioned results, it can be recommended not to use the cleaner (G) in the cleaning process of tiles of *Massaa*.

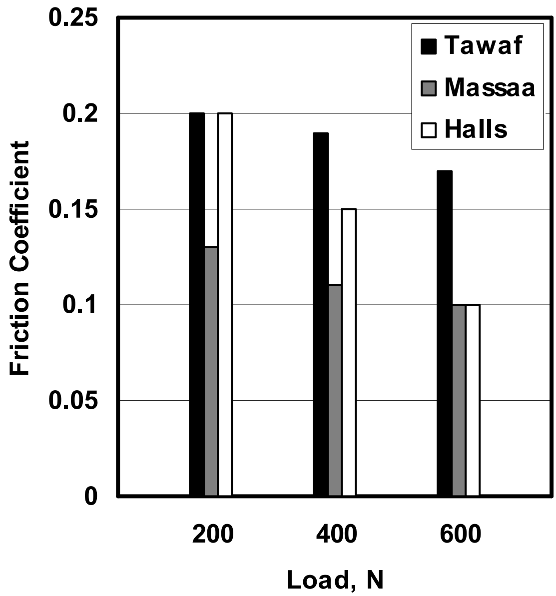

Fig. 9. Friction coefficient of wet sliding of bare foot by cleaner (G).

The highest values of friction coefficient displayed by the sliding of bare foot against the tested tiles wetted by detergent (0.0312 %) and cleaner (A) are plotted versus load in Fig. 10. Friction coefficient significantly increased where the tiles of *Tawaf* displayed the highest values followed by tiles of *Massaa* and Halls. The increase in friction coefficient may be explained on the basis that the influence of detergent is to dissolve the greases as well as fats and remove solid contaminants such as dust from the sliding surfaces. This mechanism is explained by the adhered film of the detergent molecules into the sliding surface preventing the contaminants from adhering to the sliding surface.

After drying the tested tiles, friction coefficient recorded the maximum values, where tiles of *Massaa* displayed friction coefficient of 0.82, 0.81 and 0.8 at 200, 400 and 600 N load respectively, Fig. 11. Tiles of *Tawaf* showed friction coefficients of 0.72, 0.51 and 0.47 at 200, 400 and 600 N load respectively. Tiles of Halls showed minimum friction of 0.45 at 400 and 600 N load. It is clearly shown that the increase of friction coefficient due to detergent is much effective after drying. Detergent molecular structures consist of a long hydrocarbon chain and a water soluble negative ionic group. They are alky sulfates or surfactants (from surface active agents) which are generally known as alkyl benzene sulfonates. The detergent molecules must have some polar parts to provide the necessary water solubility. The polar part of the molecule consists of three alcohol groups and an ester group.

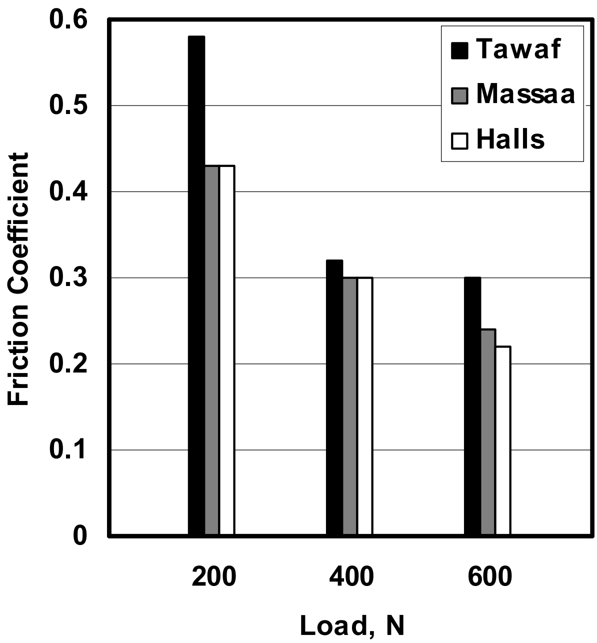

Fig. 10. Friction coefficient of wet sliding of bare foot by detergent (H) and cleaner (A).

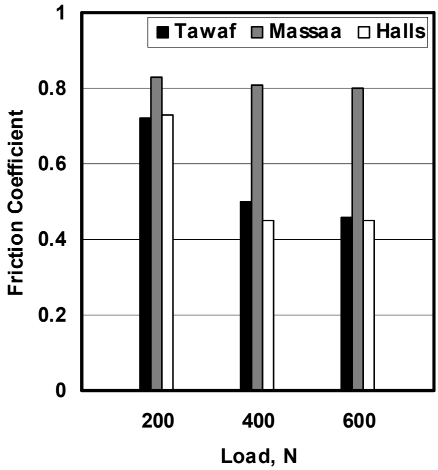

Fig. 11. Friction coefficient of wet sliding of bare foot by detergent (H) and cleaner (A) after drying.

Figures 12-15 illustrate the results of the experiments carried out using foot wearing cotton socks sliding against the tested tiles. Friction coefficient of cotton socks sliding against dry marble tiles is shown in Fig. 12, where tiles of *Massaa* displayed the highest friction values followed by the tiles of *Tawaf* and Halls. The values of friction suggested that the sliding condition is ranging between very slip-resistant and slip-resistant.

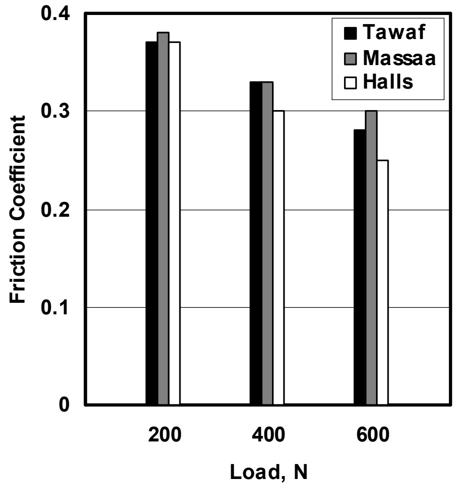

Fig. 12. Friction coefficient of cotton socks sliding against dry flooring.

In the presence of water (Fig. 13) friction coefficient was relatively higher than that observed at dry sliding. This effect may be attributed to the ability of cotton to absorb water from the surface of the tested tiles, change the contact from mixed into dry one and reduce the hydrodynamic effect of the water film. Besides, water can enhance the distribution of the electric static charge generated on the sliding surface and consequently increases the adhesion of the socks into the tested marble tiles. For all the tested tiles and normal loads, friction coefficient showed minimum value of 0.3. This condition of sliding is considered as very slip-resistant.

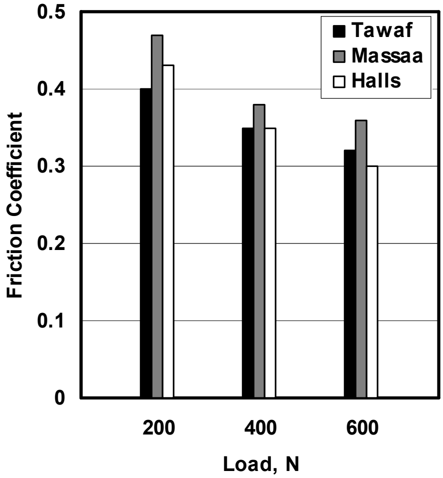

Fig. 13. Friction coefficient of cotton socks sliding against wet flooring by water.

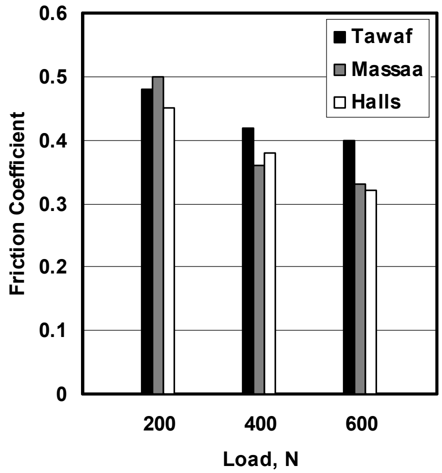

Fig. 14. Friction coefficient of cotton socks sliding against wet flooring by cleaner (F).

Friction coefficient obtained by foot wearing cotton socks sliding against the tested tiles wetted by water and cleaner (F) is shown in Fig. 14. Compared to water lubrication, friction coefficient displayed higher values in the presence of cleaner (F). The increase of friction may be attributed to the cleaner molecular structure. It seems that the cleaner which is a formulation comprising essential constituents such as surface active agents reacted with the fatty acids of foot. The mechanism of action may be explained on the basis that when the detergent is dissolved or dispersed in liquid is preferentially absorbed at the sliding surfaces, giving rise to the growth of a film of detergent molecules which absorb fatty acids and perspiration from the skin of bare foot so that the contact remains between foot and flooring.

Friction coefficient of foot wearing socks sliding against wetted tested tiles by the cleaner (G) is shown in Fig. 15. The friction values showed slight increase compared to that displayed by the cleaner (F). This increase in friction can be attributed to the effectiveness of the cleaner (G). The friction increase may be attributed to the ability of the cleaner to remove oily contaminants from the surface, where the cleaners have hydrophobic or water-hating molecular chains and hydrophilic or water-loving components. The hydrophobic hydro-carbons are repelled by water, but are attracted to oil and grease. The hydrophilic end of the same molecule means that one end of the molecule will be attracted to water, while the other side is binding to oil. Then rinsing washes the cleaner and soil away.

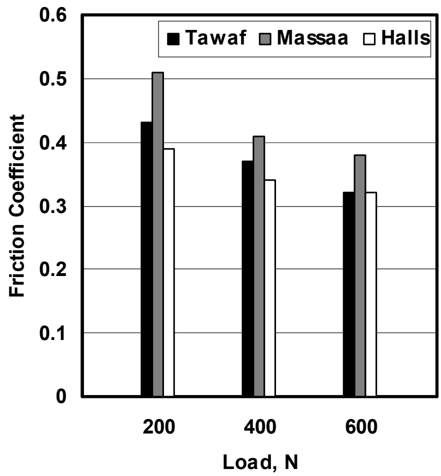

Fig. 15 Friction coefficient of cotton socks sliding against wet flooring by cleaner (G).

4. Conclusions

I. The results of static friction coefficient displayed by bare foot can be concluded as follows:

1. At dry sliding, flooring tiles of *Massaa* displayed the highest friction values, while tiles of the Halls displayed the lowest friction.

2. At wet sliding, the highest values of friction coefficient were displayed by cleaner (B), while the lowest values were observed for cleaner (C), (D) and (E).

3. The tested tiles wetted by detergent (H) and cleaner (A) gave the maximum friction coefficient after drying. Tiles of *Massaa* displayed values of friction coefficient up to 0.8.

4. The cleaner (F) displayed friction values which can be considered as slip-resistant for Tiles of *Tawaf* and Halls, while tiles of *Massaa* gave slippery sliding.

5. The cleaner (G) experienced slip-resistant sliding for tiles of *Tawaf* and Halls, while tiles of *Massaa* showed slippery sliding.

II. The results of static friction coefficient displayed by foot wearing cotton socks can be concluded as follows:

1. Tiles of *Massaa* displayed the highest friction values followed by the tiles of *Tawaf* and Halls at dry sliding. The sliding condition is ranging between very slip-resistant and slip-resistant.

2. In the presence of water, friction coefficient displayed relatively higher friction values than that observed at dry sliding.

3. Friction coefficient displayed higher values in the presence of cleaner (F) than that observed for water sliding. Tiles of *Tawaf* showed higher friction than the tiles of *Massaa* and Halls.

4. Further friction increase was observed for cleaner (G) which provide more safe walking.

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السلوك الاحتكاكى الناتج من حركة القدم العارية والمرتدية الجوارب على بلاط الأرضيات الرخامية

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المستخلص. تقدم هذه الدراسة نتائج نوعية عن معامل الاحتكاك الاستاتيكى للبلاطات المختبرة. ويزود تحليل القيم المقاسة لمعامل الاحتكاك معلومات عن كفاءة سوائل التنظيف المختبرة. كما تؤدى المعلومات الدقيقة عن المتغيرات التي تؤثر على قياس معامل الاحتكاك إلى اختيار الأنسب من سوائل التنظيف والجوارب من أجل مشى آمن بدون حوادث انزلاق.

في هذا البحث تم قياس معامل الاحتكاك الناتج من المشي للقدم العارية والمرتدية للجوارب على بلاط الأرضيات الرخامية الجافة والمبللة والمستخدمة في الحرم المكي الشريف. تم اختبار ثمانية أنواع من سوائل التنظيف بإضافتها إلى ماء الغسيل وبللت البلاطات الرخامية بها.

أجريت التجارب باستخدام جهاز اختبار صمم لقياس معامل الاحتكاك بين المطاط ومواد الأرضيات عن طريق قياس قوة الاحتكاك والقوة الرأسية الناتجة من وزن جسم الإنسان لتحديد معامل الاحتكاك الاستاتيكى في حالة الانزلاق الجاف والمبلل بسوائل التنظيف. أثرت القوة الرأسية عن طريق القدم وبلغت أقصى قيمة لها ٧٠٠ نيوتن.

بينت التجارب أن بلاطة المسعى أعطت أعلى قيم لمعامـــل الاحتكاك وصلت إلى ٠.٨ بينما أعطت بلاطة الســـاحات الداخليـــة أقل قيمة لمعامل الاحتكاك. وعموما يمكن استنتاج إن قيم معامـــل الاحتكاك قد اختلفت اختلافا كبيرا باختلاف نوعية سوائل التنظيف.

بالنسبة للقدم المرتدية للجوارب القطنيـــة أعطـــت بلاطـــة المسعى أعلى قيمة لمعامل الاحتكاك. وفى حالة وجود الماء علـــى سطح البلاطة كانت قيم معامل الاحتكاك أعلى منهـــا فـــي الحالـــة الجافة. كما أن بلاطة الطواف أعطت قيما لمعامل الاحتكاك أعلـــى من القيم المسجلة لبلاطة المسعى والساحات الداخلية.