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FRICTION COEFFICIENT DISPLAYED BY SLIDING RUBBER ON EPOXY REINFORCED BY NATURAL FIBERS

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ABSTRACT
The relatively low static friction coefficient displayed by sliding of soles on floor tiles is considered as the major reason in walking accidents indoors. The present work studies the effect of reinforcing epoxy by natural fibers such as wood, rice straw and palm fibers on friction coefficient to guarantee the availability be used as floor material and enhance the tribological and mechanical properties.

The experimental observations revealed that wood fibers reinforced composites displayed friction coefficient of values higher than that recommended in the universal building codes (0.5). It was found that friction coefficient slightly decreased with as the fiber content increased. While, significant increase in friction coefficient was caused as the applied load increased due to the increase of the contact area. Rice straw fibers experienced lower values of friction coefficient compared to wood fibers. Further decrease in friction coefficient was observed for composites reinforced by palm fibers.

KEYWORDS
Friction coefficient, sliding, rubber, epoxy, natural fibers.

INTRODUCTION
The probability of slip of foot walking on floor tiles increases and consequently accidents occur when the static friction coefficient is low. The slip and falling are related to the floor materials, contaminants, and surface propertied of the sole. The slip resistance is quantified using the static coefficient of friction. The static friction coefficient of 0.5 has been recommended as standard for unloaded, normal walking conditions in USA, [1]. The static friction coefficient values should be increased for safe walking when handling loads. In Europe, [2 - 4], Friction coefficient (μ) should be 0.3 or more, while the floor with the friction coefficient between 0.15 and 0.05 was very slippery. Several building codes have established that $\mu \geq 0.50$ is the minimum slip resistance for safe floor surfaces. While, $\mu \geq 0.60$ for walkways and elevators as well as $\mu \geq 0.80$ for ramps, [5]. The effect of the thickness on the frictional behaviour

of polymers filled by recycled polyurethane tiles was investigated, [6, 7]. Rubber mats compared to ceramic and polymeric tiles showed the highest friction values.

It was found that filling floor tiles by rubber leads to a higher contact area and more pronounced deformations when mechanically interacting and sliding on rigid material. Higher friction coefficients can be expected for rubber than for relatively harder polymers, [8, 9]. The friction coefficient difference between dry and wet surfaces depended on the footwear material and floor combinations, [10 - 14]. Friction measurements under liquid-contaminated depend on the squeeze film theory that explains the influence of the liquid on the friction values.

The tribological and mechanical properties of epoxy were enhanced by filling by rubber, [15 – 17], where rubber particles could increase the ductility and plastic deformation of epoxy. Fracture toughness could be significantly developed by adding copolymer, [18], by reducing the cracks and shear yielding of the matrix, [19 - 21]. Presence of rubber inside epoxy matrix increases the shear deformation and improves fracture toughness and consequently reduce the brittleness of epoxy resins.

Filling epoxy by recycled polymers was investigated, [22, 23]. Toughening of epoxy by filling with recycled rubber granulates was investigated, [24 - 29], to make full use of the deformation and higher contact area during loading on the rigid surfaces. Therefore, high values of friction coefficient and abrasion resistance of epoxy floor tile can be enhanced by rubber, [30 - 32]. Tribological properties of epoxy was improved by adding oil during molding, where significant reduction in friction was observed, [33 – 37]. This behavior was attributed to the oil trapped in pores after solidification that fed into the sliding surface.

In the present work, epoxy was reinforced by natural fibers such as wood, rice straw and palm fibers in contents up to 20 wt. % and tested through sliding on rubber to determine friction coefficient at dry sliding condition.

EXPERIMENTAL

Experiments were carried out to determine the friction coefficient displayed by the sliding of the tested epoxy composites on rubber surface. The test rig is shown in Fig. 1. The epoxy composites of 5.0 mm thickness were molded to one surface of wooden cube of 30 × 30 × 30 mm^3. After solidification, they were loaded into rubber sheet of 8.0 mm thickness of 60 Shore D hardness. The rubber sheet was adhered into the base of the test rig that was supported by two load cells, the first measured the friction force and the second measured the applied load.

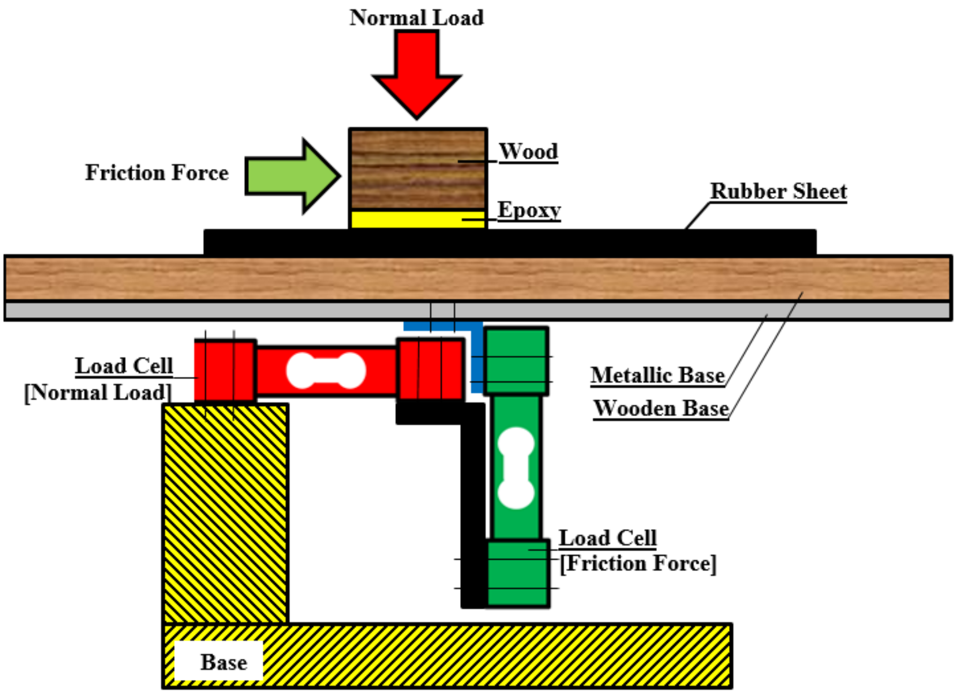

Fig. 1 Arrangement of the adhesive test rig.

Epoxy was reinforced by wood, rice straw and palm fibers of (0 - 1.0 mm), (0 - 1.0 mm) and (0 - 3.0 mm) granulate size respectively. The natural fibers were added in contents of 2.5, 5.0, 7.5, 10, 12.5, 15, 17.5 and 20 wt. %, where every experiment was repeated five times then the average values were considered. The tests were carried out at different values of normal load (2, 4, 6 and 8 N) applied by weights.

RESULTS AND DISCUSSION

It is well known that the lowest permissible value of the static friction coefficient is 0.5 recommended for floor surfaces. For disables, walkways and elevators, this value should be increased to 0.6 – 0.8. It is necessary to apply materials of high contact area and deformation to obtain high values of friction coefficient. The results of friction coefficient displayed by the tested composites are shown in Figs. 2 - 4. The values of friction coefficient observed for composites reinforced by wood fibers were higher than the recommended values mentioned above. Generally, friction coefficient decreased with increasing the wood content. As the applied load increased friction coefficient increased due to the increase of the contact area.

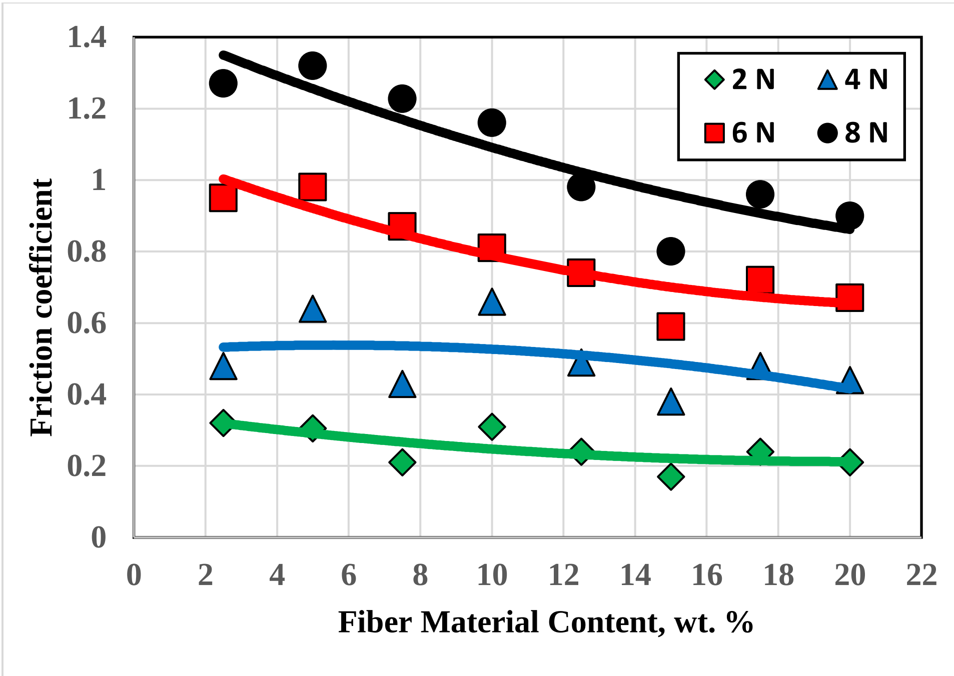

Fig. 2 Friction coefficient displayed by sliding of the tested composites reinforced by wood fibers.

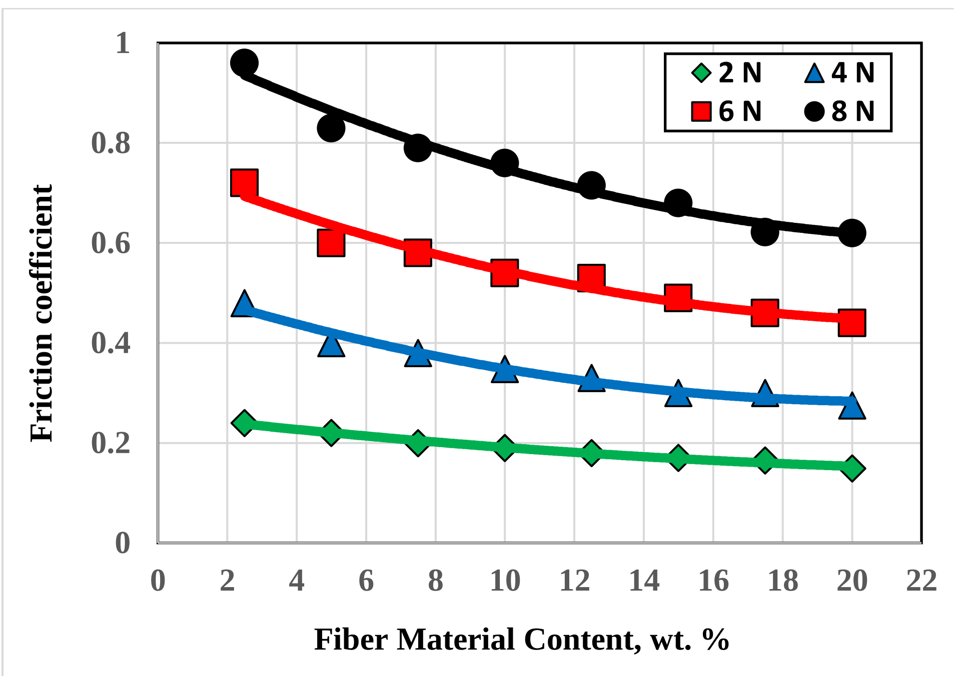

Fig. 3 Friction coefficient displayed by sliding of the tested composites reinforced by rice straw fibers.

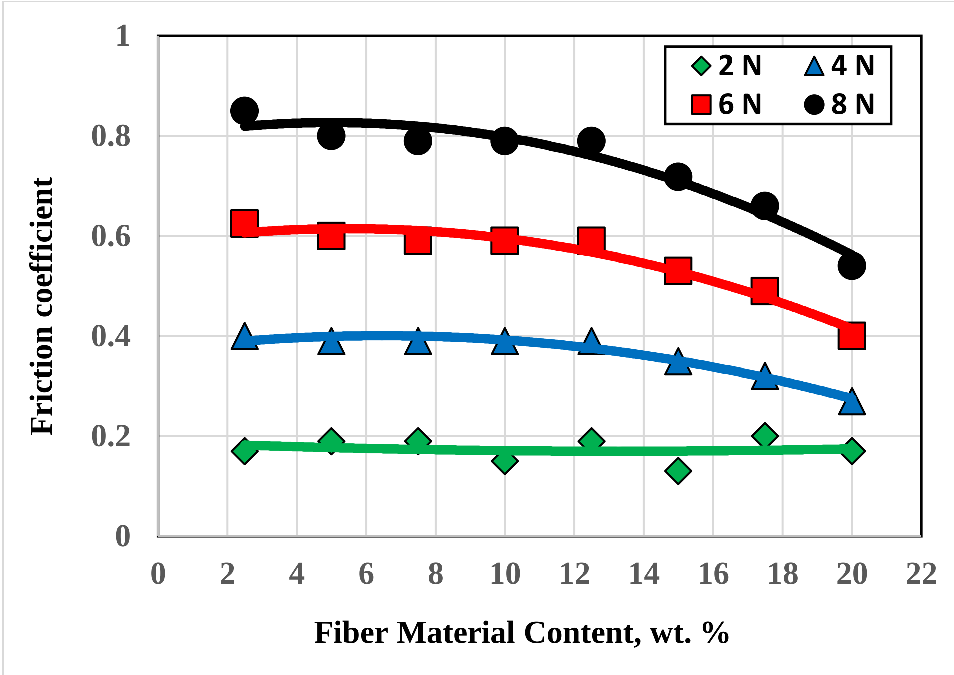

Fig. 4 Friction coefficient displayed by sliding of the tested composites reinforced by palm fibers.

Reinforcing epoxy by rice straw fibers displayed lower values of friction coefficient, Fig. 3, compared to that observed for composites reinforced by wood fibers. The highest friction coefficient values were displayed by composites containing lower fiber content. At 8.0 N load, the friction values were 0.96 and 0.62 at 2.5 and 20 wt. % fiber content respectively. Further friction decrease was observed during sliding of the tested composites reinforced by palm fibers, Fig. 4, where friction coefficient values recorded at 8.0 N load, were 0.85 and 0.54 at 2.5 and 20 wt. % fiber content respectively.

CONCLUSIONS

1. Values of friction coefficient displayed by composites reinforced by wood fibers were higher than the recommended values mentioned in the universal building codes (0.5).
2. The objective of filling epoxy by natural fibers is to enhance the tribological and mechanical properties. That was achieved by the tested natural fibers.
3. Friction coefficient slightly decreased with increasing the fiber content.
4. Increasing the applied load caused significant increase in friction coefficient due to the increase of the contact area.
4. Rice straw fibers reinforcing epoxy showed lower values of friction coefficient than observed for wood fibers.
5. Composites reinforced by palm fibers showed further decrease in friction coefficient compared to wood and rice straw fibers.

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