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ELECTROSTATIC CHARGE GENERATED ON FLOOR MATERIAL GROUNDED BY STAINLESS STEEL STRIPS

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ABSTRACT
Polymeric materials are widely used in floor material in hospital, factories and detention centers but the charge which generated induced in triboelectric process are usually referred as a negative effect either in technological applications or scientific research and they are wasted energy in many cases.

The present study aims to reduce the electrostatic charge (ESC) generated on polypropylene shoes during walking against the tested floor materials (A & B) through adhering stainless steel strips in the back of the floor material and pressing under applied different normal load for 10 seconds then separating to measure the electrostatic charge. The experimental result showed that, the electrostatic charge slightly increased by increasing the applied normal load and increasing the number of strips. This increasing refers to the phenomena of triboelectrification which generate a double layer of electric static charge on the two contact surfaces. The double layer of the electric static charge would generate an E-field on the floor material. Presence of stainless steel strips in adhered in the bake of floor material, would generate extra electric static charge on surfaces. The grounded system decreased that ESC which generated on the surface and it is clear that the floor material B generated lower ESC than that noticed by floor material B. The voltage decreased more in the presence of water/chlorine film thus because of the relative good conductivity of water.

KEYWORDS
Floor material, electrostatic charge, contact and separation test, polypropylene, stainless steel.

INTRODUCTION
Tribological behavior of polymers is reviewed since the mid-20th century to the present day. It was shown how load, sliding velocity, and temperature affect friction. Different modes of wear of polymers and friction transfer were considered, [1, 2]. Tribology is the science and technology of two interacting surfaces in relative motion and of related subjects and practices. The popular equivalent is friction, wear, and lubrication, [2, 3]. When two

materials contact each other, the upper one in the triboelectric series will get positively charged and the other one will be negatively charged, the very little repulsion energy will be available on either object while they are close together. Once they are separated will a significant of "spark" energy be stored on each object, [4 - 7]. Materials can be assessed for risks from static electricity by measurement of charge decay and by measurement of capacitance loading, [8]. As for insulators, the electron transfers only happen on the surfaces of insulators, where electrons move from the filled surface of one insulator to the empty surface of the other insulator, [9 – 11].The mechanism of charge transfer in tribocharging can be explained by three mechanisms: electron transfer, ion transfer, and material transfer, [12 - 14].

Charge and discharge associated with the rubbing between shoes and carpet are less experienced in summer rather than in winter. It indicates that the charge is suppressed in higher humidity. Experimental data have exemplified this tendency [15, 16]. However, other data show that water molecules on the surfaces convey charges in the form of ions to enhance charge separation between two surfaces. These contradictory results require precise measurement of the effect of humidity on charge generation. The electric static charge generated from the dry and water wet sliding of shoe sole against floor for people who are working in hospitals was investigated, [17]. The recycling of waste plastic in triboelectrostatic separation, depended on the triboelectric series and charging properties to predict material separation, [18]. Safe walking on the floor was evaluated by the static friction coefficient. Few researches paid attention to the electrostatic charge generated during walking on the floor. The flooring materials and footwear are affected on the generated charge, [19]. Slipping and falling are common phenomena in both workplaces and daily activities. The materials of floor or footwear, wetted condition and geometric design of the sole are related to the dangers of slipping and falling, [20 - 27]. Slip resistance of flooring materials is one of the major environmental factors affecting walking and materials handling behavior. Floor slipperiness is using the static and dynamic friction coefficient, [28, 29].

For polymers such as PTFE and PU, strain generated charge transfer of reversed charge due to material transfer. For SS, the charge transfer was of single sign, where strain reduces the frequency of electrical discharges occurring. It seems that strain changes the nature of contact between the surfaces and produces charged species, ions, electrons, and radicals. This observation it can be concluded strain can strongly influence electrostatic charging. Silicon carbide is electrically semiconducting materials. The friction and wear behaviour of silicon carbide based materials may be influenced by electric potentials applied to the tribological system, [30, 31]. Electrical resistivity of stainless steels is ~7.5 times greater than that of aluminum bronze and nearly 20 times, and the density is ~8.0 g/cm^3, which is approximately three times greater than that of aluminum alloys. Stainless steels have a high modulus of elasticity (200 MPa) that is nearly twice that of copper alloys and nearly three times that of aluminum alloys (70 MPa). Also it has a very high thermal conductivity and the corrosion resistance is frequently the most important characteristic of a stainless steel. General corrosion resistance to pure chemical solutions is comparatively easy to determine, but actual environments are usually much more complex, [32].

The present study aims to reduce the ESC generated on floor material by adhering stainless steel strips to the back of the tested floor materials. The experimental test has been carried out in dry and water/chlorine mediums when the strips were grounded and ungrounded.

EXPERIMENTAL WORK

Figure 1 illustrates the stainless steel strips that are adhered to the back of the sheets of floor material (A & B). Tests were carried out at dry and water + 1.0 wt. % chlorine dilution medium with grounded and ungrounded strips. Contact and separation test has been carried out under applied normal loads ranging from 20 to 200 N at room temperature.

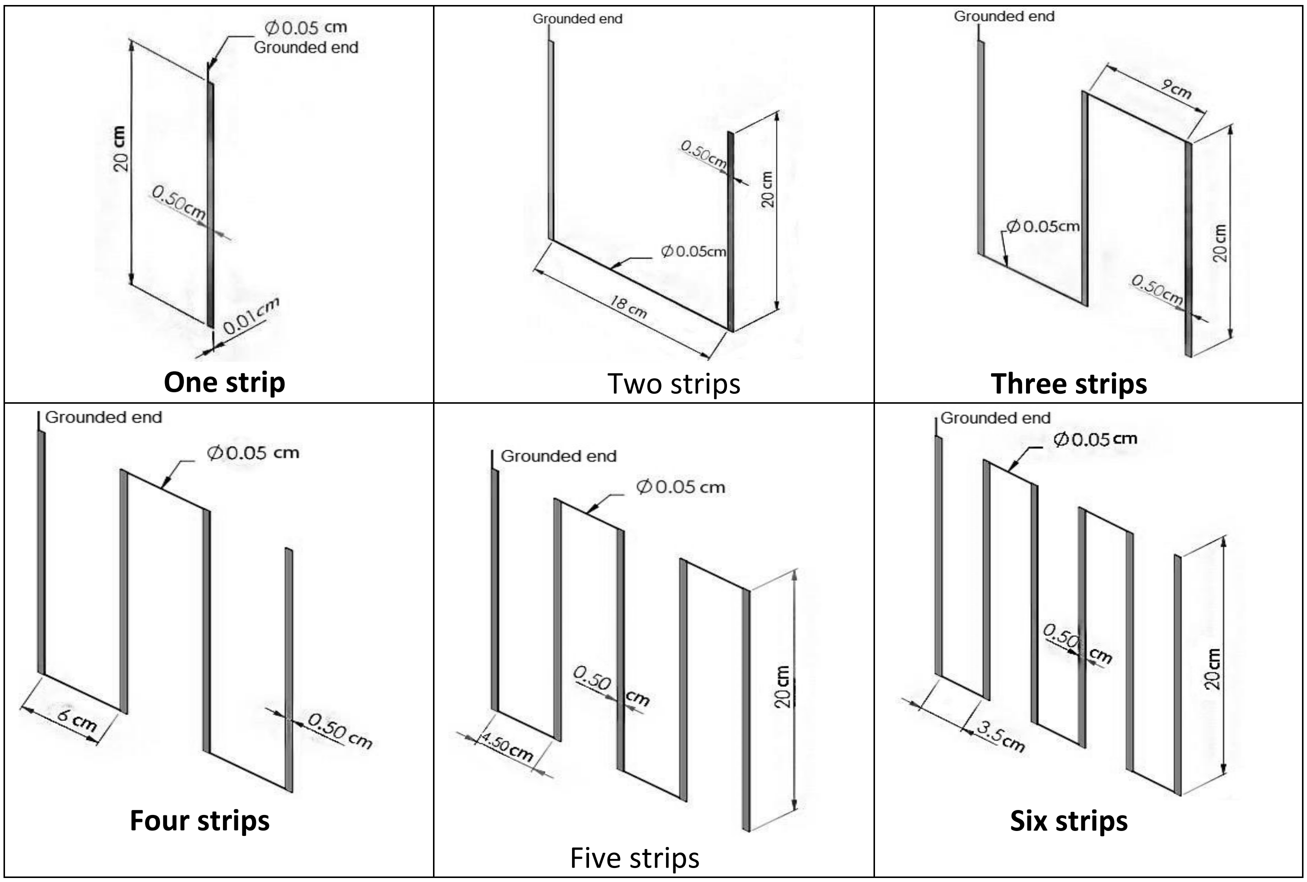

Fig. 1 Distribution of the stainless steel strips.

The ESC has been measured by using (Ultra Stable Surface Voltmeter), as illustrated in Fig. 2. The contact and separation test has been carried at dry and chlorine wet floor materials, the arrangement of the experimental test is illustrated in Fig. 3.

Fig. 2 Electrostatic charge (voltage) measuring device.

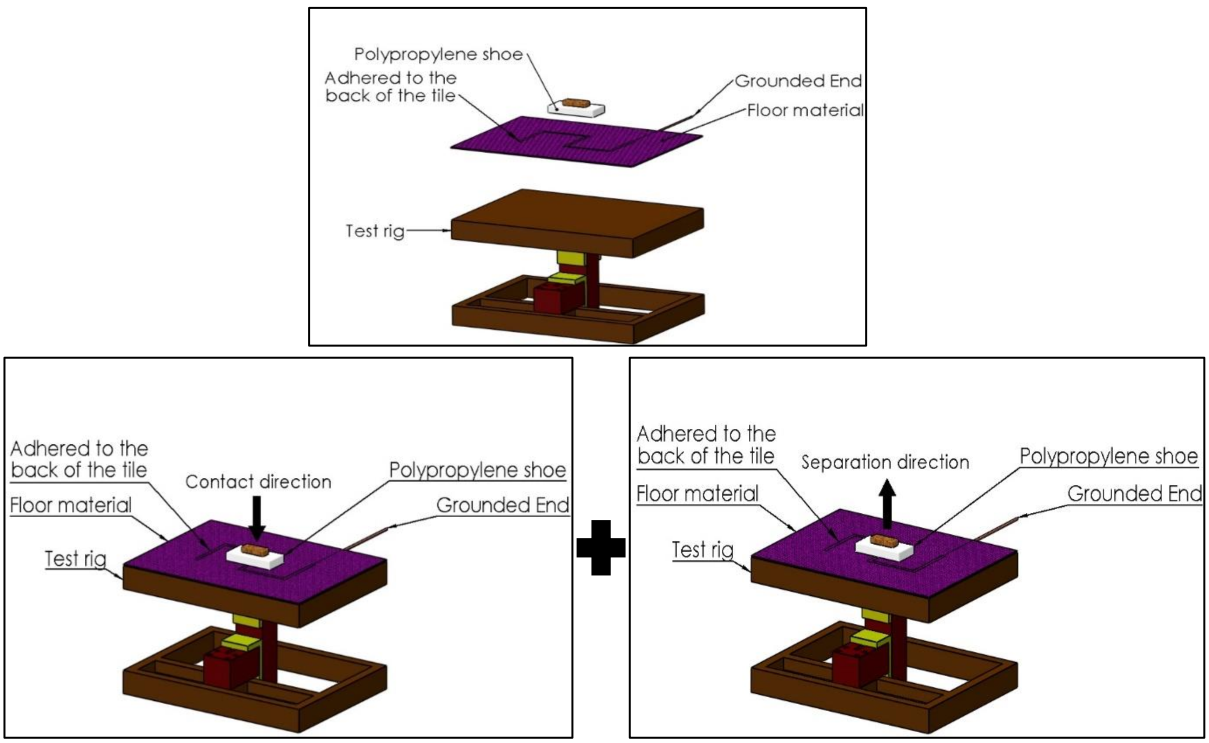

Fig. 3 Arrangement of the experimental test.

RESULTS AND DISCUSSION

Electrostatic charge of dry contact significantly increases by increasing the number of stainless steel strips where the voltage is 11, 47 and 73 volts in the floor material fitted by one, three and six strips, respectively. The presence of stainless steel strips decreases the generation of ESC where the voltage was 140 volts in the specimen free of strips. Besides, the voltage increases by increasing the applied normal load as illustrates in Fig. 4.

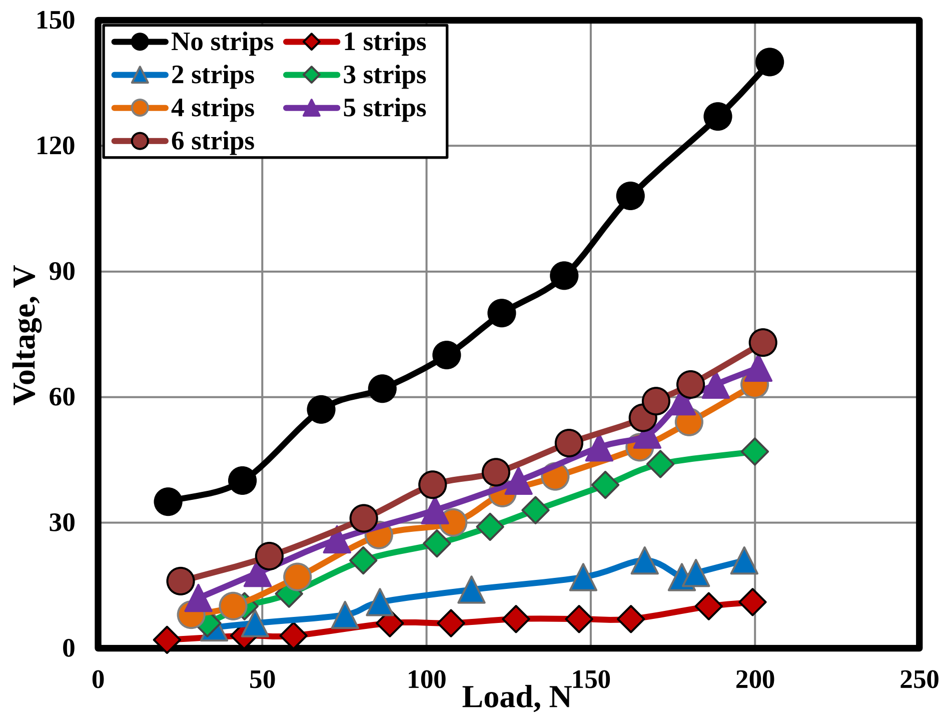

Fig. 4 Effect of number of strips on ESC on floor material (A) at ungrounded dry condition.

Figure 5 illustrates that, when the two dissimilar materials are rubbed together one will get positively charged and the other will be negatively charged. The double layer ESC generated due to phenomena of triboelectrification on the floor material, besides the presence of stainless steel strips increases the intensity of electrons and consequently generates the electric field.

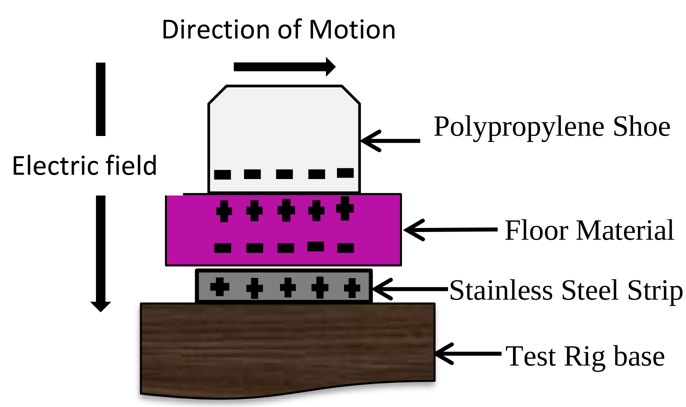

Fig. 5 Schematic illustration of ESC generated on ungrounded floor material.

The grounded design leaks an amount of ESC as illustrated in Fig. 4. The voltage decreases down to 25 volts in the floor material fitted by six strips, when the grounded end was connected to the earth, as shows in Fig. 6.

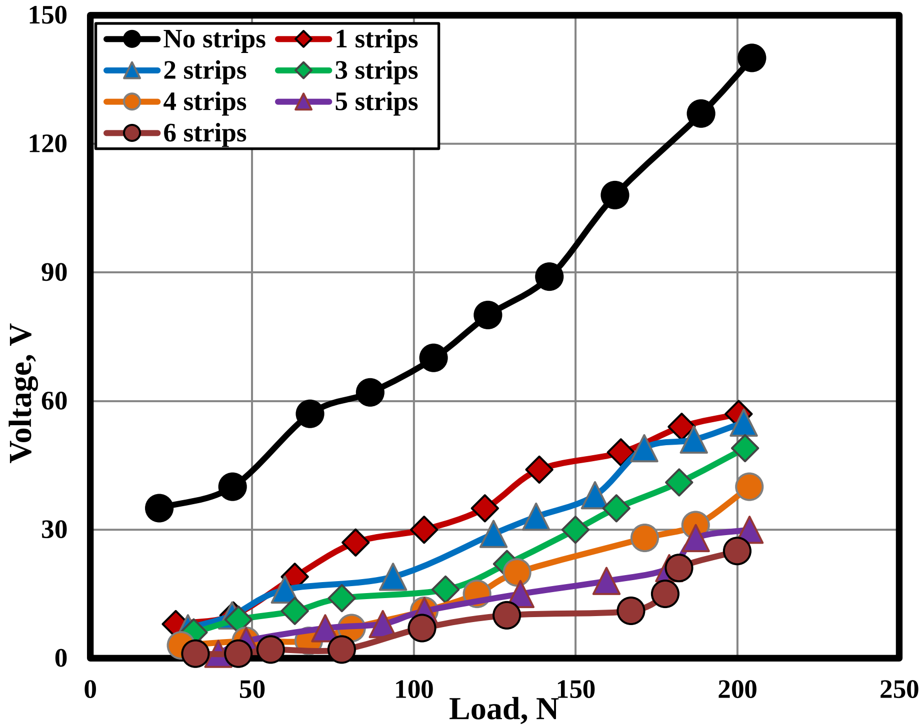

Fig. 6 Effect of number of strips on ESC on floor material (A) at grounded dry condition.

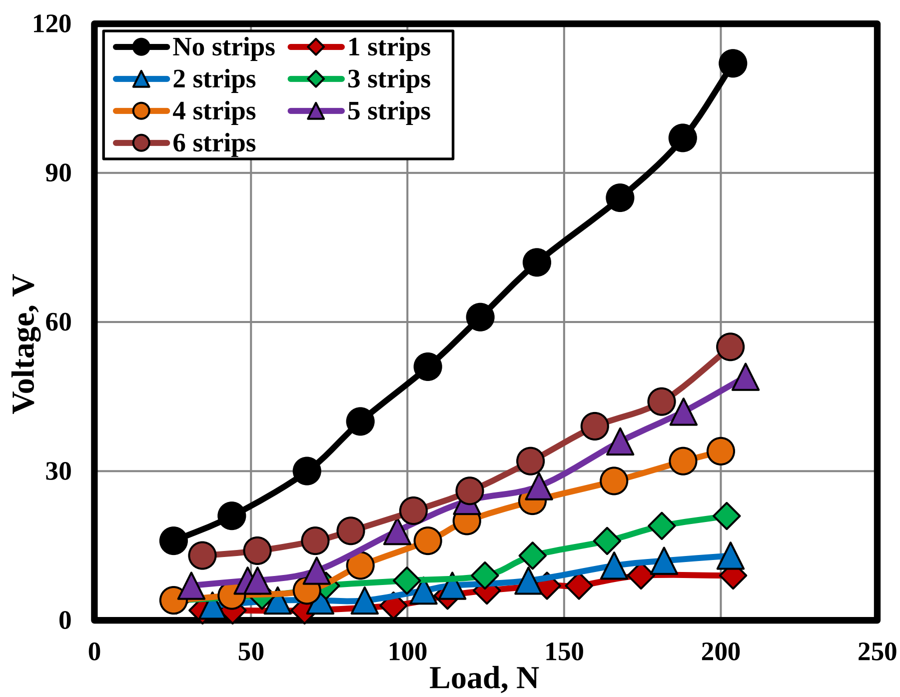

Fig. 7 Effect of number of strips on ESC on floor material (B) at ungrounded dry condition.

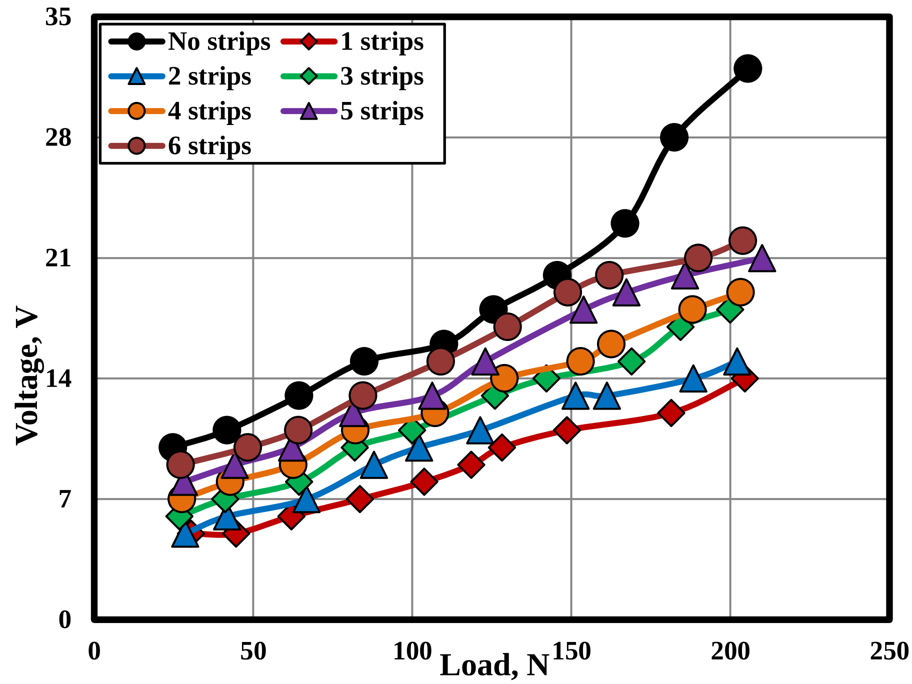

Fig. 8 Effect of number of strips on ESC on floor material (A) at chlorine wet condition and ungrounded.

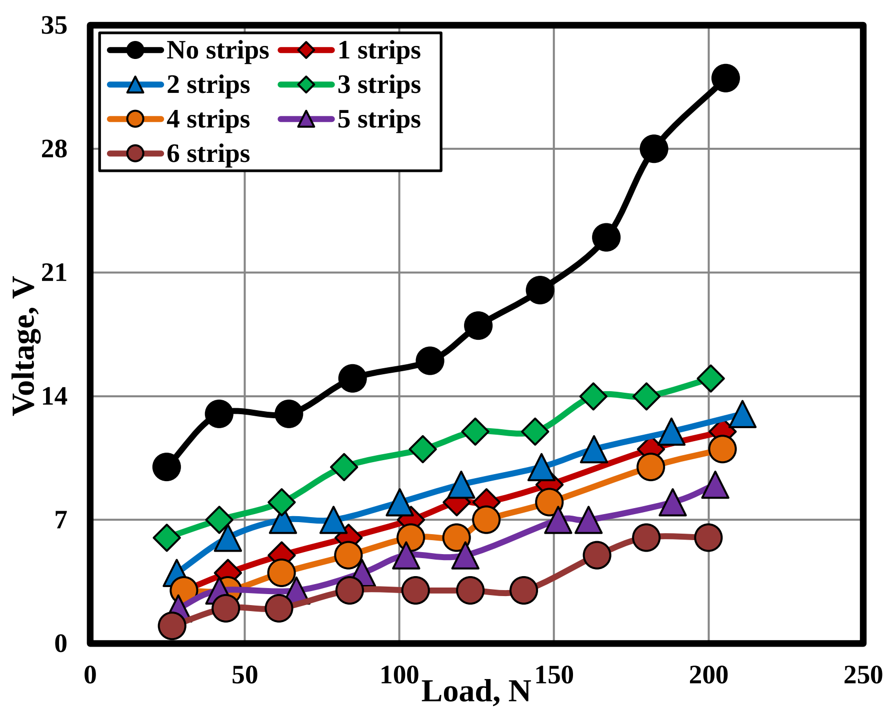

Fig. 9 Effect of number of strips on ESC on floor material (A) at chlorine wet condition and grounded.

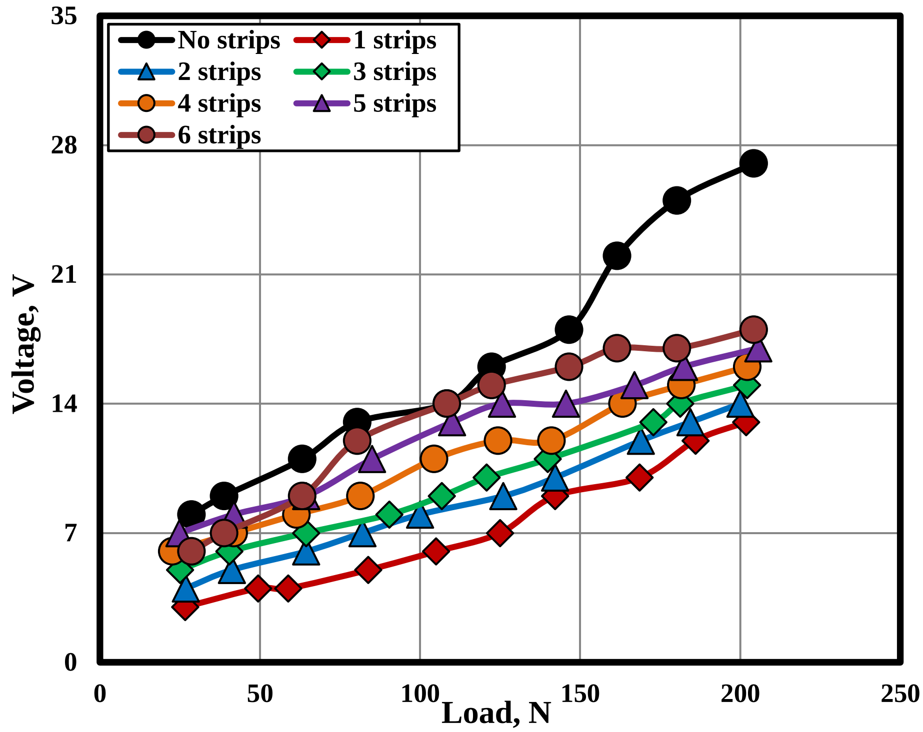

Fig. 10 Effect of number of strips on ESC on floor material (B) at ungrounded chlorine wet condition.

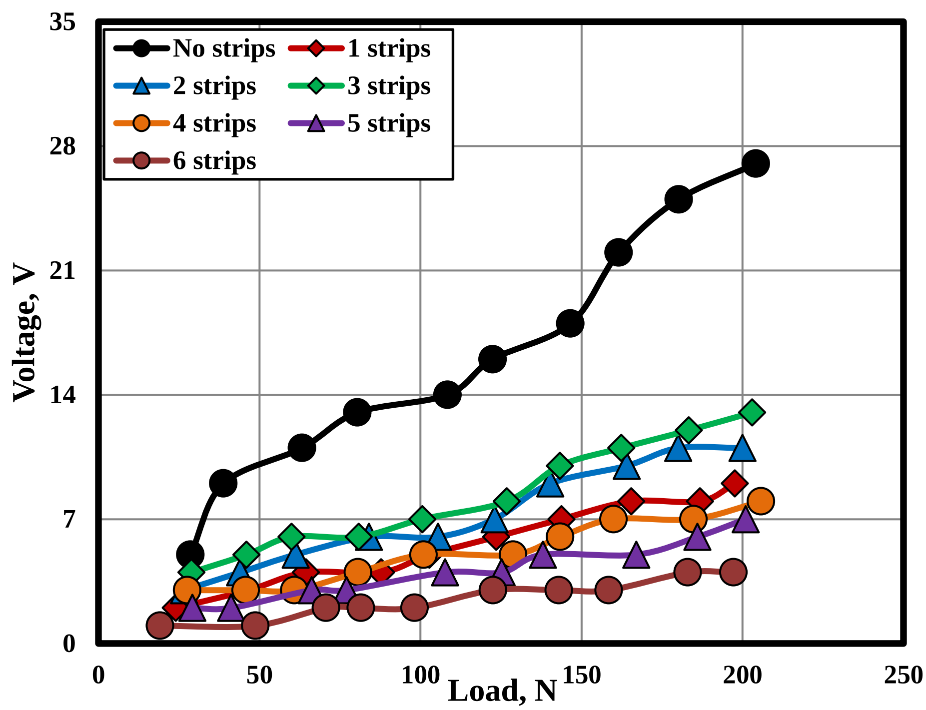

Fig. 11 Effect of number of strips on ESC on floor material (B) at grounded chlorine wet condition.

The floor material (B) generates ESC lower than that observed in material (A) because the electrical resistance of material (B) is higher than material (A). Figure 7 shows this trend where the voltage is 9, 21 and 55 volts in floor material fitted by one, three and six stainless steel strips respectively. These values are lower than that observed in Fig. 4. At water/ chlorine dilution wet surface, the voltage decreases down to 22 volts in the floor material fitted by six strips, this behavior due to the presences of film of water which leaks amount of generated ESC, Fig.8. The voltage decreases down to 6 volts in the floor material fitted by six strips in Fig. 9 while, it is 32 volts in the floor material free of strips at the same condition.

Figure 10 illustrates the effect of number of stainless steel strips on ESC at water/ chlorine wet surface, where the voltage is 18 volts in floor material fitted by six strips. This value is lower than that observed in Fig. 8 in the floor material (A). That may be attributed to the relatively higher electrical resistance of material (B) than (A). Figure 11 illustrates the minimum value in this experimental test where the voltage decreases down to 4 volt in floor material (B) fitted by six grounded strips.

CONCLUSION

1. At dry contact, the presence of stainless steel decreases the generation of ESC. Although the voltage increases by increasing the number of strips, but the generated voltage is still lower than that generated in the absence of stainless steel.

2. Water/chlorine dilution wet floor material leaks considerable amount of generated voltage. This behavior is attributed to the good conductivity of water.

3. The grounded conduction is the best way to leak generated voltage out of the contact surfaces.

4. Floor material (B) generated voltage lower than that generated by (A) at the same condition.

5. Grounded stainless steel strips decreases the generation of ESC, especially when they are adhered to the back of the floor material (B).

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