The Slip-Resistance Effect Assessment of the Anti-slip Strip on Different Contaminated Floors

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Abstract. Anti-slip strip is one of the most popular slip-resistant products indoor and outdoor, especially on the ramp. By using anti-slip strip the roughness of floor can be increased, the COF will be increased and the risk of slips and falls will be reduced at the same time. This study wants to find out the effects of slip-resistance under different floor contamination conditions while using the emery anti-slip strip. The anti-slip strips covered by steel grit provide valid slip-resistance effect. However, the slip-resistance effect will be limited when the floor covered by oil and the grooves of footwear have been wear away. In total, to provide valid slip-resistance effect, keeping the floor dry, installing the anti-slip strips, wearing tread shoes are some useful processes to reduce the risk of falling and slipping.

Keywords: Anti-slip strip, Slip& fall, Coefficient of Friction.

1 Introduction

The fall incidences take 17% of all occupational incidences in USA and 20% of all occupational incidences in UK annually, and all those slipping and falling incidences lead huge losses on workplaces [1]. Slip and fall are more easily happened to senior people. There were 2.2 million slipping and falling cases that were sent to the emergency room due to no-fatal incidents, and more than quarter of them had to be hospitalized [2]. Therefore, slipping and falling accidents induce serious safety issues [3].

One of the most popular ways of assessing slipperiness is to measure the coefficient of friction (COF) between the shoe and floor surface [4]. The lower the COF is, the slipperier the floor will be. Due to the simplicity of measuring, the static COF (μs) has been considered as one of the major indicators of floor slipperiness. A measured static COF of 0.5 has been adopted as a safety guideline in the USA [5-6]. Prior researches have shown that falling and slipping could be affected by various factors, such as the material and the roughness of the floor; the liquid and solid contamination on the floor; the material of footwear; the groove design of shoe sole; and the gradient of ramps [7-9].

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The squeeze film theory [10] is probably the most frequent adopted scientific basis describing the effects of liquid on the friction on a floor. Improving the feature of floor surface has better anti-slip effects than changing the shoe sole grooves [11-13]. In practice, the anti-slip strips are widely installed on walk ways, ramps, toilets, bathrooms and stairs to change the feature of the floor surface and prevent slipping and falling. Most of the anti-slip strips using steel grit coating to increase the floor roughness and improve the slip-resistance effects. However, the discussion about its slip-resistance effect is rare. The subject of the anti-slip strip's COF under different floor contaminations is deserved to be described. Therefore, this study wants to find out the effects of slip-resistance under different floor contamination conditions while using the emery anti-slip strip.

2 Method

The study conducted a three factors experiment. There are 4*3*2=24 combinations (4 shoe materials * 3 floor contaminations conditions * 2 floors). A total of 144 readings were collected. Four types of footwear pads were tested in this study. These included flat (no tread) and tread footwear pads made from Neolite and Rubber. For the tread footwear pad, there were grooves (1 mm wide, 3 mm deep) evenly spaced on the pad and the grooves are perpendicular to the friction measurement direction. The hardness of the Neolite and Rubber were 91±1.73 and 47±0.82 respectively.

The COF was measured under the surface conditions of dry, wet and glycerol. For the wet conditions, water was replenished in the footwear striking area during repeated strikes. The amount of water for each replenishing was 10 ml. For the glycerol conditions, glycerol was dripped evenly in the footwear striking area before each strike. The amount of glycerol replenished each time was 5 cc. There are two different terrazzo floor used in the COF measurement including regular one and the one installed 3M anti-slip strips (anti-slip floor).

The Brungraber Mark II (BM II) slipmeter was used to measure the COF. BM II has been applied to conduct friction measurement in labs and workplace [14]. The study operated BM II according to the standard test method of using the BM II published by the American Society for Testing and Materials [15]. In addition, the protocol in judging a slip or no-slip suggested by Chang [16] was used.

Finally, the study uses Paired-Samples T-test to compare the COF under different footwear materials, floor contaminates and floor.

3 Results and Discussion

The results reveal that the installing of anti-slip strips will significantly ($p<0.001$) increase the COF. Under the dry surface condition, the COF will increase 0.623、0.621、0.423 and 0.26 separately with tread Neolite、no-tread Neolite、tread Rubber、no tread Rubber shoe materials. Under the wet floor condition, with tread neolite, no tread neolite, tread rubber, no tread rubber shoe materials, the COF will

increase 0.624、0.950、0.442 and 0.945 separately. Finally, under the glycerol surface condition, the COF will increase 0.799、0.068、0.572 and 0.138 separately with tread neolite, no tread neolite, tread rubber, no tread rubber shoe materials (see table 1). Therefore, as the results shown in table 1, the anti-slip strips provide better COF significantly with the floor contaminated by water. When the floor is contaminated by oil, the tread footwear pads should be used to increase the anti-slip effect.

Table 1. Mean and Standard Deviation of the COF

Footwear pads	Surface conditions	Anti-slip floor	Terrazzo floor	Friction increase	t-value	p-value
Tread Neolite	Dry	1.073 (0.008)	0.450 (0.006)	0.623	147.836	<0.001
	Wet	1.032 (0.008)	0.408 (0.008)	0.624	111.754	<0.001
	glycerol	0.827 (0.008)	0.028 (0.004)	0.799	198.894	<0.001
No-tread Neolite	Dry	1.078 (0.008)	0.457 (0.008)	0.621	154.880	<0.001
	Wet	0.990 (0.006)	0.040 (0.006)	0.950	260.168	<0.001
	glycerol	0.068 (0.008)	0.001 (0.000)	0.068	22.235	<0.001
Tread Rubber	Dry	1.100 (0.000)	0.677 (0.008)	0.423	127.000	<0.001
	Wet	1.100 (0.000)	0.658 (0.008)	0.442	143.716	<0.001
	glycerol	0.855 (0.005)	0.283 (0.008)	0.572	186.018	<0.001
No -tread Rubber	Dry	1.100 (0.000)	0.840 (0.009)	0.260	71.204	<0.001
	Wet	0.998 (0.008)	0.053 (0.005)	0.945	276.668	<0.001
	glycerol	0.138 (0.008)	0.001 (0.000)	0.138	45.013	<0.001

Only the tread rubber footwear on the wet floor and no tread footwear on the dry floor show anti-slip effects on regular terrazzo floor. The anti-slip effects are not significant when wearing no-tread footwear and walking on the floor contaminated by glycerol (see Fig.1). Therefore, adopting the tread shoes and anti-slip strips at the same time will improve the slip-resistance effect dramatically.

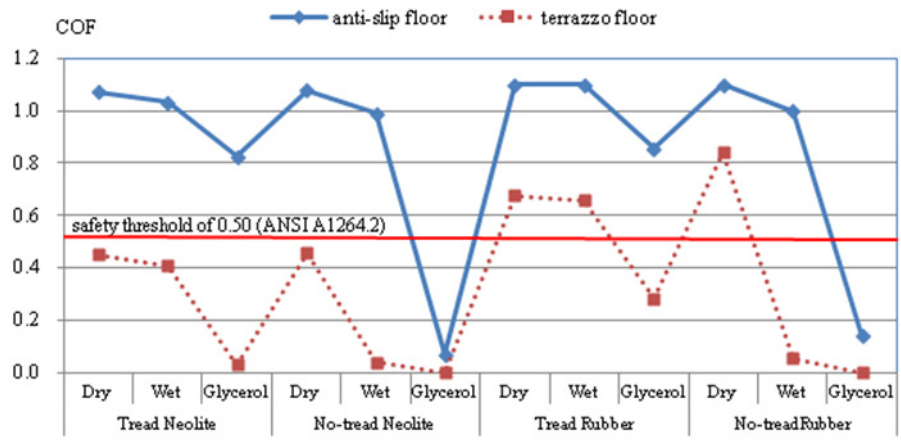

Fig. 1. The comparison of the COF under two different floors

The anti-slip strips covered by steel grit provide valid slip-resistance effect. However, the slip-resistance effect will be limited when the floor covered by oil and the grooves of footwear have been wear away. In total, to provide valid slip-resistance effect, keeping the floor dry, installing the anti-slip strips, wearing tread shoes are some useful processes to reduce the risk of falling and slipping.

4 Conclusion

Anti-slip strip is one of the most popular slip-resistant products indoor and outdoor. The study compared the effects of slip-resistant under different floor contamination conditions while using the anti-slip strip. The results demonstrated that emery anti-slip strip is really helpful on resisting slipping no matter the floor is dry or wet. However, when the floor is covered by oil, the anti-slip strips provide slip resistance effects only if the workers wear the tread shoes. Therefore, in order to perform the best ant-slip effect, the floors not only need to be kept dry, but also need to be installed with some anti-slip devices. Of course wearing the tread footwear and keeping the grooves wide & deep enough will reduces the risk of falling and slipping successfully.

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