Friction Measurements in Restaurants Kitchens

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***Abstract*—**Slip & fall are major occupational safety & health incidences. This research was conducted for floor friction coefficient measurements in four restaurants in each of Chinese, western, and western style fast food restaurants. Walkway, sink, and cooking areas for each of the restaurants were selected and 8 points on the floor in each of the area were measured. A Brungraber Mark II friction measurement device was used. A Neolite standard footwear pad was attached to bottom of the strut of the BM II. The friction coefficient measurements results indicated that Chinese style restaurants had significant lower averages and high variation in friction coefficient. The western style restaurants had also significantly lower floor COF than those of the western fast food restaurants. This implies such floor environments had high risk of slip & fall. The slip resistances of the kitchen floors in the visited restaurants were discussed.

***Keywords*—**slips & falls, friction measurement, kitchen floor, field study.

I. Introduction

WHEN walking, the foot touches with the floor in three stages [1, 2]: heel-on, foot-flat, and toe-off. When the heel touches the floor, the center of gravity (CG) of body is behind the heel and the CG must move forward. The heel then applies a forward thrust against the floor. If this forward thrust is larger than the friction, the heel slips. Fall occurs if the slip is fast enough so that the body is out of control.

Slips & falls are common at workplaces. In Taiwan, falling has account more than 15 % of all occupational incidences and has been one of the leading causes of injuries occupationally [3,4]. The 2013 official statistics [5] showed that every five to six occupational injuries might be attributed to falling. Similar reports [6, 7] may be found in other countries.

Falling may be caused by slipping, tripping, and loss of bodily balance. But slipping has been identified as the major contributor [8]. Slip resistance of the floor has been one of the major issues in discussing the risk of slipping and falling. Slip resistance of floor could be affected by floor material, floor surface profile or geometry, and most importantly floor contamination. Floor covered with liquids such as water and oil always resulted in reduction of friction and could increase the r[1]isk of slipping and falling dramatically [9, 10].

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Field measurement of floor slip resistance is one of the commonly used approaches in assessing the risk of slipping. In this research, we conducted friction measurements in restaurant kitchens to compare the friction of the workplaces and to discuss the risk of slipping and falling on the worksites.

II. Methods

A. Work Sites & Floors

Three types of restaurants were selected: Chinese (CR), Western (WR), and western fast food (WF) restaurant. Four restaurants for each of the type were selected. This comprised 12 restaurants in total. The kitchen floor environments were inspected before the study began. Each of the type of the restaurants was term as A, B, C, and D. Each restaurant may be termed using the type and a letter. For example, WR-C means Chinese restaurant C. The floors in the kitchen of both CR-A (see Fig. 1) and CR-D were ceramic tiles. The floors in CR-B (see Fig. 2) and CR-C were cement and epoxy resin (see Fig. 3), respectively. For all the four western restaurants, the kitchen floors use similar ceramics titles (see Fig 4). The four western restaurants belong to the same chain stores. They used the same type of quarry tiles (see Fig. 5). All the kitchens in restaurants have drenches covered with steel covers.

Three areas, including walkway, sink, and cooking areas, were selected in each of the kitchen in each restaurant. For each area, eight sampling spot were measured twice in each area. A total of 576 (12×3×8×2) measurements in 12 restaurants were conducted. The measurements were performed after lunch hour.

Fig.1 Ceramic tile of Chinese restaurant A

Fig. 2 Concrete floor of Chinese restaurant B

Fig. 3 Epoxy floor of Chinese restaurant C

Fig. 4 Ceramic floor of western restaurants

Fig. 5 Quarry tile of western fast food restaurant

B. Friction Measurement Device

Friction measurements were performed using a Brungraber Mark II (BMII) slipmeter (see Fig. 6). Standard Neolite footwear pad was adopted. Operations of the BM II follow the recommendations in the American Society for Testing and Materials (ASTM) F-1677-05 [11] and Chang [12]. The data collected were the coefficient of friction (COF).

Fig. 6 Friction measurements using the BM II in
The kitchen of a Chinese restaurant

C. Data analysis

Descriptive statistics and analysis of variance (ANOVA) were performed for the friction measurement data. Duncan multiple range test was performed if a factor was found to be statistically significant (α=0.05) in the ANOVA.

III. Results

The ANOVA results showed that restaurant type was a significant factor affecting the floor COF. Duncan's multiple range tests were performed. The results are shown in Table I.

TABLE I
DUNCAN'S MULTIPLE RANGE TESTS RESULTS FOR RESTAURANT TYPE

Restaurant type	Mean COF	Duncan grouping letter*
Chinese	0.44	A
Western	0.55	B
Western Fast Food	0.60	C

*same letter indicate that they were not significantly different

The means, standard deviations, and coefficients of variation (CV) of the COF for each area in the Chinese restaurant were shown in Table II. In Chinese restaurant A, all the floors were wet when the friction measurements were conducted because the kitchen workers had just finished cleaning the floor by spraying fountain water on the floor. Most of the COF measured in this restaurant was approximately 0. The concrete floor in Chinese restaurant B had pretty good slip resistance. Most of the COF values obtained in the kitchen of this restaurant were well above 0.5, a standard commonly adopted in the USA.

TABLE II
COEFFICIENT OF FRICTION (COF) FOR EACH AREA IN CHINESE RESTAURANTS

restaurant	area	mean	std	CV
A	Walkway	0.01	0.00	0
	Sink	0.01	0.00	0
	Cooking	0.03	0.02	63.92%
B	Walkway	0.77*	0.02	2.05%
	Sink	0.43	0.1	24.07%
	Cooking	0.77*	0.08	10.17%
C	Walkway	0.72*	0.08	11.21%
	Sink	0.34	0.16	45.89%
	Cooking	0.16	0.10	63.06%
D	Walkway	0.75*	0.03	4.20%
	Sink	0.49	0.07	13.81%
	Cooking	0.83*	0.06	6.78%

The means, standard deviations, and coefficients of variation (CV) of the COF for each area in the western and western fast food restaurant were shown in Tables III and IV, respectively.

TABLE III
COEFFICIENT OF FRICTION (COF) FOR EACH AREA IN WESTERN RESTAURANTS

Restaurant	area	mean	std	CV
A	Walkway	0.89*	0.11	12.87%
	Sink	0.61*	0.07	11.68%
	Cooking	0.72*	0.10	13.55%
B	Walkway	0.71*	0.04	5.22%
	Sink	0.29	0.13	45.64%
	Cooking	0.35	0.10	28.82%
C	Walkway	0.74*	0.11	15.26%
	Sink	0.27	0.13	48.35%
	Cooking	0.46	0.11	24.05%
D	Walkway	0.84*	0.06	7.44%
	Sink	0.30	0.15	51.56%
	Cooking	0.43	0.21	49.44%

TABLE IV
COEFFICIENT OF FRICTION (COF) FOR EACH AREA IN WESTERN FAST FOOD RESTAURANTS

Restaurant	area	mean	std	CV
A	Walkway	0.60*	0.05	7.66%
	Sink	0.64*	0.06	8.96%
	Cooking	0.71*	0.07	9.76%
B	Walkway	0.70*	0.07	9.88%
	Sink	0.58*	0.11	18.80%
	Cooking	0.67*	0.06	8.79%
C	Walkway	0.66*	0.02	3.57%
	Sink	0.52*	0.15	28.48%
	Cooking	0.59*	0.05	9.05%
D	Walkway	0.61*	0.02	3.56%
	Sink	0.57*	0.09	15.89%
	Cooking	0.39	0.08	20.08%

IV. DISCUSSIONS

The Chinese style restaurants had significantly ($p<0.05$) lower COF (0.44) than those of the western (0.55) and western fast food (0.60) restaurants. The western restaurants had significantly lower COF than that of the western fast food restaurants. This coincides with the general believe that the kitchens in Chinese style restaurants were more greasy than those of the other two types of restaurants. This resulted in less slip resistant floors in the working areas.

The sink areas in both the Chinese and western style restaurants had low COF than other areas. This coincides with

the findings in the literature [13]. The sink area in the western fast food restaurant, however, had higher COF than the other two types of restaurants. This was because the sinks of the fast food restaurants we visited had not started to use the sinks. The areas were dry and the surface condition was consistent with surrounding areas.

Tile was found a significant factor affecting the COF of the floor. Cement floors normally provide high COF values. However, they were not common because of their appearance and housekeeping problems. Ceramic with glaze and epoxy resin generally resulted in low COF when covered by water or other liquids. Quarry tile without glaze especially when they have embedded emery on the surface is a good choice as this type of floors provide COF higher than 0.5, a standard recommended by the ANSI 1264.

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