出國報告（出國類別：其他）

參加第十八屆IEA國際人因工程研討會

服務機關：行政院勞工委員會勞工安全衛生研究所
姓名職稱：陳志勇 研究員兼組長
派赴國家：巴西
出國期間：101年2月11日至2月18日
報告日期：101年3月21日

摘 要

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派赴國家：巴西
出國期間：101 02 11-18
報告日期：101 03
關 鍵 詞：人因工程、滑倒、肌肉骨骼傷病

內容：IEA是各國人因工程學會所組成的機構，目前台灣地區人因工程學會EST(Ergonomic Society of Taiwan)也是IEA的會員，是國際上對於人因工程研究最有影響力的組織。今年度會議中，我國清華大學工業工程系王明揚教授獲選為IEA理事長，相當不容易。對於促進我國人因工程與世界各國的交流，將有助益，特別是與亞洲地區。IEA每三年在世界各地辦一次國際研討會(IEA International Ergonomics Association The Ergonomics World Congress)，是人因工程界國際上最大的會議。會議主題含蓋目前人因工程在各領域的研究包括勞工工作安全與衛生(健康)、人體計測、滑倒、疲勞、營建業人因工程、人機介面與肌肉骨骼傷害等等數十個議題。本次參加發表本所研究成果：Assessment of slip resistance under footwear materials, tread designs, floor contamination, and floor inclination conditions。因應本會職安法新修法草案中有關人因工程的部分，我們特別關注的議題包括(1) 肌肉骨骼傷害危害因子風險評估：IEA/WHO觀點，(2)滑倒、絆倒、墜落相關論文。

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壹、目 的

IEA是各國人因工程學會所組成的機構，目前台灣地區人因工程學會EST(Ergonomic Society of Taiwan)也是IEA的會員，是國際上對於人因工程研究最有影響力的組織。IEA每三年在世界各地辦一次國際研討會，各地人因工程研究人員數千人與會，可以說是人因工程界國際上最大的會議。今年度會議中，我國清華大學工業工程系王明揚教授獲選爲IEA理事長，相當不容易。本次會議主題涵蓋目前人因工程在各領域的研究包括勞工工作安全與衛生(健康)、人體計測、滑倒、疲勞、營建業人因工程、人機介面與肌肉骨骼傷害等等議題。

本次參加IEA國際研討會主要有兩個目的:

一、 發表本所研究成果Assessment of slip resistance under footwear materials, tread designs, floor contamination, and floor inclination conditions。

二、 鑒於本會職安法修法草案中有部分與人因工程相關的條文，特別是〝重複性作業等促發肌肉骨骼疾病之預防〞以及地板通道等有關之滑倒議題，在此次會議中我們也特別注意收集相關研究，以爲後續有關預防指引編撰之參考。

貳、過 程

一、參加IEA國際人因工程研討會

本次IEA（國際人因工程年會）有上千篇論文發表。會議中有部分主題專門介紹IEA與WHO組織間的合作計畫，此一計畫透別針對工作場所有關的肌肉骨骼傷病危害評估與改善。這一議題在上一屆大會也有特別主題討論，主要是在現場危害評估方法，包括美國NIOSH 人工抬舉評估以及ACGIH 針對單調上肢作業所開發的HAL TLV等方法。另外，上屆會議中也有IEA/ILO關於人因工程檢核的技術資料開發(Ergonomic Checkpoint)，此一檢核手冊舊版國內有翻譯，新版也已發行，對於現場安衛人員進行人因工程改善是一不錯的參考資料，簡單易懂圖文並茂。本次會議中IEA/WHO 特別考慮國際人因工程標準(EN 與 ISO)中，有關工作姿勢評估、重複性動作以及施力等標準，探討工作場所中肌肉骨骼傷病危害因子的評估，並提出一套風險評估的邏輯與做法。這一部分將在下一節中進一步說明，後續在新修的職安法草案中有關〝重複性作業等促發肌肉骨骼疾病之預防〞，本會可加以參考考慮國內現況後提出指引，以為事業單位作風險評估或預防措施之參考。會中仍有關於STF(slip、trip and fall)的主題，此一主題與新修法中通道地板危害預防有關，將在第三節中說明。

這次主題分的很細，摘錄會中Parallel Sessions人因工程相關議題如下表，包括工作分析與設計、中高齡、人因工程在製造業應用、肌肉骨骼傷病、安全衛生、滑倒絆倒墜落等等。其中〝人因工程在製造業應用〞這一議題是由我國清華大學人因工程專家黃雪玲教授主持。另外，還有特別議題包括IEA technical Committees, 例如STF technical Committee meeting, Keynote speak等。

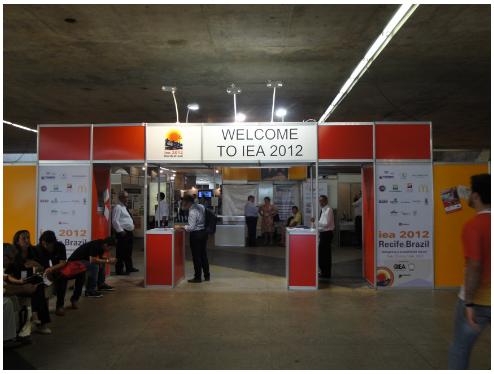


圖 本次大會佈置有些不完整，似乎有點未完待續的感覺

表 大會的研討議題

Parallel Sessions:
Activity Theories forwork analysis and design
Aging
Ergonomics analysis of work and training
Ergonomics for children and educational environments
Ergonomics in design
Ergonomics in manufacturing
Healthcare ergonomics
Human factors and sustainable
Human simulation and virtual environments
Musculoskeletal disorders
Organizational design and management
Process control
Psychophysiology in ergonomics
Safety and health
Slips, trip and falls

二、肌肉骨骼傷害危害因子風險評估：IEA/WHO觀點

由於本會在新修訂的〝職業安全衛生法〞中，第二章第六條第二項提到〝雇主對於下列事項，應妥爲規劃並採取必要安全衛生措施，以保護勞工身心健康〞，該項第三款提到〝重複性作業等促發肌肉骨骼疾病之預防〞。在從勞保傷病給付資料來看，近年來申請肌肉骨骼傷病的案例以及給付的案件數很多，可見有關的事業單位與勞工非常多，值得重視。該新修法草案中，第四十五條提到〝…違反第六條第二項…〞處新台幣三萬元以上十五萬元以下之罰緩。後續如何提出指引供事業單位參考，以及檢查單位依據何種標準作檢查，都值得研究並進一步取得共識。本節所介紹的方法，可以提供作爲後續本會發展相關指引與檢查標準的參考。換句話說，依據不同的風險評估階段，課以不同人員的責任。

在上次第十七屆IEA大會，我們特別提到〝國際上對於勞工工作場所發生的肌肉骨骼傷害危害因子現場評估方法與技術，Symposium: Prevention of Work Related Musculoskeletal Disorders 這一部份有相當多的論文。在歐洲有OCRA評估檢點方法，美國也有學者*A.Garg* 提出 strain Index ，ACGIH 也有上肢評估方法由密西根大學教授提出，這些方法具有一致性，使用細節與評估危險因子稍有不同，將來如何應用於國內供事業單位使用，值得進一步探討〞。本次十八屆IEA大會特別值得一提的是: IEA/WHO toolkit for WMSDs prevention，這是國際人因工程學會與世界衛生組織的合作案，主要目的是提供一套職業性肌肉骨骼傷病危害因子風險評估方法，協助給非專業人因工程專家使用，以爲後續現場風險評估及預防參考。此一系統性方法考慮國際標準如ISO11226 (不當姿勢)、11228 (人工搬運、全身性推拉作業)，以及相對的歐盟準EN1005。此外，也參考了各國勞工安全衛生研究機構的檢核預防技術如美國NIOSH〝Revised Niosh Lifting Equation (RNLE)〞、歐洲使用的〝OCRA checklist〞(針對重複性動與施力) 、〝Psychophysical Tables by Snook and Ciriello〞以及常用於工作姿勢評估的〝OWAS〞與〝REBA〞。

1977年，芬蘭的學者發展出一套姿勢的分析系統Ovako Working Posture Analysing System(OWAS)，對於全身的移動，包含肩部、下背部、下肢的彎曲、旋轉、位置進行評估。而後1990年代陸續發展出許多檢核表，包含針對上肢姿勢、施力、動態評估的RULA系統(Rapid Upper Limb Assessment)、對物料抬舉作業及危害分析的NIOSH Lifting Equation、針對上肢作業評估及危害因子分析的Strain Index、對於不同類型工作評估身體姿勢、施力、重複性動作的OCRA檢核表(Occupational Repetitive Action)以及2001年對手部動作、施力作危害暴露評估的ACGIH HAL(Hand Activity Level)。近年來，國際標準組織針對職業性肌肉骨骼傷病危害因子評估與管理，成立工作小組開發系統方法，嘗試將上述簡核技術加以整合。

這一項合作案所提出的系統性評估方法，基於(1) Acting on a step-by-step approach，(2) Taking into account the presence of multiple influencing factors，兩項原則，已經整合了目前已開發的技術，針對不同評估階段作爲風險確認、評估與管理之參考。不同評估階段包括:

(1) A *Basic Step* devoted to hazard identification by operative “key-enter” questions, that can be operated also by non-experts。

(2) A *First Step*, (quick assessment), for identifying 3 possible conditions: acceptable; high risk present; more detailed analysis (via tools presented at second step) necessary. This step can be operated by non-experts with only some specific training.

(3) A *Second Step*, where recognized (i.e. from international standards or guidelines) tools for risk estimation are used. This step can be operated only by persons with some specific training.

Table 1

Key enters to the evaluation of different conditions of biomechanical overload as considered in ISO 11226 and 11228 (parts 1-2-3)

THE KEY-QUESTIONS		
1 *Application of ISO 11228-1*		
Is there manual lifting or carrying of an object of 3 kg or more present?	NO	YES
if **NO**, this standard is not relevant, go to the next Key Question regarding the other standards **If YES** then go to step 2 (quick assessment)		
2 *Application of ISO 11228-2*		
Is there manual whole-body pushing and pulling present?	NO	YES
if **NO**, this standard is not relevant, go to the next Key Question regarding the other standards **If YES** then go to step 2 (quick assessment)		
3 *Application of ISO 11228-3*		
Are there one or more repetitive tasks(*) of the upper limbs in a shift? (*)where the definition of "repetitive task" is: *one or more tasks characterized by cycles lasting 1 hour or more per shift* *or* *when the same working gestures are repeated for more than 50% of the time, lasting 1 hour or more per shift.*	NO	YES
If **NO**, this standard is not relevant, go to the other Key Question regarding the other standards **If YES** then go to step 2 (quick assessment)		
4 *Application of ISO 11226*		
Are there static or awkward working postures of the HEAD/NECK, TRUNK and/or UPPER AND LOWER LIMBS maintained for more than 4 seconds consecutively and repeated for a significant part of the working time? For example: *- HEAD/NECK (neck bent back/forward/sideways, twisted)* *- TRUNK (trunk bent forward/sideways/, bent back with no support, twisted)* *- UPPER LIMBS (hand(s) at or above head, elbow(s) at or above shoulder, elbow/hand(s) behind the body, hand(s) turned with palms completely up or down, extreme elbow flexion-extension, wrist bent forward/back/sideways)* *- LOWER LIMBS (squatting or kneeling) maintained for more than 4 seconds consecutively and repeated for a significant part of the working time*	NO	YES
if **NO**, this standard is not relevant **If YES** then go to step 2 (quick assessment)		

Table 2

Quick assessment for manual lifting activities: check of an acceptable condition (green area)

LIFTING: QUICK ASSESSMENT : ACCEPTABLE CONDITION			
3 TO 5 Kg	Asymmetry (e.g. body rotation, trunk twisting) is absent	**NO**	**YES**
	Load is maintained close to the body	**NO**	**YES**
	Load vertical displacement is between hips and shoulders	**NO**	**YES**
	Maximum permissible frequency: less than 5 lifts per minute	**NO**	**YES**
5,1 TO 10 Kg	Asymmetry (e.g. body rotation, trunk twisting) is absent	**NO**	**YES**
	Load is maintained close to the body	**NO**	**YES**
	Load vertical displacement is between hips and shoulder	**NO**	**YES**
	Maximum permissible frequency: less than 1 lift per minute	**NO**	**YES**
MORE THAN 10 Kg	Loads more than 10 kg are not present	**NO**	**YES**
If all the listed conditions are **YES**, the examined task is ACCEPTABLE and it is no necessary to continue the risk evaluation If one is **NO**, **APPLY THE STANDARD: ISO 11228-1**			

Table 3

Quick assessment for manual lifting activities: check of a surely "critical" condition ("very" red area)

LIFTING AND CARRYING-QUICK ASSESSMENT : CRITICAL CONDITION (CRITICAL CODES). If only one of the following conditions is present, risk has to be considered as HIGH and it is necessary to proceed with task re-design		
CRITICAL CONDITION: presence of lay-out and frequency conditions exceeding the maximum suggested		
VERTICAL LOCATION	Hands at the beginning/end of the manual lifting, higher than 175 cm or lower than 0 cm.	**YES**
VERTICAL DISPLACEMENT	The vertical distance between the origin and the destination of the lifted object is more than 175 cm	**YES**
HORIZONTAL DISTANCE	The horizontal distance between the lifted object and the body center of gravity (medium point between the ankles) is more than 63 cm	**YES**
ASYMMETRY	Asymmetry angle (upper body rotation) more than 135° degrees	**YES**
FREQUENCY	More than 15 lifts per min in SHORT DURATION (manual handling lasting no more than 60 min. consecutively in the shift, followed by at least 60 minutes of break-light task)	**YES**
	More than 12 lifts per min in MEDIUM DURATION (manual handling lasting no more than 120 min consecutively in the shift, followed by at least 30 minutes of break--light task)	**YES**
	More than 8 lift/min in LONG DURATION (manual handling lasting more than 120 min consecutively in the shift)	**YES**
CRITICAL CONDITION: presence of loads exceeding following limits		
Males (18-45 years)	**25 KG**	**YES**
Females (18-45 years)	**20 KG**	**YES**
Males (<18 o >45 years)	**20 KG**	**YES**
Females (<18 o >45 years)	**15 KG**	**YES**
If only one answer is **YES a critical situation** is present. **Proceed with assessment with ISO 11228-1 for identifying urgent corrective actions**		

Table 5

Main methods for second level, suggested in this proposal for "risk estimation", as derived from different international standard.

METHODS FOR SIMPLE RISK ESTIMATION (SECOND LEVEL) DERIVED BY INTERNATIONAL STANDARDS AND SUGGESTED AS PREFERRED IN PRESENT PROPOSAL			
Manual Lifting	**Manual Pushing and Pulling**	**Repetitive Movements and Exertions** (Upper limbs)	**Working Postures**
Revised Niosh Lifting Equation (RNLE)	***Psychophysical Tables by Snook and Ciriello***	***OCRA Checklist***	***OWAS*** ***REBA***
From ISO 11228-1 and EN 1005-2	**From ISO 11228-2**	**From ISO 11228-3 and EN 1005-5**	**From ISO 11226, 11228-3 and EN 1005-4**
Use also recent updates regarding variable and sequential lifting tasks	*Use also updates of Psychophysical Data.*	*Use also recent updates regarding rotations between multiple repetitive tasks.*	*Use the preferred methods and recommendations from ISO 11226 and EN 1005-4*

表5是比較技術性的檢核評估技術，一般需要受過專業訓練的人員比較適合使用。

除了之前介紹的OWAS、NIOSH lifting equation 外，表中使用了OCRA檢核表作爲重複性動作的評估技術。這一技術事業單位的安衛人員比較不清楚，我們稍微介紹一下。

OCRA Index 檢核評估

OCRA Index爲勞工一天中上肢執行技術動作之實際次數(Ae)與建議次數(Arp)兩者間之比值，計算公式如式(1)，比值由小至大共分成四個等級，依序爲小於1、介於1.1至2、介於2.1至3.9及大於等於4，其代表之上肢MSDs危害風險以顏色表示分別爲綠色、黃/綠色、黃/紅色及紅色，其中綠色代表無風險，紅色則爲高風險。兩項參數決定之依據分別敘述如下：

$$\text{OCRA index} = \frac{Ae}{Arp} \quad \cdots\cdots\cdots\cdots (1)$$

其中 OCRA Index：上肢MSDs危害風險指標值

Ae：上肢執行技術動作之實際次數

Arp：上肢執行技術動作之建議次數

(1) Ae：由勞工作業過程之影片，隨機選取三個工作週期，以慢動作重播之方式，觀察勞工慣用手之技術動作。技術動作之判斷與動作次數之計算依據文獻之定義進行[Colombini D, Occhipinti E, Grieco A. Risk Assessment and management of repetitive movements and exertions of upper limbs. Kidlington: ELSEVIER SCIENCE Ltd; 2002. p. 43-110.]，以獲得各工作週期之動作次數，接著記錄各工作週期之時間，再根據各工作週期之動作次數與週期時間，換算爲勞工慣用手每分鐘執行技術動作之次數，並乘上勞工一天實際執行作業之時間(單位：分)。前述步驟完成後，便能獲得各工作週期之 Ae，最後計算平均值，作爲代表性數據。

(2) Arp：計算公式如式(2)所示，其中 CF 在本評估模型中訂爲 30 次技術動作/分；Ffi、Fpi 以作業現場資料收集所得施力程度及腕部作業姿勢之量化資料，即腕伸肌群、腕屈肌群肌電訊號(electromyography, EMG)之強度-機率分佈函數(Amplitude Probability Distribution Function, APDF)第 50 百分位數和尺偏/橈偏、

屈曲/伸展角度之 APDF 第 10 及第 90 百分位數作爲參考依據；Fai 則是觀察勞工作業過程中是否存在本評估模型中所定義之附加危害因子，如振動、帶手套作業等，與持續時間佔整個工作週期之比例，作爲參考依據；Di 之則以各工作場所現場訪談之紀錄爲參考依據，無相關紀錄之工作場所，則以一天 7 小時 40 分鐘計；Fr 於本評估模型中，考慮工作 1 小時，應休息 10 分鐘，本研究以此原則，根據各工作場所一天中工作與休息時間之分布情形，計算勞工上肢肌肉缺乏休息之時間，作爲參考依據；Fd 則以 Di 值作爲參考依據。

$$Arp = \sum_{i=1}^{n} \left[CF \times \left(Ffi \times Fpi \times Fai \right) \times Di \right] \times Fr \times Fd \quad .....(2)$$

n：重複性作業之個數

CF：每分鐘技術動作之建議次數，爲一常數

Ffi；Fpi；Fai：大小介於0~1之間的係數，係數之大小取決於操作員執行每項重複性作業時，其出力程度、作業姿勢及附加危害因子

Di：在一天中，操作員執行各項重複性作業之時間(單位：分)

Fr：大小介於0~1之間的係數，係數之大小取決於操作員於一天(班)內上肢肌肉缺乏休息之時間(單位：小時)

Fd：大小介於0.5 ~ 2之間的係數，係數大小取決於操作員一天(班)以上肢執行重複性作業之總時間(單位：分)

針對IEA/WHO的合作案，本次IEA會議有一特別規劃，包括很多篇論文，摘錄標題以爲參考:

1. Conceptual framework for development of a toolkit for prevention of work-related musculoskeletal disorders
2. Categorizing job physical exposures using simple methods
3. A toolkit for MSDs prevention - WHO and IEA context
4. A simple tool for preliminary hazard identification and quick assessment in craftwork and

small/medium enterprises (SME)

5. Hazard identification and pre-map with a simple specific tool: synthesis of application experience in handicrafts in various productive sectors
6. New tools in **Germany**: development and appliance of the first two KIM ("lifting, holding and carrying" and "pulling and pushing") and practical use of these methods
7. Evaluation of objectivity, reliability and criterion validity of the Key Indicator Method for Manual Handling Operations (KIM-MHO), draft 2007
8. HARM overview and its application: some practical examples
9. New risk assessment tools in The **Netherlands**

三、滑倒絆倒與墜落相關論文 (STF: Slip、Trip and Fall)

墜落時預防頭部受撞擊或頸椎受損是很重要的

墜落不論在哪一個國家都是最嚴重的勞工致死職災，在我國營造業也是如此。最近的高架工程或是大樓營造施工，經常可以從報章中看到相關訊息。此類研究非常重要，特別是釐清墜落原因與如何協助事業單位預防墜落。墜落往往在瞬間發生，不像平面滑倒，往往讓人措手不及毫無反應的機會。路面將滑倒時，走路者若即使發現有時可以透過關節姿勢改變，調整重心從新得到平衡。然而，即便是低處墜落，如果頭部先受重擊，受傷致死的機會仍大。或許這就是墜落可怕之處。本所人因工程研究，著手建立墜落實驗平台，並輔以電腦模擬，嘗試建立本土實驗技術，探討墜落案例原因與預防因應之道。

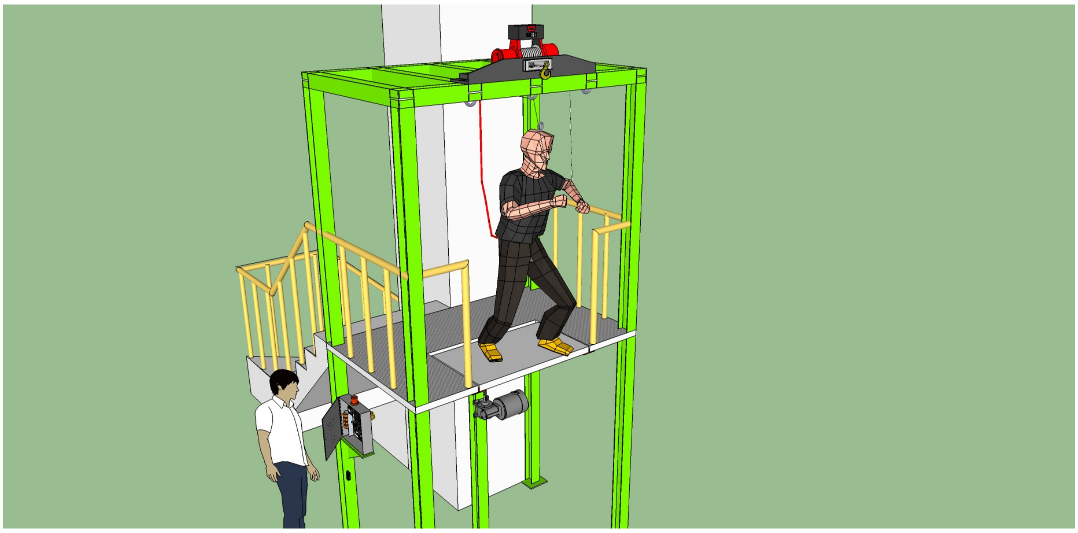


圖 本所人因工程實驗室 墜落模擬平台

本次會議日本職業安全衛生研究所(NIOSH, Japan)的研究人員發表一篇論文〝Fundamental study on relationship between human injury probability due to fall and the fall height〞，嘗試分析過去墜落致死案例，其中70%爲頭部受傷致死，頭部受傷可能是挫傷或是出血 (brain contusion or brain hemorrhage)。

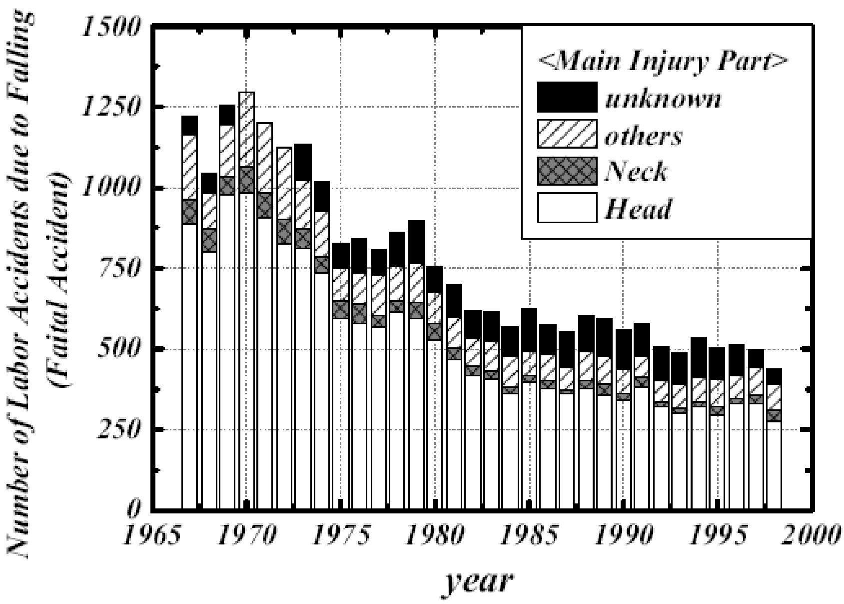


圖 Main injury region of fatalities due to falling
(Labor accident statistics in JAPAN)

An analytical result investigated by forensics experts on cause of victim's death in an emergency hospital in JAPAN

	Patients who died **after** they arrived at hospital	Patients who died **before** they arrived at hospital
Total Patients	105	40 (They all have head injury)
Head injury	54/105 (51.4%)	-
Cervical injury	4/105 (3.8%)	-
Head and Cervical injury	31/105 (29.5%)	32/40 (80.0%)
Other region injury	16/105 (15.2%)	-

這類型的傷害主要是高處墜落時，頭部受到重擊。由於大部分意外可能沒有解剖，受傷致死的部位可能僅從外部觀察。這可能導致直接致死的原因，沒有被深入了解。例如，頸椎受損導致窒息。下表可以發現到院之前死亡的案例中，頸椎受損的比例很高。該研究以模型測試發現即使300mm的高度，估算頭部將有超過10KN的衝擊力，此一力量足以造成頸椎斷裂/骨折。

但不論如何，避免頭部直接重擊受傷是預防墜落致死很重要的關鍵。過去常採用臨時構造物(temporary facilities)，例如 鷹架或護欄 (scaffolds or guardrails)以預防墜落。我們認爲後續研究可以考慮如何避免〝**墜落時頭部受撞擊或頸椎受損**〞，是可以減少致死的關鍵。

本次會議有關STF的論文，大部分是關於測量方法、鞋材與地板特性等，如下:

(1) Effect of shoe type on descending a curb

(2) Measuring step geometry using the Nose-to-Nose method: Validity and repeatability

(3) **Assessment of slip resistance under footwear materials, tread designs, floor contamination, and floor inclination conditions** (本次發表)

(4) Review of walking hazards for railroad workers
(5) Stair safety: bottom of flight illusion
(6) The stochastic distribution of vailable coefficient of friction on quarry tiles for human locomotion
(7) The development of a universal approach to testing of walkway slip resistance in the U.S.
(8) Effect of walking surface perturbation training on slip propensity and local dynamic stability

由於本會在新修訂的〝職業安全衛生法〞中，將通道、地板、階梯等引起之危害，移到第二章第六條第一項〝……雇主對於下列事項，應有符合規定之必要安全衛生設備及措施〞，第四十一條〝……處一年以下有期徒刑、拘役或併科新台幣十八萬元以下罰緩〞。因此，加強保障勞工安全衛生，也加重事業單位安全衛生的責任。但是，這類危害如何透過〝設備及措施〞來預防，何謂〝符合規定〞？後續都有努力的空間。本次研討會美國 Liberty Mutual Research Institute for Safety，Wen-Ruey Chang博士提供我他們的經驗，如下摘錄文獻。

Evaluation of a comprehensive slip, trip and fall prevention programme for hospital employees

美國勞工統計局2007年報告指出STF導致的傷害約占全部非致死性的傷病的22%。該報告同時指出在醫院同一高度的STF導致有工時損失傷害之發生率爲35.2/FTE(full-time equivalents)，其他行業平均爲20.2，醫院STF導致傷害的發生率比其他業別高出75%。醫療照護業(healthcare industry)勞工約有1千3百萬，又有如此高的STF案件，因此值得注意。NIOSH與Liberty Mutual Research Institute合作進行一項10年研究，以評估〝comprehensive STF prevention program〞的績效。從1996-1999年這些醫院STF的補償索賠率爲1.66件/100FTE，實行預防計畫後(2003-2005)爲0.76件/100FTE。另外，研究也發現因爲液體污染物(water water, fluid, slippery, greasy and slick spots)而滑倒，是最常

見的原因約占全部案件的24%。就最常見出現傷害索賠案件申請的部門而言包括，Food services, transport/emergency medical service and housekeeping staff等，這些部門的工作人員似乎走動的比例比較高，同時環境中出現液體污染物的機會也比較大。

值得我們學習的是STF預防計畫，這一計畫包括:

(1) Analysis of injury records to **identify common causes** of STFs,
(2) On-site **hazard assessments**,
(3) Changes to **housekeeping procedures and products**,
(4) Introduction of STF preventive products and procedures,
(5) General **awareness campaigns**, programmes for external ice and snow removal,
(6) Flooring changes and voluntary use of **slip-resistant footwear** for certain employee subgroups

Listing of the main strategies of the slips, trips and falls (STF) prevention programme implemented at the study hospitals.

Keep floors clean and dry

- Encourage workers to clean up, cover and/or report floor contaminants promptly.
- Install wall mounted spill pads or paper towel holders conveniently throughout the hospital to provide easy access to cleaning materials.
- Advertise the phone/pager numbers to call for housekeeping through emails, posters and general awareness campaigns.
- Install wall-mounted wet floor signs throughout the hospital to provide easy access to products to cover/identify a spill.

- Provide walk-off mats, paper towel holders, trashcans and umbrella bags near entrances to minimise wet floors.
- Provide cups, paper towel holders and trashcans (waste bins) near water fountains.
- Place water-absorbent walk-off mats with bevelled edges at hospital entrances. The mats should be large enough for multiple steps to fall on the mat and wide enough to cover the entire doorway. Ideally, the soles of shoes should not be depositing ice or water on the floor when they step off the mat. Consider use of these mats in areas where employees may be continually exposed to wet conditions.
- Use appropriate methods for cleaning and degreasing kitchen floors; choose appropriate cleaning product for the conditions; mix cleaning products according to manufacturer's directions.
- Redirect drains away from walkways with high pedestrian traffic.
- Check that pipes are correctly aligned with the drain they are emptying into.
- Unclog drains, particularly in kitchens, regularly.

Prevent entry into areas that are contaminated

- Use barrier signs that block off areas (tension rod with hanging sign across doorways, tall cones with chains, hallway barriers).
- Install pop-up tent-style warning signs in wall-mounted tubes in easy accessible locations.
- Use taller, more noticeable STF signage (48' tall wet floor signs, flashing lights on top of signs, pop-up tent style signs).
- Promptly remove wet floor signs after the floor is dry to avoid habituation.
- Completely block off area during floor waxing or stripping; place door-stopper barrier to prevent wax from overflowing into adjacent areas during waxing.

Use slip-resistant shoes

- A voluntary slip-resistant shoe programme was implemented, primarily for food service workers and housekeeping staff, and included ice cleats for home health nurses.

Keep walkways clear of objects and reduce clutter

Provide adequate lighting in all work areas including outdoor stairwells and parking garages

Secure loose cords, wires and tubing .

- Use cord bundlers and cord containers to secure cords under desks and computers and around medical and kitchen equipment.
- Cover cords on floor with a bevelled protective cover.
- Organise operating rooms so that equipment cords are not stretched across walkways.
- Consider retractable cord holders on phones in patient rooms and nursing stations.

Eliminate outdoor surface irregularities

- Consider eliminating wheel-stops in parking areas.
- Patch, fill or slope cracks, holes or changes in level in walkways and parking areas that are greater than 0.5'.
- Create visual cues; highlight changes in kerb or walkway elevation with yellow warning paint.

Eliminate indoor surface irregularities

- Replace or re-stretch loose or buckled carpeting.
- Replace mats that are curled or ripped; secure edges with carpet tape.
- Remove, patch underneath and replace indented or blistered tile.
- Consider replacing smooth flooring materials with rougher surfaces with a higher coefficient of friction.
- Patch or fill cracks in walkways that are greater than 0.25'.
- Highlight changes in kerb or walkway elevation with yellow warning paint.

Check stairs

- Ensure stairs and handrails are in compliance with safety codes and recommendations.
- Highlight the nosing of each step with contrasting paint or strips.

Prepare for ice and snow

- Provide ice cleats (or similar product) for home health and maintenance workers to put over regular shoes.
- Distribute winter weather email warnings to all workers with email access.
- Provide bins that anyone can use to spread ice melting chemicals on icy patches outside.

General awareness campaign

- Phone and pager numbers for maintenance and housekeeping departments prominently displayed and emailed intermittently to staff, to be used for reporting spills, slippery conditions, ice and other STF hazards.
- STF hazard awareness campaigns that are promoted through health fairs, posters, paycheck inserts and emails.

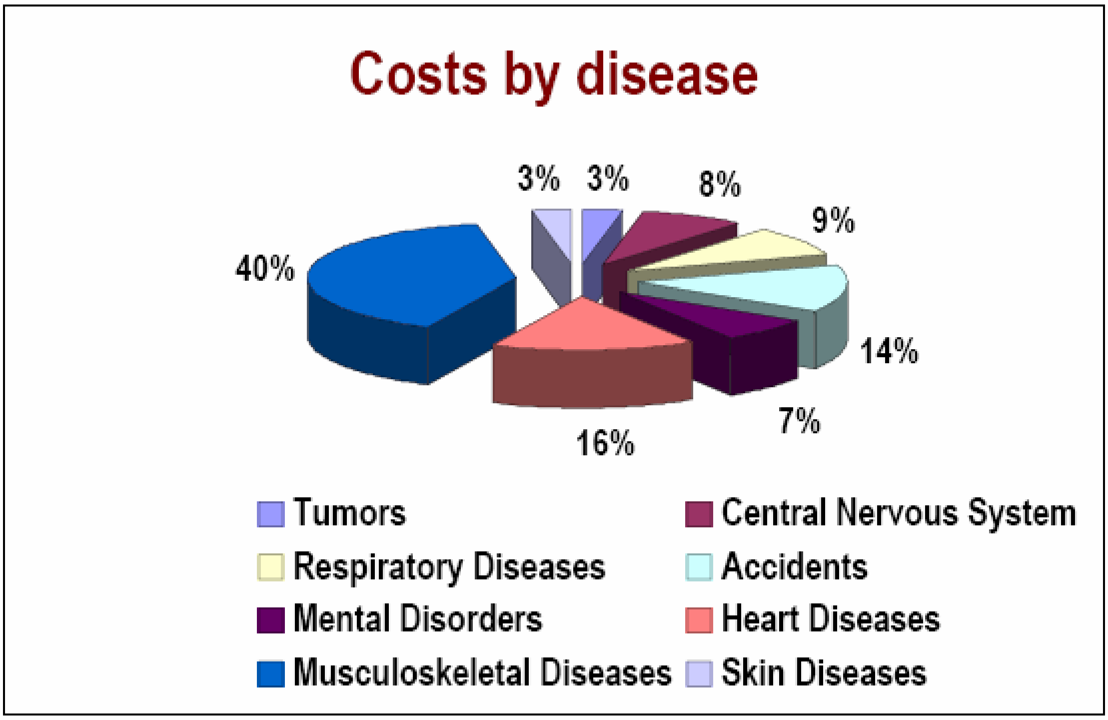
因應職安法修法，本會將來可以提供類似指引或預防計畫，供事業單位作爲因應新修法中通道、地板等之危害之預防措施。換言之，事業單位可以施行STF危害預防計畫，或是將此計畫併入其他計畫施行。

四、國際組織ISO EN ILO 在人因工程方面的作爲

本節是上屆IEA會議論文 (Ergonomics and Occupational Safety and Health: **An ILO Perspective** By Dr. Shengli Niu Senior Specialist on Occupational Health International Labour Organization Geneva, Switzerland)，在此重複說明有助於了解肌肉骨骼議題，不只是IEA WHO 關注，ILO 以及ISO EN等機構也相當關注此一議題。

ILO估計每年約有230萬勞工因職業災害或疾病死亡。 在美國製造業意外造成的損失約爲 190 billion US dollars. 在挪威直接損失約爲40 billion NOK，英國約爲£19 billion。至於人因工程在工作場所所引起的相關問題，也是上述經濟損失的原因之一。同時，這些人因工程問題也是導致肌肉骨骼傷害的原因之一。包括長時間站姿、坐姿、不良姿勢等姿勢所引起的壓力 (postural stress)以及重複性作業等都可能導致慢性肌肉骨骼傷害。重複性用力(repeated or forceful efforts)、持續靜態姿勢(sustained static loading)、解剖學上不自然姿勢 (anatomically non-neutral posture)、加速的動作(accelerated movement)等這些都可能危害肌肉骨骼系統。特別是當多個危害因子同時存在時，更可能導致傷害。暴露與傷病關係資料(exposure-response data)顯示 即使是一天2小時的暴露 (25% or less of the day)也可能有危害。下表示ILO依據傷病補償系統所估計的疾病成本，其中肌肉骨骼系統約占40%。

Table 1. Compensated costs of injuries and diseases



ILO的回應 ***The ILO's Response***

關於這些職業病問題包括肌肉骨骼傷害， ILO 在2003 Global Strategy 中要求開發新的儀器、方法針對人因工程危害預防。Relevant Conventions and Recommendations : Convention No. 127 and Recommendation No.128。 ILO 配合Global Strategy，與IEA合

作，由Dr. Wendy Macdonald (Health Sciences, La Trobe University, Melbourne, Australia)所領導的小組，發展國際版regulations, standards and laws on ergonomics at the workplace。

ILO 認爲工作環境的改變，人因工程問題已成爲重要的勞工安全衛生議題，需要進一步關注。政府、雇主以及勞工三方面都希望ILO發展人因工程相關的方案，特別是下列議題。

(1) 人因工程相關危害資料建立 The surveillance of ergonomics hazards needs to be established in response to rapid and complex changes in the world of work.

(2) 工作組織與危害因子研究 Studies and investigations need to be conducted on the occurrence of ergonomic risk factors and work organizations.

(3) 危害因子評估技術發展 It is an increasing important challenge to address risk assessment in occupational situations in which the physical work load and MSDs develop through an interaction between the workplace, leisure time activities, and individual factors.

(4) 同時注意社會心理因子。Ergonomics is often viewed in a simplified way as it focuses mainly on the physical aspects of work: force, repetition rate and posture. Psychosocial factors are often misunderstood and ignored.

(5) 非工會員以及女性勞工肌肉骨骼傷害問題 Few studies have examined differences in MSDs injury rates for men and women and for unionized and non-unionized workers. There have been reports that non-union and women workers have higher rates of MSDs. Explanations for these phenomenon could include differences in training in safer work

practices and in working experiences, different job assignments, age, sex in relation to physical size and strength, health care seeking behaviour, etc.

(6) 指引與技術手冊開發 Guidelines are needed on the major work-related risk factors that should be eliminated or minimized such as manual handling of materials, repetitive work, static work, segmental vibration, and poor psychosocial work environments. Studies and evaluations on the technological and economic feasibilities of the application of these guidelines need to be conducted.

ILO 推行兩個人因工程技術合作案: WISE (ILO) and WIND (ILO & Kawakami T, et al., 2008)。 "Work Improvements in Small Enterprises" –. WISE，在泛太平洋、拉丁美洲以及非洲推行，其中一個訓練計畫"Higher Productivity and A Better Place to Work" 協助中小企業推行簡單有效的技術改進工作環境以及效率。中文版WISE在2008年發行。WISE programme 是以六個訓練原則為基礎，build on local practice, focus on achievements, link working conditions with other management goals, use learning-by doing, encourage exchange of experience and promote workers' involvement。"Work Improvement in Neighbourhood Development" –. WIND，主要是針對農業作業改善。主要方法是參考WISE。 在解決人因工程問題上，ILO與UN以及其他國際組織合作，包括IEA, ICOH and IOHA等，者可能也是ILO在IEA、ICOH等國際會議上說明其作為的原因。The Ergonomic Checkpoints是由 IEA and the ILO 共同發展出來的手冊，ILO1996發行(ILO & IEA, 1996)。ILO目前正在與IEA合作修改此一Ergonomic Checkpoints。

IEA會議論文(**ISO 11226 and EN 1005-4** N. J. Dellemana,b, J. Dulc a *TNO Human Factors, P.O. Box 23, 3769ZG Soesterberg, the Netherlands (nico.delleman@tno.nl)* b *Paris Descartes University, UPRES Ergonomie, Laboratory of Applied Anthropology, Paris, France* c *RSM Erasmus University, P.O. Box 1738, 3000DR Rotterdam, the Netherlands (jdul@rsm.nl)*。

ISO 11226 in 2000 and EN 1005-4 in 2005 這兩個標準主要是用來評估勞工工作姿勢與動作，以預防勞工肌肉骨骼系統疲勞、酸痛以及傷害。約有歐盟(European Union) 1/3勞工在工作中感受到不舒適的工作姿勢，並有50 %勞工從事週期短的重複性工作。EN 1005-4 說明如何設定機械操作時勞工的靜態姿勢與動作，以避免傷害。下圖說明 EN 1005-4 中關於機械操作時危險工作姿勢風險分析流程。分析結果分成三部分，

(1) **'acceptable'** (the health risk is considered low or negligible for nearly all healthy adults. No action is needed)，

(2) **'conditionally acceptable'** (there exists an increased health risk for the whole or part of the operator population; the risk shall be analyzed together with contributing risk factors, followed as soon as possible by a reduction of the risks, i.e. redesign, or if that is not possible, other suitable measures shall be taken, for example the provision of operator guidelines to ensure that the use of the machine is acceptable),

(3) **'not acceptable'** (the health risk cannot be accepted for any part of the operator population; redesign to improve the working posture is mandatory).

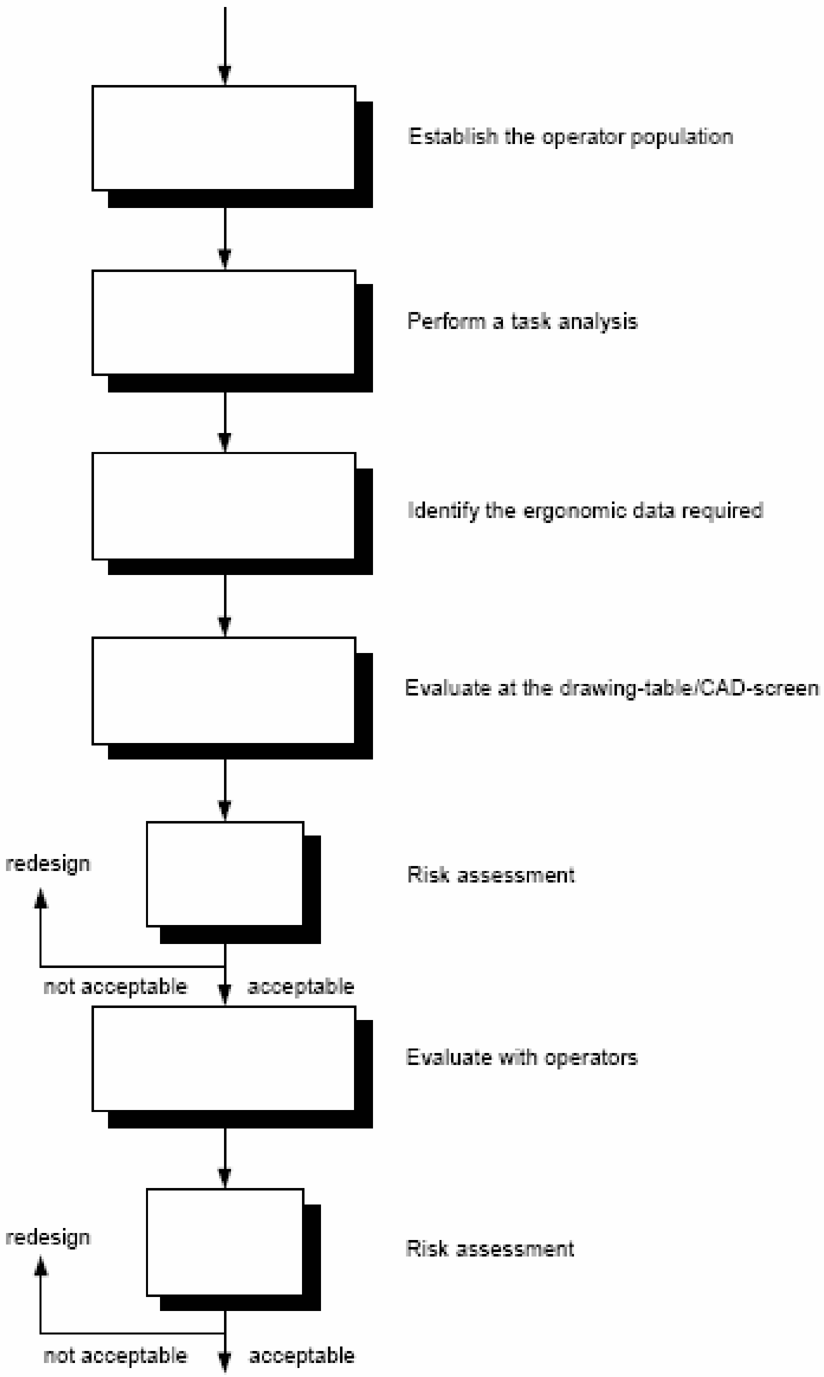


Fig. 1: Flow chart illustrating the risk assessment approach (EN 1005-4).

參、結論與建議

1. 由於本會在新修訂的〝職業安全衛生法〞草案中，第二章第六條第二項提到〝雇主對於下列事項，應妥為規劃並採取必要安全衛生措施，以保護勞工身心健康〞，該項第三款提到〝重複性作業等促發肌肉骨骼疾病之預防〞。在從勞保傷病給付資料來看，近年來申請肌肉骨骼傷病的案例以及給付的案件數很多，可見有關的事業單位與勞工非常多，值得重視。該新修法草案中，第四十五條提到〝…違反第六條第二項…〞處新台幣三萬元以上十五萬元以下之罰緩。後續如何提出指引供事業單位參考，以及檢查單位依據何種標準作檢查，都值得研究並進一步取得共識。IEA/WHO 的方法，可以提供作為後續本會發展相關指引與檢查標準的參考。換句話說，依據不同的風險評估階段，課以不同人員的責任。

2. 避免頭部直接重擊受傷是預防墜落致死很重要的關鍵。採用臨時構造物(temporary facilities)，例如鷹架或護欄 (scaffolds or guardrails)是可以預防墜落。但墜落仍時有所聞，我們認為後續研究可以考慮如何避免〝**墜落時頭部受撞擊或頸椎受損**〞，是可以減少致死的關鍵。

3. 在新修訂的〝職業安全衛生法〞草案中，將通道、地板、階梯等引起之危害，移到第二章第六條第一項〝……雇主對於下列事項，應有符合規定之必要安全衛生設備及措施〞，第四十一條〝……處一年以下有期徒刑、拘役或併科新台幣十八萬元以下罰緩〞。因此，加強保障勞工安全衛生，也加重事業單位安全衛生的責任。但是，這類危害如何透過〝設備及措施〞來預防，何謂〝符合規定〞？後續都有努力的空間。

附錄一 研討會發表之論文

Assessment of slip resistance under footwear materials, tread designs, floor contamination, and floor inclination conditions

Kai Way Li[1]*, Chih-Yong Chen[2], Ching Chung Chen[3], Liwen Liu[2]

- **Introduction:** Slip and fall incidences are common. They are not only important environmental safety issues but also important occupational safety and health problems (Leamon & Murphy, 1995). According to the statistics of the Council of Labor Affairs (CLA, 2008) during 2003 to 2008, falls are one of the major causes of occupational incidences. Starting 2003, falls increase year after year. Research on slips and falls are essential. The purpose of this study was to study the friction at the footwear-floor interface under different footwear materials, floor surfaces and the inclined angles of the floor.
- **Method:** A Brungraber Mark II slipmeter was used for friction measurements. The standard test method for the BM II proposed by the American Society of Testing and Materials (ASTM, 2005) was adopted. In addition, the protocol in judging a slip or non-slip suggested by Chang (2002) was used. To conduct friction measurements on an inclined surface, a metal rig to accommodate the Brungraber Mark II was adopted. Three inclined angles were tested: 0º, 5º, and 10º. Friction measurements were conducted in descending direction. Three contamination conditions were tested: dry, wet, and glycerol-contaminated conditions. The footwear samples included a flat composite rubber pad, a treaded composite rubber pad, a flat Neolite, and a treaded Neolite. The Shore-A hardness for the composite rubber and the Neolite were 69 and 90, respectively. A ceramic floor sample was used. The floor roughness (R_a) was 11 μm. In short, the factors of the study included footwear, contamination condition, and floor inclination angle. The dependent variable was the coefficient of friction (COF).
- **Results:** The results of the analysis of variance (ANOVA) indicated that all the main factors and all the two-way and three-way interaction effects were statistically significant ($p<0.001$). For the contamination conditions, the dry floors had significantly ($p<0.05$) highest mean COF (0.85) among all contamination conditions. The mean COF of the wet condition was the next (0.44) and the glycerol condition had the lowest (0.08). For footwear samples, the flat composite had the significant ($p<0.05$) highest COF (0.5), next was the treaded Neolite (0.49), the next was the treaded composite rubber (0.43), and the last was the flat Neolite (0.41). For the inclination angle, the overall mean COF for the 0°, 5°, and 10° were 0.48, 0.46, and 0.43, respectively. On dry floor, the mean COF for the 0°, 5°, and 10° were 0.87, 0.85, and 0.83, respectively. On wet floor, the mean COF for the

0°, 5°, and 10° were 0.46, 0.46, and 0.40, respectively. On glycerol contaminated floor, mean COF for the 0°, 5°, and 10° were 0.11, 0.08, and 0.04, respectively.

- **Discussion:** The results of the study indicated that footwear sample, floor contamination condition, and inclination condition were all significant factors affecting the COF which could lead to different risk of slipping and falling. Selection and design of shoe sole is important in the prevention of slipping & falling. In addition, large ramp angle could lead to higher risk of slipping & falling. Keeping the floor dry and have a good housekeeping are always helpful in the prevention of slipping & falling.

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