

出國報告（出國類別：國際會議）

## 參加 2018 年亞太職業安全衛生組織 研討會

服務機關：勞動及職業安全衛生研究所

姓名職稱：張承明副研究員

派赴國家：香港

出國期間：107 年 12 月 3 日~8 日

報告日期：107 年 12 月 27 日

# 摘要

此次出國主要是參加亞太第 33 屆職業安全衛生組織研討會，並發表本所研究成果「運用虛擬實境技術於勞工教育訓練之研究」。此次研討會主題為「透過溝通與合作以追求卓越」，邀請亞太地區及全球的安全衛生專業人員參與，包含專題演講及技術論文發表，另為鼓勵就讀職業安全衛生相關的科系的學生致力於提升職業安全衛生方面的研究，此次新增學生研究論文競賽活動。另與研討會與會人員共同參訪香港職業安全健康局職安健學院新成立的職安健立體虛擬實境體驗中心及其他安全訓練教室。此外並至香港會議展覽中心參觀創智營商博展及國際創意設計展覽，以及參觀香港建造業議會之「建造業創新及科技應用中心」。有關虛擬實境、物聯網、人工智慧等資通訊科技應用於許多展示項目，如何應用這些科技提升工作場所安全及提升勞工安全意識是未來努力的方向之一。

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## 壹、目的

亞太地區職業安全衛生組織(Asia Pacific Occupational Safety & Health Organization, APOSHO)提供專業人士、政策制定者、政府官員等一個交換意見、分享實施計畫的經驗及合作的平台。此次 APOSHO 第 33 屆研討會主題為「透過溝通與合作以追求卓越」，研討會邀請亞太地區及全球的安全衛生專業人員參與，包含專題演講及技術論文發表。本次出國計畫主要是參加 APOSHO 33 研討會及與與會人士交流，並發表本所研究成果「運用虛擬實境技術於勞工教育訓練之研究」，APOSHO 在研討會後另安排香港職業安全健康局職安健學院之參訪活動，另外參觀香港會議展覽中心之展覽及香港建造業議會之「建造業創新及科技應用中心」，學習新科技應用於職業安全衛生的發展。

## 貳、過程

### 一、行程

此次行程自 12 月 3 日至 12 月 8 日，主要參加第 33 屆亞太地區職業安全衛生組織(APOSHO 33)研討會並發表論文，並參觀了 3 項展示活動，行程如下：

日期	地點	內容
12/3(一)	交通去程	前往香港，準備論文發表
12/4(二)	富豪九龍酒店	參加 APOSHO 33 研討會並發表論文
12/5(三)	富豪九龍酒店	參加 APOSHO 33 研討會
12/6(四)	職業安全健康局職安健學院	APOSHO 33 之參訪行程，參訪香港職業安全衛生教育訓練機構
12/7(五)	香港會議展覽中心	參觀 1. SmartBiz Expo：創智營商博覽 2. DesignInspire 2018：國際創意設計展覽
12/8(六)	建造業創新及科技應用中心 交通回程	參觀建造業創新及科技應用中心之展示

## 二、參加亞太地區職業安全衛生組織(APOSHO 33)研討會

亞太地區職業安全衛生組織是由致力於防止職業災害和疾病的非營利團體所組成的一個國際性的組織。正式會員為亞太地區非政府機構的民間團體，不過任何職業安全衛生團體，甚或不在亞太地區之內者，亦可以副會員(Associate member)或附屬會員(Affiliate member)的身分加入該組織。該組織目前有 27 個會員，2 個副會員，9 個附屬會員，分別來自 19 個國家(或地區)。該組織之宗旨為促進亞太地區會員組織彼此間的相互瞭解和合作，並透過學有專精的會員，在職業安全衛生方面進行技術和學術交流，進而達到提升亞太地區職業安全衛生整體水準的目的。此次由英國職業安全衛生學會(Institution of Occupational Safety and Health, IOSH)香港分會主辦，參與人數超過 300 人。

本次研討會主題為「透過溝通與合作以追求卓越」，會議中安排有專題演講及 15 個論文發表場次，主題包括：採納 ISO 45001 管理系統、安全領導對組織的效益、與員工的安全溝通、虛擬實境及新科技、與學校和年輕勞工的安全溝通、安全設計等主題。專題演講摘要簡述如下。

主講者 Bonnie Yau 為香港職業安全健康局總幹事，說明「宣導」對推展業務的重要性，並介紹多種宣導影片類型。她認為防止災害類的宣導片常以驚嚇方式呈現，希望達到嚇阻效用，其結果可能有效，但這一類的宣導片，不會令人想一看再看。如果能以正面的、幽默的方式呈現，或許能達到更好的效果，並以澳洲墨爾本宣傳鐵道交通安全的公益短片「Dumb Ways to Die」為例，這個約 3 分鐘的宣導片，以可愛動畫人物呈現各種慘死方式，希望藉此提醒大家不要一時大意導致自己喪命。由於短片的獨特作風加上琅琅上口的曲調而廣受迴響，後來還被改編成遊戲、登錄移動遊戲平台，此短片可在網路上尋獲。

主講者 Dr. Olivier Lo 為國際 SOS 組織(International SOS)醫學組組長，國際 SOS 致力於海外緊急救援與 24 小時援助中心服務，以人道救援和社會責任為服務宗旨，提供空中醫療轉送、國際醫療安排協助、人身安全援助和其他外包服務。主講人介紹

全球永續性報告協會（Global Reporting Initiative, GRI）發布的「永續性報告指南」GRI 403：職業安全衛生。因應社會對企業非財務資訊與永續績效資訊揭露的需求，於 1997 年，美國「環境責任經濟聯盟(Coalition for Environmentally Responsible Economics, CERES)」及「聯合國環境規劃署(United Nations Environment Programme, UNEP)」共同成立永續性報告推行計畫(Global Reporting Initiative, GRI)，2002 年 GRI 成為獨立組織，正名為「全球永續性報告協會」，致力於企業社會責任(CSR)的推動與標準化。全球大企業多依據 GRI 指南撰寫企業社會責任報告書，揭露企業非財務資訊。其中「GRI 403：職業安全衛生」將有助於企業加強員工健康之永續經營。

主講者 Linda Reinstein 是石綿疾病意識組織(Asbestos Disease Awareness Organization, ADAO)的創辦人及執行長，該組織於 2004 年成立，致力於禁止使用石綿相關產品以消滅因石綿造成的疾病。目前有 68 個國家已禁止使用石綿，美國每年有 4 萬人死於石綿相關疾病，但美國至今尚未全面禁止石綿相關產品的進口。有鑒於石綿對人體的傷害，因此要宣導石綿的潛在危害，並呼籲各國禁止使用石綿相關產品以維護人民的健康。

在技術論文發表部份，本所發表研究成果「運用虛擬實境技術於勞工教育訓練之研究」，介紹本所研發之兩個虛擬實境 App，分別供石化業及營造業教育訓練使用，讓學員沉浸於虛擬工作場所中，模擬執行某項作業，並體感墜落、感電、物料飛落、被撞、火災爆炸等職災類型，以強化學員們對於工作場所潛在危害及職災防護重要性的認知。香港職業安全健康局發表快速安裝平台之研發，這是一個加強高處作業安全的新產品，可供外牆之修繕、保養、小規模改建及加建作業時使用。此平台之安裝、拆卸簡單快速，組件模型化及標準化，且各類別組件以顏色區分使易於鑑別，各組件並有連鎖功能。日本中央勞動災害防止協會發表日本因應國際標準 ISO 45001:職業安全衛生管理系統之發布，日本制定國家標準 JIS 45001，內容與 ISO 45001 相同，另制訂 JIS 45100，內容則包含 ISO 45001 及日本特有之安全管理措施，日本特有之安全管理措施例如零災害運動之預知危險訓練、指認呼喚、5S 等項目。英國 IOSH 代表發表溝通的重要性，溝通要確保其成效，訊息要能送達到對的人，要確認收到訊息

的人瞭解要傳達的訊息，訊息傳達到之後是否有達到訊息傳達的目的。會議中所發表的專題演講及技術論文，獲發表者同意公開的投影片資料，將於 2019 年 1 月登載於 APOSHO 的網站中。

此次會議活動，新增加一個鼓勵職業安全衛生(OSH)學生競賽活動，來獎勵學生提出創新與創意的作品，有關藉著有效的溝通來提升職業安全衛生專業。這個獎項開放給 APOSHO 19 個國家的所有就讀 OSH 的學生，包括英國、美國、日本、印尼等國家。APOSHO 33 研討會第一天下午有一場次是學生的工作坊，並邀請前 3 名的學生前來受獎，並獲免費參加研討會，前兩名均是來自英國 University of Strathclyde 。



圖 1 本所論文發表「運用虛擬實境技術於勞工教育訓練之研究」



圖 2 研討會會場中與中華民國工業安全衛生協會代表合影

### 三、參觀職業安全健康局職安健學院

此次亞太地區職業安全衛生組織研討會主辦單位於研討會議結束後，安排了參訪職業安全健康局職安健學院的行程，參觀項目有(1)職安健體驗中心；(2)樹藝工作安全健康訓練；(3) 石綿工作安全訓練；(4)飲食業安全訓練；(5)裝修維修工程及磨輪訓練；(6)密閉空間安全訓練；(7)叉式剷車模擬駕駛訓練；(8)防火安全；(9)貨車尾板安全裝置，參觀結束後並與該單位人員座談交流。

職安健學院成立「職安健立體虛擬實境體驗中心」，利用虛擬現實、三維空間仿真技術及沉浸式可視化科技，模擬出近乎真實的工作場景，讓學員在安全的情況下感受「工作意外」，透過涵蓋身體及心理的完整體驗，加強學員的安全意識和態度，並

認知到做足安全措施的重要性。目前的沈浸式體驗場已於 107 年 9 月開始啟用，該展示區首先介紹高處作業應配帶之安全防護具，再利用影片介紹即將體驗的內容，接著讓學員體驗於施工架上工作的景象，以及從 23 樓高處墜下之情境。體驗區之長寬高各約為 3 公尺，約莫香港一般房間的大小，體驗區上方設置 4 個投射機及數個感應器，投射虛擬場景在左、前、右、下方共四個平面。學員首先配戴 VR 眼鏡，在眼鏡及手上分別配戴感應器。體驗程序是模擬勞工從室內跨越窗子站到窗外的竹子施工架上，伸手拿取掛在架子上之東西時，身體不平衡接著體驗墜落情形。未來該展示區擬繼續發展局限空間、電氣危害等體驗項目。職安健學院目前正建造另一個高度 6 公尺的體驗區，未來將加入能實際體驗高度變化的功能。另，香港已建設土地面積僅約 25%，當地樹多風多，因此樹木修剪工作需求高，工作安全不容忽視，因此有樹藝工作安全訓練。餐飲業也是香港特色之一，為避免廚房內觸及灼熱表面或物質、被手工具所傷、滑倒絆倒和提舉或搬運物件導致受傷等，工作安全措施也是香港相關單位積極推廣的項目。



圖 3 參觀職業安全健康局職安健學院



圖 4 沈浸式體驗





圖 5 樹藝工作安全健康訓練



圖 6 石棉工作安全訓練



圖 7 飲食業安全訓練



圖 8 裝修維修工程及磨輪訓練



圖 9 密閉空間安全訓練



圖 10 叉式剷車模擬駕駛訓練 (堆高機)



圖 11 防火安全



圖 12 貨車尾板安全裝置

#### 四、參觀香港會議展覽中心展示活動

香港會議展覽中心在 12 月初有兩個展示活動，分別為「SmartBiz Expo：創智營商博覽」及「DesignInspire 2018：國際創意設計展覽」。「SmartBiz Expo：創智營商博覽」今年共吸引 40 個國家及地區的超過 520 家廠商參與，提供不同範疇的企業方案和創新商業意念。除了工業 4.0 外，智能城市及電子商貿亦是主要議題，大會也安排多場相關研討會，增進中小企業在這些方面的知識。其中與職業安全相關的項目為「實地工作智能系統」，該系統讓工作現場人員能透過智能系統，搭配智能眼鏡，與遠程人員保持密切聯繫。工作現場人員需配戴智能眼鏡(例如 google 眼鏡)，將現場環境透過眼鏡即時分享，使遠程人員能得到現場的資訊，可協助現場人員辨識問題並提供技術支援。

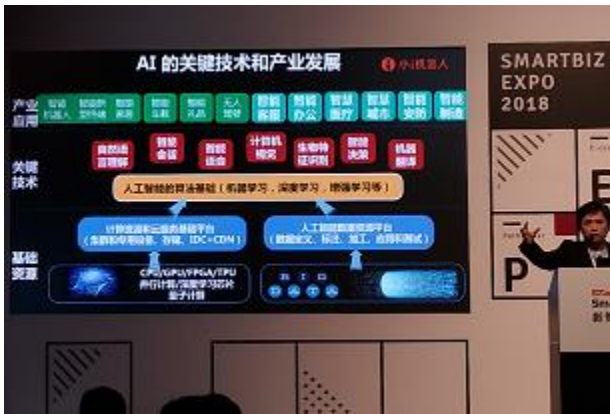


圖 13 AI 在產業發展專題演講



圖 14 實地工作智能系統

「DesignInspire 2018：國際創意設計展覽」中的主題館「城創新活」，目的是通過一系列創新產品，裝置及概念的呈現，展示如何融合技術和設計解決社會問題，共同創造樂活都市。共邀請 21 個當地及國際品牌及創新者就「機器人應用」、「STEAM 教學」及「智慧生活」來展示創新概念、構思及項目。在「機器人應用」部分包括 3D 列印陶瓷建築和繪畫機械手臂、調酒機器人、體感機器人、零售業服務機器人、醫療用智能機器人等。在「STEAM 教學」部份，STEAM (Science, Technology, Engineering, Art, and Mathematics)是結合科學、技術、工程、藝術，以及數學的跨學科教學方法，讓學生在數學邏輯的基礎下，藉由動手建構工程與呈現藝術美學，來學習科學和技術的內涵，展示項目包含水底機械人、教育玩具、教育平台等。在「智慧生活」部份，包括 BraodcastAR 技術大屏幕展示、互動投射方案、利用無線射頻辨識和投影技術的魔術桌等項目，魔術桌是以一個有噱頭的方式展示產品資訊，能刺激顧客的購買慾，亦能分析客戶消費行為等項目。

體感機械人的研發目地，是希望其可代替人類處理如拆除炸彈等高危險性的工作。使用者戴上裝有動作感應器的控制器(另一隻機械手)後，可讓機械人模仿其動作，包括手肘關節及手指屈曲等動作，可提起簡單工具及 2.5 公斤以下的物件。傳輸時間延遲 0.3 毫秒，感應器設藍牙或 Wi-Fi 裝置，將信號傳送到機械人，可在 20 公尺

至 2 公里距離內控制，控制器重 0.5 公斤，方便攜帶。機械人的頭部裝有攝錄機，當連接了平板電腦，操作人員可即時觀察機械人所在的畫面。該研發公司已為英國拆彈公司的拆彈機械人設計機械手臂，並與美國電力公司合作關於高壓電維修工作。

香港科技大學展示水底機械人，研發水底機械人的最初目的是為研究海洋，包括例如石油勘探，油污處理，海洋保育等方面，可協助在水底進行的工作，例如太深的水底，人和潛水艇都無法到達之處，可利用水底機械人在水底下工作，人則在水面控制機械人，例如進行發掘或水底拍攝作業等。

INDE 公司展示 BraodcastAR 技術，結合 3D 影院級影像和尖端軟體及硬體呈現出不同的作品，讓觀眾沈浸在浩瀚無垠的自然環境裡，另利用 LiveAvatar 系統進行限定時段演出，讓觀眾可以與外星人互動交流。



圖 15 體感機械人



圖 16 水底機械人



圖 17 BraodcastAR 技術

## 五、參觀建造業創新及科技應用中心

「建造業創新及科技應用中心」是由建造業議會成立，於 106 年 11 月底開幕，展示先進建造技術、機械和材料，向業界推廣。建造業議會於 2007 年 2 月 1 日成立，由一位主席及 24 名成員組成，成員來自代表業內勞資政學等各界人士，旨在提升業界水平，主要職能是就長遠的策略性事宜與業界達成共識、向政府反映建造業的需要及期許，並為政府提供溝通渠道，取得與建造業所有相關事項的意見。

建造業創新及科技應用中心(圖 18)展出逾三十項由當地及海外研發的建造業創新科技，共分為五個主題區(圖 19-23)：(1)一體化(Integration);(2)工業化(Industrialisation);(3)信息化(Informatisation)；(4)無限化(Infinity)；(5)智能化(Intelligentisation)。「一體化」展示區展出包括：5D 建築信息模擬(BIM)作施工工作流程用途、建築信息模擬(BIM)結合地理信息系統(GIS)作建築管理用途、項目生命週期管理的雲端解決方案等項目。「工業化」展示區展出包括：製造及裝配過程的設計、組裝合成建築法、路軌攀爬系統、創新鋁模板系統等項目。「信息化」展示區展出包括：建造業虛擬實境(VR)的應用、面容識別閘機系統、工地工人動態追蹤系統、防撞雙頻警報系統、非破壞性混凝土成熟度測試、震動監測系統、數碼化資源管理、起重裝置智能管理系統、混合實境(MR)技術在建造業中的應用、熱壓力監測系統、物聯網智能安全帽等項目。「無限化」展示區展出包括：用作工地監察的人工智能、可訂製的噪音控制材料、新型複合材料在結構加固中的應用、結構保險絲混合伸臂系統、超柔韌奈米改性聚合物水泥基防水塗層等項目。「智能化」展示區展出包括：自動牆身批盪機、多功能外牆加工機械人、仿生防震動力外骨骼、工業用外骨骼、動力外骨骼、姿勢輔助外骨骼、提重工作協助外骨骼、無人飛行載具作檢查用途、人工智能牆身檢驗及建築監控技術等項目。

當地新創公司研發的「物聯網安全帽」(圖 24)，以生物識別感應器測量工人的體溫及心跳等，以超聲波防撞感應器，於物件靠近工人身後時發出警報，以及用加速計感應工人身體動作是否異常，探測靜止時間是否過長或跌倒。「熱壓力監測系統」(圖 25)幫助建築工人預防脫水等熱相關的狀況，同時，幫助管理人員更瞭解當下建築工人的工作環境和身體狀況，以做出更好的工作安排。其他展示如圖 26-36。



圖 18 建造業創新及科技應用中心

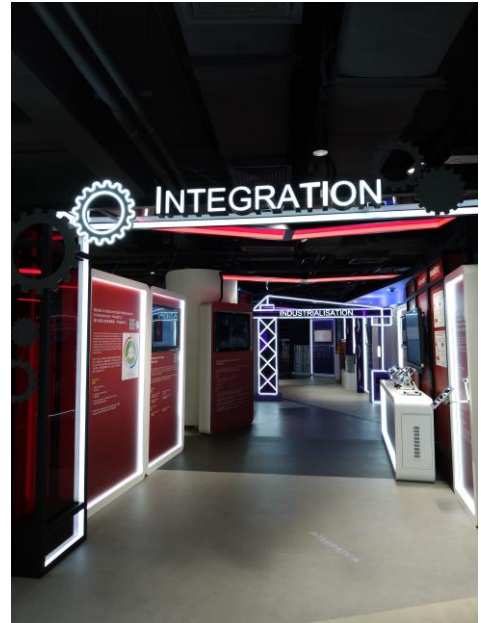


圖 19 「一體化」展示區



圖 20 「工業化」展示區

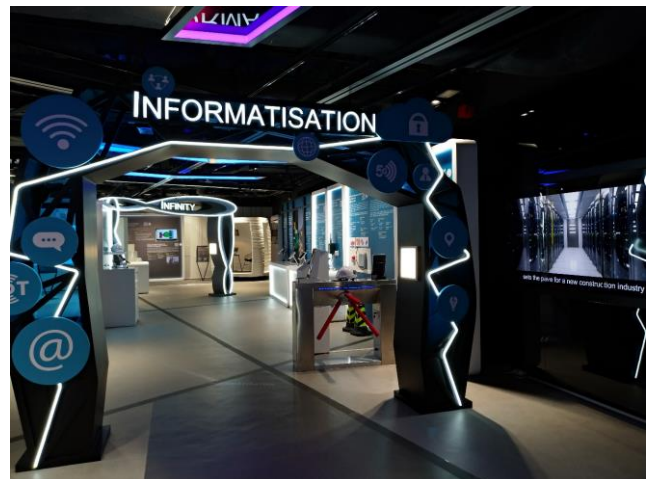


圖 21 「信息化」展示區



圖 22 「無限化」展示區



圖 23 「智能化」展示區



圖 24 物聯網智能安全帽



圖 25 熱壓力監測系統



圖 26 營造業虛擬實境(VR)的應用



圖 27 混合實境(MR)技術在建造業的應用



圖 28 建築信息模擬(BIM)的應用

### Facial Recognition Gate System 面容識別閘機系統

The facial recognition gate system integrates the base information through the worker registration card, site information and face photos to make the biometrics authentication of the site entrance and exit.

面容識別閘機系統整合了工人註冊證上的基本資料、工地資訊與人脸照片，再製作為地盤出入口生物識別驗證。

<b>Benefits 優點</b> <ul style="list-style-type: none"> <li>High Efficiency 高效率</li> <li>High accuracy 高準確度</li> <li>High security level 安全性高</li> </ul>	<b>Applications 應用</b> <ul style="list-style-type: none"> <li>Construction site 建築地盤</li> <li>Warehouse 倉庫</li> </ul>	<b>Project Reference 項目案例</b> <ul style="list-style-type: none"> <li>The Chinese University of Hong Kong Medical Centre 香港中文大學醫院地盤</li> </ul>
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圖 29 面容識別閘機系統

### Smart Management System for Lifting Gears 起重裝置智能管理系統

This online management system can be applied to manage lifting appliance and lifting gears (LGLA) with the use of NFC smartphone. It can be easily used to upload and retrieve information such as loading information and recent check-historical records, including the approval documents, e.g. Form 6, 7.

此線上管理系統可用於管理起重設備和起重裝置。通過使用 NFC 智能手機，可以輕鬆更新和檢索信息，例如負載信息和最近的檢查歷史記錄，包括批准文件，例如表格 6 或 7。

<b>Benefits 優點</b> <ul style="list-style-type: none"> <li>Not limited by the surface contamination, e.g. Oil grease 不受表面污染的限制如油脂</li> <li>Update the information remotely 遠距更新訊息</li> <li>Clear label 清晰標籤</li> </ul>	<b>Applications 應用</b> <ul style="list-style-type: none"> <li>Trace history and item information 追踪吊具資料和紀錄</li> <li>Automatic notification for expiry date approaching 自動通知失效日期</li> <li>Export data to other format 輸出至其他格式</li> </ul>
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圖 30 起重裝置智能管理系統

### Proximity Safety Alarm System (Dual Frequency) 防撞雙頻警報系統

In this proximity safety system, an active (battery powered) RFID transponder should be carried by each worker and a sensor should be mounted on mobile plant. The sensor poses an alert-parameter around the mobile plant machine using a High-Penetration Low-Frequency Radio, which triggers the transponder to release a far-range microwave signal to alert the driver of machine.

此防撞警報系統中，有源（帶電池）智能標籤卡由工人攜帶，而傳感器則安裝在車輛或機器上。智能標籤卡會被機器上高穿透低頻無線電觸發，發出警報信號以提醒機器駕駛員。

<b>Benefits 優點</b> <ul style="list-style-type: none"> <li>Not Affected by metal objects or human body 不受金屬或人體干擾</li> <li>Unaffected by Light Source, line of sight, or temperature 不受光源、視線或溫度影響</li> <li>No blind spots 沒有盲點</li> <li>High reliability 可靠性高</li> </ul>	<b>Application 應用</b> <ul style="list-style-type: none"> <li>Mobile plants 大型移動裝置</li> </ul>	<b>Project Reference 項目案例</b> <ul style="list-style-type: none"> <li>Liantang Boundary Control Point (Liang Kong) 蓮塘口岸 (香港)</li> </ul>
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圖 31 防撞雙頻警報系統

### Unmanned Aerial Vehicle (UAV) for Inspection 無人飛行載具作檢查用途

A drone with collision-tolerant is designed for inspection and exploration in complex and confined spaces.

以防撞設計的無人機檢查並探索複雜而受限制的區域。

<b>Benefits 優點</b> <ul style="list-style-type: none"> <li>Time saving 節省時間</li> <li>Lower cost 節省成本</li> </ul>	<ul style="list-style-type: none"> <li>Improve safety 提高安全水平</li> </ul>
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**Applications  
應用**

- Visual inspection of building  
視像檢查樓宇的缺陷
- Thermal inspection of building  
熱像檢查樓宇的缺陷
- Inspection of infrastructure  
基礎設施的檢查
- Inspection in confined space  
受限制區域的檢查

圖 32 無人飛行載具作檢查用途

### Workforce Tracking System 工地工人動態追蹤系統

Workforce Tracking System is a kind of innovative intelligent management of human resources for construction sites. This system uploads the registered workers' attendance and work dynamic records to the cloud server in real time. It helps not only the management team obtaining reliable manpower data for analysis in any location and at any time, but also provides data records of workers' attendance and avoids labour-management conflict.

創新智能系統為建築工地強化人力資源管理。它可將註冊工人的出勤及工作動態記錄實時上載到雲端，不但可以幫助管理層在何時何地經雲端獲取可靠的人力資料作分析，亦能夠提供確實工人出勤的數據記錄，避免勞資誤會。

<b>Benefits 優點</b> <ul style="list-style-type: none"> <li>High reliability 高可靠性</li> <li>Reduce checking cost 減低核對成本</li> </ul>	<b>Applications 應用</b> <ul style="list-style-type: none"> <li>Tunnel works 隧道工程</li> <li>Civil works 土木工程</li> <li>Building works 建築工程</li> <li>Renovation works 裝修工程</li> </ul>	<b>Project Reference 項目案例</b> <ul style="list-style-type: none"> <li>Resort Hotels in Macau 澳門大型度假村酒店</li> </ul>
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圖 33 工地工人動態追蹤系統

### Artificial Intelligence (AI) for Construction Site Monitoring 用作工地監察的人工智能

AI can help improve the efficiency of monitoring the construction site operations, manage mobile construction safety management and reduce the risk of safety accidents.

AI 可以幫助提高監察建築工地運作效率，管理移動式建築安全管理和降低安全意外風險。

<b>Benefits 優點</b> <ul style="list-style-type: none"> <li>Reduce construction safety 減少安全</li> <li>Optimize monitoring 優化監察</li> <li>Reduce management cost 減少管理成本</li> </ul>	<b>Applications 應用</b> <ul style="list-style-type: none"> <li>Site management 工地管理</li> <li>Site operation monitoring, recording and analysis 工地運作監察、記錄及分析</li> </ul>
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圖 34 用作工地監察的人工智能





圖 35 工業用外骨骼



圖 36 動力外骨骼

## 參、心得及建議

一、有關預防災害的宣導，經常以災害案例方式呈現，例如交通事故、職業災害案例等，希望達到嚇阻效用，其結果可能有效，但這一類的宣導片，不會令人想一看再看。本所製作之 3D 立體動畫「關鍵時刻」，即以漫畫人物敘述工作場所危害的驚險情形，曾於第十八屆世界職業安全衛生大會榮獲國際安全衛生影片首獎。在 APOSHO 33 研討會中，香港代表介紹澳洲墨爾本宣傳鐵道交通安全的公益短片「Dumb Ways to Die」(笨笨的死法)，以正面的、幽默的方式呈現，且背景歌曲之風格輕快清新，歌詞幽默，頗受大眾喜愛。此種宣導方式可供未來製作宣導影片之參考。


二、APOSHO 33 研討會主題為「透過溝通與合作以追求卓越」，強調勞資雙方的良好溝通有助於工作場所安全衛生的提升。美國職業安全衛生署(OSHA)在 1992 年頒布「製程安全管理法規」，「員工參與」即為 14 個管理項目之一，1999 年 OHSAS 18001 職業安全衛生管理系統，提出「溝通/參與及諮詢」，我國於 2007 年頒布「臺灣職業安全衛生管理系統指引」，員工參與為該管理系統的基本要素之一。而溝通與合作是落實員工參與應具備的技能與程序，國內在勞資雙方之安全衛生溝通與合作的相關宣導、輔導或研究較少看到，建議可蒐集國內外相關作法，加強宣導，將有助於事業單位透過溝通與合作以追求卓越。

三、在國際創意設計展覽中，在「STEAM 教學」部份，展示了水底機械人及教育玩具等項目，吸引許多兒童前往動手嘗試操作水底機械人及其他玩具。STEAM (Science, Technology, Engineering, Art, and Mathematics) 教育是結合科學、技術、工程、藝術和數學的跨領域教學架構，讓學生在數學邏輯的基礎上，藉由工程跟藝術的展示，來學習科學與技術內涵，起源於 1986 年美國國家科學委員會提出由科學、科技、工程和數學整合的 STEM 教育的綱領性建議，2006 年加入藝術(Art) 領域，培養優質科技人才、工程師、科學家及數學家，來提升國家的競爭力。聯合國教育、科學與文化組織的「教育 2030:行動架構」目標之一是鼓勵學生盡早接觸科學、科技、工程、和數學 (STEM)領域，STEAM 已成為全球教育趨勢，國內的幼兒教育業已開始推行 STEAM 教育。同樣的，職業安全衛生教育如果能及早於學生時代扎根，建立良好的安全衛生態度，安全衛生意識會自然地融入其工作、遊戲及生活，終其一生受用不盡，歐洲 EU OSHA 組織近年來在推動將職業安全衛生容入學校教育中(Mainstreaming OSH into education)，此思維可供國內主管機關參考，網址是 <https://osha.europa.eu/en/themes/mainstreaming-osh-education>。

四、此次參觀香港職業安全健康局職安健學院及建造業創新及科技應用中心等，其中虛擬實境、物聯網、人工智慧等資通訊科技已大量應用於職場安全管理措施或訓練項目，如何應用這些科技提升工作場所安全及提升勞工安全意識是未來努力的方向。

## 肆、附件

### 附件一 第 33 屆亞太地區職業安全衛生組織研討會(APOSHO 33)議程



## Day One | Tuesday 04 December

<b>08.15</b>	<b>Registration, refreshments and exhibition</b>
09.00	Welcome from the Chair Prof Vincent HO
09.10	Welcome from APOSHO Chi-Ming LAW, Secretary General, APOSHO
09.15	Guest of Honour Dr Wai-Kwok LO, Chairman of the Business and Professionals Alliance for Hong Kong
09.30	Sponsor appreciation – Thank you to our sponsors and supporting organisations
09.45	Keynote 1 Dr Constance CHAN, Director of Health – Department of Health, Hong Kong
10.15	Keynote 2 Ms Bonnie YAU, Executive Director, Occupational Safety & Health Council
<b>10.40</b>	<b>Refreshments and exhibition</b>
<b>11.10</b>	<b>PARALLEL SESSION 1</b> <i>see page 09</i>
	<b>Technical Session 1</b> Incorporation of management systems (ISO 45001)
	<b>Technical Session 2</b> Leading safety – the benefits to an organisation
	<b>Technical Session 3</b> Communicating safety to the workforce – innovative ways, engaging with cultural differences
<b>12.40</b>	<b>Lunch and exhibition</b>
<b>13.40</b>	<b>PARALLEL SESSION 2</b> <i>see page 10</i>
	<b>Technical Session 4</b> Virtual reality and use of new technologies
	<b>Technical Session 5</b> Communicating safety to schools and young workers
	<b>Technical Session 6</b> Safety in design
<b>15.10</b>	<b>Refreshments and exhibition</b>
<b>15.40</b>	<b>PARALLEL SESSION 3</b> <i>see page 11</i>
	<b>Technical Session 7</b> Sustainability – the safety link
	<b>Technical Session 8</b> Health and wellbeing – case studies
	<b>Technical Session 9</b> Working together for positive results
<b>17.10</b>	<b>Day 1 close</b>
<b>19.00</b>	<b>Networking evening</b> for all delegates – <i>see page 17</i>

## Parallel Session 1

### Tuesday 04 December | 11.10–12.40

#### Technical Session 1

Incorporation of management systems (ISO 45001)

**Room** Versailles Ballroom  
**Session Chair** Kate FIELD,  
 Global Product Champion – Health and Safety, BSI Group

#### So you want to become a risk-and-opportunity-based thinker and communicator?

Mr James WHITING, MD and Principal Risk Engineer, Risk@Workplaces Pty Ltd, *Australia*

#### Japanese OSHMS, having two dimensions of ISO 45001 and JIS 45100(so-called JIS a(alpha))

Mr Takeo HAYAKI, Director, OSHMS Center, JISHA (Japan Industrial Safety and Health Association), *Japan*

#### ISO-45001 – what have we learnt so far?

Ms Kate FIELD, Global Product Champion – Health and Safety, BSI (British Standards Institution) Group, *UK*

#### Enhance Management Systems effectiveness using technology-enabled Risk Communication

Mr JC SEKAR, CEO and Co-Founder AcuiZen Technologies Singapore Pte, Ltd, *Singapore*

Session sponsor



#### Technical Session 2

Leading safety – the benefits to an organisation

**Room** Longchamps  
**Session Chair** Mr Ameerli ABDEALI  
 Honorary APOSHO Member

#### Positive safety leadership through LEAD model

Mr Aravind APPI RAJ O, Deputy General Manager – Central Safety Co-ordinator, Mahindra and Mahindra Ltd, *India*

#### Leading safely (a practical approach)

Mr Craig DOCHERTY, CEO / Founder, Fusion Safety Management Pty Ltd, *Singapore*

#### A study of relationships between self-efficacy and perceived managerial safety practice for employees' safety performance

Mr Yoonseok CHOI, Manager/Assistant Professor, OSH Training Institute of KOSHA, *Republic of Korea*

#### Empowerment of principle employers roles through 3C (communication, compliance and commitment) and 1b (behaviour)

Mrs Nasyrah Binti IBRAHIM, Manufacturing Sector Head, Principle Employer Empowerment Research Group, NIOSH, *Malaysia*

#### Technical Session 3

Communicating safety to the workforce – innovative ways, engaging with cultural differences

**Room** Luxembourg  
**Session Chair** Mr Darren BRUNTON  
 IOSH Singapore Branch Chairman and Managing Director of KB Associates Group of Companies

#### Visual literacy: how “learning to see” benefits occupational safety

Mr John DONY, Director, Campbell Institute / National Safety Council, *USA*

#### Practical Safety Training Center @ Construction Site

Mr Matthias KROPE, Global Sales Consultant, Youngwoo Ind, *Republic of Korea*

#### HSSE communications with each organisational layer of defence

Mr Neil van KALLES, HSSE Manager (Asia), Hargreaves Industrial Services (HK) Ltd, *Hong Kong SAR, China*

#### Fire safety – how can OSH Practitioners address complacency when the evacuation alarm is initiated

Dr David GOLD, International Occupational Safety, Health and Fire Safety Consultant, *Switzerland*



## Parallel Session 2 Tuesday 04 December | 13.40–15.10

### Technical Session 4

Virtual reality and use of new technologies

**Room** Versailles Ballroom  
**Session Chair** Michael D ARGUELLES,  
National President, Association of Safety  
Practitioners of the Philippines, (ASPP)

#### **A study of using virtual reality technology for labour education and training**

**Dr Cheng-Ming CHANG**,  
Associate Researcher, Institute of Labor,  
Occupational Safety and Health,  
Ministry of Labor

**Kuo-Ching LIU**, Associate Researcher,  
Institute of Labor, Occupational Safety  
and Health, Ministry of Labor

**Chiech-Yu HUANG**, Assistant Researcher,  
Institute of Labor, Occupational Safety and  
Health, Ministry of Labor, *Chinese Taipei*

#### **Using behavioural reporting systems as a pro-active indicator to management**

**Mr Glenn PINSENT**, Global Manager,  
Health, Safety and Environment, Bristow  
Helicopters Group, *Scotland*

#### **Human-centered OSH Training – OSH Immersive Experience Hall**

**Dr Winson YEUNG**, Principal Consultant  
of Occupational Safety and Health  
Council, *Hong Kong SAR*

#### **The role and power of social media in EHS management and accident prevention**

**Mr Kim Choy FONG**, Deputy President,  
National Safety Council of Singapore,  
*Singapore*

### Technical Session 5

Communicating safety to schools and young workers

**Room** Luxembourg  
**Session Chair**  
**Dayanand KURRUMCHAND**  
– President, IOSHM (Mauritius)

#### **Occupational safety and health in school (OSH in school) – a NIOSH Malaysia approach in cultivating OSH culture at an early stage in Malaysia**

**Mr Lee Lam THYE**, Chairman of NIOSH  
Malaysia, *Malaysia*

#### **Communicating occupational health and safety messages regarding young workers: tools, strategies, and lessons from the ILO's Youth4 OSH Project**

**Dr Francisco SANTOS-O'CONNOR**,  
Senior Specialist on Occupational Safety  
and Health, Decent Work Team for East  
and South-East Asia and the Pacific,  
International Labour Organization (ILO),  
*Indonesia*

#### **The use of modern technology in OHS** **Andy LEWIS**, Director, WHS Australia, *Australia*

### Technical Session 6

Safety in design

**Room** Longchamps  
**Session Chair** Victor KWONG,  
President, HKFOSHA

#### **Enhancing design for safety through collaboration and communication – the Hong Kong experience**

**Mr Andy LO**, Chartered Safety and Health  
Practitioner, HK IOSH

**Mr Kevin CHUNG**, Communications  
Business Partner, IOSH, UK,  
*Hong Kong SAR, China*

#### **Building a collaborative future: go for BIM**

**Ms Ada FUNG**, Chairperson of  
Committee on BIM of Hong Kong's  
Construction Industry Council / President  
of Lighthouse Club (HK), Construction  
Industry Council of Hong Kong,  
*Hong Kong SAR, China*

#### **Advantages of electronic permit-to-work system in hydrocarbon industry**

**Dr Atul SRIVASTAVA**,  
Vice President – HSE Design/Engineering,  
Reliance Industries Ltd, *India*

## Parallel Session 3

### Tuesday 04 December | 15.40–17.10

#### Technical Session 7

Sustainability – the safety link

**Room** Luxembourg

**Session Chair**

Dr Dato Kanagaraja RAMAN,  
President, MOSHPA

#### Return on prevention study in manufacturing plant

Mrs Fazlin HASABAN,  
Safety Health Officer, MSOSH, *Malaysia*

#### Leading on health and safety in sustainability

Mr Richard JONES, Head of Policy  
and Public Affairs, IOSH, *UK*

#### How are people motivated to act safely? What does good safety leadership look like? How can practitioners change their vocabulary to engage and drive change?

Sam CHAN, Associate Director JLL  
and Chairman of JLL Integrated Facilities  
Management EHS Committee, JLL  
Steven BROWNE, Asia Pacific,  
Risk and Incident Director, JLL,  
*Hong Kong SAR, China*

#### Developing vision zero strategy and seven golden rules towards a sustainable OSH culture of prevention for Thai SMEs

Dr Chaiyuth CHAVALITNITIKUL,  
Honorary President of SHAWPAT,  
SHAWPAT  
Dr Chalermchai CHAIKITTIPORN,  
President, SHAWPAT  
Mr Tamrong KUNOPAKARN  
Dr Dheera PHONG-ANANT,  
*Thailand*

#### Technical Session 8

Health and wellbeing – case studies

**Room** Longchamps

**Session Chair** Dr Hyuck-Myun KWON,  
Research Professor, Yonsei University

#### Bapco – Bahrain Wellbeing Model

Dr Spyridon TROUS, Manager Medical  
Services, The Bahrain Petroleum Company  
(BAPCO), *Bahrain*

#### Effect of heat stress on the occupational health strain of industrial workmen – a case study in food manufacturing industry in India

Dr Susanta PODDER, Manager EHS,  
PepsiCo India Holdings Pvt Ltd, *India*

#### Reasonable working time and measures to improve working conditions for workers in Vietnam

Prof Le Van TRINH, Vietnam  
Occupational Safety and Health  
Association, *Vietnam*

#### Technical Session 9

Working together for positive results

**Room** Versailles Ballroom

**Session Chair** Eros ZUNIGA,  
National President, Safety Organization  
of the Philippines (SOPH)

#### How engineers and OSH professionals together can improve outcomes

Ms Sarah Emma DAVIDSON,  
North Asia EHS Director, JLL  
Mr Paul BOWER, Asia Pacific HSBC,  
Regional Engineering Director, JLL,  
*Hong Kong SAR, China*

#### Enhance communication between occupational hygienists, OHS professionals and practitioners for effective risk management

Mr Zephan Chan Yu YUN, Director  
of Operations, Head of Occupational  
Hygiene, IOM (Institute of Occupational  
Medicine) Singapore Pte Ltd  
Sriram PRASATH, Occupational Hygienist,  
IOM (Institute of Occupational Medicine)  
Singapore Pte Ltd, *Singapore*

#### Can HR and OSH work together to bring about sustainable rehabilitation?

Dr David THOMAS, Senior Lecturer  
and Portfolio Lead (Acting Head of Built  
Environment), University of Greenwich, *UK*

#### Occupational safety and health (OSH) communication: MSOSH engagement and collaboration strategies with its stakeholders

Mr Mohamad Aliasman MORSHIDI,  
HSE Practitioner, Malaysian Society of  
Occupational Safety and Health (MSOSH),  
*Malaysia*

## Day Two | Wednesday 05 December

<b>08.30</b>	<b>Registration, refreshments and exhibition</b>
<b>09.10</b>	<b>Welcome from the Chair</b> Prof Vincent HO
<b>09.15</b>	<b>Guest of Honour</b> Er Siong Hin HO, Commissioner for Workplace Safety and Health, Ministry of Manpower
<b>09.35</b>	<b>Keynote 1:</b> Dr Olivier LO, Group Medical Director, International SOS Health sustainability: OHS sustainable reporting opportunities via the GRI 403 standard
<b>10.05</b>	<b>Keynote 2:</b> Linda REINSTEIN, President/CEO, Asbestos Disease Awareness Organization (ADAO)
<b>10.35</b>	<b>Panel discussion and Q&amp;A</b>
<b>11.00</b>	<b>Refreshments and exhibition</b>
<b>11.40</b>	<b>PARALLEL SESSION 4</b> <i>see page 13</i>
	<b>Technical Session 10</b> Managing critical risks
	<b>Technical Session 11</b> Safety culture
	<b>Technical Session 12</b> Mental health and wellbeing case studies
<b>13.10</b>	<b>Lunch and exhibition</b>
<b>14.10</b>	<b>Inspiring OSH Student Award</b>
<b>14.25</b>	<b>Closing ceremony</b> Mr Matthew Cheung Kin-chung, GBM, GBS, JP, Chief Secretary for Administration, The Government of the Hong Kong Special Administrative Region
<b>14.40</b>	<b>Summary and conclusions from conference chair</b>
<b>14.45</b>	<b>PARALLEL SESSION 5</b> <i>see page 14</i>
	<b>Technical Session 13</b> Creating a safe and healthy workplace through collaboration
	<b>Technical Session 14</b> Worker engagement – practical application
	<b>Technical Session 15</b> Educating the workforce – innovative ways for engagement
<b>16.15</b>	<b>Conference close</b>

## Parallel Session 4

### Wednesday 05 December | 11.40–13.10

#### Technical Session 10

Managing critical risks

**Room** Luxembourg

**Session Chair** Prof Shuh-woei YU  
– Honorary APOSHO Member

##### What is the meaning of a safe system of work from the legal perspective

**Dr Yum Yin WONG**, Managing Director,  
Y Y Wong Safety Consultants Ltd,  
*Hong Kong SAR, China*

##### Minimising the exposure of safety critical risks – our experience in CLP

**Dr Vanessa FORBES**, Senior Director –  
Health, Safety and Environment, Group  
Operations, CLP Holdings Limited  
**Mr Stephen PANG**, Senior Process safety  
Manager-CLP Holdings Limited,  
*Hong Kong SAR, China*

##### An innovation to enhance working at height safety – rapid demountable platform for RMAA Works

**Dr Winson YEUNG**, Principal Consultant,  
Occupational Safety and Health Council,  
Hong Kong SAR  
**Mr Toran LAW**, Senior Consultant,  
Occupational Safety and Health Council,  
Hong Kong SAR,  
*Hong Kong SAR, China*

##### How collaboration can make work safer

**Mohamed Amin ABDULLAH**,  
Group HSSE, Petroliaam Nasional Berhad,  
*Malaysia*

#### Technical Session 11

Safety culture

**Room** Versailles ballroom

**Session Chair** Bernie DOYLE,  
President and Chairman,  
NSCA Foundation

##### Application of decision-making tool for safety culture study in Hong Kong industry

**Mr Chun Kuen Alex TSE**,  
Programme Director,  
The Open University of Hong Kong,  
*Hong Kong SAR, China*

##### Three lessons learned when changing safety culture

**Mr Boon Chew SOON**, Principal  
Consultant, Culture Lab Pte Ltd, *Singapore*

##### Rising to the challenge of developing a safety culture in high-profile multi-contractor major projects

**Mr Stephen POLLOCK**  
Senior Manager – Project Safety Strategy  
and Development, MTR Corporation,  
*Hong Kong SAR, China*

##### Using safety management systems to motivate change

**Nicole YIU**, Teaching Fellow, Department  
of Civil and Environmental Engineering,  
The Hong Kong Polytechnic University,  
*Hong Kong SAR, China*

#### Technical Session 12

Mental health and wellbeing case studies

**Room** Longchamps

**Session Chair** Mr JC SEKAR,  
CEO and Co-Founder AcuiZen  
Technologies Singapore Pte, Ltd

##### What's new in return to work?

##### Joining the dots for OSH professionals

**Ms Bonnie YAU**, Executive Director,  
Occupational Safety and Health Council,  
*Hong Kong SAR*

**Mr Ivan Williams JIMENEZ**,  
Research and Development Advisor,  
IOSH, *UK*

##### Perceptions of psychosocial risks in the Asia Pacific workplaces

**Mr Ivan Williams JIMENEZ**, Research  
and Development Advisor, IOSH, *UK*

##### A survey of occupational burnout and wellbeing in Hong Kong

**Ms Alice LAM**, Senior Consultant of  
Occupational Safety and Health Council,  
*Hong Kong SAR, China*





## Parallel Session 5 Wednesday 05 December | 14.45–16.15

### Technical Session 13

Creating a safe and healthy workplace through collaboration

**Room** Versailles ballroom  
**Hosted by** International SOS  
**Moderator** Mr. Patrick WONG,  
Business Development Director,  
International SOS and Future Care

Hear from a panel of industry experts about some best practices on how organisations create a safe and healthy workplace through working closely with different teams. The areas to be discussed in the panel discussion would include:

- The definition of OSH excellence and the understanding of collaboration;
- Sharing of different organisations' views and experiences in driving OSH excellence;
- Key drivers towards attaining collaboration;
- How to manage expectations and overcome challenges; and
- How success was measured.

**Capt. Pradeep CHAWLA**,  
Chairman/Managing Director QHSE  
& Training at GlobalMET, Anglo-Eastern  
Ship Management Ltd.

**Mr. Paul SCOTT**  
Executive Director, Arcadis

**Prof. Samuel YU**,  
Associate Director, Health, Safety and  
Environment Office, Adjunct Associate  
Professor, Division of Environment and  
Sustainability, The Hong Kong University  
of Science and Technology

### Technical Session 14

Worker engagement  
– practical application

**Room** Luxembourg  
**Chair** Mr Andy Lo Chartered Safety  
and Health Practitioner HK IOSH

#### Making the connection ...

**Dr Karen Elizabeth MCDONNELL**,  
Occupational Safety and Health Policy  
Adviser, Royal Society for the Prevention  
of Accidents, *UK*

**Carlene MCAVOY**, Community Safety  
Development Manager, Royal Society for  
the Prevention of Accidents  
Scotland, *UK*

#### How to get your workforce engaged with health and safety

**Mr Lance HISCOE**, Vice President,  
Asia Pacific Rim, NOSA Global Holdings,  
*New Zealand*

#### Developing health and safety culture through effective communication strategies

**Mrs Chandani KAHANDAWALA**,  
Managing Director,  
International Safety Consultants  
**Mr Gayan FERNANDO**, Head of Health  
and Safety, Siam City Cement (Lanka)  
Limited, *Sri Lanka*

### Technical Session 15

Educating the workforce  
– innovative ways for engagement

**Room** Longchamps  
**Chair** Mr Zephan Chan Yu YUN,  
Director of Operations,  
Head of Occupational Hygiene,  
IOM Singapore Pte Ltd

#### Engage for positive change

**Ms Roisin KELLY**, HSEQ Manager,  
Balfour Beatty CLG Ltd, *Republic of Ireland*

#### Effective communication in complex environments

**Mr John LACEY**,  
APOSHO Organising Committee, *UK*

#### How can we make employees more sensitive to hazards effectively?

**Mr Megumu FUKUMI**, Director,  
JISHA (Japan Industrial Safety and  
Health Association), *Japan*

## **A Study of Using Virtual Reality Technology for Labor Education and Training**

**Cheng-Ming Chang   Kuo-Ching Liu   Chieh-Yu Huang**

Institute of Labor, Occupational Safety and Health, Ministry of Labor, Taiwan

### **Abstract :**

In recent years, there are several major accidents occurred in the petrochemical industries and construction industries in Taiwan, and many workers lost their health and even lives. Despite the measures that have been established for safety and health management systems and emergency planning by large-scale enterprises, major accidents still occur. The traditional approach of safety education and training mainly use drills which need much manpower and material costs for each exercise, and therefore it is difficult to be conducted frequently.

In this study, we collected and analyzed occupational accidents in petrochemical related industries in the last five years. Next, we wrote the scenario scripts for incorrect operation and improper maintenance. Also, we conducted on-site interviews in three petrochemical industries and one occupational safety consulting company for writing the contents of script. Then we established the experiential studio and operations of several safety concept designs in the petrochemical industries using virtual reality technology. This virtual reality tools was to simulate fire and explosion accidents. Smartphones, tablets, and smart glasses can be used to repeat the exercise process. At the end, the VR app and the evaluation questionnaires regarding the traditional and immersive education training were given to 55 plant workers. The survey results showed that the trainees feel that the virtual reality teaching is easier to carry out, more attractive compared to traditional education training, and helpful for educational training.

In addition, this study also focused on the occupational hazards in the construction industry and the development of immersive virtual reality for scenarios related to site activities of the construction industry. Somatosensory interactions and hazard identifications were used including falling from high places, falling over, electrocution, collapsing, flying objects, struck-by, and so forth.

This study simulated the developmental processes of accidents by virtual reality teaching which enables workers to experience the actual situation in accidents through simulation. The workplace hazard identification training can be repeated.

### **1. Introduction**

Human errors are always considered the causes of occupational injuries, it could be physical and mental capabilities, lack of knowledge and information relevant to performing the task, and lack of the necessary skill to carry out the task. How to educate employees to be less prone to having human errors is an important issue of enterprises' education and training on occupational health and safety.

Augmented Reality (AR) and Virtual Reality (VR) development have been applied to entertainment, marketing, education, art, fashion, and many more area. VR/AR introduce a new way to learn. Virtual reality is the use of computer technology to create a simulated environment. It can provide the most robust and immersive experience. Unlike traditional user interfaces, VR places the user inside an experience. Instead of viewing a screen in front of them, users are immersed and able to interact with a 3D world. Several studies have shown that people who learn and train in VR retain the information much more deeply and for longer periods of time than those who simply use books and videos and other traditional methods. VR allows students to run the lesson as many times as needed, and they cannot be distracted while in the headset.

This study is to use VR technology to develop occupational education and training materials and hopefully to raise workers' safety awareness.

## **2. Methods**

- (1) Compile and analyze occupational accident cases in construction and petrochemical related industries.
- (2) Define the goals of VR training materials and decide what platforms to design for.
- (3) Write VR scripts. Based on the occupational injury analysis, select various operations on construction sites and in petrochemical plants, construct virtual environment and design interaction with virtual environment. Consult professionals with the script content.
- (4) Create immersive virtual reality experiences for potential hazards and incident: eight scenarios in construction industry and two scenarios in petrochemical industry.
- (5) Post training evaluation survey. Use questionnaire to evaluate the effectiveness of the VP app.
- (6) Device. Oculus Rift and 3D VR glasses were used.

## **3. Results and Discussion**

### **(1) Occupational injuries**

Domestic occupational accident cases in petrochemical related industry from 2012 to 2017 were studied, and a total of 19 accidents were collected. Among these 19 accidents, 7 can be attributed to incorrect operation and 5 improper maintenance.

From 2006 to 2016, there were 1,607 major occupational injuries in

construction industry, an average of 161 injuries each year. The leading causes of worker injuries on construction sites were falls(61.5%), collapse(10.8%), electrocution(8.1%), flying objects(4.1%), and struck-by-object(3.4%).

(2) Design of virtual reality

The scenario scripts of virtual reality were based on the previously mentioned occupational injuries case study. Two scenarios were designed for petrochemical industry, incorrect operation of a valve and improper maintenance of a pump.

Eight scenarios were designed for construction industry. It offers an interactive way to identify hazards in certain operation and environment, and creates an immersive virtual reality environment that would let users experience an incident. These eight scenario are planned as shown in Table 1.

Table 1 Eight construction industry VR scenarios

Operation/Environment	Potential hazards
Mobile crane lifting operation	Flying objects/ struck-by
Acetylene cutting operation	Fire & explosion
Floor opening/ Elevator shaft opening	Fall
Electrical device	Electrocaution
Stepladder	Fall
Working platform/Scaffold	Fall/Collapse
Steel structure work	Fall
Roof work	Fall

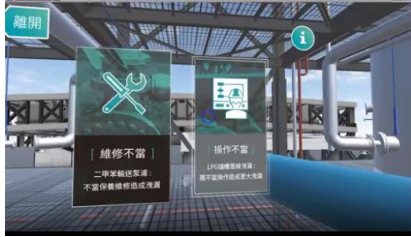
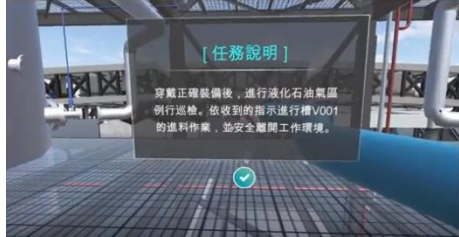
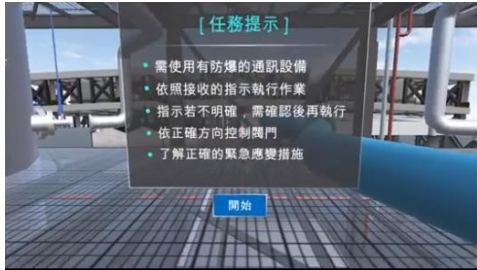



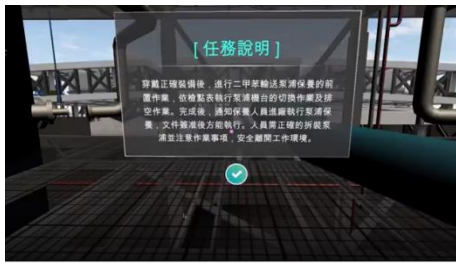

(3) Development of virtual reality

VR provides us with the opportunity to explore immersive 360-degree environments. In some of the scenes we use arrows/highlight within the virtual world to help direct the user’s attention towards a direction. Two virtual reality environments were created for petrochemical industry. One is about the pump leak due to improper maintenance and results in an explosion. The other one is a response to the LPG pipeline leak, wrong valve operation results in bigger leak. Each VR scenario has 5 interaction options to complete the assignment. The user can follow the guidelines to go through the learning process. During this process, a wrong decision will result in an explosion. Table 2 exhibits some of the scenes in this VR.

There are eight simulation working environments in construction industry VR. And each environment is designed to conduct a hazard identification and experience an incident. The user need to find the potential hazards. At the end of each section, it

will let the user to experience an incident and make a deeper impression on the user.

Table 2 Scenes in petrochemical industry VR

1 <sup>st</sup> scenario: LPG pipeline leak - incorrect operation of the valve	
<p>Choose one scenario</p> 	<p>Assignment</p> 
<p>Assignment guidelines</p> 	<p>PPE room</p> 
<p>Procedure statement</p> 	<p>Ask control room to confirm which valve to operate</p> 
2 <sup>nd</sup> scenario: pump repairment	
<p>Assignment</p> 	<p>PPE room</p> 
<p>Inform control room to shut down pump and lock out/tag out.</p>	<p>Insert blind</p>

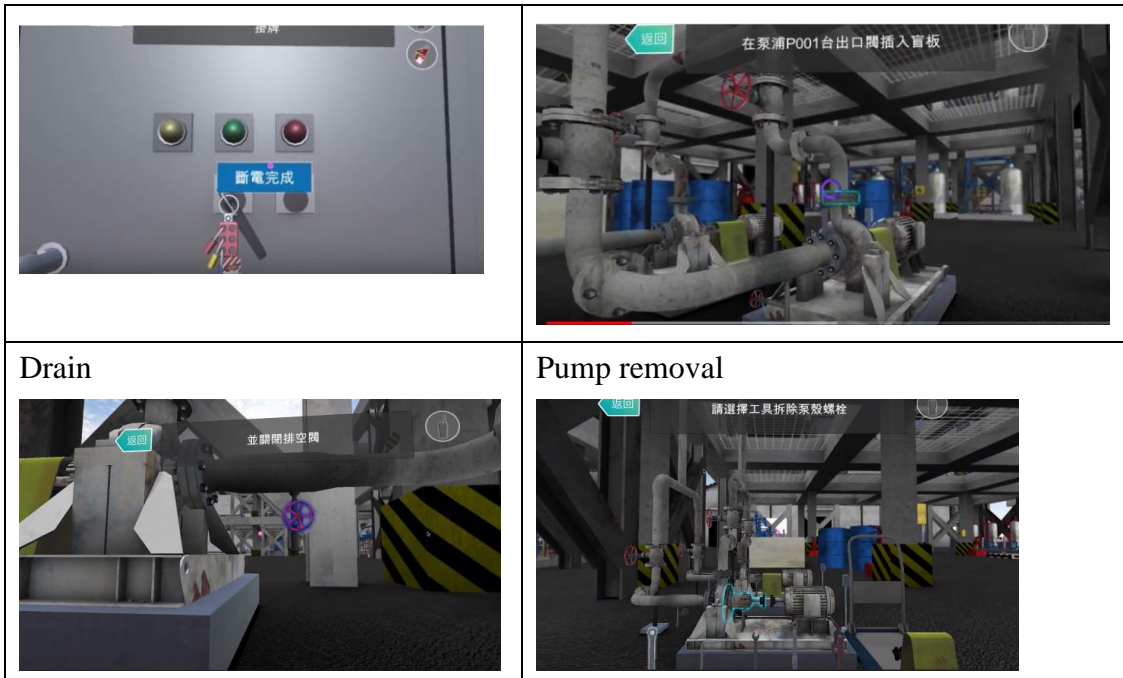






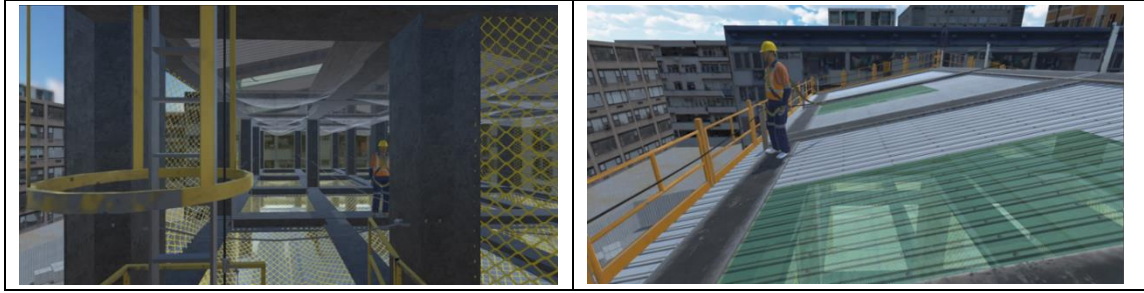


Table 3 Scenes in construction industry VR

<p>1. Mobile crane operation</p>	<p>2. Acetylene cutting operation</p>
	
<p>3. Floor opening/ Elevator shaft opening</p>	<p>4. Electrical device</p>
	
<p>5. Stepladder</p>	<p>6. Working platform/Scaffold</p>
	
<p>7. Steel structure work</p>	<p>8. Roof work</p>



#### (4) Post training evaluation survey

Petrochemical industry VR was given to 55 plant workers. The evaluation survey result showed that 95% of the users agreed that VR was a good learning support tool, 91% agreed that VR learning was more effective than traditional learning methods. However, the content was not very practical.

Construction industry VR was given to 20 construction workers. The evaluation survey result showed that 95% of the users agreed that the accident experience made them feel real, 90% felt the dangers on the construction site during the interaction process, 100% had learned safety knowledge and also like to use new VR training tool.

#### 4. Conclusion

- (1) Define the goals for the app is the most important step to consider before deciding to develop a VR app. A clear goal of what to achieve with this app is needed, whether it is a stand alone experience, a multi-story platform, or a game.
- (2) Develop VR training tool need the cooperation between two domain knowledge professionals, occupational safety/field operation knowledge and VR knowledge.
- (3) Unlike video games, VR isn't something people can watch hours-long without feeling sick. Build in breaks that prevent discomfort. This is particularly important for cardboard, which must be held close to the face.
- (4) VR Immersive Experience is more impressive than the traditional learning methods but can not replace them. It is an effective learning material and a learning support tool.