

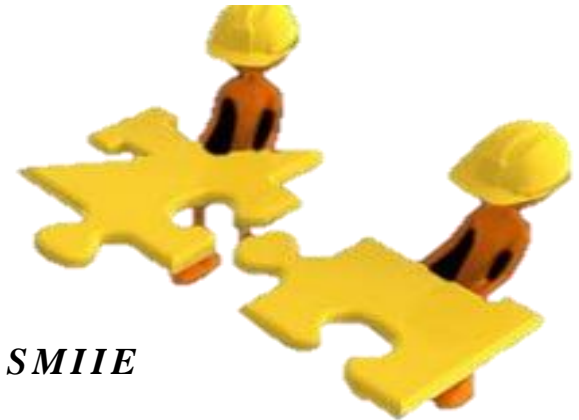
# Applications of Human Factors and Ergonomics for Construction Site Safety

## 人因工程在建造業工地安全之應用

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人因工程 Human Factors  
工效學 Ergonomics



# Objectives of Ergonomics

## 人因工程目標

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- 1) to enhance the **effectiveness** and **efficiency** with which work and other activities are carried out (提高工作和其他活動的效用和效率)
  - improved **health and safety of work** (提升工作健康與安全)
  - reduced human errors (減少人為失誤)
  
- 2) to enhance certain **desirable human values** (提升員工的工作關鍵元素)
  - reduced work fatigue and stress (減輕工作疲勞與壓力)
  - increased work comfort (提升工作舒適度)
  - increased job satisfaction (提高工作滿意度)

**Human Centred - 以人為本**



# Ergonomics Approach

## 人因工程處理問題的方式

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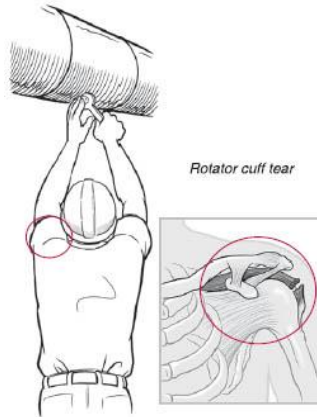
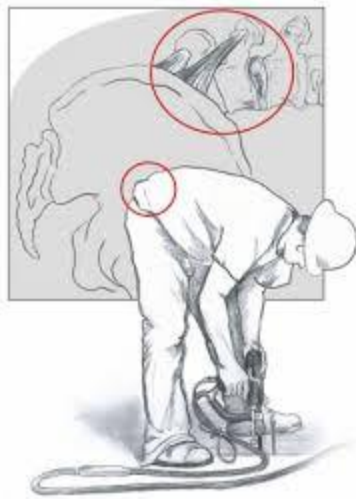
**Discovery and systematic application of relevant information about human capabilities, limitations, characteristics, behavior and motivation to the design of things and procedures people use and the environment in which they use them**

使用系統性的方法評估人的能力、限制、特性、行為和動機，並利用相關知識來設計工作系統，從而達到人因工程的目標

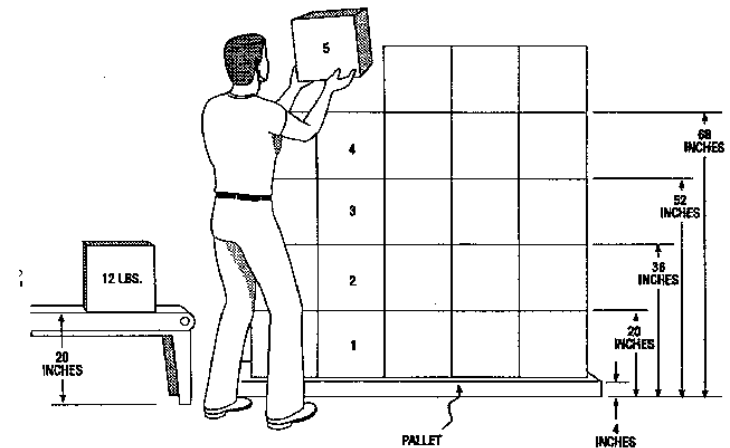
# Physical Ergonomics 物理工效學

## Manual Material Handling (MMH)

### 體力處理操作



<http://www.elcosh.org/document/2056/1427/d001051/3.html>



$$RWL = LC (23 \text{ kg} / 51 \text{ lb}) \times HM \times VM \times DM \times AM \times FM \times CM$$

<http://www.newruleproduct.com/compare/workrelatedmusculoskeletaldisorders/>

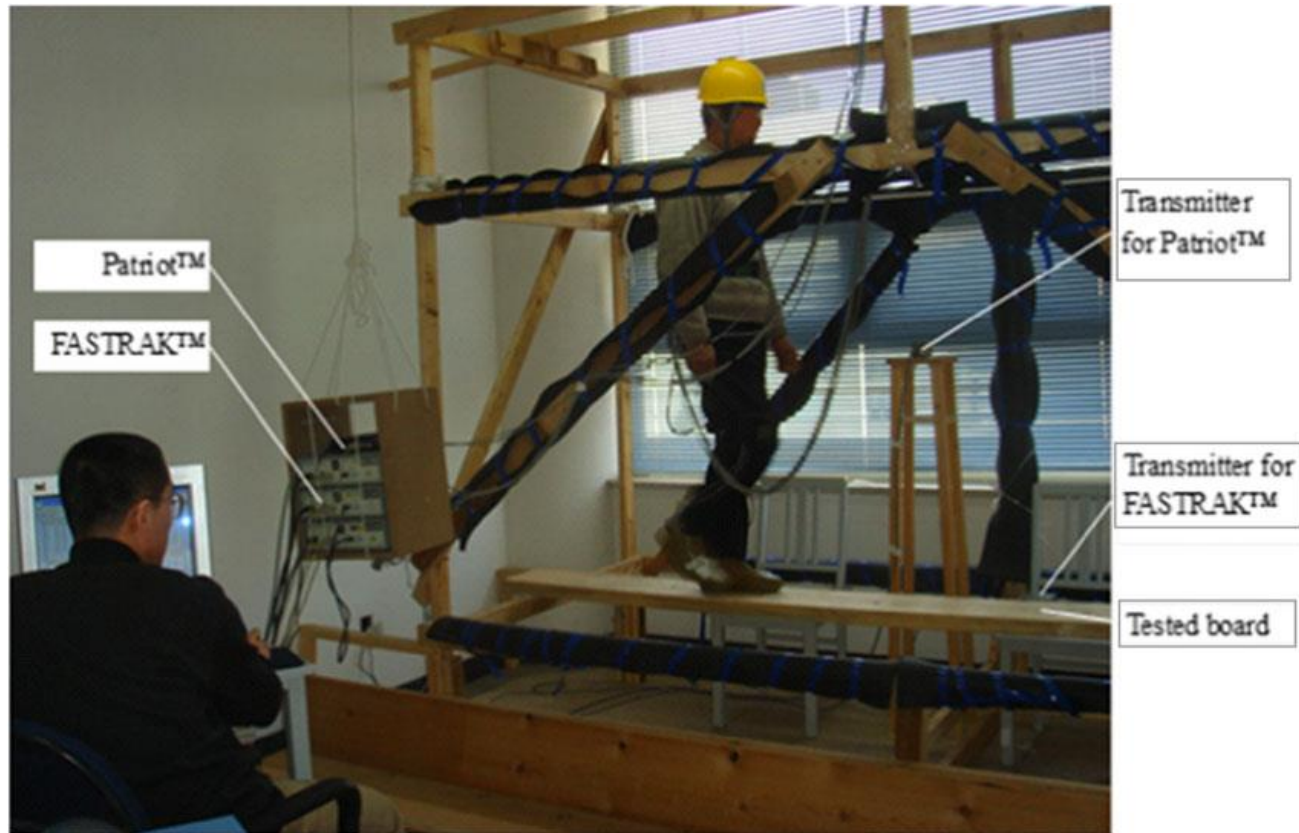
Musculoskeletal  
discomfort/disorder (MSD)  
肌肉骨骼勞損

Repetitive Strain  
Injury (RSI)  
重複性勞損



# Investigating gait adjustments and body sway while walking across wooden scaffold boards (Li et al. 2015)

關於在木橋板上行走時 工人步態調整和身體擺動的研究



Li et al., 2015, Investigating gait adjustments and body sway while walking across wooden scaffold boards, online, *Ergonomics*

# Main findings 主要發現

- Experienced workers took longer strides and walked faster, and with larger variability in body sway (familiarity and proficiency with the tasks)

與沒有經驗工人比較，有經驗的工人步伐大，走得快，並且身體擺動幅度大

- Board width and thickness, construction work experience and practice have different degrees of influences on gait adjustment and body sway

橋板的寬度和厚度、工人的建築工作經驗及訓練，對步態調整和身體擺動有不同程度的影響

- The slowest walking speed was found with the narrow-thin board condition

在窄薄的木板上工人行進速度最慢

## Explanation of researchers 研究人員解釋

Reduction of walking speed could decrease individuals' power demand associated with the potential energy and eventually reduce the risk of slips or fall

減速可以減輕行走時動力的需求, 並最終降低滑倒或跌倒的風險

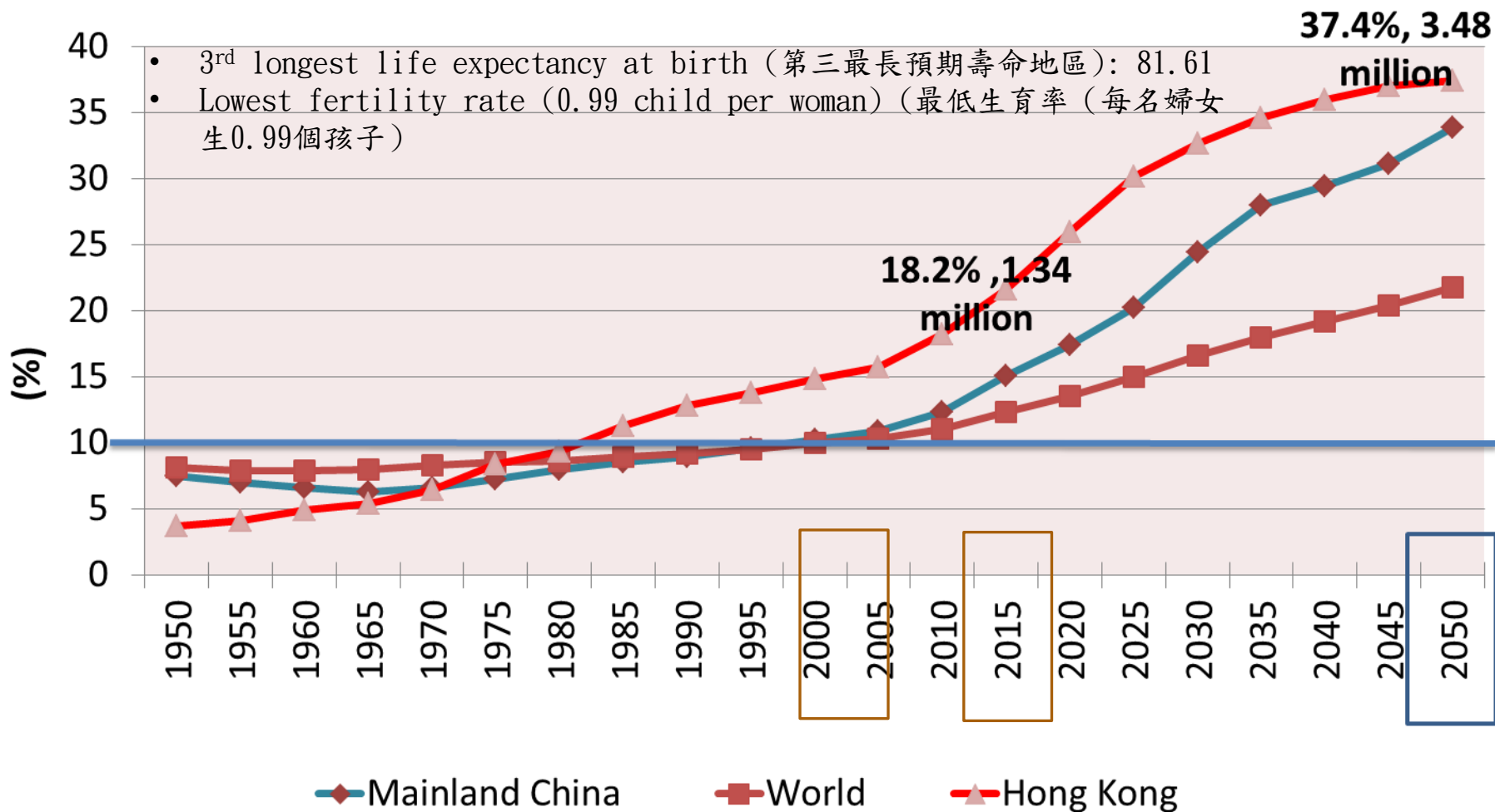
- **Question: narrow-thin (窄薄) or wide-thick (寬厚) boards?**



# Cognitive Ergonomics 認知工效學

## Population Aging 人口老齡化

Percentage population aged 60+ (60歲以上人口所佔的比例)



## Safety Related Problems 安全相關的問題

- In terms of safety, middle aged and older workers are **more susceptible to accidents** due to **decline of perception and agility**. (Yi et al. 2012)  
就安全而言，由於感知力和靈活度的下降，**中老年工人**更容易發生事故

**Table 5**

The number of fatal incidents by workers' age.

	2004	2005	2006	2007	2008	Total	%
Total	779	609	631	630	669	3,318	100
<30	45	26	31	17	21	140	4.2
30-39	159	118	94	94	87	552	16.6
40-49	242	189	214	198	235	1,078	32.5
≥50	333	276	292	321	326	1,548	46.7

Source: KOSHA annual report, 2004-2009.

# Effective use of color schemes is conducive to improve working conditions and work safety?

## 有效的配色方案可以改善工作環境並提升工作安全？

Aim (目的):

- Explore how a color scheme can help reduce accidents with specific focus on falling to a lower level and falling to the same level

探討如何通過配色方案以減少意外，尤其是高處墮下或在同一高度跌倒的意外

Suggested Color Scheme for reducing perception-related accidents in construction work sites (Yi et al. 2012)





配色方案以減少感知力退化造成的建築工地意外

- Five objects related to **fall accidents** selected:  
與墮下意外相關的五種物件：
  - Workwear 工作服
  - Safety net 安全網
  - Gondola 吊船
  - Scaffolding 棚架
  - Safety passages 安全通道
- 研究人員和相關部門開展一系列的研討會活動, 提出並評估考慮顏色匹配及可見性

- 色彩專家，總承包商和分包商
- 參與結構化訪問和討論
- Questions(問題):
  - Color conspicuity 色彩醒目度/可見性
  - Visual fatigue 視覺疲勞
  - Other cognitive issues 其他認知問題
  - Potential issues when applied to sites 應用於工地時存在的潛在問題



# Results: Color scheme for workwear 工作服的配色方案

		Case 1	Case 2
Pict- ures	Before 之前		
	After 之後		
Color palette			

- Participants' response: 參加者意見
  - The suggested color changes would create **psychological comfort**  
改進後的色彩設計能夠**提升心理舒適度**
  - The stimulating attributes of red and yellow **enhance agility**  
紅色和黃色的刺激屬性可以**提高工人的反應敏捷度**

# Organizational Ergonomics 組織工效學

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- Aging workforce 勞動力老化
- Most skilled and experienced 技術精湛且經驗豐富
- Solve the manpower shortage 解決勞動力短缺問題
- Age-related injuries? 年齡相關的傷害?



# Healthy Work in an Ageing Europe

## European Network for Workplace Health Promotion

### 老齡化歐洲的健康工作

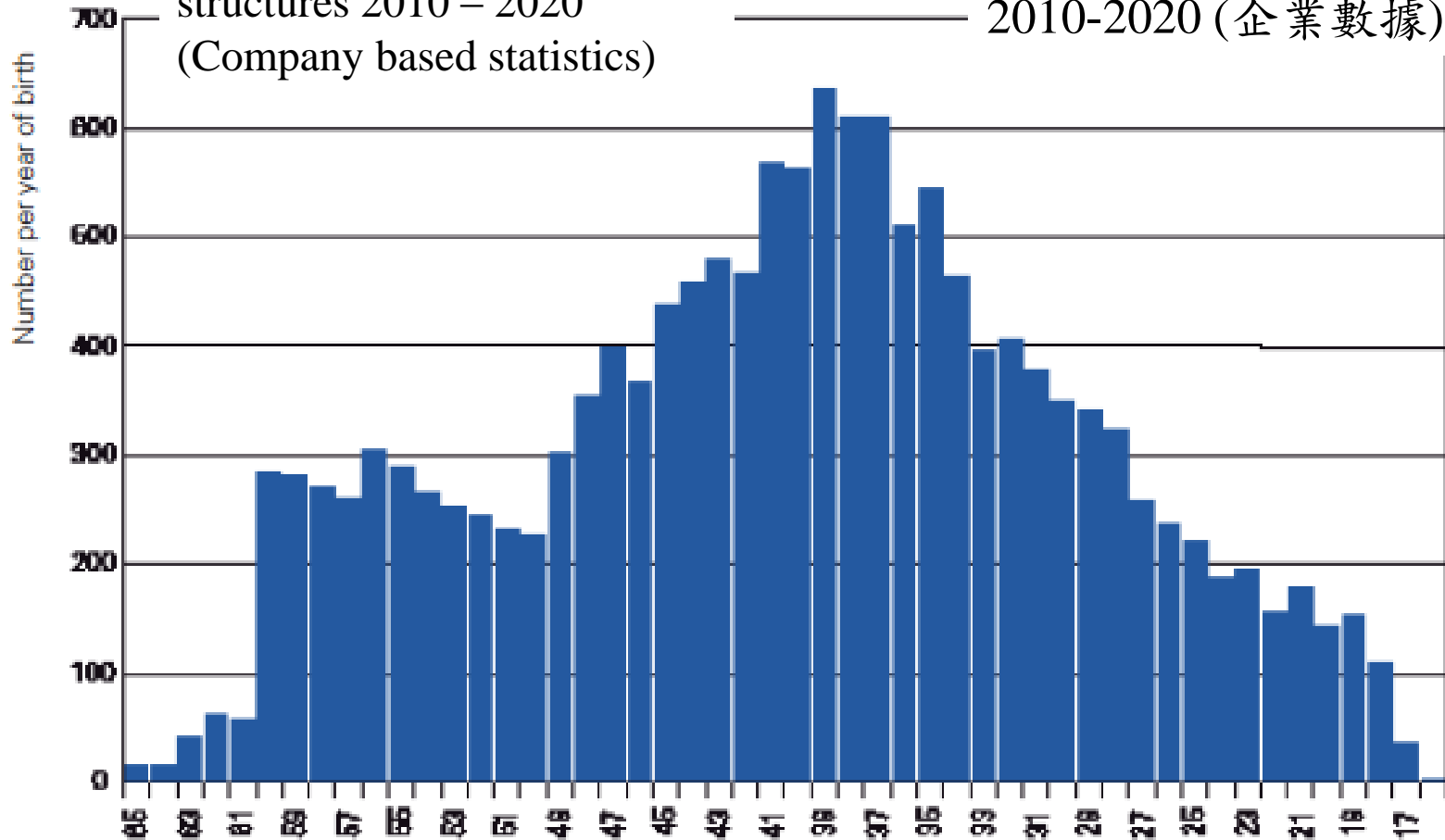
歐洲工作場所健康促進聯盟

(Morschhäuser and Sochert 2006)

# (1) Age Structure Analysis 年齡結構分析

Example: Comparison of age structures 2010 – 2020  
(Company based statistics)

例子: 年齡結構比較  
2010-2020 (企業數據)



## (2) Checklist to identify the need for actions 行動需求清單

### Workplace health promotion and integration

Certain workplaces and work areas in our company are "age-critical" (e.g. physically demanding work, cycle-dictated work, activities with high levels of pollution in the working environment).	<input type="checkbox"/>	yes
	<input type="checkbox"/>	no
We take positive action to reduce working exposures and to promote the health of the employees (e.g. ergonomic workplace design, organisation of health workshops, back school).	<input type="checkbox"/>	yes
	<input type="checkbox"/>	no
Work is performed at our company in shifts in some cases (alternating or night shifts).	<input type="checkbox"/>	yes
	<input type="checkbox"/>	no
We enable older workers, after doing night shift for many years, to stop working shifts.	<input type="checkbox"/>	yes
	<input type="checkbox"/>	no

### 工作場所健康促進與整合

工作場所或工作區域的年齡關鍵性（例如：高強度體力工作，週期性工作，工作環境污染較嚴重的工作）。

我們採取積極措施以減輕工作風險並促進員工安全（例如：人因化工作場所設計，組織健康研討會）。

我們公司的工作有時要求輪班。

夜班工作幾年後，我們允許年長工人停止輪班。

We organise the shift work to create as little impact on health as possible (planning of shift sequences, location, duration and distribution of the working time according to health criteria).	<input type="checkbox"/>	yes
	<input type="checkbox"/>	no
We organise the workflows and work deployment in such a way that older workers schedule their work themselves and can therefore largely dictate their work rhythm themselves.	<input type="checkbox"/>	yes
	<input type="checkbox"/>	no
We have sufficient information on the state of health of the workforce and possible approaches to promote health at the company.	<input type="checkbox"/>	yes
	<input type="checkbox"/>	no
Our company has a systematic in-house integration and case management (existence of an integration team, regularly applied tools, systematic data surveys, case management, deduction of preventive action)	<input type="checkbox"/>	yes
	<input type="checkbox"/>	no

我們合理安排輪班，以盡量減輕對健康的影響（規劃輪班的順序，地點，時長，以及根據健康標準分配工作時間）。

我們合理安排工作流程和發展，保證年長工人能夠自行編制工作計劃及掌控工作節奏。

我們掌握足夠的員工健康信息並且制定了健康提升計劃。

我們公司有系統的內部整合及個案管理機制（擁有整合團隊，有規律的應用工具，系統數據調研，個案管理，預防行動）



### (3) Work Ability Index (工作能力指數) (Tuomi et al. 1998, Ilmarinen 2007)

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- A tool for occupational health researchers and practitioners to **predict sickness absence** (Alavinia et al. 2009) and **disability for ageing workers** in the construction industry (Burdorf et al. 2005)

一個可以被職業安全研究員用於預測建造業年長工人病假及傷殘的工具

- **How good** are the workers **at present** and in the **near future**, and **how able** are they to do their work with respect to **work demands, health, and mental resources**?

工人當前及近期的表現如何？在工作需求、健康、腦力/智力資源方面，他們能否勝任工作？

- Findings may be useful for **formulating strategies** in assessing and improving aged construction workers' work ability for solving the labor shortage problem

研究結果有利於制定措施，以評估和提升年長工人工作能力，並解決勞動力短缺的問題。

- **Hong Kong?**

## Work Ability Index (工作能力指數)

項目	數值
1. Current work ability compared with the lifetime best 和最佳時期相比，當前的工作能力評分是	0-10
2. Work ability in relation to the demands of the job 工作能力和工作需求相比，評分是	2-10
3. Number of current diseases diagnosed by physician 被醫生檢測出的疾病數目	1-7
4. Estimated work impairment due to diseases 評估疾病對工作能力的損害	1-6
5. Sick leave during the past year (12 months) 過去一年（12個月）的病假	1-5
6. Own prognosis of work ability two years from now 對兩年後的工作能力自評	1-7
7. Mental resources腦力/智力資源評分	1-4

Range (數值範圍): 7 - 49

## Work Ability Index (工作能力指數)

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Points (數值)	Category (分類)	Work Ability Action (工作能力行動)
7 - 27	Poor (差)	Restore work ability恢復工作能力
28 - 36	Moderate (中)	Improve work ability提高工作能力
37 - 43	Good (好)	Support work ability支持工作能力
44 - 49	Excellent (極好)	Maintain work ability保持工作能力

## (4) Workshop – Work, Age, and Keeping Healthy (工作坊 - 工作、年齡、保持健康)

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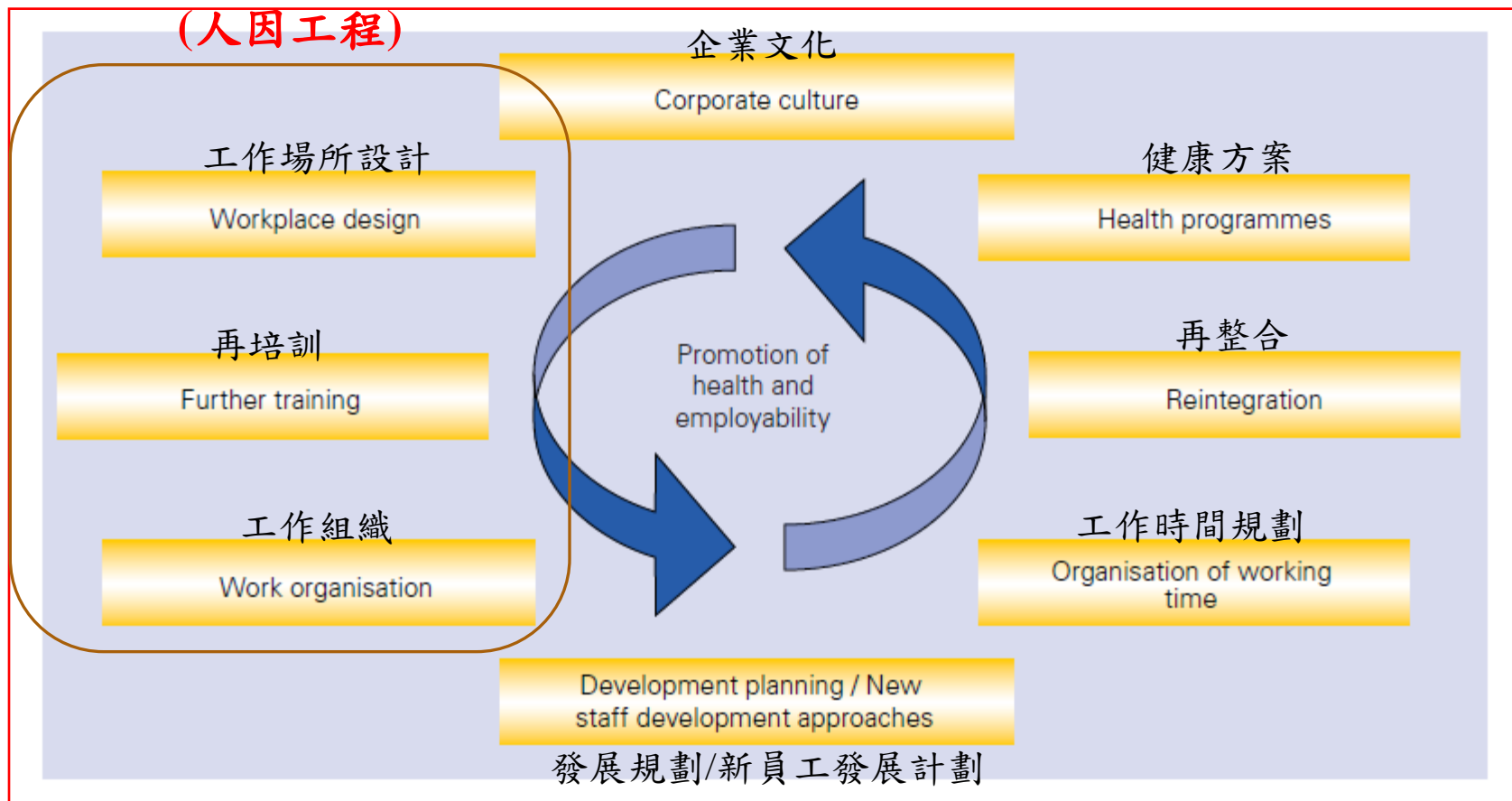
Systematically organised group discussions for :

系統地組織關於以下問題的小組討論：

- sensitising different groups of players and functions to the ‘age issue’  
向不同參與者和功能機構傳輸老齡化相關問題
- reflecting on connections between age, health and working conditions  
思考年齡、健康和工作環境間的聯繫
- ascertaining difficulties which stand in the way of ‘healthy ageing’  
探討健康老齡化道路上的困難
- develop initial solutions for promoting the health and employability of older and ageing employees  
制定提升年長僱員健康和就業能力的初步解決方案

# Action plan for an age-appropriate labour 為年齡合適的勞動力制定行動計劃

## Human Factors





## Physical Ergonomics 物理工效學

- *work postures*  
工作姿勢



- *workplace layout*  
工作場所布局

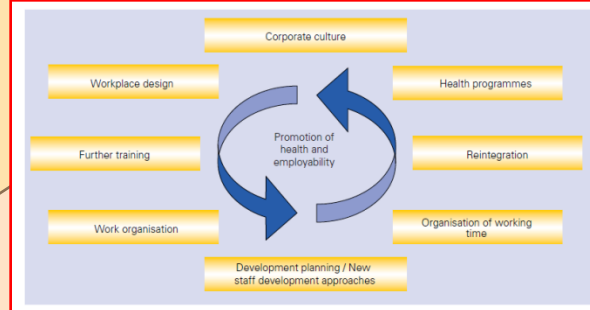
## Cognitive Ergonomics 認知工效學

- *mental workload*  
腦力負荷

		Case 1	Case 2
Pictures	Before		
	After		
Color palette			

- *training* 培訓

- *workforce management*



社會科技系統

## Organizational Ergonomics 組織工效學

**Thank you!**  
謝謝!

