Research Assessment Exercise 2020
Impact Case Study

University: The University of Hong Kong
Unit of Assessment (UoA): 18 – Planning and Surveying (land and other)

Title of Case Study: Managing Heat Stress on Construction Sites

(1) Summary of the impact

Hong Kong's hot and humid summer climate severely compromises the safety, health and well-being of construction workers. Every year, hundreds of workers are affected. Professor Steve Rowlinson's (SR) research in 2010-12 led to enhanced working conditions for the city's 250,000 construction workers. The daily 8-10-hour work regime with a 45-minute lunch break and a 15-minute afternoon break has been adjusted and the previously limited facilities improved. Now there are more and longer rest breaks, nurses stationed on site, the provision of cool water around the site and rest stations with shelter and fans so that workers can rest, cool off and recuperate. As well as inspiring and guiding these life-changing benefits for Hong Kong's aging construction workforce, HKU's research has also provided the basis for the development by Chongqing University of the first heat-stress standards for China.

(2) Underpinning research

The research underpinning this impact was commissioned by the Construction Industry Council (CIC) in 2010, but it was informed by a long record of construction health and safety research at HKU. Informed by the HKU team's field investigations and supporting published research **[d, e, f]**, the CIC published its own revised guidelines for heat stress management for the Hong Kong construction industry in 2013 **[9].** The multidisciplinary research team undertook two years' fieldwork on 34 construction sites in diverse locations in Hong Kong in 2010-2012. 216 construction workers were individually monitored all-day over two working days (all results being reported to the CIC Task Force on hot weather working). Data were recorded measuring air temperature, humidity, radiant heat, wind speed, metabolic heat generated whilst working and workers' "clothing effect". These data were used to validate a predicted heat strain (PHS) model and when combined with atmospheric readings, produced a series of limits for continuous work time. In this way, environmental thresholds were produced defining "safe work limits" and "work-rest" regimes **[e]**.

The study also identified the range of exposures that led to heat-related illness. Twenty-six reported cases of heat stress in participating workers were analysed and effective interventions against heat stress formulated and recommended. A robust theoretical basis was developed to define the climatic heat and psychosocial risks present in the cases and the relationships between risks, timing and effectiveness of interventions. This theoretical model was then used to guide content analysis of a further 36 individual onsite heat illness cases to identify critical risks. The results indicated that heat stress risks can be handled in three ways: control of exposure through an action triggering threshold system; control of continuous work time with mandatory rest regimes; and enabling self-paced working through worker empowerment **[b]**. The role of management infrastructure as a basis for effective engineering and management interventions was highlighted in the research outputs **[e]**.

In a follow-up study, Koh and Rowlinson found that workers were reporting a reduction in the feelings of heat stress that they previously suffered due to improvements in their working conditions **[f]**. Furthermore, the researchers' heat stress findings have led to the questioning internationally of the methods routinely used to assess heat stress **[d]** and the protocols for managing heat stress **[e]**. Further analysis of the data has produced an institutional model of safety management systems **[a]**. Thus, as well as benefitting Hong Kong workers directly, an informed debate into heat stress, worker wellbeing **[c]**, and institutional barriers to improvement, has been stimulated in the global construction industry and research community.

(3) References to the research

[a] Jia, Y. A., Rowlinson, S., Loosemore, M., Xu, M., Li, B., and Gibb, A. (2017) 'Institutions and institutional logics in construction safety management: the case of climatic heat stress', *Construction management and economics*, *35*(6), pp.338–367. [DOI: 10.1080/01446193.2017.1296171]
[b] Jia, Y. A., Rowlinson, S., and Ciccarelli, M. (2016) 'Climatic and psychosocial risks of heat illness incidents on construction site', *Applied ergonomics*, *53*, pp.25–35. [DOI: 10.1016/j.apergo.2015.08.008]
[c] Rowlinson, S., and Jia, Y. A. (2015) 'Construction accident causality: An institutional analysis of heat illness incidents on site', *Safety science*, *78*, pp.179–189. [DOI: 10.1016/j.ssci.2015.04.021]
[d] Rowlinson, S., and Jia, Y. A. (2014) 'Application of the Predicted Heat Strain (PHS) model in development of localised thresholds-based heat stress management guidelines for the construction industry', *Oxford Journal - Annuals of Occupational Hygiene*, 58 (3), pp.326–339. [DOI: 10.1093/annhyg/met070]
[e] Rowlinson, S., Jia, Y. A., Li, B., and ChuanjingJu, C. (2014) 'Management of climatic heat stress risk in construction: a review of practices, methodologies, and future research', *Accident Analysis and Prevention*, 66, pp.187–198. [DOI: 10.1016/j.aap.2013.08.011]
[f] Koh, T.Y., and Rowlinson, S. (2016) 'Heat Stress on Hong Kong Construction Sites – the impact of new guidelines on workers' health & safety' (presented at Half Day Workshop at the Lighthouse Club Annual Conference 2015 and reported under "Hot Weather Relief for Labourers" on HKU Knowledge exchange website https://bit.ly/2kqocQs accessed 23/8/2019)

Research grants awarded:

- Rowlinson, S. (PI), *Management of Heat Stress in Construction Workers during Hot and Humid Weather*, Contract Research commissioned by the CIC, Hong Kong, 2010 – 2013 (HK$720,000).
- Rowlinson, S. (PI), *Lowering the Curve - Construction Site Safety Improvement: Culture's Consequences*, HK RGC General Research Fund (GRF), 2014 – 2017 (HK$500,000).
- Rowlinson, S. and Smyth H. (Co- PIs), *A Comparison between Hong Kong and UK of the Health, Safety and Wellbeing Environment in Construction: Issues of Culture, Systems and Procedures in Changing Environments*, HKU-UCL Strategic Partnership Fund, February 2018- (HK$100,000).
- Rowlinson, S. and Liu, H. (Co- PIs), *Managing Thermal Stress on Construction Sites: a Prototype Risk Management Tool*, Fund for International Cooperative Innovation in Low-Carbon & Green Buildings, Joint International Research Laboratory of Green Buildings and Built Environments, Ministry of Education, P. R. China, October 2018- (RMB185,000).

(4) Details of the impact

Heat stress is a serious safety risk on construction sites in the hot and humid summer of Hong Kong. It requires management and workers to make adjustments to work procedures and processes at all levels of the construction site. However, in the first decade of this century the guidelines provided to the industry and the practices implemented, were inadequate. In 2010 and 2011, HK's Legislative Council (LegCo) raised heat stress as a serious Occupational Health, Safety and Wellbeing (OHSW) issue in Hong Kong **[1]**. In 2011, the Rebar Workers' Union and Hong Kong Confederation of Trade Unions reported a survey result indicating that 30% of rebar workers experienced heat illness on site **[2]**. Rebar workers subsequently protested, demanding improvement in conditions and drinking water provision on site. Awakened to this issue, the **CIC established a Taskforce under the Safety Committee and commissioned SR's research team at HKU to conduct a major research project to advise on improvements to the heat stress management guidelines for the Hong Kong construction industry**. The research team corroborated the LegCo and the Union complaints in a site-based survey of 216 workers that found almost 30% of construction workers on the studied sites reported heat illness cases.

On completion of the site study the issue became one of persuading committee members that urgent action was required. There was resistance from the institutional stakeholders to such a radical change to work procedures and processes and qualms about the implications for productivity. After a period

of procrastination, *[confidential content removed]* strode out of the meeting saying "if the committee is not going to mandate this then I will. *[confidential content removed]* will implement these measures next week." That one single declaration pushed the committee into accepting the scientific evidence and the proposed interventions on construction sites. The drafting of the guidelines was facilitated by a respected long-time champion of HK construction site safety, *[confidential content removed]*, based on discussions at the CIC Task Force and on HKU's reports. **The resulting "Guidelines on Site Safety Measures for Working in Hot Weather", issued by the CIC in 2013, were arguably the world's first evidence-based, construction-specific guidelines for heat stress management. Construction industry practice has significantly changed since their publication** [3]. As reported in [e] and [f] and stated in [4] and [5] the research and its dissemination significantly changed formal and informal practices in HK's construction sector, with a significantly increased focus on workers' wellbeing. All major contractors now have their own on-site nursing staff that workers can consult should they feel distressed [4] and [5]. As can be seen in [3], the HKHA saw its accident rates and fatality rates fall to almost zero and this low level has been maintained. Furthermore, analysis of data from a general medical check of all participants before they took part in the study highlighted important demographic issues. The study confirmed that the workforce is ageing (average age over 50), exhibiting hypertension, pre-diabetes, high Body Mass Index (BMI) and other conditions related to eating, smoking and drinking habits. The reporting of this evidence to the Task Force led MTRC to commission a survey of almost 2000 workers in 2013 and again in 2014 to corroborate the initial findings from our heat stress study and this led to a whole range of health and wellbeing measures introduced on construction sites in Hong Kong including the provision of site nurses. In a follow-up study in 2014-15, Koh and Rowlinson found in a survey of 250 workers a reported reduction in heat stress incidents, which subjects attributed to the range of new measures implemented based on the guidelines [f].

Hence the impact of the Guidelines is clear from individual commentaries and further research by the HKU team, with corroboration from safety performance data from HKHA, MTRC, and others. The Guidelines arising from HKU's research should be seen as an important part of the institutional infrastructure governing more healthy working practices in HK. **The primary impact of the HKU team's research has been to change the rules governing practices and management attitudes to OHSW and thereby safeguard workers' health and well-being.** Secondary impacts on changed practices and worker health are evidenced by, among other sources, the team's follow-up study and its on-going collaboration with major contractors. The studies have led to long-term collaboration with many of the leading players in the industry such as Gammon Construction Company and MTRC. **The guidelines are now mandated by the HKHA [3] in all public housing projects in Hong Kong. The MTRC has also implemented the guidelines,** extending lunchtime breaks on its construction sites by 15 minutes and introducing a morning break of 15 minutes for workers to rest in air conditioned or fan assisted cool areas and so reduce core body temperature and the effects of heat stress. The extended lunchtime break for MTRC workers reduced accidents that previously peaked between 2 and 3pm due to fatigue from continuous work, heavy lunch and inadequate rest [4]. The research team conducted over 30 workshops and disseminated its knowledge during fieldwork on over 40 construction projects, improving awareness of heat stress prevention among workers, supervisors and managers. Related **facilities, such as the provision of drinking water, ventilated and air-conditioned rest areas and sun shelters have become the norm on construction sites since the publication of HKU's research report** [5]. Implementation of the guidelines is used as an assessment criterion in the Hong Kong Government Development Bureau (DEVB) and the Hong Kong CIC's Considerate Contractors Site Scheme [6]. In the non-public sector, **HK's major private contractors took the initiative to voluntarily implement the guidelines in their practices [5] and** [7]. At an informal level, HKU's knowledge exchange workshops and the ethnographic fieldwork raised heat stress awareness among workers, managers and the general public. Appropriate facilities and safety measures are now common practice on site [8].

Former HKU PhD students who worked with Professor Rowlinson are transferring this knowledge

to other parts of the world where heat stress is also a major issue for construction workers. Dr Andrea Jia, who moved to Curtin University, furthered the research and disseminated HKU's research findings in Australia. The research has also informed climate change adaptation policies in Australia and regional development strategies in the Northern Territory, through the work of the Northern Institute at Charles Darwin University. **Chongqing University has used HKU's methods to question the validity of the ISO PHS model used for measuring heat stress in the Chinese population** **[d]**. Professor Rowlinson was presented with the Golden Helmet Award for Construction Safety Leadership at the CIC and Lighthouse Club Annual Safety Awards 2015. **The award is given to one person annually for their contribution to leading change and improvements to safety in the Hong Kong construction industry** and is given as a mark of respect and a token of honour for many years of leadership in significantly influencing safety practices in the industry. Never before has this been awarded to an academic.

(5) Sources to corroborate the impact

[1] Legislative Council meeting minutes, a) LC Paper No. CB(2)680/08-09(04), paras 18-19 and b) LC Paper No. CB(2)2044/10-11(12), paras 24-26.
[2] Hong Kong Confederation of Trade Unions, 18 July 2012. [https://bit.ly/2kiEDhw] (accessed 23/8/2019).
[3] *[confidential content removed]* (Chairperson of CIC Safety Committee; Deputy Director of Housing, HKHA) speech at CIC Seminar: Site Welfare, Health and Safety Measures on New Works Contracts of Hong Kong Housing Authority, 17 March 2017. Slides 6,7,9,10, 13- 17 [https://bit.ly/2mQDvTg] (accessed 23/8/2019)
[4] MTRC letter – attached
[5] Gammon letter – attached
[6] DEVB/CIC (2019) 26th Considerate Contractors Site Award Scheme Jointly Organised by Development Bureau and Construction Industry Council Guideline for Non-Public Works Site Participation. Development Bureau and Construction Industry Council. See 21 (g) ii Appendix V [https://bit.ly/2ksgfu8, PDF] (accessed 23/8/2019)
[7] Contractor's self-initiative on implementing the guidelines are documented in Chuanjing Ju, PhD thesis: A study of institutional complexity and contractors' safety management strategies, University of Hong Kong [http://dx.doi.org/10.5353/th_b5543991] (accessed 23/8/2019)
[8] This is documented in four unpublished research reports "Management of Heat Stress in Construction Workers during Hot and Humid Weather" (Report 1: Inception Report; Report 2: Preliminary Findings; Report 3: Review of Practice on Site; and Report 4: Scientific Base of the Updated Guidelines) the HKU research team made to CIC. Part of the evidence was published in **[a]**
[9] Construction Industry Council (2013) Guidelines on Site safety Measures for Working in Hot Weather, Construction Industry Council, Hong Kong, April 2013. [https://bit.ly/2JVXSo0, PDF] (note, Ver 2, updated April 2013, accessed 23/8/2019)