

An Update on Global Comparisons of Design for Construction Safety and Health among the United Kingdom, Singapore, South Korea, and United States

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Abstract: Construction is one of the world's biggest and the fastest growing industrial sectors, accounting for about 5% of GDP in developed countries and 8% of GDP in developing economies. In 2022, the global construction industry was valued at \$14.4 trillion which was 14.2% of the global GDP. From 2022 to 2032, global construction is expected to grow 6.2% annually due to: infrastructure development by governments; increases in green construction and industrialization. The construction industry in 2022 was the leading US industry accounting for 21.6% US GDP. But, the construction industry is one of the most dangerous industries, and has a disproportionately high rate of recorded industrial accidents (BLS, 2022). According to International Labor Organization [ILO] 2015, at least 108,000 construction workers are killed on site every year, which is approximately 30% of all occupational fatal injuries. Several countries implemented the Construction Design and Management (CDM), Design for Safety (DfS), and Prevention through Design (PtD) to alleviate the risks of fatal and non-fatal injuries in the design phase of construction projects. United Kingdom's (UK) fatality rate in 2010 for all industries was about 1/3 the US all industries fatality rate and the UK's construction fatality rate was 1/4 the US construction fatality rate. European Union (EU) countries' fatality rates were almost as low as the UK rate (Mendeloff, & Staetsky, 2014). Several other EU members had rates almost as low as the UK rate. How can the differences be explained? There are many contributing factors reported in the literature. This paper reviews and discusses the global comparisons of CDM, 2015 (United Kingdom), DfS (Singapore, South Korea), PtD (United States) initiatives and their effectiveness in controlling work site injuries and fatalities in the construction sector.

Keywords: Design for Safety, Global Comparisons, Construction Design and Management, Prevention through Design, Safety and Health

1. Introduction/Background

The construction workforce in Britain is claimed to be more stable, more experienced and less risk taking. Britain has tougher fall protection rules than those in the U.S. where falls account for a large percentage of construction fatalities. Government-funded construction, which may be safer and may more closely follow safety regulations, is a larger share of construction in Britain than in the U.S. For example, [the](#) 2012 construction of London's Olympic Park

was one of Britain's safest projects (Schneider, 2014). Oyegoke (2001) studied similarities and differences between the American and British Construction Management systems including the distribution of responsibilities and risks in both the pre-construction and during the construction stages. The main provision of Britain's Health and Safety at Work Act (HSW Act) states employers have the legal responsibility for the safety and health of their employees and others but most of their duties are expressed as goals or targets which are to be met "so far as is reasonably practical" or through exercising "adequate control" or taking "appropriate and reasonable" steps (HSE-49, 2013).

2. PtD, DfS, and CDM

2.1 Prevention through Design (PtD)

Since the mid-1990s, Prevention through Design (PtD) has become increasingly prevalent in the U.S. construction industry. The acceptance of PtD has largely been due to the removal or reduction of risks during the design development and execution phase of construction projects. PtD, also called Safety by Design or Design for Construction Safety & Health (DfCSH), is the concept of applying methods to minimize occupational hazards early in the design process, with an emphasis on optimizing employee health and safety throughout the life cycle of materials and processes. It is a concept and movement that encourages construction management/engineers or product designers to "design out" health and safety risks during project concept or design development. The PtD concept or approach supports the view that along with quality, program and cost; safety & health are determined during the design stage. It increases the cost-effectiveness of enhancements to occupational safety and health. This method for reducing workplace safety & health risks lessens workers' reliance on personal protective equipment, which is the least effective of the hierarchy of hazard control. PtD is on a "life cycle design" approach to building construction with the aim of mitigating or preventing injuries, illness, and fatalities throughout the entire process including operation, maintenance, retrofit and demolition (ASSP TR-A10-100, 2018).

2.2 Design for Safety (DfS)

The Singapore government and the industry started to become interested in the concept of Design for Safety (DfS) in the 1990s when the UK Construction (Design and Management) Regulations was implemented. However, more concrete actions only started in 2008 when the "Guidelines on Design for Safety for Building and Structures" was published by the Workplace Safety and Health Council (WSHC, 2018). At that time, DfS was promoted as a voluntary risk management process that developers and designers can utilize to collaboratively improve design to prevent workplace accidents and ill health across the lifecycle of a structure. Subsequently, the WSHC launched DfS Coordinator course in 2010 and the DfS Recognition Scheme in 2011. The training course aims to produce a group of trained coordinators to guide the DfS review processes in the industry and the DfS Recognition Scheme is meant to recognize developers and projects that implemented DfS. Furthermore, the 2014 policy document, "Implementing WSHC 2018 for the Construction Sector in Singapore" emphasized DfS as an important approach improve construction safety and health. However, the voluntary approach did not appear to motivate the industry to adopt DfS. After a series of serious construction accidents in 2014, the Singapore Ministry of Manpower decided to enact the DfS Regulations in 2015 and enforce it from 2016 onwards (WSHC, 2018). The mandatory requirements for DfS apply to all projects with a contract value exceeding S\$10 million. The requirements were focused on developers and designers, with the developers taking on most of the duties.

Construction sites in South Korea are subject to two laws related to the implementation of safety and health. One is Construction Technology Promotion Act (CTP Act) managed by the Ministry of Land, Infrastructure, and Transport. The other is the Occupational Safety and Health Act (OSH Act) managed by the Ministry of Employment and Labor. Construction safety and health policies have been changing steadily to involve all stakeholders in safety and health management systems since 2010. Among newly introduced safety systems, a distinctive system that differed from the existing safety systems was the mandatory implementation of the DfS. South Korea's Ministry of Land, Infrastructure, and Transport benchmarked the DfS system in Singapore and the U.K. in 2016 to implement it. The DfS in South Korea focuses only on accident prevention in the construction process, whereas the original concept of DfS also covers the maintenance stage.

2.3 Construction Design Management (CDM)

In Europe (UK), clients, designers (architects and engineers), and contractors involved with construction work all have health and safety responsibilities to consider before starting work. For instance, designers are legally bound to “*design out*” health and safety risks during design development to reduce or eliminate hazards in the construction and end use phases via the Mobile Worksite Directive (also known as Construction Design and Management (CDM) regulations in the UK (CDM, 2015). The PtD concept principally supports this legal requirement. Some Notified Bodies provide testing and design verification services to ensure compliance with the safety standards defined in regulation codes such as the American Society of Mechanical Engineers (ASME). Many non-governmental organizations have been established to support this aim, principally in the U.K., Australia and the United States (ECPE, 2022). In turn, based on the European statistical office (Eurostat), the UK consistently shows one of the lowest rates of fatal injury compared to countries across the EU. In 2018, the UK standardized rate of 0.61 per 100,000 employees, was among the lowest of all European countries (HSE, 2022).

European States have had the added impetus of national legislation (Aires & Gámez, 2015). Britain has significant rules that do not exist in the U.S., such as the “Construction Design and Management” Regulations (CDM, 2015), which place obligations on designers and architects to include safety in a project’s design stage, as well as throughout the construction processes (e.g., planning and risk assessments). For instance, European (UK) regulations require each company to do a safety and health risk assessment and address those risks. More specifically, CDM (2015) aims to improve safety and health by:

- Establishing a sensible work plan so risks are managed from start to finish,
- Having the right people for the right job at the right time,
- Coordinating all worksite work,
- Providing the correct risk information and how they should be managed,
- Communicating this effectively to all those involved,
- Consulting/engaging with workers about worksite risks and the mitigation.

The principal implication of CDM 2015 is that the person or business for whom the construction services are carried out, ‘the client’, is accountable for health, safety and welfare on the project (CDM Regulations, 2015). Property owners appointing professionals to perform maintenance work will face additional costs from designers and contractors for this added work and responsibility. It has been estimated that a small project, completed in less time than the 30-day threshold, could add 10-20 per cent to a project’s cost (CDM Regulations, 2015).

3. Summary of comparative analysis of CDM, DfS, and PtD

Table 1 provides a summary of comparisons Construction Design Management (CDM), Design for Safety (DfS), and Prevention through Design (PtD). Seven criteria (pertinent area/goal, application phase, design change requirements, collaboration among stakeholders, expert involvement, alternative design appraisal, and design support tools) were employed for the global comparative analysis of CDM, DfS, and PtD, respectively.

Table 1. Summary of comparative analysis of CDM, DfS, and PtD.

Criteria	U.K. (CDM)	Singapore (WSH/DfS)	South Korea (DfS)	U.S. (PtD)	NOTES
Pertinent Area/Goal	Specific requirement I: When the construction working day is more than 30 days and the workers are more than 20 at the same time.	When contract sum is greater than S\$10 million.	DfS concept: Applicable in design stage to prevent workers’ accident. It is applicable to public construction.	Prevention through Design (PtD) concept: Applicable principles at the entire life cycle (concept, design, production, operation, dismantle /disposal).	CDM 2015: Health and Safety Executive (HSE) must be notified of the project by the client (Form 10 rev). “A quick guide for clients on CDM 2015” (https://www.hse.gov.uk/pubns/indg411.htm).

	Specific requirement II: The annual construction workers exceed 500-person days in total.				
Application Phase	<u>Phase I:</u> Identification of the major hazards during the design phase. <u>Phase II:</u> Reflection of the risk at design phase by safety experts. <u>Phase III:</u> Consideration of the unremoved risk at the design phase during the pre-construction phase.	Earliest opportunity from the planning and design phases onwards.	Conduct the review in the whole design process. The report is made by at the end of design stage.	<u>Phase I:</u> Conduct the review from the beginning of the concept or design phase. <u>Phase II:</u> Conduct the review from design phase is 30%, 60% and 90% complete.	PtD is applicable to the entire life cycle of product or project. CDM focus on preparations and hazard/risk assessments/removal at or during design phase.
Design Change Requirements	Mandatory/compulsory modification as per CDM requirements.	Developers and designers must eliminate foreseeable design risks. If it is not reasonably practicable to eliminate the design risks, developers and designers have to work collaboratively to reduce the design risks to as low as reasonably practicable.	Only applicable in the design stage. The design change in the construction process do not apply DfS.	Recommendation or guidance for consideration.	PtD is a guidance vs. CDM is compulsory for design changes.
Collaboration among Participants/ Stakeholders	Mandatory sharing the information among the participants (managed by: principal designer and/or principal contractor).	Mandatory sharing of information and collaboration through DfS review meetings and DfS register (managed by developer, who can delegate the duty to a DfS Professional).	The owner and designer should participate in DfS.	Stakeholders or participants are recommended to participate in the entire life cycle.	PtD concept strongly encourage the participants of all the stakeholders, but not mandatory unlike CDM
Expert Involvement	Principal designer is assigned as facilitator, considering using specialist who is familiar with the necessary precautions, etc.	Developer or DfS Professional is to facilitate the DfS review process and manage the DfS register.	It is recommended to involve safety experts.	Little or none unless otherwise voluntarily.	PtD is voluntarily vs. CDM/client assigns "Principal Designer".
Alternative Design - Appraisal	Change of the design through regular review	Change of the design through regular review throughout the project, in	The owner has a duty for managing DfS. The approval of	Contractor should perform risk analysis when working	PtD is "design out" approach, vs. CDM requires regular

	at the design and/or construction phases.	particular the planning and design phases.	alternative design is done by the owner.	design is 30% complete of the project.	reviews thru risk assessments.
Design-Support Tools/Resources	Accessible resources and toolkits: Checklists for clients, principal designers, contractors, principal contractor, and general safety plans and requirements.	Accessible resources and toolkits: Checklists and guidelines for developers and designers; library of solutions provided by industry association; approved training conducted by industry associations.	The DfS manual provided the sample and form. KALIS operates the DfS system for supplying the information of the review process. (https://www.csi.go.kr)	Available resources and tools: design review checklists, risk assessment pro forma, various database of safe designs, design risk calculators.	PtD design has ample resources and guidance provided by NIOSH. (www.cdc.gov/niosh/topics/ptd/pubs.html) CDM related resources and toolkits are available by HSE and various consultants.

4. Discussion

This paper compares the evolution and effectiveness of various global “national design initiatives” to prevent serious injuries and fatalities in construction sectors. All in all, the findings can help better understand the prevention through design (and design for safety & health) challenges and opportunities for the construction industry, stakeholders, business decision-makers, and potential safety policy or regulation initiatives.

For instance, the following may have a positive effect increasing the application of PtD on US construction projects.

1. On March 15, 2024, US Army Corp of Engineers (US ACE) updated the EM 385-1-1 changing its title from 2014 version entitled “Safety and Health Requirements Manual” to its 2024 “Safety and Occupational Health Requirements”. This clarifies to contractors that EM 385 are Safety and Health “work” requirements, not merely an informational “manual of the safety and health requirements”. EM385 was first published in 1941, prior to and more stringent than OSHA 1970. (EM385-1-1 2014, EM385-1-1 2024). Consequently, “the U.S. Army Corps of Engineers takes pride in our outstanding safety record which falls far below the national average for accidents both construction and O&M related” (US ACE Mobile Website, nd)
2. In support of the US ACE EM 385-1-1 update, the OSHA Education Center (2024) has developed and offers four training courses for military contractors and government employees i.e. 16/24/40 Hour Courses and 8 Hour Refresher Course. Hopefully these courses will be available to the general construction industry.
3. On June 28, 2024, the US Supreme Court overturned the 1984 landmark case of Chevron vs Natural Resources Defense Council (cited more than 18,000 times in federal lawsuits) which required judges to give “deference” to federal agencies to interpret ambiguous federal laws including OSHA (Howe, June 28, 2024; Ferguson, July1, 2024). Authors believe this decision may have a positive effect on the safety and health of worksites since judges can consider company efforts beyond OSHA regulations such as a company’s use of voluntary standards such as ANSI A10 Construction Standards as they do in the UK, EU and other countries.

5. References

- Aires, M. D. M., & Gámez, M. C. R. (2015). The impact of occupational health and safety regulations on prevention through design in construction projects: Perspectives from Spain and the United Kingdom. *Work*, 53(1). DOI:10.3233/WOR-152148.
- American Society of Safety Professionals (ASSP) (2018). ASSP TR-A10.100-2018. Technical Report: Prevention through Design – A Life Cycle Approach to Safety and Health in the Construction Industry. ASSP, Park Ridge, IL, USA.
- Executive and Continuing Professional Education [ECPE] (2022). Harvard University School of Public Health.

- <https://www.hsph.harvard.edu/ecpe/>
EM385-1-1 (2014). US Army Corp of Engineers. Safety and Health Manual.
https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_385-1-1.pdf
EM385-1-1 (2024). US Army Corp of Engineers. Safety and Occupation Health Requirements.
https://www.publications.usace.army.mil/Portals/76/EM%20385-1-1%20_EFFECTIVE%2015March2024.pdf
www.hse.gov.uk/statistics/pdf/fatalinjuries.pdf
Howe, A (June 28, 2024). Supreme Court Strikes Down *Chevron*, Curtailing Power of Federal Agencies. SCOTUSBlog. <https://www.scotusblog.com/2024/06/supreme-court-strikes-down-chevron-curtailling-power-of-federal-agencies/>
Health and Safety Executive [HSE-49] (2013). *A guide to health and safety regulation in Great Britain*.
<https://www.hse.gov.uk/pubns/hse49.htm>
Health and Safety Executive (HSE-2022). Work-related fatal injuries in Great Britain, April 2022 to March 2023.
<http://www.hse.gov.uk/statistics/fatals.htm>
International Labour Organization (ILO) 2015. Construction: a hazardous work.
https://www.ilo.org/safework/areasofwork/hazardous-work/WCMS_356576/lang--en/index.htm
Mendeloff, J. & Staetsky, L. (2014). Occupational fatality risks in the United States and the United Kingdom. *Am J Ind Med.*, 57(1):4-14. doi: 10.1002/ajim.22258.
Oyegoke, A. S. (2001). UK and US construction management contracting procedures and practices: a comparative study. *Engineering Construction & Architectural Management*, 8(5-6), 403-417. DOI:10.1046/j.1365-232X.2001.00222.x.
Schneider, S. (2014). US vs. UK: Who is Safer and Why? <https://www.lhsfna.org/us-vs-uk-who-is-safer-and-why/>.
The Construction Design and Management (CDM) Regulations (2015). Health and Safety Executive (HSE).
<https://www.hse.gov.uk/construction/cdm/2015/index.htm>
U.S. Bureau of Labor Statistics [BLS] (2022). News Release. National Census of Fatal Occupational Injuries in 2021. <https://www.bls.gov/news.release/pdf/cfoi.pdf>.
U.S. Army Corp of Engineers (US ACE Mobile Website, nd). Safety and Occupational Health
<https://www.sam.usace.army.mil/Missions/Military-Missions/Construction/Celebrate-Safety/>
Workplace Safety and Health Council (WSHC) (2018). Guidelines on Design for Safety and Building and Structures. <https://designforconstructionsafety.files.wordpress.com/2018/05/dfs-in-buildings-and-structures-guidelines-nov-08-singapore.pdf>.