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The design coordination role at the pre-construction stage of construction projects

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ABSTRACT

The importance of the concept of prevention through design (PtD) to the alleviation of the problem of poor health and safety (H&S) management in the construction industry is widely acknowledged. It has been adopted in the regulatory framework for H&S in the UK construction industry through the Construction Design and Management Regulations 2015 (CDM 2015) which place on the project client obligations with emphasis on coordination of H&S at the pre-construction stage of the project by a client-appointed 'Principal Designer' (PD). Unfortunately, research into the implementation of CDM 2015 into actual practice at the pre-construction stage has been patchy. The paper reports, with respect to the PD role, on part of research undertaken to respond to this gap. It involved surveys of clients and practitioners via fourteen focus group discussion sessions with over eighty participants to develop knowledge and understanding of the PD role. The research issues included: appointments to the role; structures for discharge of the role; day-to-day functions of the PD; remuneration arrangements; and common challenges regarding the PD.

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Design; health and safety; risk management; collaboration

Introduction

It is considered that most accidents in the construction industry are preventable with better management of design and occupational safety and health (OSH) risk at the pre-construction stage (e.g. Gambatese et al., 2005; Hallowell & Hansen, 2016; Szymberski, 1997; Willumsen et al., 2019). The response of the European Council to unacceptably high levels of accidents on construction projects was the adoption of the Council Directive 1992/57/EEC on the implementation of minimum safety and health requirements at temporary or mobile construction sites (TMCS). This Directive requires the appointment of two types of coordinators for safety and health matters on construction projects that will require more than one contractor on the construction site: a pre-construction phase coordinator (PCPC) and a construction phase coordinator (CPC).

In the UK, since the first manifestation of the PCPC in the form of a 'Planning Supervisor' under the Construction (Design and Management) Regulations 1994 (CDM 1994) which transposed the Directive into UK law, the Health and Safety Executive (HSE) (the UK H&S regulatory authority) has had to respond twice to concerns about the contribution of the PCPC, attempting to change the role each time. About ten years after its implementation, CDM 1994 was replaced with the Construction (Design and Management) Regulations 2007 (CDM 2007) which changed the label 'Planning Supervisor' to 'CDM Coordinator'. CDM 2007 was in turn replaced about eight years later with the Construction (Design and Management) 2015 Regulations (CDM 2015). The key changes made in CDM 2015 are: putting much greater emphasis on the design coordination role of the PCPC and relabelling it 'Principal Designer' (PD); replacement of the requirement for competences of dutyholders with skills, knowledge and experience (SKE) of individual dutyholders and 'organisational capability' where a dutyholder is an organization; and widening the scope of the Regulations to cover, for the first time, domestic clients (individuals undertaking the building, repair or demolition of their homes but and not in furtherance of their business). These changes have met with negative reviews, with a practitioner survey conducted two years after its implementation (Knutt, 2017) revealing that: (i) over 70% were still working to the previous Regulations (CDM 2007); (ii) uncertainty remained about the PCPC role (i.e.

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attributes of the PD dutyholder); (iii) assessment of the SKE of this role still remained a challenge; and (iv) there was reluctance of Architects and Engineers to take on the role of a PD.

What is clear from the foregoing is that, for improvements in OSH performance to be achieved, there is a need to understand better OSH risk management practices during the design and preparation stage of construction projects and how the PD role can be effectively integrated to support them. There is significant variability in the OSH statistics across the EU (Eurostat, 2021), which implies that the system is being operated better in some parts of the EU than in others. As OSH outcomes in the UK are better than in most other Member States (Eurostat, 2021), these challenges experienced in transposing the Directive into national law and assessing the effectiveness of the implementation of national law into practice certainly have resonance across the entire EU.

The paper reports research aimed at developing knowledge and understanding of OSH risk management practices at the pre-construction stage of construction projects, with particular focus on how the CDM 2015 Regulations are implemented in practice. It presents, in seven sections, the findings and conclusions with respect to the H&S coordination role of the PD.

Overview of H&S coordination by the Principal Designer

The CDM Client for a project with more than one contractor is required by Regulations 5(1) and 5(2) to appoint, in writing, a PD as soon as practicable. Regulation 11(1) puts on the PD a duty to 'plan, manage, and monitor' the pre-construction phase and coordinate H&S matters during this phase. During the pre-construction phase, the PD receives from the Client Pre-Construction Information (PCI) which is information in the Client's possession or reasonably obtainable by or on behalf of the Client concerning: the project; the planning and management of the project; and H&S hazards on the site or hazards associated with the design and construction of the project. Regulation 11(6) puts on the PD a duty to assist the Client in providing the PCI to designers and contractors although there is no express requirement on the PD to assist the Client in the preparation of the PCI. Further, the PCI must inform the development of a Construction Phase Plan (CPP) before construction can start. The CPP covers the H&S management arrangements and site rules governing execution of construction work on the site. This task is to be undertaken by the Principal Contractor (PC) who is responsible for the H&S coordination during the construction phase.

A further H&S coordination responsibility of the PD is embodied in the preparation of a Health and Safety File (HSF). From Regulations 12(5) and 12(6), the HSF is intended to be a permanent and live record and must include information relating to the project likely to be needed to ensure the H&S of any person involved on any subsequent project, e.g. maintenance, extension, or demolition of the structure resulting from the prior project. Typical contents of the file may include 'as built' drawings, design criteria, in-built facilities for the maintenance of the building, operating and maintenance manuals for specialist plant and equipment and incoming services.

Literature review

Building on previous reviews (e.g. Zhou et al., 2015), a comprehensive review of literature showed that there have been two overarching categories of research and development (R&D) activities targeted at OSH issues in the construction industry (CI): (i) policy studies commissioned by governments and international organizations (e.g. Donaghy, 2009; Safe Work Australia, 2015); and (ii) investigation of the causes of accidents and ill-health. Accident causation models developed from these research initiatives put into stark relief the multiplicity of the causal factors and the myriad of ways in which poor OSH outcomes can flow from their complex interactions (Gibb et al., 2005; Golizadeh et al., 2018; Reason, 1997). It became apparent that, even if there were a single silver bullet to slay the OSH beast, any attempt to develop it in a single study would be doomed to failure for obvious impracticality. Many research initiatives have therefore examined the impact of particular concepts and factors in respect of OSH risks management. These include: (i) the prevention through design concept which research encompasses the importance and motivation (1997; Behm et al., 2014; Gambatese et al., 2005; Gambatese et al., 2017; Hallowell & Hansen, 2016; HSE, 2015; Lingard et al., 2015; Poghosyan et al., 2018), required tools by designers – including PDs – to meaningfully implement the concept (Cooke et al., 2008; Dewlaney & Hallowell, 2012; Gambatese et al., 1997; Sacks et al., 2015; Zhang et al., 2015; Zhou et al., 2012; Zhou et al., 2013), and the competence requirements of designers and PDs in respect of the concept (Ibrahim et al., 2020; Goh & Chua, 2016: Manu et al., 2019a, 2019b); (ii) culture and unsafe attitudes and behaviours of workers (Grytnes et al., 2020; Lingard et al., 2020; Sherratt et al., 2013); (iii) implementation of regulation and legislation resulting from the policy studies (Aulin & Capone, 2010; Giusti et al., 2016); (iv) corporate criminal liability for OSH (Ndekugri, 2013); and (v)

education and training (Behm et al., 2014; Lopez-Arquillos et al., 2015).

The research undertaken was designed to respond to three areas of gaps in the research literature. First, although the opportunity to take action in the interests of OSH is highest at the pre-construction phase, 90% of construction H&S research has focused on only OSH management practices during the construction stage (Zhou et al., 2015). The second area is knowledge and understanding of how the Directive and national laws implementing it have been translated into practices and procedures on projects and their impact on OSH outcomes. The only reported study into the impact of Directive 92/57/EEC covered only outlines of its transposition into national laws in Member States and changes in accident rates after the Directive came into force (Aires et al., 2010, 2016). Although there has been a proliferation of commentaries by expert practitioners on various aspects of the CDM Regulations in the UK based on reflection on their individual experiences (e.g. Shiplee et al., 2011; Webster, 2013), the literature review uncovered only reports of consultants commissioned by HSE to evaluate the Regulations with a view to appropriate amendments (e.g. Frontline Consultants Ltd, 2012) and empirical studies into the practical implementation of the CDM Regulations (e.g. Atkinson & Westall, 2010; Cameron & Hare, 2008; Webster, 2013).

The principal shortcomings of all these publications are that: they concentrated on compliance with the role requirements of the law at the expense of any detail on what CDM dutyholders actually do on projects; and the Regulations studied have long been superseded. All these sources also highlighted serious shortcomings in the practices and procedures during the pre-construction phases of projects. Particular deficiencies include insufficient focus on client duties; very little real coordination during that phase; inordinate paperwork and bureaucracy motivated more by interests in covering dutyholders' backs against legal liability than effective OSH risk management; recycling of CDM documents from previous projects without customization for risks on specific projects; and little impact on OSH on small projects. The third area of gaps in knowledge concerns how the practices and procedures have changed to meet the requirements of CDM 2015, particularly the design coordination role with focus on H&S at pre-construction phases of projects. The research question reported on in this paper concerned the different arrangements and related professional backgrounds for exercising the PD role and the relative effectiveness of the different arrangements? The sub-questions addressed are: (i) how are the structures for delivering the PD role configured? (ii) Who performs the PD role and when are PDs engaged on projects? (iii) What specific activities are carried out by way of the PD role? and (iv) what practical challenges confront this role?

Methods

It is widely accepted in the research design literature that a qualitative research design is appropriate where: there has been no research into the issues of interest and there is therefore no basis for formulating hypotheses for testing by quantitative methods; and the evidence required to meet the research aims and objectives is in the form of wide-ranging views from a relatively small number of informants with potentially different lived experiences of the phenomenon under study (e.g. Creswell & Poth, 2018). The study therefore employed a qualitative research approach. Data was collected through facilitated focus group discussions (FGDs), with saturation being reached with fourteen workshops. This data collection method offers insights into individual experiences and viewpoints and ensures depth of understanding of the phenomenon being studied (Krueger & Casey, 2009). The group interaction and dynamics among participants during FGDs encourage participants to make connections to multiple concepts, and identify and validate collective norms and practices that may not ordinarily occur during individual interviews or other forms of surveys (Hennink et al., 2020; Morgan, 1997).

The purposive sampling approach was employed in selecting workshop participants because it offered the researchers the opportunity to select participants who were 'information-rich' and could volunteer specific and in-depth knowledge about the phenomenon being investigated (Creswell & Poth, 2018; Hennink et al., 2020). To maximize access to individuals with direct experience of the issues in the research, the research team sought and obtained the collaboration of professional bodies and other influential construction industry organizations. In compliance with the UK general data protection Regulations (GDPR), participants were made to complete and return consent forms that described and the purpose of the FGDs. A total of 89 participants attended the FGD workshops. As indicated in the demographic characteristics of the FGD workshops participants in Table 1, about 70% of the participants had more than 5 years' experience of CDM Regulations. Further, about 90% of them had affiliations with reputable professional bodies in the construction industry and H&S institutions. The experiences and roles of the participants on projects include Clients, Principal Designers, Designers, Principal Contractors and Contractors. The participants allocated to the

Table 1. Demographic characteristics of focus group workshops participants.

CDM role on projects	Frequency (%)
Client	11 (12.4)
Principal Designer	27 (30.3)
Designer	4 (4.5)
Principal Contractor	12 (13.5)
Contractor	6 (6.7)
Other	29 (32.6)
Total	89 (100)
CDM experience (in years)	Frequency (%)
1–5	27 (30.3)
6–10	15 (16.9)
11–15	11 (12.4)
16–20	17 (19.1)
21–26	19 (21.3)
Total	89 (100)

'other' category were general H&S professionals involved in advisory capacities.

To ensure that the participants had similar characteristics to support open and frank discussions, workshops were themed, with participants recruited based on closeness to the workshop theme (Hennink et al., 2020; Krueger & Casey, 2009). The themes included the CDM Client, Designers and Design Integration, the Principal Designer, CDM support services, the Principal Contractor, the Contractor, and Cooperation, Coordination and Communication. A focus group script was developed and used by the workshop facilitators as a guide to ensure consistency and reliability of the data collected across the different workshops. Workshop sizes were deliberately kept within the range of 4–12 participants because there is support in the literature that limited workshop promotes effective discussion and ease of confining the discussion broadly to the issues of interest (Carlsen & Glenton, 2011; Hennink et al., 2020; Stewart et al., 2007). Some scholars (e.g. Carlsen & Glenton, 2011) advise that more information can be obtained by conducting two groups of four participants than a group of eight participants. Thus, two parallel sessions were held where, on the day, a group size exceeded eight participants.

The analysis of the data, which followed a general inductive strategy, was carried out in two phases. The first phase was one of transcribing the audio data, reading the raw transcribed data multiple times to derive concepts, patterns, themes and ideas through the researchers' interpretation of the data in the light of the research aims and objectives (Thomas, 2006). The data was then loaded into NVivo version 12. The second phase involved: coding of the data from iterative reading of the transcripts to gain insights into main patterns embedded in the data; generation of themes using an inductive coding strategy; and development of higher order themes through clustering of lower level categories (Thomas, 2006). The structure of the coding is summarized in Figure 1.

Results

The structure of the Principal Designer role

An important aspect of the research was to understand Clients' arrangements for the delivery of the PD role. As indicated in Table 2, two main configurations emerged from the analysis of the research data: reliance on third party arrangements; and exploitation of owner in-house capacity with external support.

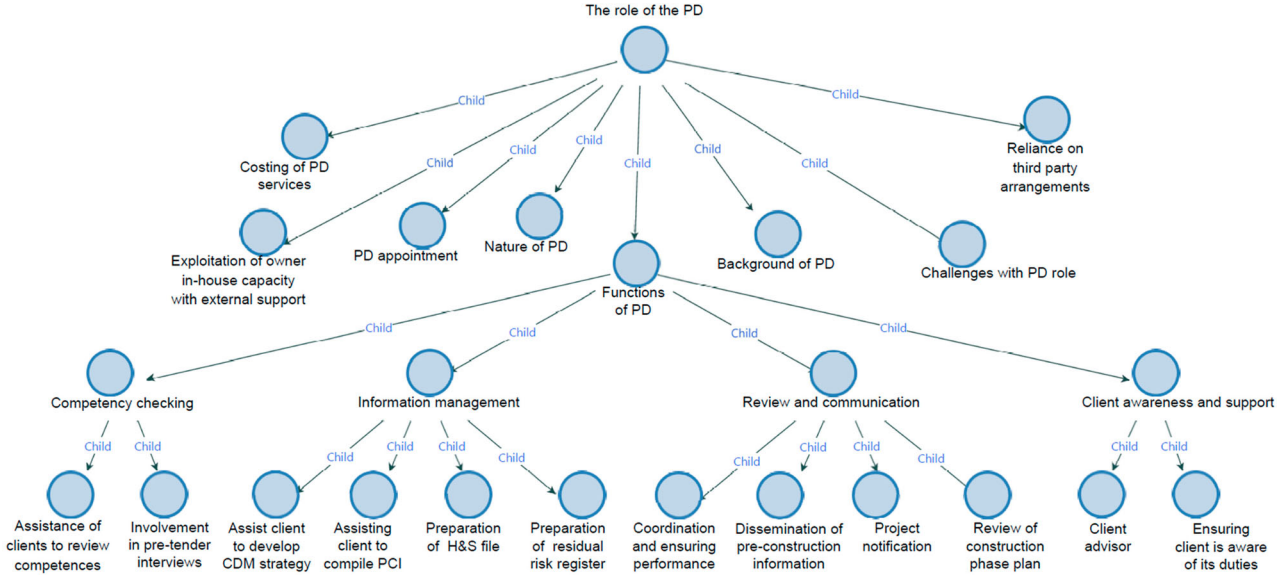

Figure 1. Project map of functions of the Principal Designer.

Table 2. The structure of the Principal Designer role.

Category	Sub-category
Reliance on third party arrangements	• Principal Contractor as Principal Designer with support from health and safety advisors and designers (14) • Lead designer as Principal Designer with support from CDM advisors and health and safety consultants (8) • Lead designer as Principal Designer (4) • Principal Contractor takes over Principal Designer role after pre-construction stage (4) • Conversion of Principal Designer role to CDM advisor after pre-construction stage (2) • Appointment of non-UK entities as Principal Designers with support from UK-based health and safety advisors (2) • Project manager as Principal Designer (1) • Project manager as Principal Designer with support from external health and safety advisors (1)
Exploitation of owner in-house capacity with external support	• Client as Principal Designer (11) • Client as Principal Designer with support from CDM advisors and health and safety consultants (2)

Note: Figures in parentheses denote the number of references to such practice in the FGD workshops.

Reliance on third party arrangements

As shown in Table 2, Clients rely on the services of third party entities (PD, PC, lead designer, project manager) for the delivery of the PD role on their projects. They appoint PCs as PD with support from H&S advisors and designers. This arrangement is often adopted on design and build (D&B) projects, particularly building projects, and received the highest number of references (14) by the FGD workshop participants. The third party may be the lead designer, who is often supported by CDM advisors and H&S consultants in the delivery of the PD role. This arrangement (referenced 8 times in the data) suggests a shift, three years after Knutt's (2017) survey, in attitudes of Architects and other Designers with more of them now taking up the PD role on projects, although with perceived deficiencies regarding H&S capability.

Another possibility is that PCs take over the PD role after the pre-construction stage. This is often the experience on smaller as well as D&B projects. The fourth variant involves conversion of the PD role to that of a CDM advisor after the pre-construction stage and tends to happen on D&B as well as some traditionally procured projects. A further arrangement is the appointment of an entity with no CDM capability as the PD but with the support of H&S advisors. This type of arrangement is most commonly encountered where a Client, with an overall business strategy of reducing the cost of project delivery, outsources design tasks to countries where design cost is relatively lower. However, due to the unfamiliarity of the lead designer appointed as the PD with UK construction regulations, they are often supported by UK-based H&S advisors. Lastly, there are instances where project managers are appointed with or without external H&S support on projects to deliver the PD role.

Exploitation of owner in-house capacity with external support

This arrangement generally is adopted by large and informed Clients. These include large infrastructure organizations, local authorities, public sector clients as well as Clients involved in specialized infrastructure projects such as airport and railway development projects. In such large infrastructure organizations, there is often an in-house Engineering Director who is named as the PD with delegation of PD responsibilities to design leadership engineers. Large infrastructure organizations in-sourcing the PD role appear common, with 11 references to it from workshop participants' responses on this issue. Where the in-house capability of the Client is inadequate, an arrangement is often made to augment it with external support from CDM advisors as well as H&S consultants. This practice is common among developers and housebuilding Clients.

The Principal Designer appointment

Table 3 shows a summary of feedback from the workshops on the timing and duration of PD appointments. Whilst early appointments of PDs on projects is referenced several times (7 number), it is significant that practitioners are still reporting that late appointments sometimes occur (4 number). Appointments take place between preparation and briefing stage (Stage 1 of RIBA plan of work) and the detailed technical design stage (Stage 4 of RIBA plan of work), but mostly at the start of detailed technical design stage. It was noted that early PD appointments made most commonly on large projects sponsored by informed Clients as well as D&B

Table 3. The nature of appointment of the Principal Designer role.

Category	Sub-category
Timing of appointment	• Early appointment (7) • Late appointment (4)
Duration of appointment	• Engagement throughout project (13) • Involvement as when services are required (4)

Note: Figures in parentheses denote the number of references to such practice by FGD workshops participants.

projects. Late appointments, on the other hand, occurred due to uninformed Clients still considering the PD as a bolt-on and thus make appointments at tender stages or just before the commencement on site.

Concerning the duration of appointment, as indicated in Table 3, the practice of PDs being engaged throughout the duration of projects is more common than PD involvement as when services are required. Generally, the nature and complexity of project risks influence decisions regarding the retention of the PD, with PDs often retained throughout the project for highly complex and high-risk projects.

The nature of the Principal Designer

The Regulations leave it open whether the PD is an individual or an organization. However, in practice as shown in Table 4, it appears the organizational agency is more often utilized on projects with 13 references in the data, in comparison with individual agency that had only one reference. This suggests that the competence as well as the resource requirements for the fulfilment of the PD role may not be entirely found in individuals and are mostly embedded in organizations. It is noted however that small and non-complex projects (i.e. some domestic projects) may be suited to individual PDs. This reflects the proportionality principle.

Concerning the professional background of the PD, as indicated in Table 4, designers (Architects and Engineers) are often appointed as PDs. Significantly, other non-design professionals (such as H&S Practitioners and Quantity Surveyors) are also appointed to the PD role, albeit with support from Designers (both in-house or external to their practices). The Designer support to non-designer PDs highlights the importance of design acumen in effectively fulfilling the PD role. Clearly, evidence in practice, thus, indicates a multifaceted competence requirement regarding the PD role, making the PD role competence requirement more of a reservoir of multiple capabilities (i.e. design and H&S).

Table 4. The nature of the Principal Designer.

Category	Sub-category
Type of agency	• Organization (13) • Individual (1)
Background	• Architect (4) • Quantity Surveyor (1) • Health and Safety Practitioner with support from Designers (1) • Engineer (1) • Quantity Surveyor with support from Designers (1)

Note: Figures in parentheses denote the number of references to such practice by FGD workshops participants.

Functions of the Principal Designer

From the analysis of the data, the role of the PD, from a practice perspective, comprises four function categories: (i) review and communication; (ii) information management; (iii) Client awareness and support; and (iv) competency checking. These categories focus on the everyday activity of organizing in both its routine and improvized forms and highlight what happens in practice on a day-to-day basis as far as the PD role on construction project is concerned. The content of each in terms of specific tasks is summarized in Table 5.

Review and communication function

There are four dimensions to this function. Firstly, the participants identified coordination of the contribution of all designers on the project regarding H&S. These tasks are precisely what Regulation 11(1) and 11(5) require PDs to perform. As part of its general duties under the Regulations, the PD is required to ensure that all Designers comply with their duties under the Regulations and see to it that all persons working in relation to the pre-construction phase cooperate with the Client and other project parties. The PD is further required to provide PCI, as soon as practicable and in convenient form, to project parties appointed or being considered for appointment. From the data, PDs constantly make Designers aware of their regulatory duties (i.e. PtD duties), encourage Designers to complete design risk registers, review drawings and design risk assessments, and provide feedback to Designers. The mechanism for discharging these duties is through design review meetings which are convened and coordinated by PDs. Design review meetings are generally attended by all design disciplines as well as the Client.

Table 5. Functions of the Principal Designer.

Category	Sub-category
Review and communication	• Coordination and assurance of designers' duty performance (37) • Dissemination of pre-construction information among project parties (4) • Project notification (3) • Review of construction phase plan (2)
Information management	• Assisting Client to compile pre-construction information (9) • Preparation of H&S file (5) • Preparation of residual risk register (1) • Assist Client to develop CDM strategy brief (1)
Client awareness and support	• Ensuring Client is aware of its duties (3) • Client advisor (2)
Competency checking	• Assistance of Clients to review competences of project parties (2) • Involvement in pre-tender interviews (2)

Note: Figures in parentheses denote the number of references to such practice by FGD workshop participants.

There are instances where Designers do not feel comfortable when their designs are challenged in the presence of other Designers at design review meetings. In some situations, PDs tactically meet design disciplines separately to address OSH risk issues before plenary design review meetings. This coordination and assurance of Designers' duty performance function appear to be the main preoccupation of PDs on projects, scoring the highest number of references (37) by the FGD workshop participants.

Secondly, as part of the 'review and communication' function, the PD ensures dissemination of the PCI among project parties. On this function, a PD noted that:

> Basically, the PCI have to be fed through. So as the surveys come in you've got to make sure that, the designers get asbestos information. It's just to make sure that flow of information is happening during the design phase. And then when the contractor is on board, he gets hold of that information as well through the tenders, through any sort of documents, make sure that information is passed on.

Thirdly, under the Regulations, construction projects scheduled to last longer than 30 working days and have more than 20 workers working simultaneously at any point on the project; or exceed 500 person days must be notified by the Client to the HSE. PDs support project clients' on this duty by completing and submitting the project form 'F10' on behalf of the Client to the HSE. Fourthly, the PD reviews the Construction Phase Plan (CPP) prepared by the PC. This function (similar to project notification to HSE) is not a regulatory duty, but PDs often undertake this task as courtesy for and on behalf of Clients when appointed on projects. It remains unclear, however, what the PD checks for and how they determine that the CPP meets an appropriate standard.

Information management

Information is critical for the safe construction, usage, maintenance or modification, usage and demolition of built assets (Goh & Chua, 2016; HSE, 2015) and this normally becomes one of the key priorities of the PD when appointed on projects. PDs fulfil this information management function in a number of specific ways. First, as required by Regulations 11(6a) and 11(6b), they assist Clients to compile PCI. It is the Client's duty under Regulation 4(4) to make the PCI available to all relevant CDM dutyholders so as to ensure that the project is carried out without risk to H&S. However, most Clients, particularly small to medium size ones, are uninformed about this requirement and, thus, depend on PDs to comply with this regulatory imperative on their behalf.

The second facet of the 'Information Management' function concerns the H&S File (HSF). PDs, for the duration of their appointments on projects, undertake the responsibility of the preparation of this document put on them by Regulation 12(5). Where PDs are not engaged for the entire project duration, particularly on some projects procured by the traditional procurement method, they handover the preparation of the HSF to PCs as required by Regulation 12(8). Some participants reported instances of PDs being re-engaged by Clients to validate HSFs submitted by PCs at project completion and handover.

Third, PDs take responsibility for the preparation of residual risk registers. They guide the design leads of the various design disciplines to populate residual risk registers, peruse the registers for duplicated risks as well as non-significant risks. In a 'Principal Designer's duties and Project OSH' workshop session, a PD indicated:

> One of the key things we do, especially when it's design and build and we know that the PD role is transferring across on complex projects, we would have detailed red, amber, green checklist as well as design risk assessments and registers.

Fourth, depending on when the PD is appointed on the project, the PD assists the Client to develop the CDM Strategy Brief. This document is intended to capture the H&S aspirations of the Client, and provides a clear orientation regarding these Client aspirations to project parties at an early stage of the project. The preparation of this document, though a main task of the PD, normally has inputs from other designers and other appointed project parties. The content of this document includes: (i) indication of the original Client brief with only the outline of the scope of works; (ii) the project timescales indicating key project milestones; (iii) indication of project strategic risks, where any unusual risks associated with the project are pointed out to project parties at an early stage of the project development process; (iv) an overview of project PCI requirements; (v) the project procurement strategy; (vi) communication strategy with information relating to the types of H&S meetings and frequency, induction processes for new project parties, communication methods or tools adopted on the project, and the approach for the preparation of the HSF; and (vii) indication of key project participants and contact details. Early appointment of the PD enhances the availability of the CDM Strategy Brief and realization of its benefits to project OSH risk management.

Client awareness and support function

PDs spend a significant amount of their time on projects supporting Clients and ensuring that they are aware of their regulatory duties. This is not a duty under the current Regulations, but appears to be a throwback to the previous advisory role of the H&S coordinator under the CDM 2007 Regulation 20(1)(a). In one of the 'Principal Designer's duties and Project OSH' FGD workshop sessions, a PD commented:

> So my role, and our company's role acting as the Principal Designer, it is to educate Clients at all times. And it's actually spending the time and actually talking to them and actually trying to make them understand what their requirements are under the Regulations.

Further, PDs act as Client advisors in respect of H&S on projects. A participant in a Principal Contractors' FGD workshop asserted that:

> So when PDs are appointed by Clients on projects, they act as their advisors. They are not spending the money, somebody else is spending the money. They have got to spend their time explaining to people how they should be spending their money with regard to health and safety.

Competency checking function

Clients, as initiators and purchasers of construction projects, employ directly or indirectly all project participants and thus have significant opportunity to influence the H&S performance on projects by way of appointments (Eban, 2016; Lingard et al., 2019). However, considering the low knowledge of Clients in respect of project H&S, PDs assist Clients to review the H&S competences of projects parties prior to their appointments. This task is not a regulatory duty of the PD. However, as part of Client expectation regarding the role, the PD supports the Client in this way. During one of the 'Principal Designer's duties and Project OSH' FGD workshop sessions, a participant stated:

> Aside from doing your mandatory role, you get hit by the Client and they expect you to do a lot more of the time, whether it is reviewing competence of appointees.

Further, PDs support the Client in checking the competence of potential CDM dutyholders through involvement in pre-tender interviews. Where PDs' functions are to be transferred to PCs during the construction stage, PDs feel a need to satisfy themselves and assure the Client that the PCs have the requisite capability to manage H&S to the best effect. It is therefore common practice for PDs to discuss the project with PCs from an H&S perspective.

Challenges of the PD role

The three most common challenges in the performance of the PD role reported by the workshop participants were: large design firms refusing PD roles when not appointed as lead designers; project managers controlling PD appointments and keeping PDs away from Clients; Architects refusing to take on the PD role. Other reported challenges were:

- Clients appointment of parties to PD role as tick box without ensuring performance;
- PD role having low profile in comparison other service providers on the project;
- Failures of PD to challenge designs properly at design review meetings;
- PD services fee prohibitive to smaller Clients;
- PD role being dynamic and often requiring correspondingly dynamic competence;
- PD appointment not a priority for Clients where effective project managers are appointed;
- Some lead designers being ignorant of the PD role on large infrastructure projects;
- Architects refusing to take on PD roles for D&B projects at construction stage;
- Clients cherry-picking PD services to resource;
- PDs often not involved in temporary works design;
- PDs not forthcoming with risk registers;
- different PDs having different versions of the design risk register.

Discussion

A general finding of the research was that compliance with the Regulations at the pre-construction stage has improved in some directions compared with the position under CDM 2007. Not only has complete failure to appoint a PD become very rare but delayed appointment has also been reduced considerably. Aspects of good practice not expressly mandated by the Regulations included: preparation of a CDM Strategy Brief by the PD soon after appointment; holding of design review meetings; preparation of project risk registers from collective synthesis of the risk registers of individual designers. However, some of the shortcomings identified in research sponsored by the HSE (e.g. Bomel, 2007; Frontline Consultants Ltd, 2012) have persisted, e.g.: recycling generic documents from project to project; generation of excessive useless information; inadequate management of risk at the pre-construction stage; and poor Client/PD leadership of compliance with the Regulations. Also, whilst there has been a higher uptake of the PD role by the mainstream design

professions compared to when the survey reported by Knutt (2017) was undertaken, it was reported that some designers, particularly architects, are still reluctant to take on the PD role. Their reluctance appears to be particularly pronounced where they are not the lead designer or the PD role extends to the construction phase on D&B schemes during which contractors frequently make changes to achieve cost efficiencies in circumstances posing H&S coordination challenges to PDs. An Engineer with a leading design consultancy in one of the workshops under the 'Design integration under CDM' theme stated:

> We do have a principle within [Company name] that if we're not in control, we're not going to get appointed as principal designer on something which somebody else is designing, effectively.

Other issues raised concerned insufficiency of time and resources provided by the Client, late appointment of PDs and poor quality PCI. This was described by one of the participants as 'fighting a losing battle,' and by another as a 'tick box' exercise. There also appears to be some concern that the multiplicity of roles often undertaken by the PD risk diminution of focus on the H&S coordination role. This is compounded by service providers already appointed to the design team talking down the importance of the PD role to the Client and tenderers for PD services undercutting each other, thus leading to a devaluation of the role.

The implications discernible from the findings that are next discussed concern: (i) PD competence; (ii) compliance by Clients; (iii) responses by regulatory authority; (iv) education and training for the PD role; and (v) future research. Actions to these implications must take account of major developments consequent on the Grenfell Tower fire disaster which occurred on 14th June 2017 and claimed the lives of 72 people.

Developments after Grenfell

The UK Government commissioned an independent review of building regulations and fire safety by an expert panel under the leadership of Dame Judith Hackitt. A major finding of the report from their investigations, the Hackitt Report, was that there were systemic weaknesses in the building regulatory regime (Hackitt, 2018). The Government accepted all the recommendations of the Report and prepared a Building Safety Bill (BSB) (HCLG, 2020a; 2020b) at the centre of which is a new building safety regulatory system to be developed that is bound to have impact throughout the wider construction industry when it becomes law. Of the interventions that will be made through secondary legislation, those most relevant to the issues in this paper include: a new regulatory framework for greater competence of a widened panoply of duty-holders involved in the design, construction and occupation of a building; a gateway system to ensure that checks for specific safety-related outcomes are met at defined points before the following stage can be commenced; a 'golden thread' of information going from the inception of the idea to procure a building to its occupation over its entire lifespan; and holding duty-holders more to account.

PD competence

An implication of the PD functions is that the PD must possess the competences necessary to perform them. For example, to coordinate the designs of others, the PD must possess the degree of technical knowledge of each of the specialist design domains, including the growing use of digital technologies (e.g. Hare et al., 2019; Health and Safety Laboratory, 2018; Sacks et al., 2015; Zhang et al., 2015), necessary to engage in discussion of relevant issues with the specialist designers on an informed basis. The PD must also have technical knowledge and understanding of risk management techniques from an H&S management perspective. Furthermore, the duty to coordinate and foster cooperation of designers with each other and the Client implies that the PD must possess appropriate soft skills (e.g. communication, collaborative working, diplomacy and steering groups from polarized positions to agreed solutions).

It is also evident from the results that different skill sets are likely to be required as H&S risks evolve over the project life cycle. This evolution suggests that, with the exception of small and simple projects, the PD role is best discharged by a team with complementary skills that, in aggregate, meet the requirements of the various stages of the project. There is therefore some merit to the current practice of having an organization as the PD. However, a design organization as PD would be appropriate only if the full set of skills can be found within its staff on the project.

Implications for clients

The important components of the duty of the CDM Client in relation to the PD are: to appoint a PD with appropriate SKE/OC as soon as practicable and, in any event, before the start of construction on site (Regulation 5(2)); to provide sufficient resources for the role (Regulation 4(1)); and to monitor performance and take appropriate remedial action (Regulation 4(3)).

There was feedback from the workshops that some Clients see their role in relation to the PD as one of simply appointing a PD. Such an approach results in non-compliance even where the PD has appropriate SKE/OC.

There has been a long-standing debate whether the background of a PD must be one of education and professional life in architecture or engineering. What is clear from the Regulations themselves is that the PD must be a 'designer', which is defined by the Regulations in wider terms than a professional architect or engineer. The variety of backgrounds from which PDs develop has created a competitive market for PD services, with charging rates of the professional design firms being towards the upper end of the spectrum. Clients should therefore be alive to the risk of appointing the least competent where it selects the PD by competitive tender based on only lowest bid prices.

The reality of the PD role is that it has to be discharged working as part of teams involving the other dutyholders and the Client's other professional advisers. The Client should consider not only the SKE/OC of the PD but also the likely impact of appointments of other dutyholders on the inevitable group power dynamics within the resulting project team. Power imbalance provides part of the explanation for the perceived inadequate leadership of PDs reported in the workshops. For example, expertise being a source of power (e.g. Bonner et al., 2002), there would be power imbalance acting as a barrier to the effectiveness of the PD if the PD expertise on the technical challenges of the project is far below that of a participating design organization accustomed to exercising project leadership. There would also be some power imbalance where another project participant carries more ostensible authority on behalf of the Client than the PD in relation to H&S management (e.g. Guinote, 2017). It was reported that Clients' project managers with little knowledge of H&S control PD appointments and may thereafter act as barriers to the performance of the PD role. It is therefore to be welcomed that action on Grenfell may extend H&S duties to project managers.

Implications for regulatory authorities

Regulation compliance theorists have demonstrated that there are multiple goals underlying regulatory compliance behaviour. Those to whom regulation is targeted, regulatees, have goals that determine their degrees of compliance or non-compliance. Goals may be material, emotional, or normative. The regulation will have the desired effect only if it impacts on regulatees' preferences. The compliance behaviour of CDM Clients is explained by the application of the extension proposed by Etienne (2011) to Lindenberg's Goal Framing Theory (GFT) (Lindenberg & Steg, 2007).

The GFT recognizes three categories of goals that drive compliance behaviour: the hedonic, gain and normative goals. The hedonic goal is a reflection of the drive to achieve pleasure, happiness and similar positive emotion or an intention to avoid their negative counterparts such as guilt and shame. An example is feelings of guilt from a fatality. The gain goal is the motivation to increase one's resources or to avoid their depletion. An example of the gain goal expressed in the workshops was motivation to increase profitability by controlling the costs of compliance with the Regulations. The normative goal gives expression to a psychological push to do the right thing. There are Clients who will do everything to avoid accidents simply because, according to their moral compass, it is the only course of action available to them.

According to Etienne (2011), all three types may apply at the same time but to different degrees and that there are two regions to an actor's attention: a foreground and background. The most influential goal occupies the centre of the foreground of the actor's attention. This is referred to as the 'goal-frame'. The others are in the background. Where the normative goal is the goal-frame, there is compliance because avoidance of injury to others is the right thing or it aligns with values on corporate social responsibility. There is therefore compliance without attention to the gain goal. The background goals can be consistent with the foreground goal and reinforce it and vice versa. Regulatees form their behaviour preferences invoking all the goals.

From this theory, the possible explanations for non-compliance by Clients include: ignorance or misunderstanding of the Regulations; incompetence; incapacity, planned unwillingness to comply or minimalist compliance; and weak enforcement. The ideal regulation and related enforcement approach are therefore one that seeks to influence these preferences towards compliance. The implication is that the regulatory authorities need to make a range of responses to the perceived non-compliance, e.g. remedial legislation, campaigns, guidance documents, review of enforcement practice (e.g. greater focus on resources and sanctions for non-compliance), and research. On the evidence available, some of these responses will form part of the regulatory system to be produced by actions on the Grenfell disaster.

Implications for education and training

The research calls for concerted action by Higher Education Institutions (HEIs), professional bodies and

industry to ensure that the education and training provision supports the development of PDs with the competences necessary to perform the identified PD functions. Similar attention should be paid to the need for Clients to understand their full responsibilities in relation to the PD role. Emphasis should put on collaborative risk management (CRM) and its requirement for not only technical design and related information technology skills but also soft skills (Friday et al., 2018). The split of responsibility is generally that HEIs develop and deliver curricula under the guidance of the professional bodies as to industry relevance. The curricula concentrate on knowledge and understanding and foundation skills that are developed and entrenched by appropriate training and experience provided by industry. In the UK, the principal accrediting professional bodies are Royal Institute of British Architects (RIBA), Joint Board of Moderators (JBM) for engineering degrees, Chartered Institute of Building (CIOB) and Royal Institution of Chartered Surveyors (RICS). These bodies have developed educational frameworks that approved HEI curricula must meet (CIOB, 2018; JBM, 2020; RIBA, 2020; RICS, 2017). Whilst there are pockets of creative and innovative integration of H&S in HEI curricula, the evidence available appears to suggest that the quality of provision and delivery across HEIs and across programmes to address these professional body requirements remains a challenge (Hayne et al., 2017; Stacey et al., 2007; Toole, 2017; University of Sheffield, 2012).

Given the multiplicity of backgrounds of PDs and the need for teams to discharge the PD role as previously argued, there is an even more pressing need for a comprehensive review of current approaches to H&S education that goes beyond the traditional design disciplines that have been the focus of past reviews (e.g. Stacey et al., 2007; University of Sheffield, 2012). Curricula must be revamped to embrace H&S risk management in design in a multidisciplinary project environment. HEIs offering different specialisms such as architecture, structural and other engineering disciplines, construction management, and quantity surveying should leverage the multidisciplinary groups possible in these institutions to simulate the environment for CRM. Design education and training, with a particular view of H&S, should consider engaging with other subjects such as ethics, social sustainability, lifecycle analysis, and public policy (MannIII, 2008; Toole, 2017). This will provide the right orientation to students and drive the right kind of leadership required for the PD role when they transition into practice. There is also a need to further develop and disseminate the suite of creative tools and pedagogies for delivery of H&S education in HEIs.

Industry training needs to be evaluated on planned outcomes in relation to the needs of the PD. There is a need to ensure that such training engages fully with H&S and CRM. This is likely to be most effective where there is an H&S department with a board level director, and also where the professional bodies are fully engaged to police this through mandatory requirements for continuing professional development. It is noteworthy that an industry competence committee is to be established as a Grenfell action. This approach will also address the criticism that the focus of regulation has been on assessment of SKE/OC with little attention on competence development.

Contribution/value

Joint leadership of H&S at the pre-construction stage by the Client and the PD is absolutely at the heart of the PtD drive mandated by CDM 2015 and the EU Directive on which it is based. Unfortunately, there is little guidance on evolving practice in the exercise of this leadership. The study reported by this paper is the first to capture this practice empirically and to suggest improvement actions. This paper thereby plugs gaps in knowledge and understanding of the compliance behaviours of Clients and the specific actions PDs take towards compliance with their duties. The four PD functions and their constituent tasks identified in the paper provide an appropriate foundation on which Clients may enter into negotiations with candidates for appointment as PDs. The findings are useful to not only the UK construction industry but also the construction industries of EU member states because of the shared regulatory framework mandated by the EU Directive which forms the foundation for the CDM Regulations in the UK. The findings of this research therefore serve as a useful lens for evaluating the PD equivalent roles across the EU.

It has been reported that adoption of this EU Directive in many EU countries has resulted in some reduction of accidents (Aires et al., 2010; Farina et al., 2013; Giusti et al., 2016). Considering the global PtD drive, the EU approach to it and how it works in practice must therefore be matters of considerable universal interest. The experience of CDM Regulations in the UK provides pointers on how the PtD concept could be put into practice in countries where the traditional lead designer still carries the design coordination responsibility. The findings suggest that strategic options open to such lead designers include designation of a specific individual or team with appropriate competences to assume responsibility for the design coordination at an arm's length from other members of the lead design organization.

Limitation of the research and implications for future research

A limitation of the research is that most of the feedback from the Client perspective was based on observations of other dutyholders. Participants from Client organizations were from mainly infrastructure organizations and university estates departments. Research based on direct feedback from Clients is therefore recommended.

Workshop respondents were very scathing about the quality of the PCI, CPP and HSF. One participant described them as often terabytes of irrelevant or useless information put together with digital tools. Research is obviously needed to improve them not only as standalone documents for effective H&S management during design and construction but also as vital links in the 'golden thread' of information on residential buildings over their lifespan as very eloquently recommended in the Hackitt Report. The PD is just one of new roles created in the construction industry in response to increasing project complexity and change generally. Others, the functions of which overlap those of the PD, include Design Manager (Emmitt & Ruikar, 2013) and Information Manager (CIC, 2018). Further research is needed to understand: the interfaces between them and implications for teamwork and group power dynamics where all three exist on a project; and how one role may transition into another and implications for education and training.

The difficult task of ensuring that the Client not only makes a timely appointment of the PD but also provides sufficient resources for the discharge of the role cannot be achieved without the availability of cost standards for the role. Such standards could be in the form of cost or man days per pound of the contract price on a sliding scale. Such standards could be put to good use in the following ways: estimating the PD services component of project budgets; and evaluation of the adequacy of the resources for prosecution purposes. As such cost standards are not available in the public domain, remedial research aimed at developing them is also needed.

Conclusions

The general consensus was that some gains have been made by the move from CDM 2007 to CDM 2015. Not only is failure to appoint a PD very rare but the PD is appointed much earlier in the project cycle. However, there is considerable room for improvement in the areas of assessment of the PD for appropriate competence and ensuring that they have adequate resources for discharging the role. The barriers against compliance include: lack of awareness of the Regulations, misunderstanding of the real nature of their duties; financial constraints; and intentional non-compliance. A multi-faceted approach to enforcement by the HSE is therefore called for.

The working environment of the PD is very demanding in terms of team-working competences. Coordination of the designs of others is at the heart of the role. To inspire the confidence of the other designers, the PD must possess not only broad knowledge of the contributory design domains but also high-level interpersonal skills to handle the inevitable conflicts. For this reason, except for simple and straightforward jobs, the PD is best as an organization with the full set of skills. Failing that, independent CDM or H&S advisors may be engaged. The Client needs to take account of power imbalances in assembling the project team. The Client also needs to bear in mind that, in the cut and thrust of real commercial life, self-serving advice to adopt a minimalist approach to the PD role may be offered by some candidates for membership of the project team.

There was hardly any serious suggestion that there is anything wrong with the Regulations themselves. Instead, the concern was about the non-compliance behaviours of some Clients, which raises questions about the adequacy of enforcement. Courses of action open to the HSE include: increase campaigns to encourage better resourcing of PDs; provide standards for assessing the resources needed by the PD (e.g. as a fraction of the contract price); ensuring that their inspections of live projects include scrutiny of actual PD resources; prosecution of this type of non-compliance, which has been rare. Concerted action by HEIs, the professional bodies and industry is needed to improve the education and training for the PD role.

The value of the research goes beyond the UK and EU countries in which the PD role is a legal requirement. The reported organization of the PD role provides pointers to how lead design organizations in other countries may structure their design coordination responsibilities.

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References

Aires, D. C., Gamez, M. C. R., & Gibb, A. D. F. (2010). Prevention through design: The effect of European directives on construction workplace accidents. *Safety Science*, *48*(2), 248–258. https://doi.org/10.1016/j.ssci.2009.09.004

Aires, D. C., Gamez, M. C. R., & Gibb, A. D. F. (2016). The impact of occupational H&S regulations on prevention through design in construction projects: Perspectives from Spain and the United Kingdom. *Work*, *53*(1), 181–191. https://doi.org/10.3233/WOR-152148

Atkinson, A. R., & Westall, R. (2010). The relationship between integrated design and construction and safety on construction projects. *Construction Management and Economics*, *28*(9), 1007–1017. https://doi.org/10.1080/01446193.2010.504214

Aulin, R., & Capone, P. (2010). The role of health and safety coordinator in Sweden and Italy construction industry. In P. Berret, D. Amaratunga, R. Haigh, K. Keraminiyage, & C. Pathirage (Eds.), *CIB World Congress proceedings, CIB, building a better World, World Congress 2010*. University of Salford, Manchester. 5 October 2010. Retrieved August 9, 2021, from https://portal.research.lu.se/portal/files/5488407/1612116.pdf

Behm, M., Culvenor, J., & Dixon, G. (2014). Development of safe design thinking among engineering students. *Safety Science*, *63*, 1–7. https://doi.org/10.1016/j.ssci.2013.10.018

Bomel Ltd. (2007). Improving the effectiveness of the Construction (Design and Management) Regulations 1994, Establishing views from construction stakeholders on the current effectiveness of CDM.

Bonner, B. L., Baumann, M. R., & Dalal, R. S. (2002). The effects of member expertise on group decision-making and performance. *Organizational Behavior and Human Decision Processes*, *88*(2), 719–736. https://doi.org/10.1016/S0749-5978(02)00010-9

Cameron, I., & Hare, B. (2008). Planning tools for integrating health and safety in construction. *Construction Management and Economics*, *26*(9), 899–909. https://doi.org/10.1080/01446190802175660

Carlsen, B., & Glenton, C. (2011). What about N? A methodological study of sample-size reporting in focus group studies. *BMC Medical Research Methodology*, *11*(26), 1–10.

CIC. (2018). *CIC BIM protocol* (2nd ed.). Retrieved June 8, 2021, from https://cic.org.uk/admin/resources/bim-protocol2nd-edition-1.pdf

CIOB. (2018). *CIOB undergraduate education framework* (2018 ed.). CIOB.

Cooke, T., Lingard, H., Blismas, N., & Stranieri, A. (2008). ToolSHeD^{TM}: The development and evaluation of a decision support tool for health and safety in construction design. *Engineering, Construction and Architectural Management*, *15*(4), 336–351. https://doi.org/10.1108/09699980810886847

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing Among five approaches* (4th ed.). Sage.

Dewlaney, K. S., & Hallowell, M. (2012). Prevention through design and construction safety management strategies for high performance sustainable building construction. *Construction Management and Economics*, *30*(2), 165–177. https://doi.org/10.1080/01446193.2011.654232

Donaghy, R. (2009). *One death is too many inquiry into the underlying causes of construction fatal accidents*. HMSO.

Eban, G. (2016). Major construction projects at airports: Client leadership of health and safety. *Journal of Airport Management*, *10*(2), 131–137.

Emmitt, S., & Ruikar, K. (2013). *Collaborative design management*. Routledge.

Etienne, J. (2011). Compliance theory: A goal framing approach. *Law & Policy*, *33*(3), 305–333. https://doi.org/10.1111/j.1467-9930.2011.00340.x

Eurostat. (2021). Accidents at work by sex, age and NACE Rev. 2 activity (A, C-N) Dataset. Retrieved Feb 17, 2021, from https://ec.europa.eu/eurostat/databrowser/view/HSW_N2_01__custom_591457/default/table?lang=en

Farina, E., Bena, A., Pasqualini, O., & Costa, G. (2013). Are regulations effective in reducing construction injuries? An analysis of the Italian context. *Occupational and Environmental Medicine*, *70*(9), 611–616. https://doi.org/10.1136/oemed-2012-101087

Friday, D., Ryan, S., Sridharan, R., & Collins, D. (2018). Collaborative risk management: A systematic literature review. *International Journal of Physical Distribution & Logistics Management*, *48*(3), 231–253. https://doi.org/10.1108/IJPDLM-01-2017-0035

Frontline Consultants Ltd. (2012). *Evaluation of the construction (design and management) Regulations 2007, a report prepared by Frontline Consultants for the HSE*. HSE Books.

Gambatese, A., Gibb, A. G., Brace, C., & Tymvios, N. (2017). Motivation for prevention through design: Experiential perspectives and practice. *Practice Periodical on Structural Design and Construction*, *22*(4), 04017017. https://doi.org/10.1061/(ASCE)SC.1943-5576.0000335

Gambatese, J. A., Behm, M., & Hinze, J. W. (2005). Viability of designing for construction worker safety. *Journal of Construction Engineering and Management-ASCE*, *131*(9), 1029–1036. https://doi.org/10.1061/(ASCE)0733-9364(2005)131:9(1029)

Gambatese, J. A., Hinze, J. W., & Haas, C. T. (1997). Tool to design for construction worker safety. *Journal of Architectural Engineering*, *3*(1), 32–41. https://doi.org/10.1061/(ASCE)1076-0431(1997)3:1(32)

Gibb, A., Hide, S., Haslam, R., Gyi, D., Pavitt, T., Atkinson, S., & Duff, R. (2005). Construction tools and equipment – their influence on accident causality. *Journal of Engineering, Design and Technology*, *3*(1), 12–23. https://doi.org/10.1108/17260530510815303

Giusti, T., Capone, P., & Getuli, V. (2016). Design and safety: From the EU directives to the national legislation. In A. Saari, & P. Huovinen (Eds.), *Proceedings of the CIB World building Congress 2016Volume III: Building up business operations and their logic shaping materials and technologies* (pp. 652–663). Tampere University of Technology.

Goh, Y. M., & Chua, S. (2016). Knowledge, attitude and practices for design for safety: A study on civil and structural engineers. *Accident Analysis and Prevention*, *93*, 260–266. https://doi.org/10.1016/j.aap.2015.09.023

Golizadeh, H., Hon, C. K. H., Drogemuller, R., & Hosseini, M. R. (2018). Digital engineering potential in addressing causes of construction accidents. *Automation in*

Construction, *95*, 284–295. https://doi.org/10.1016/j.autcon.2018.08.013

Grytnes, R., Tutt, D. E., & Andersen, L. P. S. (2020). Developing safety cooperation in construction: Between facilitating independence and tightening the grip. *Construction Management and Economics*, *38*(11), 977–992. https://doi.org/10.1080/01446193.2020.1726978

Guinote, A. (2017). How power affects people: Activating, wanting, and goal seeking. *Annual Review of Psychology*, *68*(1), 353–381. https://doi.org/10.1146/annurev-psych-010416-044153

Hackitt, J. (2018). Building a safer future – Independent review of building regulations and fire safety: Final report, HM Government. Retrieved March 7, 2021, from http://www.gov.uk/government/publications

Hallowell, M. R., & Hansen, D. (2016). Measuring and improving designer hazard recognition skill: Critical competence to enable prevention through design. *Safety Science*, *82*, 254–263. https://doi.org/10.1016/j.ssci.2015.09.005

Hare, B., Campbell, J., Skivington, C., & Cameron, I. (2019). *Improving designers' knowledge of hazards*. IOSH Research Report.

Hayne, G., Kumar, B., & Hare, B. (2017). Design hazard identification and the link to site experience. *Proceedings of the ICE – Management, Procurement and Law*, *170*(2), 85–94. https://doi.org/10.1680/jmapl.16.00014

HCLG. (2020a). *Draft building safety bill, CP 264, HM government*. ISBN 978-1-5286-2088-8. Retrieved March 7, 2021, from http://www.gov.uk/official-documents

HCLG. (2020b). *Building safety bill: Explanatory notes, CP 264-EN, HM government*. ISBN 978-1-5286-2088-8. Retrieved March 7, 2021, from http://www.gov.uk/official-documents

Health and Safety Laboratory. (2018). *Improving health and safety outcomes in construction: Making the case for building information modelling (BIM)*. HSE Report.

Hennink, M., Hutter, I., & Bailey, A. (2020). *Qualitative research methods* (2nd ed.). Sage.

HSE. (2015). *Managing health and safety in construction: Construction (design and management) Regulations 2015. Guidance on Regulations*. Health and Safety Executive.

Ibrahim, C. K. I. C., Belayutham, S., Manu, P., & Mahamadu, A.-M. (2020). Key attributes of designers' competency for prevention through design (PtD) practices in construction: A review. *Engineering, Construction and Architectural Management, Vol. Ahead-of-Print, No. Ahead-of-Print*, https://doi.org/10.1108/ECAM-04-2020-0252

JBM. (2020). *Guidelines for developing degree programmes*, Version 2 Revision 1–05 March 2020.

Knutt, E. (2017). *CDM 2015 survey: The results are in*. Retrieved February 2, 2018. https://www.healthandsafetyatwork.com/construction/cdm-2015-survey-results

Krueger, R. A., & Casey, M. A. (2009). *Focus groups: A practical guide for applied research* (4th ed.). Sage.

Lindenberg, S., & Steg, L. (2007). Normative, gain and hedonic goal frames guiding environmental behaviour. *Journal of Social Issues*, *63*(1), 117–137. https://doi.org/10.1111/j.1540-4560.2007.00499.x

Lingard, H., Oswald, D., & Le, T. (2019). Embedding occupational health and safety in the procurement and management of infrastructure projects: Institutional logics at play in the context of new public management. *Construction Management and Economics*, *37*(10), 567–583. https://doi.org/10.1080/01446193.2018.1551617

Lingard, H., Saunders, L., Pirzadeh, P., Blismas, N., Kleiner, B., & Wakefield, R. (2015). The relationship between pre-construction decision-making and the effectiveness of risk control: Testing the time-safety influence curve. *Engineering, Construction and Architectural Management*, *22*(1), 108–124. https://doi.org/10.1108/ECAM-08-2013-0074

Lingard, H., Wakefield, R., & Walker, D. (2020). The client's role in promoting work health and safety in construction projects: Balancing contracts and relationships to effect change. *Construction Management and Economics*, *38*(11), 993–1008. https://doi.org/10.1080/01446193.2020.1778758

Lopez-Arquillos, A., Rubio-Romero, J. C., & Martinez-Aires, M. D. (2015). Prevention through design (PtD): The importance of the concept in engineering and architecture university courses. *Safety Science*, *73*, 8–14. https://doi.org/10.1016/j.ssci.2014.11.006

Mann III, J. A. (2008). Education issues in prevention through design. *Journal of Safety Research*, *39*(2), 165–170. https://doi.org/10.1016/j.jsr.2008.02.009

Manu, P., Gibb, A., Drake, C., Jones, W., Bust, P., Mahamadu, A.-M., & Behm, M. (2019b). *Skills-knowledge-attitude-training-experience (SKATE) in "Designing for occupational health of construction workers"*. B&CE Charitable Trust.

Manu, P., Poghosyan, A., Mahamadu, A.-M., Mahdjoubi, L., Gibb, A., Behm, M., & Akinade, O. (2019a). Design for occupational safety and health: Key attributes for organizational capability. *Engineering Construction and Architectural Management*, *26*(11), 2614–2636. https://doi.org/10.1108/ECAM-09-2018-0389

Morgan, D. L. (1997). *Focus groups as qualitative research*. Sage.

Ndekugri, I. (2013). The consulting engineer and corporate manslaughter risk. *Proceedings of the ICE – Management, Procurement and Law*, *166*(3), 128–136. https://doi.org/10.1680/mpal.11.00045

Poghosyan, A., Manu, P., Mahdjoubi, L., Gibb, A., Behm, M., & Mahamadu, A.-M. (2018). Design for safety implementation factors: A literature review. *Journal of Engineering, Design and Technology*, *16*(5), 783–797. https://doi.org/10.1108/JEDT-09-2017-0088

Reason, J. (1997). *Managing the risks of occupational accidents*. Ashgate.

RIBA. (2020). *The way ahead: RIBA Education and Professional Development Framework*.

RICS. (2017). *Associate assessment quantity surveying and construction, February 2017*.

Sacks, R., Whyte, J., Swissa, D., Raviv, G., Zhou, W., & Shapira, A. (2015). Safety by design: Dialogues between designers and builders using virtual reality. *Construction Management and Economics*, *33*(1), 55–72. https://doi.org/10.1080/01446193.2015.1029504

Safe Work Australia. (2015). *Work health & safety perceptions construction industry*.

Sherratt, F., Farrell, P., & Noble, R. (2013). UK construction site safety: Discourses of enforcement and engagement. *Construction Management and Economics*, *31*(6), 623–635. https://doi.org/10.1080/01446193.2012.747689

Shiplee, H., Waterman, L., Furniss, K., Seal, R., & Jones, J. (2011). Delivering London 2012: Health and safety. *Proceedings of the*

ICE – Management, Procurement and Law, *164*(5), 46–54. https://doi.org/10.1680/cien.2011.164.5.46

Stacey, N., Williamson, J., Schleyer, G. K., Duan, R. F., & Taylor, R. H. (2007). *Integrating risk concepts into undergraduate Engineering courses*. Proceedings of the 3rd International CDIO conference, MIT, Cambridge, Massachusetts, June 11–14, 2007.

Stewart, D. W., Shamdasani, P. N., & Rook, D. W. (2007). *Focus groups. Theory and practice*. Sage.

Szymberski, R. T. (1997). Construction project safety planning. *Tappi Journal*, *80*(11), 69–74.

Thomas, D. R. (2006). A general inductive approach for analysing qualitative evaluation data. *American Journal of Evaluation*, *27*(2), 237–246. https://doi.org/10.1177/1098214005283748

Toole, T. M. (2017). Adding prevention through design to civil engineering educational programs. *Journal of Professional Issues in Engineering Education and Practice*, *143*(4), 02517005. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000344

University of Sheffield. (2012). *Healthy design, creative safety: Approaches to health and safety teaching and learning in undergraduate schools of architecture*. HSE Research Report RR925.

Webster, M. (2013). The use of CDM 2007 in the London 2012 construction programme. *Proceedings of the Institution of Civil Engineers – Civil Engineering*, *166*(1), 35–41. https://doi.org/10.1680/cien.12.00010

Willumsen, P., Oehmen, J., Stingl, V., & Geraldi, J. (2019). Value creation through project risk management. *International Journal of Project Management*, *37*(5), 731–749. https://doi.org/10.1016/j.ijproman.2019.01.007

Zhang, S., Sulankivi, K., Kiviniemi, M., Romo, I., Eastman, C. M., & Teizer, J. (2015). BIM-based fall hazard identification and prevention in construction safety planning. *Safety Science*, *72*, 31–45. https://doi.org/10.1016/j.ssci.2014.08.001

Zhou, W., Whyte, J., & Sacks, R. (2012). Construction safety and digital design: A review. *Automation in Construction*, *22*, 102–111. https://doi.org/10.1016/j.autcon.2011.07.005

Zhou, Y., Ding, L. Y., & Chen, L. J. (2013). Application of 4D visualization technology for safety management in metro construction. *Automation in Construction*, *34*, 25–36. https://doi.org/10.1016/j.autcon.2012.10.011

Zhou, Z., Goh, Y. M., & Li, Q. (2015). Overview and analysis of safety management studies in the construction industry. *Safety Science*, *72*, 337–350. https://doi.org/10.1016/j.ssci.2014.10.006