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Awareness of the prevention through design (PtD) concept among design engineers in the Philippines

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ABSTRACT
The "Prevention through Design" (PtD) concept considers construction safety during the design process. Several countries are currently practising PtD, including the UK, Singapore, Malaysia, Australia, and the USA, which is still not the case in the Philippines. The study presented in this paper aimed to indicate the current level of awareness of the PtD concept among the structural engineers and purposed to generate a basis of initiatives to introduce or improve the understanding and adoption of PtD in the Philippines. A knowledge, attitude, and practice (KAP) questionnaire was distributed to survey respondents selected through a snowball sampling method, consisting of structural engineers currently working in the Philippines. Sixty-one (61) structural engineers responded and were analysed in this study. Results indicated that PtD was relatively a new concept for most structural engineers in the Philippines. Similarly, the designers' knowledge of the concept was still low. However, structural engineers viewed PtD as necessary and its implementation as essential in the construction industry. Despite the known concerns in the PtD implementation, structural engineers favoured the adoption of the concept. The paper also discussed challenges and key drivers for implementing PtD in the Philippines based on the questionnaire results and supporting literature reviews. The findings and methodology presented in this paper could serve as a baseline for a larger sample size covering other design trades, such as architectural, electrical, and mechanical design services leading to the broader adoption of PtD in the Philippines. Furthermore, the framework of this study could also apply to other countries with similar contexts.

KEY WORDS
construction safety, Prevention through Design, Design for Safety, Philippines, KAP, structural design

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Introduction

The construction industry is an occupationally risky environment. Recorded statistics have shown that the number of accidents in the construction industry is higher than in other manufacturing industries (Sousa et al., 2014). The injury and illness rate was approximately five times greater than in all other industries on average (Hallowell, 2012). The Occupational Safety and Health Administration (OSHA) of the United States Department of Labor

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reported that 21.1 % of total fatalities in 2018 occurred in the construction industry. Though the Architecture, Engineering, and Construction (AEC) industry aspired to a "zero accidents/injuries", it is still far from such vision considering the recorded accidents in the construction. Also, the records of accident fatalities in construction still significantly increase despite the construction safety endeavours (Zhou et al., 2015).

Every construction project has inherent health and safety risks, and mitigating these risks can be done proactively or reactively. According to ANSI/AIHA Z10 standard, in the hierarchy of controls for occupational accidents, hazard elimination is the most cost-effective and practical approach to prevent hazards in the construction workplace.

For construction hazard elimination, which is considered a proactive assessment, this should be done before the project's construction phase. The increased recognition of the designer's influence on the construction of a project has led to a safety management innovation called Prevention through Design (PtD).

It is essential to investigate the current awareness of the concept's prospects before establishing a starting point for its adoption or diffusion. Therefore, the present study aimed to indicate the current level of PtD awareness among designers in the Philippines. Also, this study aimed to identify the designer's perceptions and concerns about the implementation of PtD. This study purposed to generate a basis of initiatives to introduce or improve the understanding and adoption of PtD in the Philippines.

As a part of a larger research endeavour about PtD adoption nationally, this study focused only on one specific design trade as the target group, i.e., structural design. The researchers aspired to have a comprehensive study with data from different design trades. Nevertheless, each design trade involved in a construction project faces unique occupational safety challenges and needs a thorough separate study.

The remainder of the paper is structured as follows. Section 2 provides a brief review of relevant literature in PtD and the Construction occupational health and safety in the Philippines. Section 3 explains the data-gathering methodologies, the study framework, and analysis tools.

Section 4 details the analysis results while discussing the study's results and other connotations in Section 5. Finally, the paper provides conclusions and future research recommendations.

1. Literature review

1.1. Prevention through Design (PtD)

Empirical studies have established a link between design features and their construction process as an accident causation factor (Haslam et al., 2005; Hide et al., 2003; Suraji et al., 2001). Researchers used retrospective analysis to analyse recorded construction accidents and found that design correlates with construction site accidents. For example, Behm (2005) reviewed 224 fatality reports from the Fatality Assessment Control and Evaluation (FACE) database of the National Institute for Occupational Safety and Health. The study showed that 42 % of the recorded fatalities in construction could be linked to design. Driscoll et al. (2008) also asserted that design was a significant contributor to work-related fatal injury based on the analysed record from Australia. Henceforth, the viewpoint of construction safety hazard assessment on the project's design phase has gained attention from researchers.

The main concept of Prevention through Design (PtD) is the consideration of construction safety during the design process (Behm, 2005; Gambatese, 1998; Toole & Carpenter, 2013). The idea suggests a higher proactive construction safety assessment accounting for the project's design phase as a possible stage for considering construction safety. In PtD, designers must consider construction workers' safety while performing design tasks. It requires designers to make design decisions based on how the project affects construction workers' inherent risk and include safety considerations during constructability reviews. However, it does not require a designer to take an active role in construction safety during construction, nor holds the designer partially responsible for any construction accidents (Toole & Gambatese, 2017).

PtD has been called Design for Safety (DfS) in Singapore, Construction Design Management (CDM) in the UK, and Safe Design in Australia. The US National Institute for Occupational Safety and Health (NIOSH), in 2007, launched its PtD initiative to make it a standard practice to analyse occupational hazards. In Singapore, the Manpower Ministry enacted the DfS Regulations in July 2015, which was enforced from August 2016. In Malaysia, a PtD-based guideline was introduced by the Occupational Safety and Health in Construction Industry (Management) (OSHCI(M)).

The following terms are how scientific papers referred to the idea of PtD:

- Prevention through Design (PtD) (Ferrante, 2010; Hallowell et al., 2016; Karakhan & Gambatese, 2017; Kasirossafar & Shahbodaghlou, 2013b; Toole & Carpenter, 2013);
- Design for Safety (DfS) (Jin et al., 2019; Lee et al., 2020; Mering et al., 2017);
- Safety in Design (Horberry, 2014; Li et al., 2020; Taiebat et al., 2012);
- Design for Occupational Safety and Health (DfOSH) (Manu et al., 2019; Poghosyan et al., 2020);
- Design Risk Management (Harvey et al., 2019; Mesaros et al., 2019).

1.2. The Philippines construction occupational health and safety

The Philippine construction industry faces many challenges and problems regarding construction health and safety (Demeterio et al., 2019). For instance, in 2018, the Philippine Statistics Authority (PSA) published a report for 2015 – 2016 from a nationwide sample survey covering 12 926 establishments with 20 or more workers. The LABSTAT report stated 2 115 cases of occupational injuries in the construction industry. Three out of every five (66.1 % or 1 399) cases of occupational injuries were cases without workdays lost, while the rest were temporary incapacity cases (32.6 %) and fatal cases (0.6 %) (Philippine Statistics Authority, 2018). The Philippines has several sets of OSH rules and regulations for general occupations. Examples are the Presidential Decree (PD) 442 on Labour Code of the Philippines — Safety and Health Standards and the Republic Act 11058 on Strengthening Compliance with Occupational Safety and Health Standards and Providing Penalties for Violations. However, there was still no institutional effort to introduce the PtD concept in the construction industry in the Philippines. Furthermore, no existing regulations mandate the designers to consider workers' safety in their designs.

2. Methods

2.1. Study design

A nationwide cross-sectional study was performed to evaluate PtD-related awareness using the snowball sampling method through a structured questionnaire. The questionnaire survey technique could help to provide a broad understanding of the phenomenon investigated in this study (Bryman, 2016). Also, the speed, low cost, and scalability of administering questionnaires (Dalati & Gómez, 2018) were considered an advantage of the survey method, especially as the COVID-19 pandemic continued during the time of research. The questionnaire framework was developed based on the study by Goh & Chua (2016) and Che Ibrahim & Belayutham (2020) on Knowledge, Attitude, Practice (KAP) of PtD, complemented by previous research work on PtD. The KAP questionnaire is one of the tools used to determine current knowledge, attitude, and practices in medical and health disciplines in producing an evidence-based intervention (World Health Organization, 2008). Its key components were considered suitable to this study in exploring the awareness of the PtD concept among design engineers in the Philippines. Hence, the KAP questionnaire was framed as follows:

- General information: gathering the demographic information of the respondents.
- Section A. PtD Knowledge: determining the current knowledge and understanding of PtD.
- Section B. PtD Attitude: assessing the respondent's perception of PtD implementation.
- Section C. PtD Practice: considering the possible challenges and problems in applying PtD in the construction industry.

2.2. Study area and sampling

As of 2020, the Philippine Institute of Civil Engineers (PICE) registered 92 316 active professional members working in different civil engineering professions. The specific number of structural engineers was challenging to determine from this list since anyone with a civil engineering license in the Philippines can work as a structural designer. Nevertheless, the Association of Structural Engineers of the Philippines (ASEP) published a record of more than 900 active members as of 2020. The list was used to reach each prospected participant. However, aiming for views from structural designers in general and not limited to a specific institution, a supplementary search for respondents was carried out on an available social media professional network LinkedIn, which is an online professional and career development networking of different disciplines, including structural designers/engineers. Therefore, a search for qualified participants through LinkedIn was done with search keywords such as “Structural Engineer Philippines”, “Senior/Junior Structural Engineers Philippines”, and “Proprietor/Owner/Principal Structural Engineers Philippines”. In total, three hundred (300) active prospects working as structural designers were identified, contacted, and requested to answer the questionnaire (representing a sampling frame of this research). In total, 145 agreed to participate in the study. In addition, each respondent was requested to share the questionnaire with their colleagues, subordinates or friends working as structural engineers in the Philippines. The survey administration process began with the researchers asking for consent from the prospected respondents to participate before sending the questionnaire. Due to the COVID-19 pandemic, the questionnaire was sent via email instead of regular mail to avoid delays by the postal services. Out of 145 questionnaires sent, 61 completed forms were received, representing a response rate of 42 %.

2.3. Analysis

The study used a descriptive statistical analysis in making conclusions for each question and in general. Most questions of the questionnaire used the Likert scale. Therefore, it was necessary to show the results in plots or graphs to provide simple descriptive visualisations.

At each point in the scaling of the Likert scale, corresponding linear numeric response values were reflected. Thus, the data can be considered parametric and used for statistical description using the mean and standard deviations (Norman, 2010; Sullivan & Artino Jr, 2013). The questionnaire’s content was structured to obtain awareness of the respondents on PtD and extract some hints of drivers to adopt the concept successfully.

3. Analysis results

3.1. Respondent demographics

Respondents returned sixty-one (61) filled-out forms. The demographic breakdown of respondents (Table 1) shows the fair distribution of respondents’ years of experience and ages. Twenty-eight per cent (28 %) of the respondents had at least three years of experience, 60 % — four to 20 years of experience, and 11 % — more than 20 years of experience. In the Philippines, a graduate of the civil engineering bachelor’s degree has to take the Philippine Regulation Commission’s (PRC) board examination and be 21 years old. Thus, the average age of respondents was 33, ranging from 22 to 61 years.

3.2. Knowledge and understanding of PtD

To have a better demographic view of the study, the respondents were further grouped into private

Tab. 1. Demographic information of the respondents (n = 61)

Variable	Category	N	%
Age (years)	≤30	35	57
	31 - 50	20	33
	>50	6	10
	< 4	17	28
Experience (years)	4 –20	37	60
	>20	7	12
Work sector	Public	10	16
	Private	51	84
Position	Civil/Junior/Associate/Senior Engineer	41	68
	Firm Manager/Principal/Owner/Proprietor	10	16

and public sectors. The private group was further split into employees and management or firm/company ownership roles. The groups were Civil/Junior/Associate/Senior Structural Engineer (68 %), Manager/Principal/Owner/Proprietor Structural Engineer (16 %), and Public Design/Civil, Structural Engineer (16 %). The variability of work experience and age gave credibility and less biased analysis, covering opinions from novices to more experienced respondents.

KAP questionnaires were sorted, and four questions were analysed to determine how the respondents encountered PtD (Table 2). The first two questions were both direct on when and how respondents learned about PtD. Results show that most respondents (57 %) learned about PtD just after reading the questionnaire. Thirty-four per cent (34 %) said they learned about it from their company, while very few (only 12 %) learned about PtD through education, e.g., tertiary education, published papers, and training courses. Almost no (95 %) respondents attended a PtD training course.

Referring to Table 3, the overall mean level of PtD understanding among the designers was low. Though the majority had indicated they had an average understanding (mode = 3), a considerable number of respondents have indicated they had less than average understanding of PtD, thereby pulling the mean to 2.62. Designers working in the public sector had a higher understanding of the concept compared to the private. Further demographic analysis within the private sector shows a slight difference in the mean level of understanding between owners and employees. The duration of work experience is a factor for the level of understanding among structural engineers, as its mean level rises with increasing years of experience. Also, the table provides the level of familiarity with the PtD concept among structural engineers. The overall level of familiarity was of the average level ("somewhat familiar"), which the majority of the respondents also had pointed out (mode = 3). However, the respondents in the private sector were more familiar with the concept than those working in the public sector. More experienced structural engineers (with work experience longer than 20 years) had more understanding and were evidently more familiar with the concept. The younger practitioners (with less than four years of experience) had little understanding and familiarity with the concept. Results presented in Tables 2 and 3 show that respondents were not aware of the PtD existence in the industry. However, they somehow understood the concept when it was introduced. Also, the PtD concept was more familiar to designers with more experience with structural design.

Furthermore, PtD is just one of the terms used by researchers, but in general, its core idea is the consideration of safety in the design phase. Respondents may have unknowingly implemented the idea though

Tab. 2. Results on how respondents encountered PtD

Questions	Answers	N	%
When did you first learn about PtD?	Just now, after reading this questionnaire	35	57
	After I started my profession	21	34
	Before I started my profession	3	5
	Other	2	3
How did you first learn about PtD?	Just from this questionnaire	35	57
	Through my company	19	31
	Tertiary education	4	7
	Scholarly published papers	1	2
	Seminars or training courses	2	3
Have you attended any PtD courses?	Yes	3	5
	No	58	95
How often have you been asked to address construction worker's safety In the design phase?	(5) Always	0	0
	(4)	6	10
	(3) Sometimes	17	28
	(2)	11	18
	(1) Never	27	44

Tab. 3. Mean level of understanding and familiarity of the designers with PtD

Variable	Category	N	Understanding		Familiarity	
			Mode	Mean	Mode	Mean
Overall		61	3	2.62	3	3.02
Work Sector	Public	10	3	3.3	1	2.4
	Private	51	3	2.49	3	3.13
	Owner/Manager	10	2	2.80	3	3.60
	Employee	41	3	2.41	3	3.02
Work Experience (years)	< 4	17	3	2.47	3	2.65
	4–20	37	2	2.54	3	2.92
	>20	7	3	3.43	5	4.43

Scale Indicator: 1 (Very Poor/Not Familiar at All), 3 (Average/Somewhat Familiar), 5 (Excellent/Very Familiar)

they have not encountered the exact terms used by the researchers, such as PtD or DfS. Thus, the designers were asked whether they were often asked to address construction workers' safety during the project's design phase. Results showed that only 28 % answered they were asked sometimes. However, almost half (44 %) of the respondents were never asked to do so (Table 2). Upon further analysis, those who have been asked to consider construction safety in their designs have a high level of familiarity (20 out of 23 or 87 %) on PtD. In comparison, only 25 out of 38 (68 %) of those who have not been asked to consider construction safety in their design were familiar with PtD (Table 4). Since designers were rarely required or asked to incorporate construction health and safety assessments in their designs, their familiarity with the concept was also low. In addition, these results could imply that the capability of designers to mitigate construction hazards were not recognised or that the other construction stakeholders, contractors, and clients were also unaware of PtD.

A new idea, product, or practice can be adopted as the first step according to the diffusion of innovation model (Rogers et al., 2014; Potoczek, 2021; Bharadwaj & Deka, 2021). In the knowledge stage, the person becomes aware of an innovation and how it functions. The results showed that the majority of the structural engineers in the Philippines still had no idea the PtD concept existed. Further research demonstrated that OSH of the Philippines still had not specifically introduced the PtD or DfS concepts among designers, unlike Singapore and Malaysia in the Southeast Asian region (Che Ibrahim & Belayutham, 2020; Goh & Chua, 2016). The PtD concept is still relatively new for structural designers in the Philippines.

Some respondents indicated having encountered the PtD idea at their company. Thus, companies could be a viable medium for introducing the PtD concept among structural designers. However, its importance should be exhibited by incorporating the PtD idea in educational programmes to make aspiring engineers aware at the earliest stage. The lack of PtD acknowledgement is also the reason for no PtD training offered or organised for designers. Certain companies and governmental institutions have offered and organised a course on Construction Occupational and Health (COSH). However, the course is intended for safety officers/engineers on-site and not for structural or design engineers.

Despite the lack of PtD knowledge, results showed that overall, respondents had a considerable understanding and familiarity with PtD. The structural design aims for structural safety to the end-

Tab. 4. Cross-Tabulation of the effect of being asked to consider safety in design to the familiarity of PtD

Have you been asked to address construction workers' safety in the design phase?	Level of familiarity		Total
	≥ "Somewhat" (≥ 3)	< "Somewhat" (<3)	
≥ "Sometimes"	20	3	23
< "Sometimes"	25	13	38
Total	45	16	61

users. To some extent, the structural design includes the structural stability of the building and the safety of construction workers. In PtD or DfS concepts, the words "safety" and "design" are very close to the structural designer's nature of work. In this study, the likeness of the concept may be one of the reasons many structural engineers were at least somewhat familiar with the concept. However, respondents were given a short PtD definition in the questionnaire, which may have influenced the analysis results.

3.3. Attitude towards PtD

As part of awareness level inquiry among structural designers about PtD, it would also be valuable to determine their perceptions about the concept and its details. Table 5 shows that designers were all optimistic about the importance of PtD implementation. They all believed that PtD would decrease the construction industry's rate of accidents. Furthermore, no disagreement was found among the designers that their duty should involve design for construction safety. No further demographic analysis of the results was made in terms of these aspects since the results showed an overall favourable agreement on the subject.

Table 6 shows the respondents' perceptions of each example of PtD guidelines regarding its effectiveness to improve construction safety and the practicality of each item to be applied in their designs. These examples of PtD guidance for design were taken from suggestions of earlier literature and published design guidelines from other countries. The selected items were in line with the structural design aspects and could be incorporated into their works. Overall results showed that the designers perceived the given items to decrease construction hazards effectively. Moreover, designers saw the practicality of applying each item in their design. It was observable that some items have high mean values. Upon closer observation, the items with high mean values were general design concepts that may apply to PtD, for example, item 1. However, when it comes to detailed design concepts that may apply to PtD (e.g., item 5), some respondents were somehow hesitant about the effectiveness and practicality of such items.

Aside from the designer interest in PtD, there must be some external motivation that should push its implementation (i.e., to drive the designers towards PtD implementation). Referring to Fig. 1, forty-four per cent (44 %) of the structural designers considered the contractors as the top motivator to push them to apply PtD. Designers knew that construction site safety was the responsibility of the contractor. Thus, a push from the direct source of concern is necessary. Furthermore, as the direct builder, a contractor has the knowledge and experience concerning construction site safety that should be shared with designers (Gambatese et al., 2017; Tymvios et al., 2012). Hence, designers would rely on the contrac-

Tab. 5. Designer's Attitude Towards PtD

Attitude towards PtD	Level	%
	5 (Very Important)	62
	4	30
Implementation of PtD	3 (Somewhat Important)	8
	2	0
	1 (Not Important)	0
	5 (Strongly agree)	77
Designer's duty	4	13
Should involve design for	3 (Neutral)	10
Construction safety?	2	0
	1 (Strongly disagree)	0
	5 (Strongly agree)	72
PtD will decrease the rate of injuries and	4	18
Fatalities in the construction	3 (Neutral)	10
Industry	2	0
	1 (Strongly disagree)	0

Tab. 6. Designers' mean level of perception on the effectiveness and practicality of PtD items

No.	Examples of the PtD guidance for design	Effectiveness	Practicality
1	Design the structural members to withstand all anticipated construction loading during fabrication, storage, erection, and final connection	4.62	4.11
2	Design member depths to allow adequate headroom clearance around stairs, platforms, valves, and all areas of egress	4.57	4.31
3	Design members which are consistent in size, light-weight, and easy to handle	4.41	4.28
4	Design columns with holes at 21 and 41 inches above the floor level to provide support locations for lifelines and guardrails	4.03	4.00
5	Locate column splices between 2 and 3 feet above the finished floor level, and two-story intervals	3.95	3.92
6	To allow a sufficient walking surface, use a minimum beam width of 6 inches	3.74	3.59
7	Consider alternative steel framing systems, which reduce the number of elements and where beams are landed on supports rather than suspended between them	3.97	3.72
8	Design welded connections such that weld locations can be safely accessed	4.46	4.23
9	Limit the lift heights of steel erection	4.39	4.07
10	Use a metal deck and concrete fill rather than a slab that requires temporary formwork	4.07	3.79

Scale indicator: 1 (Not at All Effective/Not at all Practical), 3 (Somewhat Effective/Somewhat Practical), 5 (Very Effective/Very Practical)

tors' knowledge and experience to guide them aside from the responsibility concerns.

Based on their understanding of PtD, structural engineers had a very optimistic attitude towards the concept. The majority of the respondents strongly agreed on the necessity of incorporating PtD in their work.

Despite being fresh to the PtD concept, respondents saw that the PtD implementation would help the industry with its construction safety issues. Furthermore, this positive attitude from the structural engineers would set an optimistic tone to encourage the adoption and boost the diffusion of PtD in the Philippines.

3.4. Perspective of the PtD practice

In this part, though PtD was not yet implemented in the Philippines, structural designers were asked in the questionnaire about their perceived challenges and issues of possible PtD adoption in the industry. The items (Table 7) reflected concerns regarding the direct PtD implication to the designers. Designers ranked these items by choosing the rank number in

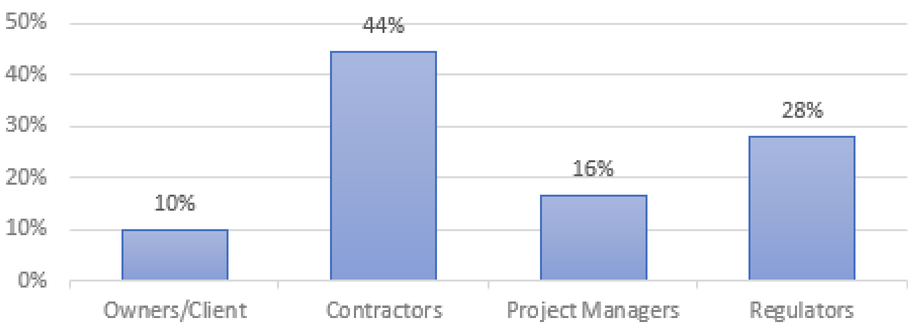

Fig. 1. Who should push designers to apply PtD

the dropdown menu beside each item, marking one (1) as the topmost concern, and a higher value of ranking meant a lower level of concern. Each corresponding mark of ranks was considered a score. The ranking was based on the sorted sum of the scores for each item, where the lowest sum has the top rank. The top concern of the designer was the liability involved when participating in the PtD process. Secondly, designers were concerned about additional incentives for such work and could not afford to do it voluntarily.

Respondents were given an open-ended question on the general problems they would face when practising PtD. They were allowed to point out and add a particular problem or select from the given examples. These items were the perceived barriers of PtD implementations from different works of literature. As shown in Fig. 2, the topmost problem designers perceived in PtD implementation was the cost consideration from the client or company (75 %). Designers also identified the availability of design guides (61 %), design tools or software (54 %), and checking standards for analysis (54 %).

Concerns regarding the assumption of liabilities were the most prominent when considering the PtD aspect of the design. Structural designers were among the many stakeholder groups engaged in risk management throughout the construction life cycle and may be reluctant to assume the risk for all stakeholder groups (Weidman et al., 2015). However, the PtD concept does not attach such liabilities to the designer. Instead, PtD just encourages designers to be safety conscious in their design works (Gambatese et al., 2008; Gambatese, Gibb et al., 2017; Toole & Gambatese, 2008; Votano & Sunindijo, 2014). If implemented, PtD would be an additional task for designers, who were also concerned about doing it voluntarily. Accordingly, designers would naturally seek additional compensation, considering the liabilities involved as viewed by the designers. This top faced or anticipated concern was similar to the study conducted by Che Ibrahim & Belayutham (2020) in Malaysia and Goh & Chua (2016) in Singapore. Moreover, while developing tools and guidance materials, it is essential to improve the PtD knowledge among engineers (Jin et al., 2019; Qi et al., 2014). The results indicate a current lack of PtD guidance material and the need for publicity of existing materials, but this is understandable for a country that has not introduced the PtD concept yet. Nevertheless, there were already efforts to develop PtD guidance material in other countries, e.g., Behm et al. (2012) and Workplace Safety and Health Council (2011).

The items reflected in Fig. 2 were specific concerns that could hinder the PtD implementation from the designer's perspective. Based on the result,

Tab. 7. PtD Implementation concerns

Rank	Concerns in PtD implementation
1	It will give me liabilities for accidents that may occur during the construction
2	I have to do it voluntarily
3	It will result in complications in the procurement process
4	It will compromise my design creativity

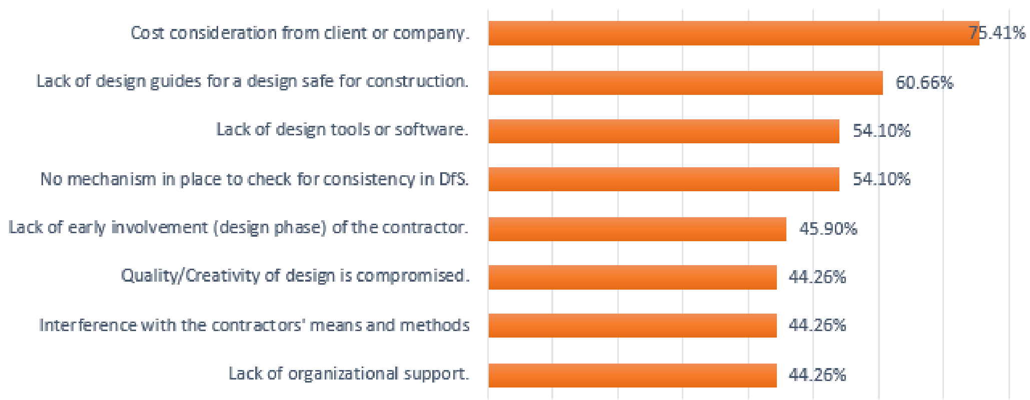

Fig. 2. Problems faced in PtD practice

designers focused more on their basic needs for the PtD adoption, such as incentives and designer tools (design guidelines, software and checking tools), rather than the construction industry's management practices. Hence, considering the listed items as possible barriers to PtD implementation, data suggests that it would be best to head start intervention for PtD adoption among the designers in the Philippines by providing them with tools that would boost their ability to perform in PtD.

4. Discussion

The following synthesis discusses the perceived challenges and key drivers for the PtD adoption among designers in the Philippines as extracted from the respondent answers to the survey questions. The answers provided some insight needed for the successful adoption of PtD in the Philippines, and the items were framed based on the outlined research objectives and scope.

4.1. Perceived key drivers for the PtD adoption in the Philippines

PtD, as a proactive approach, is recognised to be effective as a general concept for the field of occupational safety and health. However, the construction industry's dynamic nature compared to the manufacturing industries made it more challenging to implement. Furthermore, many stakeholders were involved in the construction industry, making it difficult to instil the concept without complicating its system dynamics. Other countries that attempted to adopt PtD encountered such friction in the PtD implementation, and the Philippines will not be exempt from facing such challenges. In particular, the items listed in Table 7 and Fig. 2 signify the apparent concern in the PtD implementation. The concerns and problems mentioned above also hinder PtD adoption. Consequently, PtD adoption can be directly driven by needs, such as the provision of design tools. Nevertheless, from a higher perspective, systematic avenues could be manipulated to inculcate PtD into stakeholders' safety culture.

This study focused on the designer perspective and suggested particular drivers to PtD implementation in the Philippines. PtD acknowledges the capability of designers to influence the health and safety of the construction through their designs. At the same time, it explicitly considers giving high value to safety in construction from the designers (Tymvios & Gambatese, 2019). To succeed in the PtD application, researchers believed that it must start from the designer's mindset to have safety consciousness in their design work, to which respondents agreed. The PtD application among designers in the Philippines is viable but needs some practical intervention for its successful implementation.

4.2. Equipping designers with knowledge and tools

Education is known to be the best way to introduce a concept. Accordingly, as cited by most of the studies on PtD implementation, PtD education could be a valuable information driver on PtD, especially for younger engineers (Behm et al., 2014; López-Arquillos et al., 2015; Olivencia et al., 2017). Mann III (2008) viewed education as the main driver to ensure the success of PtD implementation. The findings in this study indicated that to develop an awareness of construction safety among designers, construction OSH must be included in the education curriculum. An education intervention for PtD adoption would increase students' awareness and knowledge of construction OSH (Behm et al., 2014). PtD curriculum will equip the student with knowledge and develop skills to prepare for a safety-conscious designer. Rubio-Romero et al. (2014) insisted that it would be difficult for designers to implement a new concept that they have not studied. An educational drive is, therefore, necessary to improve PtD awareness and application.

Likewise, to educate and enhance designer awareness is by providing PtD training. The majority of the respondents have not attended any PtD training. The numbers were understandable because PtD was still not implemented. However, designer training needs to be considered in the PtD adoption intervention because designers should possess sufficient knowledge of construction process issues and familiarity with construction safety hazards and their mitigations. PtD training will help designers to be efficient in PtD application (Goh & Chua, 2016). Thus, with appropriate guidance materials and information, PtD training will surely equip the practising designers for PtD.

Several technological tools were available for construction safety management, especially software. The availability of analysis software tools is another avenue considered to help designers know and apply PtD. It is inevitable now that design software could enhance the awareness of its users in terms of the aspects it is capable of. Particularly, the emergence of the Building Information Modelling (BIM) technologies has revolutionised the safety culture and management of the construction industry (Olugboyega & Windapo, 2019). BIM technology is a suitable tool to integrate safety management with its dynamic visualisation, especially on the design stage. BIM-based tools in construction safety can be considered a basis to enhance workers' safety by employing these new technologies (Bhagwat et al., 2021; Fargnoli & Lombardi, 2020). Its digital nature allows it to be customised with multiple interdisciplinary applications. For OSH, examples of BIM applications are knowledge-based tools (Bloch & Sacks, 2020; Fargnoli & Lombardi, 2020; Zhang et al., 2013), fall preventions (Jin et al., 2019; Zhang et al., 2013), risk identification and quantification (Jin et al., 2019; Kasirossafar & Shahbodaghlou, 2013a; Kim et al., 2020), and virtual realities (Bhagwat et al., 2021; Yan et al., 2020). Studies have shown that BIM in construction applications can improve workers' safety performance (Fargnoli & Lombardi, 2020; Ganah & John, 2015). With its digital 3D nature along with its capability to hold information, BIM technologies were very suitable for PtD. First, designers can check directly or collaboratively with other stakeholders on the project on a 3D model and have a visual or virtual safety assessment of PtD concerns of the project's design model. Secondly, BIM's ability to be customised for a specific trade or task is an open opportunity for PtD aspects to be incorporated in the software tools or in the project model itself. Examples were automation of safety checking (Melzner et al., 2013; Mering et al., 2017), identification of safety risks (Malekitabar et al., 2016), and automation of additional PtD aspects in design detailing (Rodrigues et al., 2020; Zhang et al., 2015). Thus, Practical BIM applications can be an essential tool for PtD educational training and, most importantly, an efficient tool for designers.

4.3. External push to designers

As is true for most significant innovations in design and construction, PtD carries considerable risks for early adopters and specific groups within the industry (Toole & Erger, 2019). Based on the study results, designers acknowledge the risks and barriers to the PtD implementation in the Philippines. Though designers were seen as the main actor of PtD, it is important to provide a motivational force to promote and support PtD applications.

Main construction stakeholders can influence safety performance in the construction (Tymvios et al., 2012; Wu et al., 2016). Thus, motivation from each of the stakeholders would be relevant to push the PtD practice. These external motivations may come from other construction industry's main stakeholders: contractors and clients. Some of the respondents indicated learning about PtD through their company. However, few respondents were asked by their contractor or client to consider construction safety in their design. Results implied there was still a lack of acknowledgement from other construction stakeholders for the capability of designers to mitigate construction safety and health. This outcome suggests a need for an information drive to reach out to the direct stakeholders involved in the construction industry on the PtD awareness.

The traditional practice places the responsibility for the construction H&S implementation with the contractor. Consequently, in terms of a push to apply PtD, most structural engineers believed that the contractors should drive them to consider the H&S of the construction and apply PtD. With the most common type of project delivery method, the Design-Bid-Build, the coordination between designers and contractors was not prevalent. However, improving the collaboration between designers and contractors is one of the motivations of the PtD concept. Thus, other project delivery methods or contract standards should be explored or applied to improve the designer's participation in health and safety in the construction. Also, the project owner or the client plays a vital role in the overall project and definitely can influence project safety (Huang & Hinze, 2006). The owner controls the project and provides the financial resources needed for the design, and is in the position to influence the collaboration of construction stakeholders to consider safety (Gambatese et al., 2017). Thus, PtD implementation can be pushed through with the persuasive influence of the owner. As seen in the result of the questionnaire, the designers were concerned about the cost considerations from the client. Designers were afraid of implementing PtD voluntarily. Unless the designer is convinced that PtD analysis provides added value, an incentive for the additional task should be given to the designer, which is in the client's capacity.

Furthermore, regulatory bodies play important roles in reinforcing the legislation of PtD for the construction industry to comply. PtD was initially introduced as a voluntary scheme in some countries like Singapore and the USA. Later, it became a mandate in Singapore through their Ministry of Manpower (Goh & Chua, 2016). Respondents indicated that aside from the contractor, regulators and engineering institutions could push designers to apply PtD. The current results implied the need for industry associations and regulatory agencies to reach out to engineers. Institutional organisations in the Philippines served as a respected, authoritative, and proactive voice in developing codes and standards of professional practice. For example, the ASEP produced the National Structural Codes of the Philippines (NSCP) for structural engineering practice aside from the general National Building Code of the Philippines of the national government. Therefore, professional engineering institutions in the Philippines could also push or mandate the PtD concept to their subordinates.

Conclusions

The study explored and aimed to determine the current awareness of structural designers of the PtD concept in the Philippines. It purposed to generate bases of initiatives to introduce or improve the PtD understanding and adoption. Results indicated that PtD was relatively a new concept for most structural engineers in the Philippines. Despite the lack of PtD awareness, based on their understanding, structural engineers viewed PtD as necessary and its implementation as essential in the construction industry. Despite the known concerns in PtD implementations, structural engineers favoured the adoption of the concept. Respondents perceived the liabilities involved, cost considerations, and availability of design tools and guidelines to be the challenges of PtD implementation. The study also had synthesised the results and shed some light on the perceived challenges and key drivers for implementing PtD in the Philippines based on the questionnaire results and supporting literature reviews. The methods and findings of this study could provide a baseline for a future study with a larger sample size covering other design trades, such as architectural design, electrical design, and mechanical design leading to the adoption of PtD in the Philippines. Furthermore, the framework of this study could also apply to other countries with similar contexts.

The researchers aimed for a careful and comprehensive study. Nevertheless, multiple design trades of the construction industry would be challenging in one comprehensive questionnaire. Thus, further studies on the context of other design trades were highly recommended for a comprehensive view from the designers. Similarly, the views of the contractors and clients are also considered vital for the PtD adoption and are then recommendable for further studies. Future work is prepared on framework development for the diffusion intervention or improvement of the PtD concept in the Philippines.

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