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Development of compliance checklist system for landed housing construction activities

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Abstract. In the construction industry (landed housing), most of the accidents and near-misses in occur due to unsafe behavior of the employers and employees. Lacking compliance with regulations is also one of the causes of accidents and near-miss occurrence in the construction industry including for landed housing development). This paper aims to identify Building Operations and Works of Engineering Construction (BOWEC) requirements under Factories and Machinery Act with Regulations (Act 139), Law of Malaysia for landed housing construction activities. Behavior-Based Safety (BBS) approach is used to develop a compliance checklist based on the BOWEC requirements. The developed checklists were validated in terms of its validity by using case study in the construction industry. After the validation processes, the final checklist is ready to be used. The final checklists are divided into two parts; (1) the checklist for the employer and (2) the checklists for employees. Workplace assessment was conducted using the developed checklist. The finding reveals that more than half of the construction activities are comply with the legal requirements.

1. Introduction

In developing countries, construction industry is one of the essential national backbones. There are various types of activities in construction industry and indirectly have a highly complex and hazardous environment that may cause more injuries and fatalities [1]. The construction industry is third in the ranking of occupational sectors with regards to the accident rate [2]. The construction industry is known as the place that possesses high level of hazard and risk to the employees [3]. It is because the employees in the construction industry work in high dealing with machinery equipment and external activities.

In the construction industry, there are three levels of construction which are: building construction, civil/heavy construction and industrial construction. However, in Malaysia, there are many construction sites which are involved with the building construction of landed housing. Many accidents are associated with building construction of landed housing such as falling from height, drowning, struck by support formwork and machine-related [4].

To maintain safety and health in construction industry, a Behavior-Based Safety (BBS) is the proposed tool to manage the employer and employees work activities, which is from unsafe behavior to safe behavior that can prevent accident and injury from occurring. BBS checklist is used to evaluate behavior of employer and employees at the workplace [5]. For the BBS implementation and procedures, it is based on “DO IT” application process [6]. In addition, the BBS checklist that is



developed in a system is more easy for the observer to make the observations, and makes the finding process convenient because the data is saved timely.

The regulation used in the Malaysia construction industry is Factories and Machinery Act 1967 under the scope of (Building Operations and Works of Engineering Construction, BOWEC) (Safety) Regulations 1986 [2, 7]. So, to ensure safety and health of employer and employees in construction sites, it must comply with BOWEC regulations and other supporting regulation in Malaysia 's legislation [6, 8]. Therefore, to support the above requirement, this paper is aimed to highlight the BOWEC 1986 requirement, and then apply it into the BBS approach for landed housing construction activities. In addition, Occupational Safety and Health Act (OSHA) 1994 [9], also reviewed to further understand the needs of legal requirements at Malaysia construction industry.

2. Methodology

2.1. Analyze the elements and requirements of BOWEC Regulation 1986

In this study, the Deming Cycle (figure 1) is adopted to develop the BBS checklist. The cycle starts from Plan, Do, Check and Act. This cycle provides a structure for iterative testing of changes to improve quality of systems. The method is widely accepted and being applied in numerous occupational safety and health related publications such as in Azmi and Aziz [10] and Hang and Sukadarin [7]. The elements of BOWEC Regulations 1986 (FMA 1967) as specified by DOSH Malaysia were analyzed for construction landed housing. The elements of requirements were served as the basis for the information that is used to develop the BBS checklist.

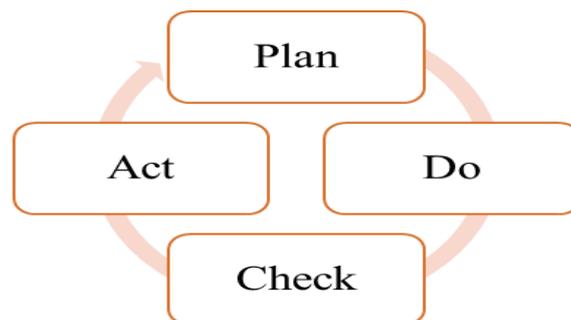


Figure 1. *The Deming Cycle.*

2.2. Development of BBS checklist

After the requirements of BOWEC Regulations, 1986 are extracted for the construction industry (landed housing), The BBS checklist was developed by using Microsoft Words 2016. The development of BBS checklist was divided into two parts which are BBS checklist for employer and BBS checklist for employees.

2.3. Development of system BBS checklist

After the development of BBS checklists for employer and employees were validated by subject matter expert in occupational safety and health field, the system of BBS checklists is developed by using Microsoft Access 2016 based on the BOWEC requirements in the construction industry (landed housing) that serves as guide in complying the requirements. The development process took about two months to be completed.

2.4. Validation of system BBS checklist

After the BBS system is completed and tested so that it can be run smoothly with the subject matter expert, the system was sent to be validated and used at a construction industry (landed housing) which is located at Kuantan, Pahang. The adapted techniques including a case study supporting with series of observation and interviews with employer and employees at the chosen construction site.

2.5. The calculation of the compliance percentage by BOWEC Regulation 1986 requirements

The compliance percentage of the construction industry (landed housing) with BOWEC requirements was then conducted using equation (1) below.

$$\frac{C}{N} \times 100 \quad (1)$$

where C and N are the number of compiled and total number of questions by each part, respectively.

3. Results and Discussion

3.1. Analysis of the elements and requirements of BOWEC Regulation 1986

Table 1 shows the elements in BBS checklist, which is for construction industry (landed housing) based on BOWEC Regulation 1986 requirements. As can be seen, it contains 13 parts from BOWEC Regulations 1986 that focusing for construction industry (landed housing).

Table 1. BBS element for construction industry (landed housing) based on BOWEC Regulation 1986.

Part	BBS Elements
1	General provisions
2	Concrete work in construction site
3	Assembly of structural steel and precast concrete in construction site
4	Good and safe condition of roof, gutters, windows, louvres and ventilators in construction site
5	Use of safety belts in construction site
6	Use of ladders and step-ladders in construction site
7	Use of scaffolds in construction site
8	Demolition work in construction site
9	Excavation work in construction site
10	Handling and storage, use and disposal of material in construction site
11	Use of piling in construction site
12	Blasting work and use of explosives in construction site
13	Use hand and power tools in construction site

3.2. Development of BBS checklist

The developed of BBS checklists were validate. BBS checklists were validated in two phases. The first phase of validation is named as face validity. This face validity is conducted by subject matter expert (SME). The second phase of the validation process is named as content validity. The content validation is conducted with on-duty Safety and Health Officer in the construction industry (landed housing). For the content validity, the validation process is repeated for two times which are at the off-site and on-site.

3.2.1. Face validity. Face validity has been conducted with subject matter expert (SME). One of the recommendations by SME during the validation process is to make an improvement of BBS checklist such as to change of parts and elements in the BOWEC regulations requirements with a simple and more understandable statement that may be more convenient to be used by low educated workers. Figure 2 shows the example of an improvement that had been done in the BBS checklist as

recommended by SME. It is shown an example of BBS checklist before and after face validation process by SME.

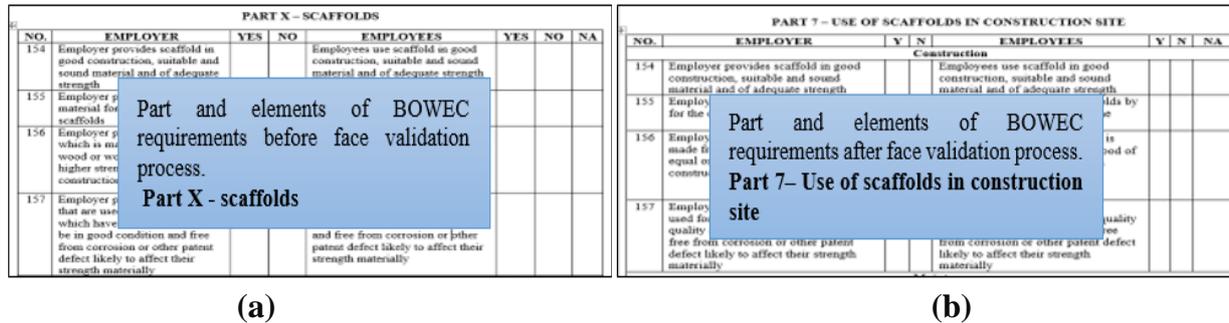


Figure 2. (a) BBS checklist before the validation process (b) BBS checklist after the face validation process.

3.2.2. *Content validity.* The second phase of validation is content validity has been done by on-duty Safety and Health Officer from the construction industry (landed housing) background. For the second phase of validation, the validation process was conducted two times which is at off-site and on-site construction project. These two times of validation are conducted by the different on-duty Safety and Health Officer.

Off-site content validity has been done with an on-duty Safety and Health Officer who comes from the construction industry (landed housing) background. The recommendations by on-duty Safety and Health Officer were taken into consideration and improvements were made. For example, one of the suggestions is to add a column for a “remarks” section. The purpose of this “remarks” section is to make notes if some information needs to be added when the process of data collection is ongoing. The involved Safety and Health Officer also agreed all the elements in the BBS checklist that have been summarized based BOWEC Regulation 1986 requirements are valid to be used in construction sites. figure 3 shows the example of improvement of BBS checklist that has been made based on recommendation by the Safety and Health Officer.

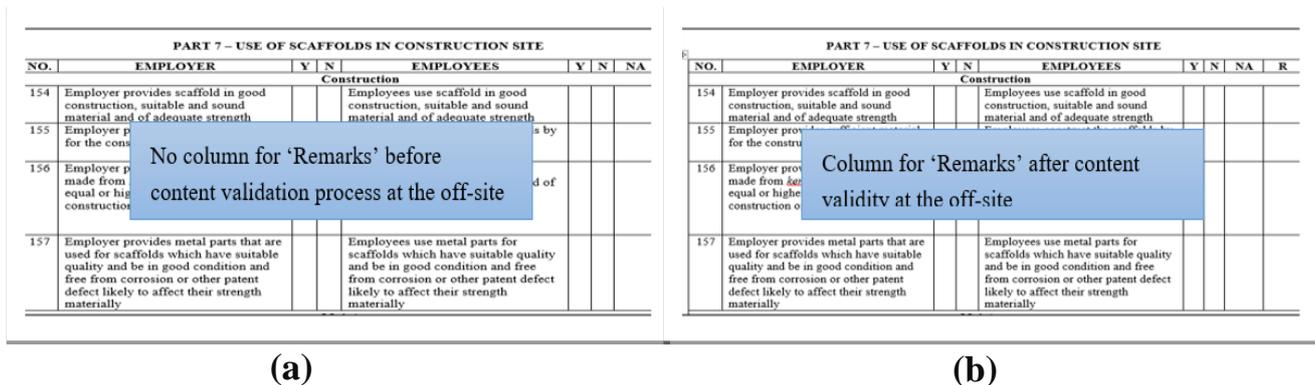


Figure 3. (a) BBS checklist before content validation process at the off-site and (b) BBS checklist after content validation process at the off-site.

On-site content validation has been done with an on -duty Safety and Health Officer who also from construction industry (landed housing) background. The recommendation has been made based on the suggestions by the Safety and Health Officer. Among the suggestions, it would be beneficial if the BBS checklist can be prepared as short as possible but can be understood by all level of organization in construction site. The on-duty Safety and Health Officer also suggested improving the scope of

elements in BBS checklist to becoming smaller and specific by only focusing on one type of construction.

At the beginning of extraction process of BOWEC Regulation 1986 requirements, the elements were covers from part 2 until part 16 in the BOWEC Regulation 1986 document. So, the checklist became too general to be used at the construction site that focuses on the work of developing landed housing. Based on the needs of landed housing development, there are only a few elements in BOWEC Regulation 1986 that are applicable. So, at the early stage, the drafted BBS checklist, was consists of 310 checklists. So, an improvement has been done by reducing it to 45 checklists of employer and 43 checklists of employees. Figure 4 shows the examples of improvements of the BBS checklist has been made based on recommendations by Safety and Health Officer.



Figure 4. (a) BBS checklist before content validation process at the on-site, (b) BBS checklist after content validation process at the on-site

3.3. System developed for Behaviour-Based Safety Checklist

Computerized BBS checklist has been developed by using Microsoft Access 2016. The Microsoft Access 2016 was used to create a system and store information for reporting, referencing and analysis of the compliance audit based on BOWEC Regulation 1986 requirements for landed housing construction work. Figure 5 shows the example of BBS checklist interface in a system.

Figure 5. The example of BBS checklist interface.

3.4. Compliance of landed housing construction site with the BOWEC Regulation 1986.

Simple percentage calculation used to measure the compliance of landed housing construction site with the BOWEC Regulation 1986. As can be seen in the table 2, there are 61 questions has been developed for employer's checklist, and 60 questions has been developed for employee's checklist.

However, during the site visit, only 45 questions that applicable to the chosen construction site for employer's checklist. Meanwhile, for employee's checklist only 43 questions that found applicable.

There are three parts which were not applied in collection of data's site. The parts are part 8, part 11 and part 12. Based on BOWEC Regulations 1986, part 8 is demolition work. Demolition work is not applied in the involved site. For part 11, is piling. Piling was not applied because this site only uses a rough foundation as to reduce cost. The last part is part 12, whereby the requirement that needs to be followed for blasting work and the usage of explosives material. This is because of the study construction site was not built at the hilly area.

There are three parts which complied 100% with the BOWEC Regulation 1986 requirements for employer's and employees' checklist. The parts are part 2, part 3 and part 4. Overall percentage of employer and employees complied with the BOWEC Regulation 1986 requirements are 82% and 77%, respectively.

Table 2. Details number of Parts in the BBS checklist system and finding on the legal requirement.

Part	Employer's Checklist			Employee's Checklist		
	Total no. of the question (N)	Comply = YES (C)	C/N (%)	Total no. of the question (N)	Comply = YES (C)	C/N (%)
1	11	10	91	10	8	80
2	1	1	100	1	1	100
3	1	1	100	1	1	100
4	3	3	100	3	3	100
5	3	2	67	2	1	50
6	1	0	0	1	0	0
7	6	6	100	4	3	75
8	5	-	-	5	-	-
9	7	4	57	7	4	57
10	7	6	86	8	7	88
11	6	-	-	7	-	-
12	5	-	-	5	-	-
13	5	4	80	6	5	88
Total of questions		61			60	
Item's measured	45	37	82	43	33	77

4. Conclusions

This study concludes the result of the objectives. The BOWEC Regulation 1986 requirements in construction industry (landed housing) was analysed. The BBS checklist was developed based on BOWEC Regulation 1986 requirements in construction industry (landed housing) by using Microsoft Words 2016 and Microsoft Access 2016. The BBS checklist was validated by using case studies in construction industry (landed housing) located at Kuantan, Pahang, Malaysia. Authors believe the developed system will encourage the construction industry to comply with the current legislations and at the same time may encourage more research works in order to help construction industry to manage their site and keep them safe.

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