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Learning from Defects in Design and Build Hospital Projects in Malaysia

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***Abstract*—Defects detected during the Defects Liability Period of a construction project suggest that the project management team have not managed the project effectively somewhere during the project implementation stage. Clients, especially those with little project management experience are usually at a lost in trying to configure how this should be dealt with. Resolving issue relating to construction defects can be vexing and time consuming, but clients are frequently pressed for time to occupy and operate the building. Consequently, they unusually end up rectifying most of the defects themselves and at their own cost.**

In appreciating the need to resolve this continuing problem in design and build public hospital construction projects in Malaysia, a research was mooted to learn from the study of defects and investigate how best defects can be managed. The study aim is to understand the nature of the defects to track their root cause. Four Malaysian public hospitals are chosen as the case study. Semi structured interview with the senior hospital management representatives were conducted to understand the reasons underpinning the defects. The findings suggest that with a comprehensive methodology in place, defects can be effectively traced and categorized to track their cause. If this is in place, clients can have better recourse to address the issue of defects, particularly with respect to how the defects can be managed, who should be responsible and what not to be repeated in future.

Keywords-Construction defects; design and build; public hospital; Malaysia; Defects Liability Period

I. INTRODUCTION

Construction failure can be associated to defects and shortcomings during the project implementation process of construction projects. However, frequently parties managing construction projects are somewhat unmindful of the defects and their causes, and thereon take the necessary action if and when they happen. A number of design and build (DB) hospital projects developed in Malaysia fall within this category. Most defects are not properly recorded and resolved, and in end, this frequently results in significant cost overruns.

The paper presents the research, which investigate the types of defects inherent in DB hospital projects. This is the aim to understand the nature of the defects to track their root cause. In line with this aim, the research objectives are to: (1) investigate the types of defects, (2) analyse their causes, and (3) explore the possibility of tracking their root cause to the project implementation.

II. THEORETICAL FRAMEWORK

A. Construction Defects

Construction defects are commonly defined as a failure or shortcoming in the building's function, performance, statutory or user requirements, and this may occur in its structure, fabric, services or other facilities [1][2][3]. Whilst [2] associates building defects mostly to the building operational phase, [3] and [4] maintain that defect not only manifests itself also before and during the construction stage.

Reference [5] conceives defects in construction as manifest within a few common interrelated factors, and this includes their cause, erroneous action, defect consequence and corrective measure. Defects in buildings are commonly classified as patent and latent defects [6]. Patent defects can be clearly recognized during inspection during the construction and the project's Defects Liability Period (DLP). Latent defects usually appear over time when the building is occupied. Patent and latent defects in buildings are serious issues and failure to address them would most likely contribute to additional rectification cost, hamper the smooth operation of the building and reduce its service life.

The recognition of the need to examine the causes of defects, their implications and explore better ways to prevent can be traced to the early 1980s. The study on the cause and effect of defects in buildings converge to suggest that most of the defects are a consequence of 'weaknesses' in the project implementation process. Whilst poor specifications, selection of materials, workmanship and supervision the common cited causes of defects, poor design decisions are identified as the most significant contributor to the defects. The important role that designers play to eliminate defects have commonly been highlighted [1][2][7][12]. They have the duty to ensure that all the client requirements are well captured, translated and communicated to the other project team members

throughout the project implementation process [7], supported with proper documentation system.

B. Design and Build

The need for a more integrated design and build process, faster project delivery with a consortium taking sole responsibility over the project, usually on a lump sum fixed price coupled with the adversarial nature of the traditional procurement systems which separates the design and construction teams has led to the popularity of the DB procurement system [8][9][10]. DB procurement is recognized as an ideal substitute in many public projects and private in many countries [11][10]. Reference [12] and [10] define DB as alternative procurement approaches which promote a single entity or consortium who takes sole responsibility over the project, usually on a lump sum fixed price.

DB became popular in Malaysia in the 1980s and 1990s with the Public Work Department (PWD) taking the lead role. A typical DB project implement process would involve the end-user initially identifying a project and applying to secure a budget. Once approved, PWD would manage to implement the project on behalf of the end user government agency until completion. To facilitate the implementation process, three documents, (i) DB Condition of Contracts, (ii) Guidelines for Management of Design and Build Projects, and (iii) Guidelines for Project Brief Preparation to outline the framework of the project management process. Notwithstanding, several researches [13][14][15] revealed that weakness in DB project management approach are persisting. This includes cost and time overruns and quality problems emanating from the culmination of unfamiliarity with the DB process problems and flaws within the project management process.

C. Defects in Design and Build Public Projects in Malaysia

Defects are common in Malaysian educational and hospital projects developed on the DB procurement system [16], and have consequently caused the government a considerable sum of money to rectify. Because of the seriousness of the problem, the Ministry of Education went to the extent of suspending the use of DB procurement system in their projects from 2005-2010 (in the 9th Malaysia Plan). The Ministry of Health was similarly dissatisfied with the delivery of their DB hospital projects, especially pertaining to the large number of defects that came with the completed projects. They warned that in future, they will not accept hospitals with such problem.

Evidence of defects repeated in many projects even when constructed by the same contractor [16][17] propounds the view that studying the nature of the defects and possible approaches to track their root cause very necessary [5][7][16][18]. In the absence of educational building projects implemented with the DB procurement system, hospital projects were chosen as the case study for the research.

D. Rationale for Tracking Construction Defects

There are three key stages involved in the projects; they are the design, construction and occupation stages. Within this context the research was developed on the premise that if these three stages are effectively implemented, the end product i.e., the building handed over to the end-user should be able to perform as expected and problem free. Clients should be satisfied and get the value for money from their investment. Conversely, if there are not achieved, there are weaknesses in the project design and/or construction process stages.

III. Research Methodology

Four DB public hospital projects in Malaysia are chosen as the case study. This was in the justification that there were very few available education DB project at the time of research but there were available data from DB hospital projects that can serve as excellent case studies. Furthermore, hospital projects are usually more complex and there are much that can be learnt from hospital projects which can be applied in other building projects. A mixed method research approach was adopted. First, a quantitative research method was adopted to record and classify defects identified during the DLP of the projects. Data on the defects were obtained from a specially appointed DLP Management Consultant for these projects were sorted, sieved, grouped and transferred into the SPSS software. The measure of central tendency, using the frequency analysis was used to analyse the pattern defects.

The qualitative research method by analyzing project audit documents was adopted to investigate the types and causes of the defects. Semi-structured interview with the senior hospital management representatives who were charged with taking over the completed hospital building were undertaken understand the reasons underpinning the defects. This data were then converted and transcribed into Microsoft Word format and manually analysed.

IV. Findings

The quantitative findings from the data collection were divided into the following groups for the analyses.

A. Defects Identified Based on Scope of Works

Because of time constraints, only patent defects were identified. The analysis on the type of defects based on the scope of works was carried out for each hospital and the findings are shown in Table 1 and Fig. 1.

TABLE 1 Number of Defects

Scope of Works	Number of Defects			
	Hospital A	***Hospital B***	***Hospital C***	***Hospital D***
Architecture	2164	2315	2301	1302
Civil & Structural	894	393	443	32
Mechanical	2584	1208	1121	681
Electrical	1172	2262	1510	651
Bio-Medical	1704	83	98	77
Total	**8518**	**6261**	**5473**	**2743**

Table 1 shows the number of defects based on the scope of works for the four identified hospitals. Hospital A was observed to record the highest number of final defects, followed by Hospital B, Hospital C and Hospital D.

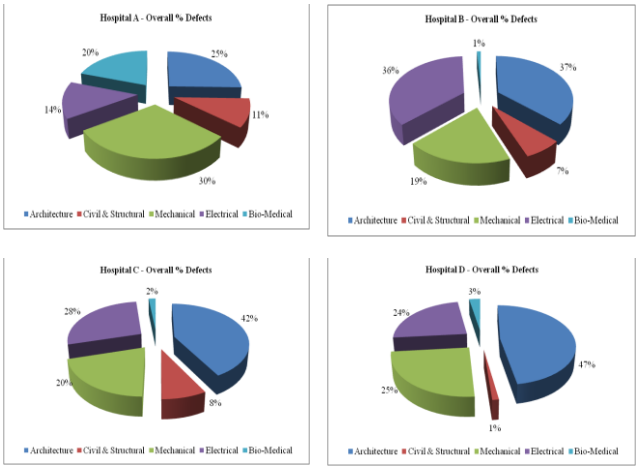

Figure 1. Percentage of defects based on scope of works

Majority of the defects identified were architectural works, followed by electrical works and civil and structural defects, with the exception of Hospital A which recorded a slightly different result in civil and structural works.

B. *Defects Categorisation*

Defects identified from (A) were followed up with the analysis of their cause. These were classified into: (1) Design causes, (2), Workmanship causes, (3) Materials causes and (4) Lack of Protection causes. The findings are shown in Fig. 2.

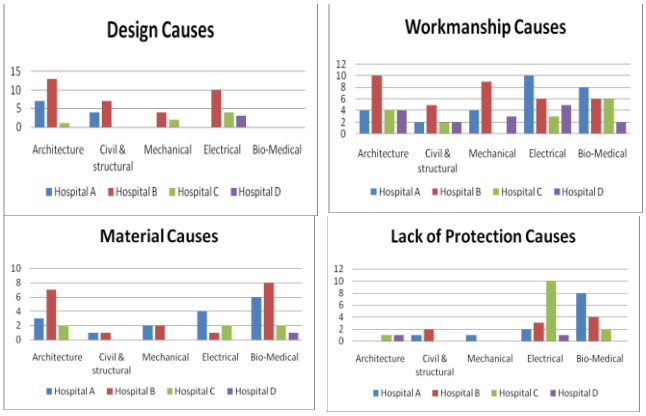

Figure 2. Defects categorization based on scope of works

Defects caused by workmanship contribute to the most number of defects, followed by lack of protection, materials and design causes. The Building Elements which were found to be most defective according to the scope of works are tabulated in Table 2.

TABLE 2 DESCRIPTION OF THE HIGHEST DEFECTIVE ELEMENTS

Hospital	Scope of Work	Defects Categorisation	Element
Hospital A	Mechanical	Workmanship	Plumbing, air-conditioning, mechanical & ventilation system, fire protection
Hospital B	Architecture	Design, workmanship, material	Doors & ironmongery, ceiling, wall, floor and finishes, signage, sanitary fittings, roof, crack
Hospital C	Architecture	Design, workmanship, materials	Doors & ironmongery, sanitary installation, finishes, ceiling, built-in and loose furniture, fitting,
Hospital D	Architecture	Workmanship, lack of protection	Doors & ironmongery, ceiling, wall, floor & finishes, built in & loose furniture

The most detective elements in architectural works are doors and ironmongery and finishes. Plumbing installation and air conditioning system tends to be most defective in mechanical works.

C. *End-user Feedback*

The interviews with four senior hospital management representatives from different hospitals were focused to: (1) possibly trace the root cause of the defects, and (2) identify the necessity of a Third Party to manage the defects during the DLP. The findings that emerge from the interview were as follows:

a) *Getting the contractors to resolve the defects*

> *"….the numbers of defects identified from each hospital at the start of the DLP were very large but almost all the defects were rectified with Certificate of Making Good Defects issued before the end of the DLP"*
>
> *Respondent 2, 3, 4*

b) *Overall feedback towards the building defects*

There were variable satisfaction levels between the respondents from the different hospitals.

> *"…generally we are happy with the completed hospital building"*
>
> *Respondent 1,3,4*
>
> *"… we are generally unhappy with the finished works"*
>
> *Respondent 2,4*

c) *Wrong choice or poor specificaion*

There was a general dissatisfaction over the selection and procurement of some of the materials, equipment's and specifications, and this contribute to operational problem when taking over the building.

"...there are some bio-medical equipment which are obsolete"

Respondent 3

"...the purchasing is done by someone else and the installation is done by others"

Respondent 1

d) Contractual issues

There was a common dissatisfaction over ambiguity or discharge of contractual obligations.

"... the hospital authorities should be given a written warranty by the contractors "

Respondent 2

"...PWD and the DLP Management Consultant should make sure that contractor fulfill their obligations "

Respondent 3

"...there are discrepancies between what is actually put up and the as-built drawings "

Respondent 4

e) Need for a third party to manage the defects

There was a common agreement for a third party to manage the defects during the DLP. The present DP project management process does not have the provision to allow for a comprehensive defect identification audit to be carried out.

"...we are very happy with the performance of the DLP Management Consultant"

Respondent 2, 4

"...the hospital management cannot solve problem on our own "

Respondent 3

"...the DLP Management consultant is very useful as a third party...I don't think PWD would be able to do this by themselves"

Respondent 4

V. DISCUSSIONS ON THE FINDINGS

A number of key findings emerged from the analysis. Firstly, a comprehensive Defects Liability Management process is fundamental if defects are to be comprehensively detected and rectified during the project's DLP. A special designated party need to be assigned to capture and record all the defects, propose the rectification method and monitor closely the works undertaken by the contractor. This may be an additional cost to clients, but the cost can be offset by the defects being resolved, which might cost the clients directly or indirectly even more.

The incidence of the large number of defects suggests that 'gaps' exists within the current DB system practiced in these projects. This needs to be critically investigated. The adequacy of the DB project implementation framework underlined in the DB Condition of Contracts, Guidelines for Management of Design and Build Projects, and Guidelines for Project Brief Preparation adopted needs to be investigated. This should be carried out together with re-establishing the roles and tasks that must be performed by all parties in the project.

While generally the final quality standards of the hospital was deem acceptable by the majority of end users, in some key areas these need to be further clarified. Ambiguity in the determination of specifications together with the construction design and drawings needs to be removed.

There is also much that can be learnt from the data on the defects. Findings from this study provided useful insights on what caused the defects, and the inherent type of defect that tends to occur in each building element (architectural, mechanical, electrical, civil, bio-medical). This can serve as a useful lesson for the DB project management team on what and where to be more careful when dealing with these elements in future projects.

With the application of the right statistical tools, the nature of defects can be correlated to the scope of works within the projects. Notwithstanding, most of the defects are interrelated. For instance, workmanship defects may exist not only due to poor workmanship but may actually originate from ambiguities in the specifications and detail drawings.

VI. CONCLUSION

Findings from this research underline the significance of re-learning defects in DB projects. Within the project context, the findings also suggest that the adequacy of the current DB project implementation process is in question. The study of defects identified during the DLP can be very significant as a control mechanism to ascertain the validity and reliability of a project's implementation process. Without this study there is little that can be achieved to assess whether the project management team has achieved economy, efficiency and effectiveness in their project management process.

The research posits that this must be seen as a positive systematic approach that can encourage better co-ordination and co-operation amongst the DB design team, end-user and contractors towards achieving zero defects in future projects.

VII. FUTURE RESEARCH

The research to-date has only analysed defects in DB hospital projects in Malaysia at the 'first level'. Tracking the inter-relationships and the "ripple-effect" of the causal relationships of defects appear possible and this is underlined for the next stage of the research.

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