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CONSTRUCTION DEFECTS IN RESIDENTIAL BUILDING PROJECTS: PILOT STUDY

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A vast number of studies about construction defects have been published in different countries, confirming that construction defects are a global issue. This problem often adversely affects the budgets, timing, and quality of construction projects. The lack of understanding about which construction tasks are prone to defects make implementation more uncertain and increases the chances of defects. This study seeks to identify and understand the behavior and pattern of task actions that are more prone to defects through the anatomy process of a specific task. The first objective in this study was to identify, track, and record construction defects during the execution of a number of actions within a specified task. The second objective was quantifying which actions are more prone to construction defects and determining the reasons why. Fifteen case studies were conducted on residential buildings, which included 45 items focusing on the column sub-task. Initial results suggest that some actions within specific sub-tasks are more susceptible to defects. This research aims to improve the understanding of construction defects and solutions, enhance cost controls, reduce time overruns, and improve execution quality.

Keywords: Residential projects, Tasks pattern, Saudi Arabia.

1 INTRODUCTION

A significant improvement in quality practices in the construction industry has limited the overruns in project costs via reduced construction defects, which often occur in the execution phase. However, a considerable body of research has argued that the construction industry is still one of the most common industries to suffer from defects compared to other industries, such as the manufacturing industry. To overcome obstacles that might adversely affect budgets, timing, and quality of construction projects, some considerations must be made due to the nature of the industry. One of these considerations is the evaluation and analysis of construction sub-tasks—in particular, its sensitivity toward construction defects. Research questions: First, to what extent does sub-task sensitivity toward defects differ from other sub-tasks? Second, which factors play a vital role in sub-task sensitivity?

There are very limited studies, which have attempted to analyze sub-tasks in specific items. In a certain task, there are a number of sub-tasks that differ in its characteristics and degrees of complexity. This may increase or decrease the sensitivity toward defects for each single sub-task (Almusharraf and Whyte 2012). This study investigates the phenomenon of defects in the residential construction industry via understanding and drawing its pattern. Next, this study provides a procedure that may

avoid or mitigate defects. As a part of this research, a pilot study has been conducted on 15 residential projects in Saudi Arabia.

2 BACKGROUND

Many studies have been published addressing the phenomenon of construction defects and seeking to improve the industry.

2.1 Definition of Construction Defects

Various terminologies have been used to describe technical problems in the construction industry, such as defect, fault failure, and nonconformance (Mills et al. 2009). However, the term "defects" appears to be the most popular term to express this phenomenon. Furthermore, there are different perceptions between researchers to identify an explicit definition of construction defects (Sommerville 2007). Thus, a credible diagnosis process for the problem might be less available than expected.

In this study, some appropriate definitions will be adopted from previous studies to identify the intended meaning of construction defects. Burati and Farrington (1987) defined defect as "a deviation of a severity sufficient to require corrective action". They also defined deviation as "a departure from established requirements" (*ibid*). Knocke (1992) defined defect as "the physical manifestation of an error or omission", while Mills et al. (2009) called it "a tangible occurrence that can be rectified".

2.2 Effects of Construction Defects

Construction defects are one of the most common obstacles that have an impact on a project's progress, which can result in a reduction in stakeholders' satisfaction. The consequences of these defects include costs, schedules, or quality issues. Roughly 2% to 6% of contract values were spent to rectify defects in different types of projects (Josephson 1999). Another study estimated that rework in construction was around 3% of contract values for residential projects, and 2.4% for industrial projects (Love and Li 2000). A task's characteristics are one of the most common causes that may lead to construction defects, as discussed below.

2.2.1 *Task characteristics*

Construction defects during the execution phase have numerous sources, and may occur any time during a project's life (Priemus and Ale 2010). These sources have been divided in the literature into two main areas: task elements and non-task elements. Task elements are related to the nature of task characteristics (e.g., task size) (Bonner 1994; Pitz and Sachs 1984), whereas non-task elements are related to requirements needed to perform a task (i.e., human factor) and a task's surroundings (i.e., weather) (Fayek et al. 2003).

Task characteristics (e.g., task's size or information loads) differ from task to task (Campbell 1988). This differentiation has its own reasons, which stem from the nature of each task. For example, increasing information loads may increase task complexities, whereas raising a task's size may not influence a task's complexity. Task complexity indicates the extent of influence of each characteristic on the task. This is

strong evidence that complexity as a characteristic influences tasks more than other characteristics (Bonner 1994). This study will focus on variation rates between tasks.

The literature review indicates a gap in knowledge concerning investigating and analyzing task characteristics in construction defects. Therefore, the current study examines the extent of task susceptibility to defect exposure during the execution phase, and determines the task characteristics that often contribute to this problem.

3 RESEARCH OBJECTIVES

The current study aims to model the interaction of task characteristics (i.e., task elements) with task-related factors (i.e., non-task elements). Based on task susceptibility to exposure to defects and the expected rates of defects for each sub-task, the task sensitivity will be determined. It will determine which task characteristics and task-related factors contribute significantly to each defect. This study argues that identifying a task's sensitivity toward construction defects could provide a clear understanding into the nature and behavior of each task.

To fulfill this aim, there are a number of objectives that should be achieved:

- Measuring and observing a number of sub-tasks and identifying the deviation rate for each sub-task. After that, determining which sub-tasks are more prone to defects than other sub-tasks.
- Using review literature to identify all task characteristics and task-related factors that may contribute to construction defects. After that, determining which factors often lead to defects.
- Modeling each sub-task pattern via statistical tools.

This paper will investigate the first objective. The remaining objectives will be discussed in future papers.

4 METHODOLOGY

Case study methods depend on collecting sufficient information about an individual, a group, an event, or an entire organization so that researchers can explicitly and effectively understand its behaviors (Yin 2004). A pilot study with multiple cases has been undertaken to examine sub-task deviations during the execution phase. Each case study contains both qualitative and quantitative research. Qualitative research is conducted to identify deviations via direct observation of sub-tasks. Quantitative research is conducted to measure rates of deviation for each sub-task.

5 DATA COLLECTION

Primary data have been collected from fifteen projects. All of the projects are residential buildings in Saudi Arabia. The projects have been chosen based on the variation practice levels of quality. In each project, there are three items that have been observed. For all the projects, a total of 45 items have been observed. For each item, 10 sub-tasks were observed during execution phase and all of the deviations have been recorded.

6 RESULTS AND DISCUSSION

In this section, the results will be discussed in two areas: a) the rate of defects per sub-task, and b) the rate of defects per project.

6.1 Defects per Sub-task

The rebar task has been divided into 10 sub-tasks as shown in Table 1. Findings show that rates of deviation between the sub-tasks are very high. For instance, sub-task 1, used to gather required information from documents (such as drawings) to implement the column, has zero errors. It has been observed that the labor at the site has sufficient ability to obtain the correct information from the right documents. Similarly, both sub-task 2 (steel fabrication for the longitudinal bar) and sub-task 7 (setting the spacing between the longitudinal bars) have zero defects. In contrast, sub-task 10, which is the concrete cover (i.e., setting the sufficient space to cover the column cage), has the highest rate of defects (53% from the observed columns in all projects). This is because some workers omitted setting adequate space between cages and formwork, or ignored using spacers before closing the formwork.

Table 1. Sub-task deviation (%).

Projects	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	**Total**
Rebar Sub-Tasks																
Dimensions																
1 Document errors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0%**
Steel Fabrication																
2 Bar length	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0%**
3 Ties and stirrups	3	0	0	0	0	0	0	0	3	3	0	0	0	3	0	**27%**
Cage Assembling																
4 Cage tying	3	3	0	0	0	0	3	0	3	3	0	0	0	3	0	**40%**
5 Ties spacing	3	0	0	0	3	3	0	0	3	3	0	0	0	0	0	**33%**
6 Ties quantity	3	3	0	0	0	0	0	0	3	3	0	0	0	3	0	**33%**
7 Bars spacing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0%**
8 Bars quantity	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**7%**
Cage Positioning																
9 Cage fixing	3	3	0	0	0	3	1	0	3	3	0	1	0	3	0	**44%**
Concrete Cover																
10 Column spacer	3	3	0	0	0	0	3	3	3	3	0	0	0	3	3	**53%**
Total (per project)	**63%**	**36%**	**0%**	**0%**	**9%**	**18%**	**21%**	**9%**	**54%**	**54%**	**0%**	**3%**	**0%**	**45%**	**9%**	

Table 1 shows that the rate of defects per sub-task for cage positioning and fixing, cage tying, ties spacing, ties quantity, ties and stirrups, and bars quantity is 44%, 40%, 33%, 33%, 27%, and 7%, respectively. For each sub-task, there are different conditions that might lead to construction defects. There is insufficient space to mention them in this paper, so this paper merely sets the variation in defects.

The variation of the defects rate between sub-tasks indicate that susceptibility to defect exposure and rates of defects differ for each sub-task. Thus, sub-task 10 has the highest susceptibility to defect exposure. In contrast, sub-tasks 1, 2, and 7 have the lowest susceptibility to defect exposure.

6.2 Defects per Project

Despite the pilot study conducted on 15 residential projects, some considerations should be taken regarding the level of quality practiced during the task execution for each project. Table 1 shows the rate of defects per project. Some projects have common denominators. For instance, project-1 (P1), project-9 (P9), and project-10 (P10) share the same defects in similar sub-tasks.

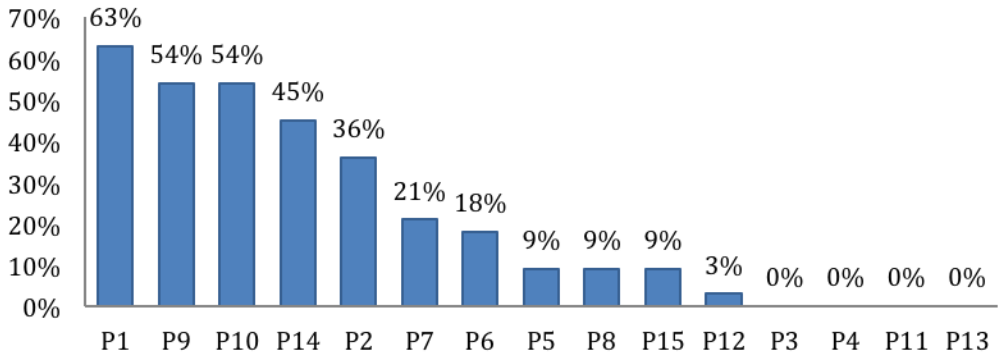

Figure 1. Defects rate per project.

Figure 1 gradually shows the defects rate per project. There are seven projects containing more than 10% of defects (P1, P9, P10, P14, P2, P7, and P6) and four projects contain less than 10% of defects (P5, P8, P15, and P12). Moreover, zero defects have been recorded in the last four projects (P3, P4, P11, and P13). This variation will be used (in future work) to identify sub-task sensitivity against construction defects.

7 CONCLUSION

Defects, which often occur during execution phase, is a major issue in the construction industry. This study begins to address one of the listed objectives—identifying the deviation rate for each sub-task—then determines which sub-task is more prone to defects than other sub-tasks. Findings show that the variation of the defects rate between sub-tasks indicate that susceptibility to defect exposure and rates of defects differ for each sub-task. There are some sub-tasks that have high rates of defects (e.g., setting the concrete cover), and other sub-tasks have almost negligible rates of defects (e.g., steel fabrication for the longitudinal bar). Other findings show that the variation between projects in terms of defects rate is very high, ranging from zero to 63%. Future research will cover the remaining objectives through modeling construction defects and integrating a model with direct causes of the defects.

References

Almusharraf, A., and Whyte, A., Defects Prediction Towards Efficiency Gains in Construction Projects, Research, *Development, and Practice in Structural Engineering and Construction*, in Vimonsatit, V. and Singh, A. and Yazdani, S. (ed.), 985-990, Research Publishing Services, Perth, Western Australia, 2012.

Bonner, S. E., A model of the effects of audit task complexity, *Accounting, Organizations and Society* 19(3), 213-234, 1994.

Burati, J. L., and Farrington, J. J., *Costs of Quality Deviations in Design and Construction*, Construction Industry Institute, U.S.A., 1987.

Campbell, D. J., Task complexity: a review and analysis, *The Academy of Management Review*, 13(1), 40-52, 1988.

Fayek, A., Dissanayake, M., and Campero, O., Measuring and Classifying Construction Field Rework: A Pilot Study, Executive Summary prepared to the Construction Owners Association of Alberta, Department of Civil and Environmental Engineering, The University of Alberta, Canada, 2003.

Josephson, P. E., and Hammarlund, Y., The Causes and Costs of Defects in Construction: A Study of Seven Building Projects, *Automation in Construction*, 8 (6), 681-692., 1999.

Knocke, J., *Post-construction liability and insurance*, *1st Ed.*, London; New York: E and FN Spon, 1993.

Love, P. E. D., and Li, H., Quantifying the causes and costs of rework in construction, *Construction Management and Economics*, 18, 479-490, 2000.

Mills, A., et al., Defect Costs in Residential Construction, *Journal of Construction Engineering and Management*, 135(1): 12-16, 2009.

Pitz, G. F., and Sachs, N. J., Judgment and Decision: Theory and Application, *Annual Review of Psychology*, (35), 139-163, 1984.

Priemus and Ale, Construction safety: An analysis of systems failure, *Safety Science*, Elsevier Ltd., 48, 111–122, 2010.

Sommerville, J., Defects and rework in new build: An analysis of the phenomenon and drivers, *Structural Survey*, 25(5), 391-407, 2007.

Yin, R. K., *The Case Study Anthology*, Sage, Thousand Oaks, CA, 2004.