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Analysis of Root Causes of Construction Defects by Correlation Approach

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Abstract: ***Understanding defect causes are indispensable to its prevention. This paper aims to identify the correlations between the root causes of construction defects, so as to obtain insights about the complex mechanics of defect causation and assist in developing effective defect prevention strategies. Data was collected through a questionnaire survey of 52 professionals in the construction industry. Correlations analysis showed that time pressure, financial constraints, Misunderstanding clients requirements and organizational culture were the most influential root causes.***

Keywords: Defect, error, failure, root cause.

1. Introduction

A defect is the physical manifestation of an error or omission and are amongst the most common problems in construction industry that can significantly degrade projects performance. A construction defect is "failing or shortcoming in the function, performance, statutory or user requirements of a building". Defect costs ranged from 2% to 6% of construction costs. Thus, if projects are to succeed, it is imperative to prevent defects. Defect prevention necessitates two major stages: a qualitative and a quantitative stage. The qualitative stage involves systemically identifying and classifying the various causes of defects .On the other hand, the quantitative stage involves observing the most important causes so as to improve aspects of the system that are most capable of restraining defects' recurrence .This paper aims to extract the major causes resulting in defects from extensive literature review; and subsequently conduct a survey with industry practitioners to confirm and revise the causes and then analyze their correlations.

2. Objective

The objective of the construction defect analysis are the following: To identify project root causes(latent conditions, Pathogens),To identifying and analyzing correlations between the root causes of construction defects.

3. Mechanics Of Defect Generation

To prevent construction defects, one must first identify and recognize where these originates. A root cause is the most basic reason for an undesirable condition or problem. If the root cause of the problem is not identified, then one is merely addressing the symptoms and the problem will continue to exist. For this reason, identifying and eliminating root causes of problems is of utmost importance. Inorder to identify the root causes of construction defect, the Swiss Cheese Model was utilized. Based on the Swiss Cheese model, defect causes can be traced back to any of the four descending layers of a system (Fig. 1). The first three layers (*Organizational Influences*, *Defective Supervision*, *and Preconditions for Defective Acts*) represent the root causes and the fourth layer (*Defective acts)* represents the direct causes. The root causes are also called *latent conditions* created by higher echelons of the organization owing the emplacement of risky decisions, practices and circumstances. Since the Defective Acts have already being identified in the authors' recent study [4], this study will complementarily focus on identifying the *latent conditions.*

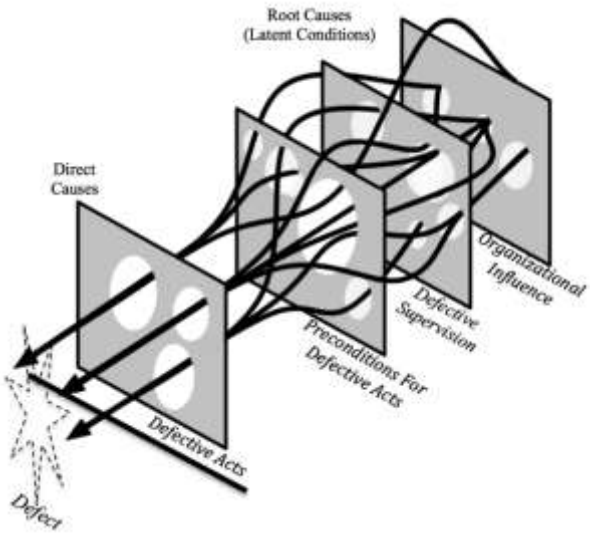

Figure 1: The Mechanics of Defect Causes (The Swiss Cheese Model).

4. Methodology

In order to identify the latent conditions, this paper involves a combination of a deductive and an inductive approach.

Deductive Approach
The deductive aspect involved the identification of the root causes, attributed to the latent conditions through extensive literature review. The identified latent conditions are

classified into each layer in the Swill Cheese model as shown in Table1 to Table 3.

1) Organizational influences

Organizational influences (shown in Table I) are decisions made by upper level management that can directly affect practices of the supervisors. These decisions work their way down the Swiss Cheese Model causing the defective act.

Table1: Organizational Influences

Label	Latent Condition
L1	Insufficient liquidity or start-up budget
L2	Organizational Culture
L3	Unstable positions of personnel
L4	Inadequate employee training
L5	Allocating unfit or incapable supervisors/engineers for duty
L6	Getting involved in projects that are beyond the organizations capacity
L7	Low managerial priority for quality
L8	Workplace quality system
L9	Financial constraints upon operational expenses
L10	Time pressure & constraints
L11	Lack of support from the main office to the site
L12	Lack of support from the main office to the site

2) Defective supervision

At this level the supervisors can influence the conditions of the worker. Inadequate supervision (shown in Table2) in return feeds into the precondition layer.

Table 2: Defective Supervision

Label	Latent Condition
L13	Change orders
L14	Failure to correct a known problem
L15	Inadequate supervision
L16	Supervisor/s not adhering to rules or procedures
L17	Poor document control
L18	Lack of client Involvement
L19	Lack of clear schedule float
L20	Contractor misinterpreted designers' instructions
L21	Designer issued misleading drawings/instructions
L22	Misleading instructions from worker's direct supervisors
L23	Misunderstanding clients requirements
L24	Poor coordination between the project team

3) Preconditions for defective acts

This layer is the most bottom layer of the latent conditions. It includes condition of the worker, environmental factors and personal factors. Preconditions are usually the most immediate cause of the defective act.

Table 3: Preconditions For Defective Acts

Label	Latent Condition
L25	Impaired or poorly maintained tools/machinery
L26	Inappropriate materials supply
L27	Technical/Constructability challenges and constraints
L28	Site Mismanagement
L29	Workers' adverse psychological state (Stress)
L30	Workers' insufficient skill or knowledge level

5. Data Collection

Inductive Approach

The inductive aspect involved conducting a questionnaire with 52 industry professionals to confirm and revise the identified root causes. Respondents from the major job positions were composed of project managers, site engineers, structural engineers, estimation engineers ,contractors and others. It is crucial to note that 50% of the respondents had a level of experience of 5+ years. The questionnaire used to ask respondent's to identify a defect instance that was most familiar to them and their perceptions about its causes. Respondents were provided with a list of 30 latent conditions (Table 1 to Table 3) extracted from the literature. The respondents were asked to indicate, using a six-point Likert scale, to what extent did these root causes contribute to the occurrence of the elected defect. The scale ranged from "Not relevant" for non-existing or un-influential latent conditions, to a highest rate of "Extremely Relevant". Respondents were also provided with an opportunity to identify and rate additional latent conditions that they deemed missing from the list. These additional factors were used to confirm the comprehensiveness of the 30 latent conditions. In most cases, the additional factors were redundant with those identified in the list. In few exceptional cases, the additional factors were held till the end of the survey period and were merged with the pre-identified list. The final lists of latent conditions are same to those provided in Table I to Table 3.

6. Results Analysis

Correlation

In order to investigate the relationship between root causes, Pearson's Correlation analysis was conducted. The following defect root cause pairs were identified to be highly correlated:

- Time pressure & constraints (L10) and Misunderstanding clients requirements (L23) (r= 0.995).
- Organizational Culture (L2)and Poor coordination between the project team(L24) (r=0.993).
- Inadequate supervision (L15)and Impaired or poorly maintained tools/machinery (L25) (r = 0.993).
- Lack of motivation/commitment to work (L12) with Contractor misinterpreted designers' instructions (L20) (r = 0.988).
- Poor document control (L17) and Contractor misinterpreted designers' instructions (L20) (r = 0.983).

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