A MATRIX-BASED FRAMEWORK FOR MODELING CHANGES ACROSS MULTIPLE ENTITY TYPES IN CONSTRUCTION PROJECTS

ABSTRACT

Changes are inevitable in a construction project, and they can occur for various reasons. Such changes can cause severe disruptions, however, and in particular, they can impact the time, cost, and other aspects such as labour productivity, safety, and working relationships of a construction project. Change management in construction is an essential aspect of project management. A key challenge in change management is to identify changes and predict their impacts before their implementation so that the negative impacts of changes can be minimized. However, the large variety of entity types such as teams, components, deliverables, activities and parameters, as well as the complex interdependencies that exist among these entity types, makes it difficult to predict change impacts. Changes made to any type of entity are likely to propagate to others. It is necessary to be aware of not only individual change impacts but also complex change propagations and their impacts across entity types. Hence, the overall objective of the research is to develop a framework for modeling changes across multiple entity types in construction projects.

The literature review reveals that existing methods lack a structured approach for early change identification and that these methods are limited to predicting changes and their impacts in single entity type only. Certain studies have recognized the need for multi-entity modeling; however, these studies are limited to the classification and generation of propagation paths, and they lack a approach to quantify change propagations. Further, the exploratory case study reveals that practitioners also find it difficult to predict change impacts because techniques and tools used for the design and construction planning of projects do not facilitate the

quantification of change impacts across entity types prior to change implementation. Hence, there is a need for a modeling framework to manage changes proactively.

The proposed change-prediction framework integrates two matrix-based modeling methods: Axiomatic Design (AD) and Multiple Domain Matrix (MDM). The framework consists of three major segments: 1) identification of changes, 2) the tracking of change propagations, and 3) estimation of change propagation impacts. Initially, relationships between functional requirements and design parameters must be modeled and analyzed using AD to finalize the entity types. When any change in functional requirement is initiated, changes in entity types can be identified in a structured manner. Next, the interrelationships of entity types must be modeled in the MDM to track change propagations. A quantitative approach is proposed to quantify changes in terms of time at parameter level in the MDM. Further, change impacts on other entity types are estimated semi-automatically from the revised durations of parameters in the MDM.

An abductive-based case study research method has been adopted to develop the existing theory in change prediction research. The research method is divided into three parts: problem formulation, framework development, and validation. In Part 1, literature review is conducted to identify research gaps. An exploratory case study was conducted across 19 different projects to investigate the existing practice and identify the root causes of changes. Around 67 industry experts were interviewed to understand the problems on managing changes in the entire construction project life cycle. The research problem is formulated by triangulating the findings of the literature review and the exploratory case study. In Part 2, a change prediction framework is developed based on a comprehensive set of requirements which are identified from the literature review and exploratory case study. Further, case studies of eight different projects were conducted to explore selected matrix-based modeling methods: AD and MDM. In Part 3, the proposed framework is applied and validated in three ongoing construction projects – multi-

story apartments, underground metro, and hospital building. The validation reveals that the proposed framework is quite useful in predicting changes and helps in minimizing errors during the implementation of changes. Overall, the proposed change prediction framework can aid design and construction stakeholders to identify, schedule and quantify changes proactively across multiple entity types in a construction project.