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An integrated system for change management in construction

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Abstract

Change management in construction is an important aspect of project management, as changes constitute a major cause of delay and disruption, and it is widely accepted by both owners and constructors that change effects are difficult to quantify and frequently lead to disputes. The development of change management systems should consider many elements of the project processes and address all internal and external factors that influence project changes. This paper presents an integrated change management system developed to represent the key decisions required to implement changes and to simulate the iterative cycles of concurrent design and construction resulting from unanticipated changes and their subsequent impacts. The system integrates a fuzzy logic-based change prediction model with the system dynamics model of the Dynamic Planning and control Methodology (DPM), which has been developed to evaluate the negative impacts of changes on construction performance. The developed system can be used in managing change scenarios on projects and also in evaluating change effects depending on the available information at the early stages of projects.

Keywords: Change management; Fuzzy logic; Dynamic planning

1. Introduction

Changes in construction projects are common and likely to occur from different sources, by various causes, at any stage of a project, and may have considerable impacts. Based on time, change could be anticipated or emergent, proactive or reactive, or pre-fixity or post-fixity. Based on need, change could be elective or required, discretionary or non-discretionary, or preferential or regulatory. Based on effect, change could be beneficial, neutral or disruptive. Change management relates all the internal and external factors that influence project changes. It seeks to forecast possible changes; identify changes that have already occurred; plan preventive impacts; and coordinate changes across the entire project [1]. Inconsistent management of the change process can result in many disruptive effects. Some of these consequences can be relatively easy to measure, while others are more difficult to quantify. Change management is considered an integral part of project management. This paper presents the development of an integrated system for improved change management. The following section reviews the work done on this topic.

1.1. Literature review

Research on modelling the change process in construction has tended to focus on the identification of factors affecting the success of a change process, and resulted in guidance for best practice in change management. Examples of such guidance include: a concept for project change management [2], best practices for managing change efficiently [3], a generic procedure for issuing a change order request [4], an analysis method to reduce the overall rate of construction change orders [5], a best practice guide to present best practice recommendations for the effective management of change on projects [6], and an advanced project change management system [7].

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Research has also been undertaken on evaluating the change effects on certain project elements. These studies dealt mainly with a single factor or a single project element such as: construction change order impacts on labour productivity at the craft level [8], effect of the size of change and its impact time on a project [9], a linear regression model that predicts the impact of change orders on labour productivity [10], the risk of changes to safety regulations and its effect on a project [11], and decision tree models to classify and quantify productivity losses caused by change order impacts [12].

Change management has been the focus of different IT systems. For example, an integrated environment for computer-aided engineering was developed by Ahmed et al. [13], which is a blackboard representation that integrates a global database, several knowledge modules, and a control mechanism to systemize object changes. Peltonen et al. [14] proposed an engineering document management system for changes that incorporated document approval and release procedures. Spooner and Hardwick [15] developed a system with rules for coordinating concurrent changes and for identifying and resolving conflict modifications. Ganeshan et al. [16] developed a system to capture the history of the design process, initiate backtracking, and determine the decisions that might be affected when changes are made in the spatial design of residential buildings. Krishnamurthy and Law [17] presented an interesting change management model that supports multidisciplinary collaborative design environments. Another change management system was proposed by Mokhtar et al. [18] for managing design change in a collaborative environment. The model is capable of propagating design changes and tracking past changes. Soh and Wang [19] proposed a constraint methodology based on a parametric technique to coordinate design consistency between different geometric models and to facilitate managing design changes. Hegazy et al. [20] introduced an information model to facilitate design coordination and management of design changes. Important dependencies between building components were represented by this model to help identify the ripple effect of changes between components. Also, a reporting system was used to view the history of all changes made by all disciplines. A more generic IT system was presented by Karim and Adeli [21] which is an object-oriented (OO) information model for construction scheduling, cost optimization, and change order management. Charoenngam et al. [22] developed a Web-based change order management system that supports documentation practice, communication and integration between different team members in the change order workflow.

The above literature on change management and evaluation mainly focused either on the identification of the change process, best practice recommendations for managing change during the project life cycle, or on the evaluation of the change effects on a single project parameter. Much of the discussion is presented in categorical ways with little attention being paid to modelling the dependent data or simulating the iterative cycles of concurrent design and construction that result from unanticipated changes and their subsequent impacts on project performance. Therefore, there is a clear need in the construction industry for research work to focus on modelling this dependency, especially for multi-disciplinary causes and effects, and planning such iterative tasks.

Some of the IT systems developed for change management are integrated systems that represent design information, record design rationale, facilitate design co-ordination and changes, and notify users of file changes. These systems were developed mainly to deal with reactive changes, particularly design changes. The research presented in this paper focuses on both proactive and reactive changes. Reactive changes represent the events when a change occurs and the project team starts to take actions to remedy the consequences of this change. While the proactive changes represent the events when a change is likely to occur in a later stage and the project team plans to minimize the disruptive effect of these changes. Because the effect of changes always concern practitioners, the concept of change effects in the proposed system is presented in the following section.

1.2. Change effect on project life cycle

Studying the life cycle of changes and their impact on construction performance during actual execution shows that construction projects are inherently complex, dynamic, and involve multiple feedback processes [23]. The uncertainty and complexity of design and construction projects are usually driven by these feedback processes. There are only two types of feedback processes: reinforcing (that generates other changes or makes errors) and balancing (that resolves such changes and errors). Dynamics in a system arise from the interaction of these two types of feedback processes among the components of the system, not from the complexity of the components themselves [24]. Fig. 1 shows the basic simultaneity of the reinforcing and balancing feedback in design and construction projects. The control actions to address changes can have the intended effect of resolving the issues that initiate the control actions, if the decision is correct and well implemented. At the same time, they can produce a side effect that may create some unintended problems, if the decision is incorrect, not well implemented, exceeds the time frame of its effectiveness or if a project manager does not realize the impact of the control actions on other related activities.

In addition, the reconciliation of the gap between the initial work scope and the actual work scope can also result in these feedback processes. After the project starts, the actual work scope may be increased, since additional work is often added to the project scope in order to deal with changes. Moreover, these unintended effects become more detrimental when concurrent engineering techniques are applied. This is because the decision to take control actions against unanticipated additional work has to be made within the complex inter-relationships of activities, even with a lack of complete information about predecessor activities [25].

Based on this concept, the research presented in this paper integrates the work done on the stage of "Change identification", shown in Fig. 1, and the work done on simulating the uncertainty resulting from feedback processes caused by change.

A generic change process model was developed to give full definition for the change over the time of its occurrence and to