Construction Methods

Innovation and Safety

David Barnes
Editor

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Construction naturally lends itself to innovation in design and will be subjected to value analysis to judge benefits in terms. An area of specific importance is the continuing need to improve safety during the construction process and in the period of post-occupation by clients. The method of procurement selected for an international construction project will depend on the type of project and client needs. Students of this text will fully appreciate the practical aspects of being a construction engineer and manager, the dual nature—both technical and managerial—of the responsibilities.

About the Editor

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Preface

In chapter one, we described the selection of construction methods: a knowledge-based approach. The appropriate selection of construction methods to be used during the execution of a construction project is a major determinant of high productivity, but sometimes this selection process is performed without the care and the systematic approach that it deserves, bringing negative consequences. This chapter proposes a knowledge management approach that will enable the intelligent use of corporate experience and information and help to improve the selection of construction methods for a project.

Chapter two explains a design and application of hydraulic-walking incremental launching equipment. This chapter designs novel hydraulic-walking incremental launching equipment. The working principle of the equipment is proposed. Considering that the contact in incremental launching construction is a typical elastic contact problem, and changes in contact state will directly affect the stability of the incremental launching, this work proposes the equilibrium equations of computational contact mechanics and numerical analysis method for the incremental launching equipment through analyzing the working process of the equipments.

In chapter three, we described the natural pozzolan as a partial substitute for cement in concrete. In this chapter, the use of natural pozzolan as a partial cement substitute in concrete materials is investigated. By means of a test series, four mixes using three types of natural pozzolan, as well as a Class F fly ash, are evaluated. The effectiveness of each pozzolan in controlling alkali-silica reactions has been studied.

Chapter four is given the detail of trend of the research on public funded projects. As one of the main means to deliver service, Public Funded Projects (PFPs) always play a vital part in the de- velopment of the human society.

Chapter five explained the dynamic identification techniques to numerically detect the structural damage. Damage detection in civil engineering structures using changes in measured modal parameters is an area of research that has received notable attention in literature in recent years. In this paper two different experimental techniques for predicting damage location and severity have been considered: the Change in Mode Shapes Method and the Mode Shapes Curvature Method.

In chapter six, we described a simplified procedure for the seismic design of hybrid connections in precast concrete structures. The correct use of non-adherent prestressing techniques in beam-column connections can significantly increase the seismic performance of precast concrete frames, making them a competitive alternative to the traditional cast-in-place concrete structures.

Chapter seven is given the detail of about the reliability of punching verifications in reinforced concrete flat slabs. Reinforced concrete slabs are a widely diffused structural solution either in Italy, or abroad; this for a series ofadvantages connected to their structural conception and their performances. However, this series of advantages is obtained as a result of proper design, especially oriented to appropriately sizing the thickness of the plate itself.

In chapter eight, we described the modularization in the construction industry using a top-down approach. A major challenge for companies offering highly complexsystems and highly engineered customized products isto reduce delivery times while increasing productivity andthe quality of the finished product.

Editor

Contents

Chapter 1

SELECTION OF CONSTRUCTION METHODS: A KNOWLEDGE-BASED APPROACH

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ABSTRACT

The appropriate selection of construction methods to be used during the execution of a construction project is a major determinant of high productivity, but sometimes this selection process is performed without the care and the systematic approach that it deserves, bringing negative consequences. This paper proposes a knowledge

management approach that will enable the intelligent use of corporate experience and information and help to improve the selection of construction methods for a project. Then a knowledge-based system to support this decision-making process is proposed and described. To define and design the system, semi structured interviews were conducted within three construction companies with the purpose of studying the way that the method' selection process is carried out in practice and the knowledge associated with it. A prototype of a Construction Methods Knowledge System (CMKS) was developed and then validated with construction industry professionals. As a conclusion, the CMKS was perceived as a valuable tool for construction methods' selection, by helping companies to generate a corporate memory on this issue, reducing the reliance on individual knowledge and also the subjectivity of the decision-making process. The described benefits as provided by the system favor a better performance of construction projects.

INTRODUCTION

Given the impact construction methods have on productivity, quality, and cost, their selection is a key decision for the proper development of a construction project, and it is one of the main factors affecting the productivity and efficiency of construction projects [1]. Also, it is considered as one of the five potential areas of productivity loss according to the European Construction Institute (ECI) [2]. These facts highlight the significance of an appropriate selection of construction methods for a project since deficient methods for executing the work can cause significant losses of productivity on site [3].

Then, how can this selection of construction methods be done correctly? This paper proposes to address this decision problem from the perspective of knowledge management (KM). The implementation of this approach is particularly appealing for the construction sector [4] and is a powerful tool that can help this industry to innovate and improve its performance [5, 6].

Construction companies have difficulties in the management of the information and knowledge associated with construction projects, combined with the fact that much of information about previous projects is not reused because there are not adequate

mechanisms for its storage [7]. In addition, the knowledge created in the field is not usually shared, which tends to produce its loss [8]. This situation eventually affects decision-making processes because correct decisions are the result of the careful management and analysis of the information and knowledge available [9].

This paper presents a knowledge management approach that includes both a KM application framework and a prototype system developed to verify the framework of the KM approach. The objective of the system is to support decision-making for the correct selection of construction methods for a construction project. The next sections present the main background on the selection of construction methods and knowledge management, the conceptual development and main features of the proposed knowledge system, and, finally, the operation of the prototype system used to validate the proposal.

GENERAL BACKGROUND

Selection of Construction Methods

Construction methods are the means used to transform resources into constructed products [10]. According to Illingworth [11], programming and management techniques are of little value for a project if construction methods are not the most optimal in terms of cost or are not safe to run. The selection of construction methods affects not only the selection of the activities and their work sequence, but also its duration [12]. In construction, this process is highly iterative and requires the construction team to examine a variety of data sources as well as tap into its own experience base to formulate a set of efficient methods [13]. In cases like this, when a decision problem has at least two conflicting criteria and at least two solution criteria, the problem is considered a multi criteria decision analysis [14].

Knowledge Management in the Construction Industry

It was in the mid-80s that people began to appreciate the increasingly prominent role of knowledge in the competitive environment [15],

with the emergence of knowledge-based organizations [16]. This new approach recognizes the knowledge as one of the most valuable assets of an organization away from the traditional economic view, which recognizes knowledge as something external to the company and with no connection to the economic process [17]. Moreover, this approach gives a clear structure to manage knowledge, with greater emphasis on the knowledge itself and with a hierarchy above information and data [18]. Thus, it is possible to define knowledge management as the way in which organizations create, capture, and use knowledge to achieve organizational objectives [9].

Construction companies obtain most of their knowledge from the projects they undertake. However, the knowledge generated within each project is finally stored in reports that remarkably few read or is lost because the people involved move to a new project, leave the company, or retire [19, 20], taking with them not only their tacit knowledge, but also a potential source of competitive advantage.

Regarding how to manage knowledge in the selection of construction methods, Ferrada and Serpell [18] indicate that construction companies use the knowledge of individuals to carry out this process. There is not an organizational-based learning process that allows acquiring the relevant knowledge.

Knowledge management in the construction industry is a focus of different types of research work, for example, studies that have tried to understand how to implement knowledge management in construction companies and also the perceptions of people about this topic [4, 5, 21, 22]. Others have focused on developing ontologies and classification systems [23–26].

Learning has also undergone some studies [27–29] as well as the development of knowledge management models [30, 31], the development of systems to store and share knowledge [32], and the development of knowledge maps [33–37].

Other lines of research have focused on understanding the impact of technology in data capture in the field [38], in the management of documentation [39, 40], and in the development of methodologies for the capture and reuse of the knowledge created in projects [19, 41]. Other researchers have studied how to share tacit knowledge within communities of practice [42] and how to make a live capture and reuse of project knowledge [43]. The importance of collaborative

knowledge management has also been addressed [44], and in recent years there have been studies about the use of mobile technologies in construction [45], among others.

A Knowledge Management Approach for the Selection of Construction Methods in Construction Projects

To study how the selection of construction methods is currently carried out in the local industry, a methodology based on case studies was selected because if there is a relationship between the phenomenon under study and its context, this technique is considered an appropriate research strategy [46, 47]. Then, three Chilean construction companies participated in the research. Table 1 details companies and professionals interviewed in each case. Data was collected using semistructured interviews. The organizational model of the CommonKADS methodology for developing knowledge management systems [48] was used as a reference for preparing the interviews.

Table 1 companies participating in case studies.

Company	Certification	Construction markets	Established in the year	Number of professionals interviewed
A	ISO 9000	Civil, industrial, and building work	1960	5
B	ISO 9000	Residential, institutional, commercial, and tall buildings work	1989	6
C	ISO 9000	Civil, industrial, and building work	1978	3

Results of the case studies show that the selection of construction methods is largely based on the previous experience of professionals. It is a process characterized by the complexity of the analysis, the high dependence on individual experience and teamwork, and the need for expert knowledge. Companies' senior management recognizes the need for a structured system to allow a better management of their knowledge by storing it correctly and making its employment less difficult. In addition, knowledge acquisition is not part of an appropriate process, so people have no obligations or incentives to participate in this activity. This situation was highlighted as one of the main barriers for organizational learning about

construction methods. An important part of this research focused on the identification of knowledge gaps in the process of selecting construction methods. The case studies reveal that main gaps exist in the activities "search for construction methods" and "application of the decision criteria." Regarding the first one, interviewees indicated that people have an extremely limited time for this activity. Furthermore, individual's knowledge is a fundamental input of this activity considering that there is not a database of stored lessons learned, nor are there procedures for their effective management. Related to the application of the decision/selection criteria, a critical activity for the adequate project performance, it currently depends heavily on the decision maker intuition, and then, decisions are not comparable across projects. Thus, it becomes necessary to reduce the subjectivity and variability of the decision-making process by making it explicit about the most influential decision criteria for selecting construction methods. Results from interviews allowed identifying the key criteria to use in the selection of construction methods, which include project duration, cost, product characteristics, construction method characteristics, and environmental characteristics. The criterion "product characteristics" has two associated sub criteria: build volume and quality requirements, while the criterion "characteristics of the construction method" has five associated sub criteria: familiarity with the construction method, health and safety, level of automation of the method, level of interference with other operations, and availability of the method. Finally, the criterion "environmental characteristics" has four sub criteria associated: location and access, climate, obstacles/topography, and available space. These criteria were validated with experts of the studied companies and used for the development of the knowledge system for the selection of construction methods.

Based on the results of the case studies, the proposed approach for the knowledge system incorporates both knowledge management techniques and technologies. Knowledge management techniques are applicable since there is already a valuation of collaboration and team work in construction companies. The consistent application of these techniques should encourage the creation and transmission of the knowledge associated with the selection of construction methods. For this process, different techniques might be used as follows:

(i) Brainstorming, a technique for generating ideas and creating knowledge that helps to solve problems;

(ii) Formal instances of knowledge acquisition, which can be of two types, (1) project-related such as team meetings or final project meetings and (2) Associated with the selection of construction methods itself, such as meetings with experts, suppliers, or meetings to discuss problems during the execution of a methodology and determine any possible solution;

(iii) Interaction face to face, valued in organizations and that should be encouraged in a structured way;

(iv) Research and development transfer meetings, since construction methods relate directly to innovation.

Regarding knowledge management technologies, the information and knowledge gained were stored in organizational databases associated with a knowledge portal called Construction Methods Knowledge System (SCMC in its Spanish acronym). This knowledge portal on a web platform provides easy access from any location and has the capacity of storing in databases all information associated with construction methods. Furthermore, a decision-making support system for the selection of construction methods was accessible from this portal.

The information was stored in the form of construction methods sheets. Each sheet (Table 2) contains the knowledge linked to the selection of construction methods as identified in the case studies. Thus, each sheet focuses not only on the technical aspects of each method, but also on two issues that are of importance in the development of the process:

(1) The selection of subcontracts and

(2) The search for experts, whether internal or external.

All this facilitates the study of each construction method as this information will be stored in one place—the organizational database—saving time and effort in the search.

Table 2 construction methods sheet.

Construction methods sheet			
Discipline:			
Operation:		Code:	Related to other sheets:
Construction method:			
Degree of automation:	**Yield:**	**Cost:**	**Risk level:**
Used in the company: yes/no		**Degree of interference with other operations:**	
Restrictions:		**Restriction type:**	
		Space	Competencies
		Inspections/permits	Weather
		Topographic	Machinery
		Materials	Security
Type of project where it has been used		**Project names**	
Labor requirements		**Materials requirements**	
Equipment and machinery requirements		**Temporary requirements**	
Fundamental activities		**Work process**	
Subcontracts that perform the method		**Experts on the method**	
Is there any lesson-learned associated to this construction method?			

Different aspects were considered to design the final construction method sheet. First, apply the same construction method to different projects. Second, store information in the construction methods sheet using a unified format. Third, the sheet should be simple and easy to fill. Fourth, allow an overview of the construction method, and include a list of experts who may be contacted in case more detail is required. Fifth, indicate if lessons learned about the method exist and if so, show them and allow their download. Sixth, indicate the degree of automation [10], risk level and degree of interference with other operations, and features that might be measured using a scale 1–5, where 1 indicates the lowest automation value for the analyzed item and 5 represents the highest value.

For the decision-making support system, the knowledge related to decision criteria was acquired in meetings with experts on construction methods selection, realized during the case studies as previously indicated.

Prototype Design and Construction

System Requirements

For the design and development of a system, it is necessary to know its requirements, which can be of two types: functional and nonfunctional. Functional requirements are inputs, outputs, processes, and data stored needed to satisfy the system improvement objective, while nonfunctional issues are a description of other features, characteristics, and constraints that define a satisfactory system [49]. Main functional requirements of the system have to

do with its ability to store and deploy construction methods sheets, allow finding these sheets within the database, and edit and delete them as necessary. They also highlight the need for the system to upload and download files and to be accessible via the Internet. Main nonfunctional requirements include the need for different types of users, the possibility to upload files in Word or pdf format, the option to export construction methods sheets to MS Excel, and the need to view the system properly using common browsers.

Based on the requirements defined for the system, the computer applications that compose the SCMC were selected. This study began with the search of computer programs available in the market for each of the two principal components of the SCMC: (1) the knowledge portal and (2) the system to support decision making. This task was carried out to determine if appropriate software was available in the market in order to reduce the programming work or to start all programming from scratch if needed.

Regarding the knowledge portal, there was a wide variety of software available in the market, including Alfresco, Tiki Wiki, and MS Office SharePoint, to name just a few. The evaluation of these software packages considered the analysis of various factors, such as system applications number and type, the allowance of modification of their programming code, and their cost. Finally, the best option was to design and construct the system from scratch so that needs of construction companies would be met. For the decision support system, developing software was the least suitable alternative, because commercial software such as Expert Choice and Make it Rational offered what was exactly needed for this part of the prototype. The online system Make it Rational was selected for this purpose, because it is easy to use and allows access through the web. This software uses the Analytic Hierarchy Process (AHP), one of the most widely applied multi attribute decision making methods [50]. The basic idea of this method is to convert subjective assessments of relative importance to a set of overall scores or weights [50]. AHP uses quantitative comparisons to select the preferred alternative by comparing alternatives in pairs, based on their relative performance with respect to a criterion.