CONSTRUCTION TECHNOLOGY

Edited by
Paul S. Chinowsky

CRITICAL CONCEPTS IN CONSTRUCTION

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CONTENTS

VOLUME IV INTELLIGENCE, KNOWLEDGE AND NETWORKS

INTRODUCTION

As the last compilation in the *Computer Technology* set, Volume IV moves from the visual dynamics of Volume III to a focus on the underlying requirement to share knowledge as the key to overall effectiveness in construction organizations. Volume IV covers a broad set of topics from expert systems to virtual team and ending with project networks. However, this diversity has a common foundation in the role of knowledge in developing successful construction projects. In each of the sets within this volume, the role of knowledge at the organization level and at the project level is spotlighted. These spotlights shine on different aspects of this application, from capturing knowledge within expert systems to sharing knowledge in virtual teams and finally to expanding knowledge throughout project networks. However, the underlying message remains consistent that the ultimate success of a project or an overall organization is dependent on the ability to capture and share expertise or knowledge throughout the organization. Whether the organization is temporary or permanent, the strength of the organization lies in the breadth of individuals who have access to the breadth of knowledge that resides in the network.

The first set of papers in Volume IV provides an introduction to the field of expert systems within construction. As one of the most promising areas of study in the late 1980s, expert systems and later knowledge-based systems provided the promise of capturing expertise that could be applied to many scenarios without having the expert present to address the issues directly. The promise of these systems is seen in each of the papers as they address the potential impact of expert systems and artificial intelligence. Of note in this group is the paper by Cherneff et al. that presents the MIT work that influenced many of the researchers who were to follow in this area. Once again, the set of papers in this section should be viewed as representative and as a starting point to investigating the broad set of research that was undertaken concurrently during this time period.

The second grouping of papers in Volume IV moves the discussion of knowledge-based systems from the generic potential of the systems to a specific application in site layout. The problem of site layout is considered

one of the more difficult issues in construction as it is both a temporal and a spatial problem. Site layout requires knowledge of sequencing, spatial relationships and materials management, to name only a few of the interlocking concerns within the overall problem. As such, site layout was put forward as a challenge that knowledge-based systems might be able to address as the issue was less algorithmic than a base scheduling or estimating problem. In response, as illustrated by the papers in this group, several research efforts placed specific emphasis on addressing the site layout question. Of particular note in this group is the first paper by Tommelein et al. that arguably began and popularized the challenge of applying knowledge-based systems to the site layout issue.

The third set of papers in Volume IV moves the discussion from the initial interest in applying knowledge to construction issues to a focus on capturing and managing knowledge within the construction organization. The move to knowledge management in the early 2000s focused on how information technologies could assist organizations in capturing knowledge within project teams. This focus has expanded over the last decade to include large and small organizations as well as global organizations. However, success in this area has been mixed, as highlighted in the Carrillo and Chinowsky paper. This has not stopped organizations from continuing their pursuit of knowledge management. The ambition for knowledge management keeps expanding to a global perspective, as illustrated by Javernick-Will. However, the question of success remains as a challenge for researchers. It remains apparent that a successful knowledge management process is necessary for construction organizations to succeed, but it remains unclear how to successfully implement the grand vision that has been placed before the industry.

Following the focus on knowledge management is the focus on virtual teams. This connection is made due to the relationship between capturing knowledge and sharing knowledge. The capture of knowledge is valuable, but unless organizations can determine how to effectively broadcast knowledge the knowledge remains as a resource rather than as a change resource. One of the keys to reaching this sharing is the use of virtual teams to create collaboration beyond a co-located team. However, as highlighted by Chinowsky and Rojas, the managing of a virtual team presents challenges that can be quite different from traditional teams. This challenge is emphasized by Neff et al. and by Ramalingam and Mahalingam as they explore the necessary conditions for virtual team success. In each case it is found that putting a team together is only the first component of collaboration. The key component for success requires an understanding of the individuals, their roles, and their motivations within the context of a project environment.

The final group of papers in Volume IV brings to a close the discussion on knowledge and collaboration by addressing the role of network connections in achieving collaboration and knowledge sharing. In this group of five papers, the concept of networks is explored through the evolution of the

topic in the field of computer technology. In one of the most cited papers in the four volumes, the Jin and Levitt paper provides the starting point for the discussion as it highlights the work in Virtual Design Teams. This influential work has extended into many areas, but remains focused on the potential to capture the interactions of project teams through the lifecycle of a project. Building on this modelling legacy, the Son and Rojas paper spotlights the work by Rojas to bring an agent modelling approach to network dynamics. Finally, the paper by Chinowsky and Taylor closes Volume IV and the overall collection by addressing the next challenges for network research specifically and knowledge management overall as both a research topic and a basis for construction industry success as a whole.

In summary, Volume IV presents a focused perspective on the role of knowledge in the construction industry. Volume IV presents the realization that successful temporary and permanent organizations must rely on knowledge capture and sharing to enhance effectiveness and overall success. A solution to achieving this goal remains to be found. However, significant steps have been taken and a broad set of implementations have been attempted within the industry. As with every other application of computer technology in the construction sector, the challenge to achieve a better solution provides the motivation for the continued exploration of this critical topic.

Part 15

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DECISION MODELS AND EXPERT SYSTEMS IN CONSTRUCTION MANAGEMENT

A. Warszawski

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Abstract

The construction process is an interaction of projects to be constructed, and management which determines the schedules and regulates the flow of resources necessary for their realization.

Three types of decision tools are examined. The first are analog models (graphs, charts, diagrams, networks, flowlines, etc.) which represent, in a graphical manner, the main attributes of the project and their effect on schedule and budget.

The second group are mathematical models which, through manipulation of relationships between project attributes, indicate optimal allocation solutions in terms of cost or profit. Such models can be used for location, bidding, pricing, investment, valuation and other types of managerial decisions.

The most advanced group of decision tools—the expert systems—can manipulate normative data (prices, productivity figures, equipment dimension and capacity, etc.), use mathematical algorithms for solution, and also employ unstructured decision rules based on experts' opinions.

1. Introduction

Development of formal decision-making procedures in 'construction management' has been of interest to researchers and practitioners ever since this field became a distinctive and recognized discipline of academic study and teaching.

The first generation of decision tools in construction were simple analog models (graphs, charts and diagrams, etc.) which by clear representation of the relevant features of a project, helped the decision-maker in his planning and control tasks. More sophisticated versions of these tools (precedence

networks, flowlines, etc.) allowed for manipulation of key attributes of the system and revealed its influence on the solution to the problem.

A further step in this direction was the introduction of mathematical models, which through rigorous representation of the main relationships between system parameters and application of sophisticated mathematical techniques, could be expected to yield an optimal solution to the problem under consideration. Obviously such models could be effectively used only when the pertinent relationships in the system under consideration could be quantified and all the data necessary for their operation was available. It appeared, however, that existence of such conditions was an exception rather than a rule, in cases involving more than an isolated aspect of the construction activity.

With the development of computer capabilities, attention in managerial sciences turned towards less formalized tools. These tools, sometimes referred to as expert systems, could reflect in a better way human decision-making patterns and also utilize, in an orderly and consistent way, all the available data, both quantitative and non-quantitative, relevant to the solution of the problem. They could therefore be better suited to deal with complex and often ill-defined problems of the real-life construction activity. The following paper will survey the domain of construction management decisions and the applicability of these various decision tools to different construction instances.

2. Construction management decisions

A typical domain of construction management decisions is a construction company which simultaneously operates several projects at different locations. The construction process in such a company is an interaction of the following entities:

- projects under construction, or to be constructed. The construction process consumes resources over time (materials, labor, equipment) to produce a specified finished project (building, bridge, road, etc.) or a part thereof;
- company's pool of resources—its workers, management, equipment, stores and other assets—with which the projects are constructed;
- outside world from which the company purchases, rents or hires its resources, and also receives the orders for its projects. The outside world includes the market—clients, suppliers of materials, equipment, labor and services—and the environment which affects the physical performance of construction work;
- management, which, through bids and orders, brings in project contracts from the outside world and regulates the flow of resources to the projects in progress.

A schematic representation of orders and physical resources flows in a construction company, is shown in Fig. 1.