CONSTRUCTION TECHNOLOGY

Edited by
Paul S. Chinowsky

CRITICAL CONCEPTS IN CONSTRUCTION

ROUTLEDGE

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CONTENTS

VOLUME III VISUALIZATION AND MODELLING

INTRODUCTION

Many of you reading this compilation of papers may be starting here in Volume III, Visualization and Modelling. A case can be made that the topics in this volume are the most recognizable efforts in the computer technology domain. The visual nature of modelling together with the number of general press stories written about the topic makes this an area that is recognizable on a global scale. However, many individuals interested in nD visualization or BIM technologies do not know the extensive history that preceded today's research and development efforts. Volume III of this collection responds to this gap in understanding by providing an overview of the areas and significant achievements that have resulted in today's visualization achievements. The topics in Volume III combine a foundational understanding in the field together with the latest modelling advancements. In the former, the topics of design-construction integration and building models provide the reader with a historical understanding of the incremental advances that were required to fully support today's advanced modelling techniques. The second half of Volume III moves from the foundational to the current as the topics of nD visualization and BIM are presented. The reader is encouraged to utilize both sets of papers to gather a complete understanding of the path undertaken by researchers in this domain.

The concept of visualization and modelling begins with the idea that computing technologies can assist design-construction teams in achieving greater levels of collaboration. At the core of this collaboration are the building models required to permit the transfer of information between the project stakeholders. As such, the first two sections in Volume III focus on these underlying facets of the overall information collaboration domain. The first of these sections emphasizes the foundational work in design-construction integration. The papers in this section reflect the breadth of researchers in the field who contributed to the advances required to achieve today's state-of-the-art. However, as with any area, the list is representative and not exhaustive. Given that caveat, these papers provide a strong starting point from which to embark on an understanding of the pursuit for design-construction integration. The first two papers in this section by Howard et al. and by Teicholz and Fischer characterize the global visions that were being developed for integration in the late 1980s and early 1990s. The papers represent the bold thinking that was being introduced for breaking the barriers between the industry silos. The next three papers in the group build on this vision by introducing the advances through the 1990s that were made in implementing the original visions. And finally, the section concludes with a focus on where we are today and how this work is impacting the field of construction. Of note here is the paper by Froese that specifically asks the questions of how these research efforts are actually changing the manner in which construction management is perceived and undertaken.

The second grouping of papers in Volume III complements the design-construction integration set by focusing on the building models that were required to support integration. The papers in this set provide an overview of the key achievements in building model development and how these developments contributed to the expansion of the visualization and BIM research efforts. As seen in the selection of papers, the time period in which the main body of this work was undertaken is once again from the late 1980s through the early 2000s. The work is also global in nature with concurrent research efforts undertaken in many locations. However, in contrast to many of the research topics covered in this set, the building model research stands out because of the collaboration between the researchers in this field. Many of the research efforts represented by this set of papers were coordinated to achieve a building standard that could be used to achieve integration. This is emphasized by the Tolman paper which provides an overview of the push to achieve integration standards. The section ends with the paper by Bouchlaghem et al. which addresses integration and sets the stage for the visualization and BIM work in the second half of Volume III.

The third set of papers in Volume III focuses on the visual aspect of integration, nD visualization. In this section, the move to a visual representation of construction planning is presented from the initial concept through today's application. In terms of concept, the use of nD visualization is often attributed to the groundbreaking work by Fischer and as such is reflected by the Koo and Fischer paper leading off this section. However, the 4D work by Fischer was paralleled by many researchers investigating the potential for expanding the use of 3D technologies. This parallel pursuit is captured in the papers by Whyte et al. and Kamat and Martinez. Each of these emphasizes a different aspect of the rapid rise in visualization technology in the early 2000s. Today, the application of nD technology continues to grow and the potential extension of the technology as well as the application of the technology appears limitless. The selection of the Zanen et al. paper to conclude this section reflects this potential as it spotlights the immediate potential of this technology to change how construction management is undertaken.

The final group of papers in Volume III complements the nD visualization group by presenting the work in Building Information Management (BIM).

Where nD visualization has moved construction management forward in terms of visually analyzing construction projects, BIM has worked in parallel to ensure that the information required to make decisions about these projects is available within the building models. Expanding upon the advancements made in the building model research, BIM has turned the concept of uniform information models into practical application. Today, the construction industry is transforming how it undertakes large projects with an emphasis on information coordination with design teams. As highlighted by the Dossick and Neff paper, the discussions surrounding BIM are no longer whether it will be feasible, but how to overcome the hurdles between traditional industry silos. BIM technology has matured into a mainstream element of the construction industry.

Volume III highlights the rapid advance over 25 years of computing technology in the modelling and visualization fields. Perhaps in no other area has technology matured from vision to mainstream application in such a compressed time period. However, the future of this technology remains open. The active research in this field promises to provide further advances in many aspects of the construction process. The next decade promises advances that may only be starting as visions in today's research labs.

Part 11

DESIGN-CONSTRUCTION INTEGRATION

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COMPUTER INTEGRATION

Reducing fragmentation in AEC industry

H. C. Howard, R. E. Levitt, B. C. Paulson, J. G. Pohl and C. B. Tatum

Source: *Journal of Computing in Civil Engineering*, 3:1 (1989), 18–32.

Abstract

Emerging and existing computer technologies can be synthesized in ways that provide new kinds of decision support for integrating the data, design decisions, and knowledge normally dispersed among the many participants in the architecture/engineering/construction (AEC) process. This paper briefly examines the origins and impacts of fragmentation in the industry in the U.S. and describes six thrust areas where computer-integrated design and construction can substantially improve the competitiveness of the U.S. AEC industry and the quality of its products. In each of these thrust areas, AEC problems pose important challenges to developing technologies for artificial intelligence, graphic and nongraphic databases, process automation and robotics, and management and dissemination of technology. The application of these advanced computer technologies and the AEC industry offers the promise of significant gains in productivity and will infuse new excitement into civil engineering education and practice.

Introduction

The U.S. architecture-engineering-construction (AEC) industry is highly fragmented compared with many of its Asian and European competitors. This fragmentation exists both within individual phases of the construction process (e.g., the design phase), as well as across project phases from planning through design and construction and into facility maintenance and operation. The problems arising from fragmentation affect productivity and competitiveness throughout the AEC industry. Since constructed facilities account for over half of the capital investment of manufacturing industries, fragmentation in the AEC industry increases costs across the entire economy.

Emerging computer technologies such as artificial intelligence, databases, and robotics offer the promise to permit U.S. firms, which are more organizationally fragmented than their international competitors, to achieve significant levels of integration in decision making, while continuing to exploit the advantages of specialization that produced such major gains in productivity before the mid-1960s. In this paper we explore the depth and importance of the industry's fragmentation and the prospects for improved productivity and competitiveness through computer-integrated design and construction. In particular, we focus on specific thrust areas where emerging computer science technologies offer real hope for solving the problems of AEC industry fragmentation.

Fragmentation in AEC industry

The degree of vertical fragmentation (between project phases, e.g., planning, design, and construction) and horizontal fragmentation (between specialists at a given project phase, e.g., design) in the U.S. AEC industry is unparalleled in any other manufacturing sector. The latest census of the U.S. construction industry reveals that it consists of over 1,400,000 establishments, of which over 930,000 have no employees and the remainder have an average of ten employees. The designers of constucted facilities are similarly fragmented by specialty area and by specialty within specialty. It is not uncommon to find 20 separate design firms involved in various aspects of a major high-rise building's definition. Moreover, the buyers of construction are very fragmented. Individual real estate developers, home buyers, entrepreneurs, and a myriad of state and local agencies constitute a very fragmented customer base. There are a few major consumers of construction; the U.S. Army Corps of Engineers, the General Services Administration, and the nation's largest private manufacturing organizations are large buyers of construction. However, their cumulative purchases are probably less than 25% of the industry's output.

The combination of vertical and horizontal fragmentation of the marketplace results in small specialized firms that frequently serve local geographical markets. Moreover, the U.S. tradition of open bidding for construction results in intense competition, unpredictable workloads, and low overheads, including essentially zero investment in research and development for the industry. Specialization may offer some flexibility and benefits to the industry, but it produces tremendous costs in the form of fragmented decision making. Lack of integration among the planners, designers, lenders, builders, and operators of constructed facilities misses important opportunities for improved project performance. Contingencies for risks arising from a lack