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INDUSTRY
INSTITUTE

**CONSTRUCTABILITY
IMPROVEMENT
DURING
ENGINEERING AND
PROCUREMENT**

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A Report To
The Construction Industry Institute
The University of Texas at Austin

Under the Guidance of
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EXECUTIVE SUMMARY

Constructability is the optimum use of construction knowledge and experience in planning, engineering, procurement and field operations to achieve overall project objectives. This report is an investigation into how construction knowledge and experience may be most effectively utilized during the engineering and procurement phases of projects. A primary purpose of the study is to develop constructability enhancement tools for project management and middle management. These tools are presented in the form of major constructability concepts and useful applications of the concepts.

Research activities consisted of an investigation into the state-of-the-art, data collection, and formulation of constructability concepts, and applications.

Industry concern for cost- and schedule-effectiveness has drawn attention to project constructability. Many of those with previously unorganized efforts are now initiating constructability programs, and those with programs continue to increase their effectiveness. Constructability is also receiving attention from the research community. The Business Roundtable, the University of Texas, the Electric Power Research Institute, and Heriot-Watt University have conducted extensive studies on the nature of constructability and ways in which it may be enhanced. The state of constructability continues to be advanced.

Beyond investigations of the state of the art, constructability data was collected in various ways. Project personnel were interviewed at both construction sites and home offices, topical discussions were held with panels of experts, and CII constructability task force members discussed their own experiences. In all, hundreds of constructability ideas were collected and analyzed for the purpose of abstracting concepts.

The result is seven constructability concepts for execution during the engineering and procurement phases of projects.

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CHAPTER I

INTRODUCTION

What Is Constructability?

The Constructability Task Force of the Construction Industry Institute (CII) based at The University of Texas has defined *constructability* as follows:

Constructability is the optimum use of construction knowledge and experience in planning, engineering, procurement and field operations to achieve overall project objectives.

The infusion of construction knowledge into activities preceding construction will result in efficient site operations. The reference to *overall project objectives* is also important. It is an acknowledgment that construction efficiency considerations often must yield to project operability, maintainability, or aesthetic goals. Most often, however, a balance of such objectives is both desirable and achievable. The effective use of construction knowledge and experience is the mechanism often missing for achieving that balance.

Scope of the Research

This report is an investigation into how construction knowledge and experience may be most effectively utilized during the engineering and procurement phases of projects. A primary purpose of this study is to develop constructability enhancement tools for project management and middle management. Specific research objectives and scope limitations include:

1. Identify constructability improvement ideas related to engineering and procurement; focus on electrical, instrumentation, piping, and structural work.
2. From specific ideas, identify a limited number of significant concepts that project personnel may use to

- generate additional specific ideas.
3. Analyze the constructability concepts; explore the details of execution, advantages and disadvantages, limitations and appropriate conditions, and organizational and timing aspects.
 4. Advance the methods of data collection and analysis.
 5. Identify needs for future research.

Barriers to constructability improvement, quantified benefits of constructability improvement, and the establishment of a constructability database are not explicitly addressed herein.

Definition of Terms

Constructability is an information-intensive pursuit. As such, a hierarchical structure for information has evolved from the deliberations of the CII Constructability Task Force. The terms *idea*, *concept*, and *application* are used to convey this hierarchy. In this research these terms have taken on special meaning and their usage should be read as deliberate. The following definitions are offered:

Idea. A communicated thought which may or may not directly enhance constructability. Ideas may unquestionably support constructability, may be controversial, or may represent personal preferences. Ideas are information units in the origination phase.

Concept. A significant, distinct, and executable objective for enhancing constructability. Concepts are not specific or unique with respect to project type or organization. Concepts are abstracted from analysis of ideas. Project managers should be keenly aware of constructability concepts.

Application. An executable specific action that is tactical in nature and that may be viewed as an implementation of a concept. Applications represent the best ideas and may be numerous in number. Middle managers should be aware of constructability applications.

Structure of the Report

The structure of the remainder of the report is briefly presented in this section.

Chapter II. Seven constructability concepts pertaining to engineering and procurement are summarized. Common concept themes are also presented.

Chapter III. The state-of-the-art of constructability is discussed. Industry practices are reviewed and the findings of recent research activities are presented.

Chapter IV. Research methods are discussed. Data collection efforts and the methods of data analysis are explained.

Chapter V. The seven constructability concepts are analyzed in detail. Applications of the concepts are also presented.

Chapter VI. Major research findings are reiterated, and needs for additional research are identified.

CHAPTER II

CONSTRUCTABILITY CONCEPTS

How Is Constructability Accomplished?

The primary contribution of this research is the identification of seven concepts for enhancing constructability during the engineering and procurement phases of projects. These concepts are constructability catalysts that transcend project peculiarities and organizational distinctions. They are tools to be taken advantage of and muscles to be exercised.

The Concepts

Construction-Driven Schedule. Design and procurement schedules are construction-driven. A construction schedule must be developed before design and procurement schedules may be developed. For long-lead engineered equipment, a procurement schedule must be developed before engineering schedules may be developed.

Simplified Designs. Designs are configured to enable efficient construction. Overly complex, difficult-to-construct details are avoided. Plant layout is simplified. Designers are aware of construction difficulties and designs reflect this awareness.

Standardization. Design elements are standardized. Repetition is taken advantage of. Economy of scale and the benefits of the learning curve are enjoyed. Minor differences in construction elements that result in false economy are eliminated.

Module Engineering/Preassembly Scoping. The scoping of preassembly and the design of modules should occur early in the engineering phase. Designs should facilitate fabrication, transport, and installation.

Accessibility. Designs promote accessibility of manpower, material and equipment. Lifting equipment access needs are considered.

Adverse weather. Designs facilitate construction under adverse weather conditions. Hot, cold, and wet weather effects are minimized. Alternatives to weather-sensitive materials are employed.

Specifications. Specifications are reviewed in detail and serve to simplify the field construction process. Owner, designer and constructor personnel review and agree to all specifications.

These concepts identify ways in which construction knowledge and experience may be most effectively utilized during the engineering and procurement phases of projects; ways in which engineers and designers may facilitate a more efficient field operation. The sequencing of design and procurement, the scoping of design, and the detailed execution of design may all be modified to enhance constructability.

These concepts are also characterized by some common themes. These themes stress good project management practices:

1. Project personnel should always be mindful of an important objective: capital cost reduction. Accurate measures of project success should be understood and utilized. Examples: quality/capital cost, operability/capital cost, plant output/capital cost.
2. Past practices should be challenged, innovations should be rewarded, good ideas should be developed, and successes should be documented.
3. Inter-organizational communication should be encouraged and planned for, particularly between designers and constructors.
4. Decision-making should involve the "doers." A bottom-up approach results in a more informed decision.
5. Engineering problems are often addressed in parts, but solutions need to be holistic. An extra step involving the integration of parts is needed.
6. Some early expenditures of effort have significant payoffs later. Additional engineering efforts often reduce field

efforts. Special studies may be appropriate for "big ticket" items.

Aggressive adoption of the concepts should significantly improve the chances of project success.

CHAPTER III

STATE OF THE ART

This chapter is a brief review of the state of the art in constructability improvement. Two questions are addressed: What are owners, designers, and constructors doing to promote constructability? What are the findings of recent constructability research activities?

The first question is addressed with a presentation of survey results and a discussion of two pioneering corporate constructability programs. The findings of four research projects are presented in response to the second question. For further reading, refer to the bibliography.

Corporate Constructability Programs

Survey Results. In August 1984, a survey questionnaire was sent to the 34 member companies of CII. This questionnaire was designed to determine the current level of constructability practiced by the member companies. It was also used to determine candidates for further participation in the study and potential project sites to investigate.

As of September 1984, 23 of the 34 companies had responded. The responses have been totaled and are presented in Table 3.1.

Most companies view their constructability programs as extensive and comprehensive or at least above average. While a limited number of printed materials were returned as requested, nine of the respondents have developed such materials. Also, the primary focus of constructability programs appears to cover a broad range. The project planning phase receives the most attention, but the average respondent indicated two project phases in which constructability is addressed.

It appears that constructability is not as neglected as once believed. Certainly many companies have been addressing constructability, but do not refer to it by that name. To these organizations, constructability is simply good

Table 3.1 Corporate Constructability Programs**Questionnaires returned:**

23 of 34

Profile of Respondents:

Project owner	14
Engineering contractor	4
Construction contractor	1
Engineer-constructor	4

Effort devoted to constructability:

Extensive, comprehensive	9
Above average	9
Average	2
No response	3

Printed Material on Constructability:

Companies having material	9
Companies with no material	14

Primary focus of constructability program:

Project planning	18
Detailed design/procurement	13
Construction field operations	11
Other	6