



CONSTRUCTION INDUSTRY INSTITUTE

PREFABRICATION,
PREASSEMBLY,
MODULARIZATION, AND
OFFSITE FABRICATION IN
INDUSTRIAL CONSTRUCTION:
A FRAMEWORK FOR
DECISION-MAKING

Construction Industry Institute

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Prefabrication, Preassembly, Modularization, and Offsite Fabrication in Industrial Construction: A Framework for Decision-Making

**Prepared by
The Construction Industry Institute
Prefabrication, Preassembly, Modularization, and Offsite
Construction Project Team**

**Research Summary 171-1
July 2002**

Reviewed by CII 23Jun04

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The University of Texas at Austin.

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Printed in the United States of America.

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Executive Summary

Prefabrication, preassembly, modularization, and offsite fabrication (PPMOF) offer potential benefits that are more important than ever in today's markets. Owners want better facilities faster, at the lowest possible cost, and always safer. For the right project conditions, PPMOF can help achieve the owners' goals.

PPMOF also can help project teams meet the challenges of demanding schedules, adverse site conditions, and limited availability of skilled labor. Using these methods, however, requires careful consideration of their implications for engineering, transportation, coordination, and project organization.

Managers considering PPMOF need a systematic method to evaluate the potential benefits and barriers to using these special methods on their projects. CII formed the PPMOF Project Team to update and extend prior CII efforts and to help improve project performance through use of PPMOF. The project team chose to focus on identifying the requirements for effective use of PPMOF on industrial projects, and then developed a framework to use as a decision aid about possible use of these methods. The framework includes a decision-timing map, a flow chart, tools for strategic analysis, and suggestions for a more detailed tactical analysis.

The results described in this summary build on and extend prior CII work on this subject, based on industry drivers that strongly favor increased use of PPMOF. The purpose is to present the benefits of PPMOF and motivate decision makers and project teams to fully consider PPMOF using the decision framework. The successful CII Project Definition Rating Index (PDRI) tool for analysis of project readiness has improved project performance; the PPMOF analysis framework can bring similar benefits in evaluating possible use of these special methods.

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Introduction

Prefabrication, preassembly, modularization, and offsite fabrication (PPMOF) are construction methods that offer owners an opportunity to improve the performance of their capital projects. Previous CII research on the use of PPMOF found that these methods, when properly used, can help to overcome project challenges such as adverse site conditions, lack of skilled labor, demanding schedules, and permitting issues. The research also found that PPMOF provides substantial opportunities for project teams to achieve a wide range of benefits, including:

1. Reduction in overall project duration
2. Improvement in productivity
3. Reduction in field labor needs and costs
4. Risk reduction through a more predictable work process and shop environment.

Although these past findings are valid today, the drivers for the application of PPMOF are stronger than ever. CII tasked its PPMOF Project Team to:

1. Update, strengthen, and enhance the knowledge, experience, and lessons learned base of the architecture, engineering, and construction industry regarding PPMOF.
2. Increase the awareness and understanding among owners of capital projects of the opportunities to improve project performance and the requirements and implications posed by these methods.
3. Reevaluate the owner's role in capital projects and how decisions are made at the strategic and tactical levels of implementation.

4. Provide decision-makers throughout the life cycle of a capital project with a more robust framework and tools for evaluating, selecting, and implementing these methods.
5. Establish PPMOF as a possible CII Best Practice.

The CII project team chose to focus on the identification of key requirements for effective use of PPMOF in industrial projects and then to develop a framework for making decisions on PPMOF applicability and feasibility for a project.

Definitions

The following definitions guided this research:

- Prefabrication: a manufacturing process, generally taking place at a specialized facility, in which various materials are joined to form a component part of a final installation; a common practice on most industrial projects today.
- Preassembly: a process by which various materials, prefabricated components, and/or equipment are joined together by different crafts at a remote location for subsequent installation as a sub-unit. It is generally focused on a system; also a common practice on most industrial projects today.
- Module: a major section of a plant resulting from a series of remote assembly operations and may include portions of many systems; usually the largest transportable unit or component of a facility.
- Offsite fabrication: a practice of preassembly or fabrication of components both offsite and onsite at a location other than the final point of installation.

Problem Statement

The use of PPMOF changes some elements of project execution and places new demands on how the project is managed. Although

the use of each method is defined by the specific conditions in a given project, the following general concepts apply to most applications:

- Use of these methods requires an awareness of their benefits, implications, and risks; a well-defined project scope; proper timing of early decisions regarding their use; and specialized knowledge and experience to manage their implementation.
- Successful application of these methods requires proper planning and decision-making processes, including the business impacts and all project factors driving or impeding implementation.
- There is a tradeoff that must be evaluated between the benefits that these methods may bring to a project and increased requirements for the project, such as structural steel, freight, engineering, and coordination.
- The nature of PPMOF may increase the requirements for design detailing and procurement logistics and limit the ability to inspect the work in progress if the fabrication shops are not located close to the field site.

The rapid rate of technological change in manufacturing, construction materials, equipment, and methods, and in particular advances in information/communication technologies, have rendered much of the published knowledge and experience on these methods out-of-date. In addition, while some companies have employed PPMOF successfully, the industry in general has not fully recognized the potential for project improvements from the use of PPMOF. This has been primarily the result of a lack of awareness of the benefits and a tendency to postpone key decisions on PPMOF feasibility, which can preclude its use. Also, because of new technologies and the changing construction environment, factors influencing the decision-making process have expanded and changed rapidly during the last decade.

Background and Current State-of-Knowledge

While the concept of using PPMOF for projects perhaps can be traced back to Egyptian pyramids and Greek temples, the modern E&C industry has only recently started to take significant advantage of these construction methods. To increase the awareness and understanding of PPMOF in the construction industry, CII has previously funded several research projects on the subject. These investigations identify the potential of these methods to positively impact the construction process. They also document the drivers, benefits, barriers, and implications for the decision-making process regarding their use.

Tatum, Vanegas, and Williams, in an early CII research project, used case studies developed from interviews and site visits to: (1) determine current practices at the time in the use of these methods in both industrial and building construction projects; (2) identify the forces that prompt their use; (3) describe general processes used to evaluate and implement them; (4) identify project implications and benefits resulting from their use; and (5) develop guidelines for their effective use. A follow-up research project developed the CII product MODEX. Although now archived by CII, MODEX determined the feasibility of modular construction technology for a particular process or power plant construction project.

The next development by CII was an education module on modularization that has been used to learn about:

1. the opportunities for improving project performance using preassembly and modularization.
2. the conceptual framework for evaluating the forces prompting their use.
3. the technical and managerial implications generated by their use.
4. specific actions in planning and use of these methods.

A recent Center for Construction Industry Studies study revealed that the use of preassembly and modularization has nearly doubled since the mid-1980s. Prefabrication and preassembly are currently being used in a wide range of construction activities including equipment, instrumentation, iron work, mechanical, piping, structural assembly, and welding (see Figure 1).

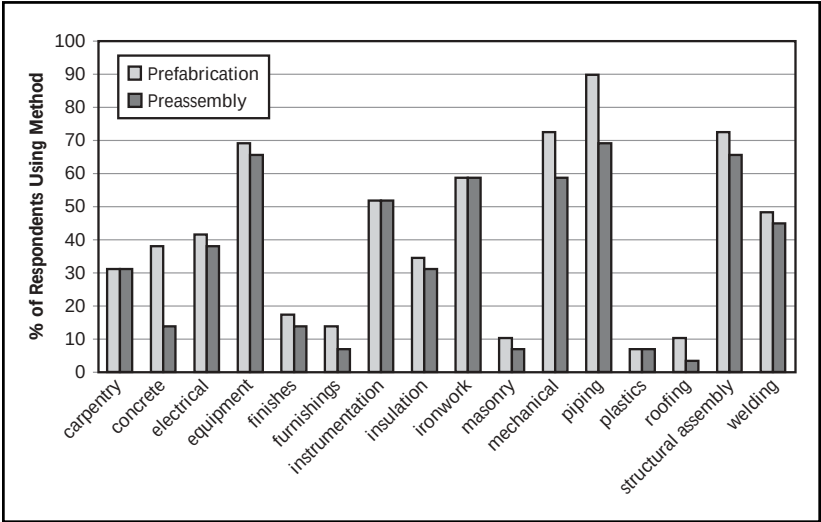


Figure 1. Use of PPMOF in Construction

The current state of PPMOF knowledge falls into the following three broad categories:

1. Identification of examples of using these methods, and of the principal implementation drivers, benefits, barriers, and implications.
2. Identification of general factors to take into account when evaluating the potential use of PPMOF in a project, such as the ones shown in Table 1 (on next page).
3. Appropriate timing for investigation of these factors in the project delivery process.

Table 1. Project Parameters for Evaluating the Feasibility of Modularization (Deemer 1996)

Overall Cost	Detailed Design
Schedule	Procurement
Safety	Fabrication
Operability and Maintenance	Transportation
Quality	Construction
Impact on the Local Environment	Secrecy
Marketability	

A void in the knowledge is the lack of a solid framework for analysis and decision-making regarding the potential use of PPMOF in a specific project.

One drawback concerning the use of PPMOF is that it can reduce the flexibility that an owner has in defining the scope of a project later in the project life cycle. For example, an early decision to use preassembly or modularization can set maximum sizes and quantities of equipment based on design and transport constraints, which can create a problem since the scope of the project might not be well defined. In this case, any future changes in project scope exact a premium, thus reducing cost and schedule benefits. It should be noted that late changes cause similar problems in traditionally constructed projects as well.

Drivers and Benefits

Business demands and the construction environment are driving continued interest in the use of PPMOF. For example, business owners demand high levels of value, safety, quality, productivity, and performance in their capital projects for their competitiveness and profitability. They are still expecting effective and efficient project delivery with tight cost and schedule control. In addition, owners face a current and projected shortage of skilled labor. PPMOF can transfer work to alternate locations both on and off the site.

Many drivers promote the use of PPMOF in projects. Likewise, many potential benefits stemming from their use can be realized. Drivers and benefits, which are often closely related, both play a critical role in determining the feasibility and extent of beneficial use of PPMOF on a project. This chapter discusses drivers and benefits and provides an overview of factors that may lead to using PPMOF.

Cost

Cost savings from using PPMOF are largely driven by field and shop labor rate differentials, productivity differentials, and support costs. Other savings may be associated with site overhead reduction, such as scaffolding and time related overhead costs, installation efficiencies, and standardization of designs. PPMOF drives a more disciplined construction approach that may result in more efficient use of the craft labor onsite due to improved labor densities and less elevated work. A CII study of industrial construction projects found that in some cases, costs were reduced by as much as 10 percent for overall project costs and 25 percent for onsite labor costs (Tatum et al. 1987). Cost reductions were largely attributed to the lower cost of offsite labor. A best practices