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Industrial Engineering/Manufacturing Techniques for Enhancing Construction Project Performance

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Industrial Engineering/Manufacturing Techniques for Enhancing Construction Project Performance

**Prepared by
Construction Industry Institute
Research Team 265, Industrial Engineering/Manufacturing
Techniques for Enhancing Construction Project Performance**

**Research Summary 265-1
January 2014**

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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

This document summarizes the efforts of CII Research Team (RT) 265, Industrial Engineering/Manufacturing Techniques for Enhancing Construction Project Performance, to investigate the applicability of well-known industrial engineering (IE) techniques to common problems in field project operations. The team isolated and adapted a number of techniques that allow construction site personnel to solve problems by identifying and deploying the appropriate IE techniques.

Although the mention of IE usually evokes images of time and motion studies, modern industrial engineering offers a broad collection of tools and techniques that can be adapted to everyday construction site situations. These time-tested methods represent solid commonsense solutions to the problems that create non-value added (NVA) time spent on construction sites everywhere. Previous CII research has determined that NVA activities consume between 50 and 75 percent of the available time on a jobsite. This persistent drain on productivity provided the impetus for establishing RT 265 to identify any industrial engineering techniques that will minimize NVA activities on jobsites.

RT 265 was composed of IE and design-build subject matter experts from owner and contractor organizations. During the research process, members of both groups contributed their expertise to help determine which IE techniques to adapt. They did this by systematically assessing the problems typically encountered on construction sites and matching them to the IE techniques under study. The team adapted and modified these basic techniques for field project operations. The intent was to make them usable by superintendents, warehousemen, and craft foremen, as well as by project managers and planners who are responsible for assembling and managing the resources for construction projects regardless of size.

The researchers first made a series of project site visits to interview superintendents, foremen, and project managers, to get their input on what they needed in terms of industrial engineering tools and techniques. The research team then used this input to develop a software tool on a dot-Net platform that was envisioned as a handy onsite source of IE advice. While this resource was ultimately not produced, the information presented in the tool is accessible in Research Report 265-11, *Industrial Engineering/Manufacturing Techniques for Enhancing Construction Project Performance*.

Introduction

CII chartered Research Team (RT) 265 to research the possibility of improving the cost, schedule, quality, and safety of field project operations through the application of industrial engineering (IE)/manufacturing techniques to everyday construction issues. Team members were IE and design-build experts from owner and contractor organizations. From its beginnings, IE has focused on improving profitability and reducing costs, and a common contemporary view is that its techniques have been formulated to eliminate waste of time, money, materials, energy, and other resources.

The RT 265 research focused on identifying IE techniques that could reduce non-value added (NVA) activities identified by previous CII research teams as significantly contributing to loss of productivity on construction sites. The team considered this an appropriate target because previous CII research has revealed that NVA activities consume between 50 and 75 percent of the available time on a jobsite.

The research team set the following objectives:

- Develop an approach that will help the end user identify waste that can be corrected with an IE technique. Waste is the expenditure of resources for any goal other than the creation of value for the end user. “End user” is defined as the superintendents, foremen, warehousemen, and others who work on a construction site, as well as those individuals responsible for planning the execution of construction projects.
- Construct a methodology for matching the most appropriate IE techniques to the targeted problems.
- Answer the question, “Which type of tool would guide the onsite application of IE techniques to problems that previous research has identified as causing poor performance?”

There are two fundamental limitations to the scope of this research:

- The team focused exclusively on field project operations and selected upstream activities that have a direct impact on them. Upstream issues, such as engineering, contracting strategies, vendor selection, and relationship development were excluded.
- The team focused on the top four or five opportunities for improving field operations and worked to match IE techniques to address them.

The deliverable of the research (tool) was to have the following characteristics:

- a straightforward way to match the four or five most significant opportunities for elimination of NVA activities in field project operations with appropriate IE techniques
- a simple software-based user interface to match construction problems with IT techniques
- practical guidelines for using the techniques
- a less detailed extension of the first deliverable that identifies some additional opportunities for improvement in field project operations and the IE techniques that might be used to gain improvements.

The research team set about looking for previous CII research that would provide insight into problems on construction sites that directly affect productivity. Three previous research teams provided input:

- RT 191 – Application of Lean Manufacturing Principles to Construction
- RT 215 – Work Force View of Construction Productivity
- RT 234 – Lean Implementation at the Project Level.

From this past research, the RT learned that NVA activities account for 50 to 75 percent of the available time on a construction site. Also from previous research, the team isolated five significant factors contributing to

NVA: 1) incorrect materials, 2) inadequate equipment, 3) lack of appropriate tools, 4) absence of information, or 5) insufficiently qualified personnel. Additional research identified IE techniques that might solve some of the problems mentioned above. Drawing on their knowledge and experience, the industrial engineers on the team generated a list of useful IE techniques and identified the benefits of implementing them.

Early in this effort, the research team concluded that a survey-based approach was not feasible and would not bring value to the effort. Instead, the team took a different approach, a key element of which was to identify the end users of the deliverable. Based on the preliminary thinking done during the application process for this research, as well as on team discussions, the RT determined that the end users would be superintendents, foremen, warehousemen, and similar personnel on construction sites.

To determine these users' needs, interviews were arranged at a project at an existing power plant in Mobile, Alabama, and at a courthouse remodeling project for the U.S. General Services Administration in Atlanta, Georgia. A civil superintendent, ironworker foreman, warehouse manager, project manager, and construction manager were among those the team interviewed to get insight into which features would be useful for them and which could be included in the tool prepared by the research team. During these interviews, it became apparent that another class of end user could benefit from the tool, namely, those responsible for project planning. This realization prompted the team to include problem-solving elements in addition to the tool's design and planning aspects.

Referencing the significant factors contributing to NVA drawn from previous CII research, the team developed problem identification flowcharts (PIFs) to identify root causes that could be corrected by application of IE techniques. From the results of this analysis, the team noticed that, in addition to addressing specific problems, IE techniques could also help improve several design processes. Several were

selected as the basis for further development of a tool that could help field personnel correct unwanted situations and help office personnel effectively plan project execution. Those the team selected for development include the following:

- site design
- laydown area design
- warehouse design
- work area design
- work station design
- small tool management
- work management.

The RT developed an interactive computer application as the tool for end users. The application was designed to use a dot-Net platform that could be loaded and executed on any computer running windows, with no additional software to add. It contained three levels of information:

1. simplified information for problem solving
2. immediate background for additional information for design or planning
3. full background for gaining an expanded understanding.

As mentioned above, while this tool was ultimately not produced by CII, its information can be accessed in Research Report 265-11, *Industrial Engineering/Manufacturing Techniques for Enhancing Construction Project Performance*.

Research

When the research team first discussed its research goal and scope, it became obvious that to achieve the research objectives, it would be necessary to take an innovative approach. The original research question posed by CII was “How should the industry use industrial engineering/manufacturing techniques for enhancing construction project performance?” The RT elaborated on this question, asking further “What type of tool would be useful on a construction site that would apply IE techniques to problems that previous research has identified as causing performance problems?”

After some debate, the RT determined that the final deliverable should be a software tool that would facilitate the implementation of IE techniques on construction sites. In order to maximize the chances that this tool would be accepted and used by construction site personnel, the RT decided first to identify the end users’ needs, and then build a tool to meet those needs. This process required that the RT clearly identify who the end users of the software tool would be before developing the tool or its content. In essence, the RT’s purpose became that of creating a tool that would guide construction personnel to apply IE techniques to solve common problems encountered at construction sites.

As discussed above, the team reviewed previous CII research to ascertain the knowledge that had been produced on this subject and to determine whether any conclusions from that research could be applied to the RT 265 effort. These studies offered the following conclusions:

- **Research Team 191, Application of Lean Manufacturing Principles to Construction**, concluded that lean concepts provided a methodology for eliminating waste and increasing value. This research also included case studies to validate the business benefits of applying lean manufacturing tools in project execution.

Another conclusion from this research is that NVA activities consume between 50 and 75 percent of the available time on a construction site. This percentage was derived from crews performing direct work. NVA was defined as anything that takes time, resources, or space, but does not add value to the product or service delivered to the customer. From the case studies conducted, the NVA activities were grouped into four categories: waiting, extra processing, transport, and motion.

- **Research Team 215, Work Force View of Construction Productivity**, conducted interviews with construction craft personnel and their foremen from the concrete, mechanical, electrical, and structural crafts. The team chose these craft professionals as interviewees because their respective crafts consume the majority of labor hours, and are usually on the critical path for most industrial construction projects. From the 10 significant factors that the team identified as influencing jobsite productivity most, RT 265 chose five as a starting point for its work. As listed above, these five factors were 1) incorrect materials, 2) inadequate equipment, 3) lack of appropriate tools, 4) absence of information, or 5) insufficiently qualified personnel.
- **Research Team 234, Lean Implementation at the Project Level**, identified types of waste that need to be eliminated in order to increase profit. It also established key activities in the individual phases of a project, including the construction phase, that would result in reduced cost and increased execution speed. Some of those activities include the following:
 - Implement the principle of providing materials and tools at the point of usage through site stores and assembly packages.
 - Maintain commonly used and relatively small items in site stores. Replenish, using vendor-managed inventory.
 - Apply other appropriate lean tools and methods in site assembly.

RT 265 decided to focus on one reason to enhance construction project performance, namely, to reduce NVA activity. To maintain this focus, those members of the team with expertise in construction identified specific problems on the construction site that lead to NVA. RT members with IE expertise were then engaged to understand the fundamental root causes of these problems; once they had identified these causes, they could identify IE techniques that would address these problems. This analysis was based on their knowledge of successful applications of these techniques to analogous problems in other industries. It became clear to the RT that a survey approach would not bring value to the research, nor would such an approach be conducive to producing the planned deliverables.

Surveys are a common and sound research approach when the objectives of the work are to tease out expert opinion or trends among an experienced group. Conceptually, this was the nature and scope of the previous CII research that the RT reviewed: the primary objective was to identify and assess the most commonly used practices in order to address a specific issue and to determine whether common practice is, indeed, best. Because the original RT 265 research question asked for IE techniques, the RT judged that a different approach was necessary.

Both industry and academic team members quickly observed that because IE techniques are not currently well understood or practiced within construction, it would be unlikely that a survey could provide meaningful data on them. On the other hand, the members of the RT with IE expertise soon discovered that there are many functions on a jobsite that are similar to the functions in other industries in which IE techniques have been widely and successfully applied. Hence, the approach focused on allowing the different groups within the RT to concentrate on their areas of expertise.

Members of the team who were subject matter experts (SMEs) in construction could identify jobsite functions with which NVA activity had been associated. The IE experts on the team worked with the construction SMEs to identify the root causes of the NVA so that the