APPLICATION OF LEAN MANUFACTURING PRINCIPLES TO CONSTRUCTION

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The subject set forth in the reviewed CII report #191, authored by James E. Diekmann, Mark Krewedl, Joshua Balonick, Travis Stewart, and Spencer Wonis, is concerned with the applicability of "lean production" principles, currently being implemented in manufacturing, to the construction industry. The manufacturing industry has seen dramatic improvements in productivity and quality, while reducing cost and lead times. The construction industry has not seen such positive results. Improvement opportunities are in demand. However, both of these industries involve the management of complex operations and strive to deliver a quality product in the shortest feasible time possible. Moreover, in each of these industries it is important to save money and stay competitive. Given these similarities, we wish to decipher if the lean manufacturing principles can be applied to construction and if similar benefits could result. The primary question in this report that the authors seek to answer is, "Does lean practice hold potential for improving construction?"

The authors develop the study by presenting to the readers the theory behind lean thinking. In doing so they state a set of research questions, create a lean assessment instrument, and conduct six case studies. They finally present a set of conclusions and recommendations in support of this assumption that lean practices does indeed hold potential for improving construction. The reader is initially introduced to "lean" and lean theory from the perspective of the manufacturing industry. The Toyota Motor Company, the founder of lean production principles, is integral to this background. These principles or goals include reducing lead times, eliminating non-value adding activities, and reducing variability and are facilitated by methods such as pull scheduling, simplified operations, and buffer reduction. Finally, tools mentioned in the report that have been created to aid these methods include Value Stream Mapping, Just-in-Time, and Continuous Improvement.

With this background knowledge established and identified, the manufacturing and construction industries are compared and contrasted. The comparable aspects of the two are highlighted and focused on in support of the study presented. Also noted are the differences between manufacturing and construction and the difficulties in applying certain lean concepts to construction. Important issues that surface in the report include the greater degree of discretionary behavior and increased uncertainty evident in construction. But with this in mind, the comparable aspects of lean manufacturing and lean construction are grouped into the principles of customer focus, culture/people, workplace organization/standardization, waste elimination, and continuous improvement with built-in quality. A definition of lean construction is stated as "the continuous process of eliminating waste, meeting or exceeding all

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customer requirements, focusing on the entire value stream and pursuing perfection in the execution of a constructed project."

The goals set for the research team included the development of a comprehensive set of lean principles and validation of these by field observations of lean behavior, value stream mapping, and interviews with early lean adopters. Two tasks were performed in parallel. First, in order to better understand value and waste in the construction operation, a value stream mapping (VSM) was conducted. This type of analysis allows for greater understanding of the value stream of the product, or in other words, identifies types of wasted activities and practices that ultimately do not add value to the project. Along with this, the other task was performed to obtain a better understanding of the lean behaviors that are actually practiced in construction. In accomplishing this, the research team distributed questionnaires and conducted interviews. The report discusses the validation of the questionnaire and the research team proves that it is a reliable tool for measuring conformance to lean principles. This was done with contractors involved in the case study, as well as lean researchers and other companies that have already begun practicing lean construction. From all of this, best practices and recommended actions are drawn.

This approach was implemented in six case studies. Three case studies focused on the process of structural steel erection and the other three focused on the process of large bore pipe installation. The VSM method allowed the team to analyze the field operations and decipher which actions were of value to the project and which were not. The amount of time workers spent on tasks were monitored and logged into corresponding categories of work. The three categories used are value adding (VA), non-value adding (NVA), and non-value adding but required (NVAR). Examples of non-value adding but required work are material positioning and in-process inspections. As the report states, this category includes operations that are required for construction operations, yet have no permanent effect on the finished product. VSM results revealed that out of the combined workable hours for the three structural steel erection case studies, only 11.4 % was VA. The process piping case studies showed 7.5 % to be VA. Further defining this value resulted in added work; or in other words, activities that the client is interested in purchasing.

The study presented is shown to be valid through interviewing, questionnaires, and case studies. Lean practice does hold potential for improving construction. A set of lean principles and best practices is established and recommendations are given to future adopters of lean thinking.

The five major lean principles that the authors conclude are applicable in the construction industry are:

- Customer focus
- Culture/people
- Workplace standardization
- Waste elimination
- Continuous improvement/built-in quality

Subprinciples that stem from these major principles are rated and assessed for applicability. The report suggests that these can be used as a guide for creating a construction organization that moves closer to the ideal of lean production. Moreover,

the report concludes with recommendations for new adopters, but also identifies some of the barriers to developing a lean company of which to be aware.

Critique

This report strongly addresses the issue of adopting lean practices in construction. The concluded principles and recommendations also show themselves to be meaningful. Overall it was very effective, giving a great summary of where lean construction originates and what the current state of practice is. Up to this point, it was a kown fact that construction is different in many ways from traditional manufacturing. But the report gives a great summary of applicable principles, steps toward becoming lean, and likely benefits to a construction organization. The conclusions drawn seem quite valid and consistent with the evidence provided.

The authors deal with the problems presented in a scholarly manner and provide references for many of the known figures in the area of lean production. Included are those from the manufacturing and construction industries. Most of the key players that have contributed to the application of lean manufacturing principles to construction are cited in this report. The authors seem to agree with and accept many of their viewpoints.

The report is very organized, most notably in the sequence of sections. First, it brings the reader up to speed with the history of lean production and explains the theory in a timely fashion that should be understandable by the majority of audiences. An extensive review is included on the relevant management theories. Given that this background knowledge is readily available in the report, it makes for a powerful reference document. It greatly facilitates the learning of lean thinking in construction and allows for quicker review. Going along with this, the glossary of terms was a great addition. The report appears professionally written and readable. Also, layout throughout the document was appropriate and figures or tables are useful for providing the reader with a clear and more meaningful representation of the information.

This report seems to be intended mostly for the moderately experienced practitioner. Having a background in manufacturing and/or construction will be beneficial but certainly not necessary. This report should, more likely than not, keep the interest of leaders in the construction industry who are interested in the benefits shown to arise from lean practices.

In addition, the construction operations chosen in the case studies were very welcoming to a value stream analysis. The method was very effective and the results clearly showed that there was room for improvement in the construction process. When conducting a VSM in a manufacturing setting, a current state value stream map of the current process is first created. This map is analyzed, changes are made for improvement in flow, and a new state map is created by the research team. This approach was a great step forward in the attempt to apply lean manufacturing principles to construction.

Another interesting aspect of this report was how worker movement studies were incorporated, similar to studies conducted by industrial engineers and operation analysts in the manufacturing and service industries. This is because it further supports the idea that productivity in construction operations can be improved and that there are many tools, techniques, and creative methods which show this.

Future research and work is still plentiful. It was evident before reviewing this document and still seems obvious that a major problem in construction involves the area of supply chain management and design information. These are bottlenecks that are inhibiting the flow in the construction process, causing road blocks for further value generation. As the report states, in order to view the entire value stream, the process must be observed from the onset to the end of the project . This is difficult in construction and the reasons are stated in the report. Regardless, it is agreed that more effective supply chains and reliability in design information are focus areas. Also, as said before, metrics for measuring lean construction performance need to be determined and utilized. This is essential for continuous improvement. Just as it is critical in the manufacturing industry, it is critical in construction as well. Finally, the report gives a great overview of lean construction techniques. It mentions specific tools and methodologies that have been developed, like Last Planner™ and JIT, but does not go into extreme detail on each of these as this has been previously done by others. It presents audiences who are previously unfamiliar with such ideas with an inclusive summary about the elements of lean construction and makes suggestions for implementation.