



CONSTRUCTION INDUSTRY INSTITUTE®

LEAN PRINCIPLES IN CONSTRUCTION

Construction Industry Institute

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Lean Principles in Construction

**Prepared by
The Construction Industry Institute
Lean Principles in Construction Project Team**

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Executive Summary

The development and application of lean principles in manufacturing have had a dramatic impact in that industry on product costs, capital requirements, quality, cycle times, inventory, and space needs. The construction industry, where significant waste can be identified in the processes of designing and constructing facilities, could perhaps reap similar rewards if the lean principles similar to those in manufacturing could be applied. Major differences exist in the two industries, but construction's processes could no doubt be improved.

CII began an investigation into this problem by forming the Lean Principles in Construction Project Team (PT 191). The mission of PT 191 was to examine the potential use of lean principles that were developed in the manufacturing industry for adaptation and use in the construction industry. As part of its investigation, the project team had the objectives of determining if the lean principles as defined in manufacturing can be applied to the construction industry, and if not, are there other principles that are more appropriate for construction?

The team began by defining lean construction as: *"the continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream, and pursuing perfection in the execution of a constructed project."*

The project team's most significant finding was the large amount of waste activities (defined as anything that takes time, resources or space but does not add value to the product or service delivered to the customer) in construction as compared to manufacturing. The research determined that only 10 percent of field construction activities add value (according to lean manufacturing standards).

PT 191 interviewed lean manufacturers, early adopters of lean construction methods, and academics and theorists from around the world. Using all of this information led to the identification of five lean construction principles:

- Customer focus
- Culture and people
- Workplace organization and standardization
- Elimination of waste
- Continuous improvement and built-in quality

These principles and numerous sub-principles that were arrived at through team member analysis and discussion can significantly benefit both owners and contractors. They are described in this publication.

Although PT 191 could not identify anyone who has been successful in applying the lean theory to the entire engineer-procure-construct (EPC) process, it believes that a huge opportunity for improvement exists in the industry through the application of the lean construction principles. Those principles and the research that was the foundation for their development are summarized in the following pages.

Acknowledgements

PT 191 wishes to acknowledge the tremendous contributions of lean practitioners who expended time and effort in imparting their knowledge and experience to the team's efforts. Their insight was critical to our work. Several have asked to remain confidential, so we will not specifically name any contributing company in this publication.

Introduction

Over the past three decades the U.S. manufacturing industry has made significant progress in productivity improvement and product quality while lowering product lead times. Conversely, the U.S. construction industry has seen a decline in its share of Gross Domestic Product, and changes in its annual productivity growth rate remain controversial.

Manufacturing organizations in the U.S. have achieved the following results:

1. Half the amount of human effort in the factory required
2. Half the manufacturing space required
3. Half the engineering hours to develop a new product
4. Less than half needed inventory on site
5. Increased quality of products
6. Increased variety of products
7. Increased flexibility of manufacturing operations
8. Decreased lead times

The reason for such striking improvements is the implementation of lean production ideas and systems, which has been a major driver in the resurgence of U.S. manufacturing. The question addressed by this research is, "Are lean manufacturing principles useful and applicable to the construction industry?"

Lean philosophy, broadly defined, can apply to design, procurement, and production functions. PT 191 limited the scope of this research to enhance the overall understanding of lean principles in construction. This report thus focuses primarily on construction field production operations.

A Brief History of the Lean Production Movement

The foundations of lean production were developed in post–World War II Japan, when its manufacturing industry underwent a complete rebuilding. Lean pioneers Kiichiro and Eiji Toyoda and Taiichi Ohno of the Toyota Motor Company developed many of the underlying principles of lean production. The impetus occurred when Kiichiro, president of Toyota at the time, demanded that Toyota “...catch up with America in three years. Otherwise the automobile industry of Japan will not survive.”

At the time, the limited raw materials and inadequate space for inventory in Japan fostered an atmosphere in which concepts such as just-in-time (JIT) and zero inventories became necessary. During 1950, Eiji Toyoda visited American auto manufacturers to study mass production. Japan’s labor productivity at the time was one-ninth that of the U.S., and it became obvious to Toyota that it could not compete by depending on economies of scale to produce massive volumes for a small market that did not have the same type of demand. Toyota then made the strategic decision to focus its manufacturing efforts not on massive volumes of a product but rather on many different products in smaller volumes.

In his numerous experiments focused on reducing machine setup times, Ohno, Toyota’s chief production engineer, noted that the cost of producing smaller batches of parts was less than that of producing larger quantities as practiced in the U.S. Ohno also managed to reduce the amount of time required for machine setup from an entire day to three minutes, a task that enabled Toyota to increase the flexibility of its production lines as well as reduce production times. The concept of JIT was developed to complement this new production philosophy undertaken at Toyota.

The contributions of quality pioneer W. Edwards Deming to post–World War II Japan altered the way Japanese manufacturers viewed quality. Deming’s Total Quality Management (TQM) system permeated throughout organizations to create a quality culture, where quality became the primary goal of producers. After World War II, quality had

taken a back seat to production, and it was reasoned that intensive inspection at the end of the process would be adequate. With its focus on the entire organization, TQM addressed issues that were relatively new to the manufacturing industry at that time, such as employee empowerment, continuous improvement and the concept of proactively building quality into products versus the reactive nature of inspecting for quality at the end of the process.

The Japanese would improve on the teachings of Deming and create Total Quality Control (TQC). Thus, coupled with the company's move toward multi-skilled teams, guarantees of lifetime employment and pay raises linked only to seniority within the company, Toyota began to create a culture in which the quality of its product improved dramatically. In addition to shifting the focus of Japanese manufacturers to quality,

From this background, the Toyota Production System was created in the early 1960s through the combination of compensation for geographical restrictions, astute observation of current problems within the industry, development of JIT and the teachings of the quality movement, among other factors. The Toyota Production System presents an outline of the foundations of lean production. Figure 1 illustrates the forces that influenced the development of lean production.

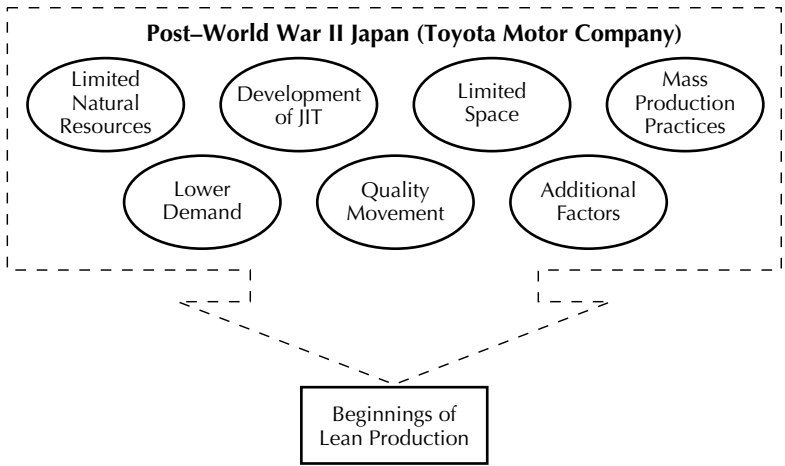


Figure 1. The Beginnings of Lean Production

In the late 1970s, this new production system was brought to the U.S. and contributed to a manufacturing renaissance that continued for the next three decades. Studies have shown the incredible benefits lean production methods have brought specifically to the automobile manufacturing industry, where the ideas originated. The visible success of lean principles in the automobile industry and in manufacturing generally has prompted other industries to adapt and apply these concepts to achieve similar benefits.

Lean Construction Principles

After a literature search, PT 191 surveyed contractors (both lean and non-lean) to learn about lean practices that are currently employed in the construction industry. The team then developed and defined five lean construction principles:

- Customer focus
- Culture and people
- Workplace standardization
- Elimination of waste
- Continuous improvement and built-in quality

PT 191 found that lean behavior among construction contractors usually is confined to the first two principles cited above. The remaining three principles are more difficult to implement, particularly because of the vast differences between the manufacturing and construction industries. Also, the use of those last three principles, even among contractors actively pursuing the lean ideal, is rare for to be truly lean requires changes to every aspect and every level of an organization.

Construction's processes can be improved, and applying lean principles can be key to that improvement. Becoming lean is a long-term, comprehensive commitment that requires a cultural change for the organization.

Differences between Construction and Manufacturing

From the research, PT 191 noticed similarities and differences between “manufacturing principles” and “construction principles.” Most of the following was developed within the team as a direct result of the research information.

Customer Focus

1. Constructors do not control the entire supply chain.
2. The largest constructors control only one percent of the market whereas in manufacturing largest manufacturers may control 20 percent or more.
3. Owner’s are much more involved in product features/ configuration, cost, schedule, and process.
4. Responsibility for success is shared between producer and consumer in construction.

Culture/People

5. High turnover results in less opportunity for training.
6. Construction workers are craft skilled, in manufacturing they are process specialized.
7. Production requirements, access, and schedules are governed by multiple contracts.

Workplace Standardization

8. Construction has a fluid organization at the project level.
9. The configuration of the production environment changes all of the time, more difficult to maintain visual management systems.
10. Production people move through product, not product through production people.
11. Construction has more difficult supply change relationship, different suppliers/subs in different geographic regions.

12. There are alternate ways of doing each task; production methods are in the hands of the workers not manufacturing engineers.
13. The typical construction project is what manufacturers would consider a proto-type, generally construction only produce one-off products.

Elimination of Waste

14. To a large extent the production sequence is discretionary.
15. Material flow is not steady-state; supply lines are different at different project locations.
16. Construction material storage location and amounts are different at different points in the project.
17. Construction can change the execution time by adding or subtracting resources.
18. Construction is resource paced and manufacturing is typically machine paced.
19. Construction is impacted by weather.

Continuous Improvement/Built-in Quality

20. High turnover/less opportunity for training.
21. Ability to develop a quality-tracking program is difficult.
22. Production time is measured in hours sometimes days in contrast to manufacturing where it is measured in minutes or seconds.

The primary issue common to this list is the much greater degree of discretionary behavior and larger amounts of uncertainty that is evident in construction. Whereas in manufacturing, production systems are defined by and controlled by the configuration of the production line, in construction the production system is defined by project managers and the individual workers.