

# INFLUENCE OF LEAN CONCEPTS ON SAFETY IN THE LEBANESE CONSTRUCTION INDUSTRY

Mohamad A. Awada<sup>1</sup>, Bachir S. Lakkis<sup>2</sup>, Ali R. Doughan<sup>3</sup>, and Farook R. Hamzeh<sup>4</sup>

## ABSTRACT

Lean management is a philosophy that aims at streamlining processes in the workplace to improve value and minimize waste. This paper examines the impact of implementing lean concepts on reducing work accidents in the construction industry in Lebanon. Three concepts will be studied and evaluated: the Last Planner System, Visualization, and the "Five S" Process. For this purpose, a questionnaire survey was prepared and addressed to professionals in the field involved in different construction projects to display their opinion towards these concepts. The conducted study indicated that most engineers and managers are interested in implementing new construction management processes, while also maximizing value and minimizing waste on their projects. The majority of respondents agreed that there is a significant influence of lean concepts on safety in construction sites. The study also identifies that the lack of knowledge and understanding of the lean philosophy and concepts, and the lack of transparency among project participants act as a major constraint against implementing the three lean concepts, addressed in this study, in the Lebanese construction industry.

## KEYWORDS

Lebanon; Safety; Lean Management; Last Planner System; Visualization; Five S Process

## INTRODUCTION

All construction companies adopt safety management strategies to reduce accidents and comply with safety regulations. Although these regulations do not require formal safety structures, compliance with them is not sufficient to eliminate accidents and assure a completely safe environment (Gambetese and Pestana 2014).

In fact, improving safety in construction remains a priority in almost every country around the world, since the construction industry stands out among all other industries as the main contributor to severe and fatal accidents (Ghosh and Young-Corbett 2009). Lean

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<sup>1</sup> Undergrad Student, Civil and Environmental Engineer, American University of Beirut, Lebanon, +96171471035, maa222@mail.aub.edu

<sup>2</sup> Undergrad Student, Civil and Environmental Engineer, American University of Beirut, Lebanon, +96171340172, bsl01@mail.aub.edu

<sup>3</sup> Undergrad Student, Civil and Environmental Engineer, American University of Beirut, Lebanon, +96170006345, ard08@mail.aub.edu

<sup>4</sup> Assistant Professor, Civil and Environmental Engineering, American University of Beirut, Lebanon, +9611350000, Farook.Hamzeh@aub.edu.lb

management is argued to be a viable form of safety management. It focuses on standardizing processes in the workplace to improve value and minimize waste.

Work accidents and injuries are considered a major source of waste in construction, and consequently lead to high costs. These accidents introduce variability in the production process, resulting in major disruption of the workflow, which lean construction aims to stabilize (Gambetese and Pestana 2014). In addition, lean management processes can be effective in reducing injury-related construction accidents and improving labor performance (Zhu 2014).

The objective of this paper is to examine the impact of implementing lean concepts on reducing work accidents in the Lebanese construction industry. Three concepts will be studied and evaluated: the Last Planner System, visualization, and the “Five S” process. These concepts are selected because they are major tools embodying lean philosophy, they are the closest to be implemented, and they represent basic lean knowledge that can be later built on. The first part of the paper explores lean construction practices and their relation to safety. The second part studies the implementation of these lean concepts and their impact on safety conditions in construction projects. The paper will conclude by presenting the challenges and barriers for applying the three mentioned lean concepts in the Lebanese construction industry.

## **LITERATURE REVIEW**

The construction industry has been experiencing continuous growth in order to meet the rising expectations and needs of people throughout the world. Despite the technological advancements that this industry has witnessed, it remains a major employer for laborers often employing between 9 to 12 percent of a country’s working population (International Labour Organization, 1999). However, there have been numerous amounts of worker injuries and fatalities that have occurred onsite over the years. As a result, many companies worldwide have pushed for designing and developing enhanced safety programs to control the aforementioned problem, but the challenge remains in applying these safety guidelines throughout the construction process. Ikpe et al. (2012) conducted a cost-benefit analysis regarding accident prevention, and their findings show that the benefits of accident prevention outweigh the costs of accidents by a ratio of 3 to 1 (Ikpe et al. 2012).

Lebanon is a developing country that is still recovering from a 15-year civil war that ended in 1990, and after which the construction industry started booming. However, onsite safety was never granted the required importance as far as employing strict legislation and monitoring systems by the government to control the potential risks that this profession holds. The Lebanese workers’ compensation law grants an injured laborer full medical care, 75 % of his daily salary since the occurrence of the injury, and compensation in case of permanent damage or fatality. However, very few construction companies proceed with work-accident insurance premiums that protect the workers and cover their injuries (Awwad et al. 2014).

It is important to mention that the majority of the labor force in the Lebanese construction industry is non-Lebanese, which is a one reason why employers neglect insuring labor. In an interview with The Daily Star newspaper, two foreign workers complained about the rare provision of medical insurance by their employers, forcing them

to pay out of their own pockets. They went on to recall the death of one of their colleagues while working onsite. “He was working on the sixth floor of a building fitting electricity cables. He didn’t have a harness, he fell and died” (Armstrong 2012). This example is one of many which represents the malpractice of safe construction in Lebanon. Therefore, change is necessary to develop a safe working environment, and hence an improved construction process.

Poor safety is considered as a form of waste on construction sites, since injuries will be costly on several levels of the process such as: human sufferance, compensation costs, lost time, lost productivity, and higher employee turnover (Nahmens 2009).

Some researchers developed an interaction matrix between lean construction and safety management practices to further understand the underlying relationship. The results indicate evidence of the interaction between lean production practices and safety management practices (Antillón et al. 2011). Thus, using lean concepts may be useful to guarantee a safe working environment in construction sites (Basher 2011). This study will focus on three main lean concepts: The Last Planner System, Visualization, and the “Five S” process in construction sites.

### **Last Planner System**

Some lean concepts and tools that have been used for production planning and control (e.g. LPS) can be easily applied to safety planning. For example, a performance indicator called PSW (Percentage of Safe Work Packages), similar to PPC, is potentially effective for safety control (Suarin et al. 2001). Moreover, the LPS has proven to be an effective concept for improving the productivity of the production units (Leino and Elfving 2011).

The goal of the Last Planner System is to improve the reliability of workflow using pull and reverse phase scheduling, look-ahead planning where tasks are subjected to constraints analysis, and determining the best courses of action for the execution of work (Antillón 2010, Hamzeh et al. 2015). Wehbe and Hamzeh (2013) integrated a risk assessment method into the Last Planner System (LPS) to forecast and assess the risks associated with construction tasks as part of work planning.

LPS can be considered as a complementary program for all safety measures on site. Strategies applied by LPS can be easily assigned with safety planning, thus increasing the efficiency of safety measures. A safety culture built according to the LPS standards is based on a higher involvement of the field workers, allowing them to point out the different risks they face during construction (Forman 2009).

### **Visualization**

Visual control first started in the manufacturing industry, and is considered a prerequisite for continuous improvement and process control. Nowadays, it is recommended for the implementation in the construction industry. It includes posting signs for safety, hazards, schedules, and quality standards. One of the major causes of accidents onsite is the unsafe working condition, which is due to inadequate supervision and poor visualization (Shrestha et al. 2011). The purpose behind increased visualization is communicating key information effectively to the workforce by posting various signs and labels around the construction area (Enshassi and Abu Zaiter 2014). Visual management can be extended for safety

purposes by displaying current accident rates and raising current issues in order to increase hazard and safety communication effectiveness (Antillón 2010).

### **“Five S” Process**

The “Five S” program comprises a series of activities for reducing waste that lead to defects, errors, and injuries in the workplace. Without work organization, many wastes accumulate with time, problems are covered up, and the process becomes dysfunctional (Liker 2004). The Toyota Way translated the five S’s (seiri, seiton, seiso, seiketsu, and shitsuke) to English as follows:

- Sort: Sort through items and clear out rarely used ones by red tagging
- Straighten (orderliness): Organize and label a place for everything
- Shine (cleanliness): Maintain work areas and machines clean to avoid hurting quality and machine failure
- Standardize (create rules): Develop rules to sustain the previous 3 S’s
- Sustain (self-discipline): Keep a stabilized workplace in a process of ongoing improvement

Lean systems use “Five S” to support a smooth flow of information and material. “Five S” is also a process to help bring problems to the surface, and can be part of the visual control process. Recently “Five S” was modified to 6S (the above mentioned “Five S” and Safety) to give importance to safety at the workplace (Anvari A. 2011). “Six S” implementation in the construction industry would be beneficial with the addition of safety, as this industry suffers from weak implementation of safety protocols, especially in developing countries.

## **METHODOLOGY**

In this exploratory study, a questionnaire survey was prepared and conducted with thirty professionals in the field working for fourteen different companies. These professionals were involved on twenty mid-sized projects, ranging from residential buildings, hotels, and hospitals. The chosen projects are all executed by local companies, rather than international, to guarantee that the results represent the Lebanese construction industry. Some of the professionals completed the questionnaire through an interview, while others preferred to email their response.

The respondents were briefed on the purpose of the study, and were assured that the collected information will be secured. The survey questions are based on a Likert-type scale with the neutral point being neither agree nor disagree as follows:

(1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

The questions are divided into three different sections:

- *Section 1:* This section focuses on the extent of knowledge and degree of implementing safety criteria and the studied lean construction techniques.
- *Section 2:* This section deals with the benefits of implementing lean techniques in construction sites from a safety perspective.
- *Section 3:* This section discusses the several barriers that prevent the implementation of lean construction techniques in construction projects.

The survey questionnaires and their corresponding results are presented in the following section.

## RESULTS AND DISCUSSION

This section presents the results collected from the survey along with the population description.

### Population Description

The following subsection will present a brief description of the sample considered for the survey. The criteria used to classify the sample were: Years of Experience, Type of Organization and Specialty, and Number of Employees per Organization.

Table 5: Distribution of Sample Based on Years of Experience

| Years of Experience | Frequency |
|---------------------|-----------|
| < 1                 | 2         |
| 1-5                 | 7         |
| 5-10                | 12        |
| 10-20               | 7         |
| > 20                | 2         |

Table 6: Distribution of Sample Based on Type of Organization and Specialty

| Type of organization | Specialty  | Frequency |
|----------------------|------------|-----------|
| Owner                | -          | 4         |
|                      | Civil      | 10        |
| Site Engineer        | Electrical | 5         |
|                      | Mechanical | 2         |
| Contractor           | -          | 9         |

Table 3: Distribution of Sample Based on Number of Employees

| Number of Employees | Frequency |
|---------------------|-----------|
| < 500               | 20        |
| 500-1000            | 8         |
| > 1000              | 2         |

## Results

Table 4 summarizes the professionals’ response regarding safety programs in their companies. Most of the construction companies in Lebanon value safety in their projects, however more than 50% of the respondents claimed that field supervisors are not certified in accredited safety courses.

Table 4: Safety Conditions in Construction Sites

| Statement  | 1     | 2     | 3     | 4     | 5     |
|--|-------|-------|-------|-------|-------|
| The company’s safety program is fairly established                                 | 10.00 | 13.33 | 20.00 | 33.33 | 23.33 |
| The company’s annual safety-induction training is instructive                      | 3.33  | 20.00 | 13.33 | 40.00 | 23.33 |
| Most of the company’s field supervisors are certified in accredited safety courses | 23.33 | 30.00 | 16.67 | 16.67 | 13.33 |
| Safety issues are given priority   | 10.00 | 13.33 | 16.67 | 23.33 | 36.67 |

Table 5 summarizes the professionals’ response regarding lean construction philosophy in general, and the three studied concepts in specific. The results show that lean theory is not widely recognized by the Lebanese construction companies. In general, most of the construction professionals are interested in implementing new construction management concepts, such as employee empowerment, risk analysis, and site organization. This falls under the umbrella of minimizing waste and maximizing value in the company’s projects.

The majority of the respondents were not familiar with the studied lean concepts (Last Planner System, Visualization, and the “Five S” Process), but their answers showed that some ideas within these concepts are applied in their companies. For instance, only 30% of the respondents claimed to have knowledge of the “Five S” process, while more than 60% of the respondents claimed that their companies regularly maintain the site clean.

Table 5: Lean philosophy and Safety

| <i>Statement</i>   | 1     | 2     | 3     | 4     | 5     |
|--|-------|-------|-------|-------|-------|
| The company is familiar with lean construction management  | 26.67 | 30.67 | 26.67 | 10.00 | 0.00  |
| The company exhibits interest in improving construction processes                                | 6.67  | 13.33 | 23.33 | 16.67 | 40.00 |
| The company is familiar with the Last Planner System   | 23.33 | 30.00 | 16.67 | 16.67 | 13.33 |
| The company is familiar with the concept of PPC (Percent Planning Completion)                    | 20.00 | 23.33 | 16.67 | 26.67 | 13.33 |
| The is company interested in increasing the empowerment of the employees                         | 10.00 | 10.00 | 20.00 | 33.33 | 26.67 |
| The company involves project’s participants (owner, contractor, designer) in planning            | 20.00 | 26.67 | 20.00 | 16.67 | 16.67 |
| The company is familiar with the concept of Visualization in construction sites                  | 10.00 | 10.00 | 20.00 | 40.00 | 20.00 |
| The company promotes a safety system that aims at identifying, analyzing and controlling hazards | 10.00 | 36.67 | 13.33 | 20.00 | 16.67 |
| The company provides enough safety signs in the construction site                                | 6.67  | 10.00 | 23.33 | 30.00 | 30.00 |
| The company is familiar with the “Five S Process” in construction                                | 30.00 | 30.00 | 10.00 | 20.00 | 10.00 |
| The company is keen on keeping the site clean  | 0.00  | 10.00 | 26.67 | 26.67 | 36.67 |
| The company regularly organizes, sorts, and labels a place for different items                   | 0.00  | 10.00 | 16.67 | 36.67 | 36.67 |

## Last Planner System

Table 6 summarizes the professionals’ response regarding the influence of the Last Planner System on safety in construction sites. Most of the respondents indicated that the employment of a safety committee during the different phases of a project positively influences onsite safety. In addition, 70 % of the respondents claimed that the involvement of workers in the planning phase and their continuous empowerment help reduce construction accidents. Such results were expected, as LPS provides a minimum exposure to the inherent construction hazards when workers are involved in the preconstruction phase. Furthermore, the respondents stated that employing a weekly work plan during the construction phase is of great importance. It is worth mentioning that most of the respondents claimed that their companies do not employ a separate safety plan, rather safety is mentioned in a master plan.

As a result, an effective integration between the Last Planner System and safety planning can improve safety conditions in construction projects.

Table 6: Influence of Last Planner on safety

| <i>Statement</i>   | <i>1</i> | <i>2</i> | <i>3</i> | <i>4</i> | <i>5</i> |
|--|----------|----------|----------|----------|----------|
| It is important to have a reliable safety committee responsible for workplace self-inspections, accident investigation, etc. | 0.00     | 10.00    | 20.00    | 26.67    | 43.33    |
| Involving workers in the planning phase is important for onsite safety   | 6.67     | 10.00    | 13.33    | 50.00    | 20.00    |
| Employee empowerment is necessary for onsite safety  | 6.67     | 6.67     | 16.67    | 40.00    | 30.00    |
| Employing a weekly work plan schedule (WWP) contributes to having onsite safety  | 0.00     | 13.33    | 13.33    | 33.33    | 40.00    |

## Visualization

Table 7 summarizes the professionals’ response regarding the influence of increased visualization on safety in construction projects. Most of the respondents stated that their companies use different types of instruction boards and safety signs on site, to ensure a lower accident rate. In addition, 80 % of the respondents stressed the importance of effective communication on site regarding safety. Therefore using visual tools for communicating important safety instructions is key for maintaining a safe environment in construction sites.

Table 7: Influence of Visualization on Safety

| <i>Statement</i>   | <i>1</i> | <i>2</i> | <i>3</i> | <i>4</i> | <i>5</i> |
|--|----------|----------|----------|----------|----------|
| The employment of a safety system is important for onsite safety                           | 0.00     | 0.00     | 16.67    | 26.67    | 56.67    |
| Installing safety signs and instruction boards enhances onsite safety                      | 0.00     | 3.33     | 10.00    | 30.00    | 56.67    |
| Improving the communication between different parties increases safety during construction | 0.00     | 6.67     | 13.33    | 26.67    | 53.33    |

**“Five S” Process**

Table 8 summarizes the professionals’ response regarding the influence of implementing the “Five S” process on safety in construction. The majority of the respondents claimed that implementing “Five S” concepts improves on-site safety conditions. More than 70% of the respondents agree that designating a place for every item, sorting through materials, and reducing all kinds of waste improve onsite safety conditions. They also confirmed that many accidents resulted from wastes and chaos in the workplace.

Table 8: Influence of “Five S” process on safety

| <i>Statement</i>   | <i>1</i> | <i>2</i> | <i>3</i> | <i>4</i> | <i>5</i> |
|--|----------|----------|----------|----------|----------|
| Keeping the area clean with the progression of work improves safety onsite   | 6.67     | 13.33    | 13.33    | 26.67    | 40.00    |
| Associating every item with a corresponding place improves safety onsite   | 6.67     | 13.33    | 16.67    | 26.67    | 36.67    |
| Storing materials leads to better safety onsite  | 0.00     | 10.00    | 13.33    | 30.00    | 46.67    |
| Reducing all kinds of waste (inventory, motion, overproduction...) within the site boundaries enhances safety onsite | 10.00    | 10.00    | 16.67    | 36.67    | 26.67    |

Table 9 summarizes the professionals’ response regarding the constraints against the implementation of the studied lean concepts in the Lebanese construction industry that ultimately impact site safety. Most of the respondents indicated that the lack of knowledge and understanding of the lean philosophy, fear of implementing new techniques, resistance to change and the lack of self-criticism represent major constraints in the way of lean implementation. Additionally, the lack of transparency between the different project participants stands against lean implementation, with 70 % of the respondents agreeing to the aforementioned. Also, the traditional working behavior represents a major barrier for the implementation of the “5S” process, since workers have the mentality that they are hired to do the construction work and not to clean up the workplace.

Table 9: Constraints that have a direct impact on the implementation of the studied lean concepts in Lebanon

| <i>Constraints</i>   | <i>1</i> | <i>2</i> | <i>3</i> | <i>4</i> | <i>5</i> |
|--|----------|----------|----------|----------|----------|
| Lacking knowledge of the above lean concepts stands in the way of implementing them                    | 0.00     | 3.33     | 20.00    | 33.33    | 43.33    |
| The traditional worker attitude stands in the way of implementing the “5 S” process                    | 0.00     | 6.67     | 20.00    | 50.00    | 23.33    |
| Reluctance of project participants to share risks stands in the way of implementing the LPS            | 0.00     | 16.67    | 23.33    | 30.00    | 30.00    |
| Lack of transparency among different partners in a project impedes the efforts of implementing the LPS | 13.33    | 10.00    | 16.67    | 36.67    | 23.33    |



## **CONCLUSION**

The findings of this paper represent the extent of the application and influence of lean construction concepts (the Last Planner, Increased Visualization, and the “Five S” process) on safety in the Lebanese construction industry. There appears to be several structural and cultural barriers that stand in the way of successful implementation. By disregarding these factors, organizations will not be able to determine what improvement efforts should be taken, where they should be allocated, and which of them yield the best outcomes. The results of this study may be used to aid professionals and companies in the Lebanese construction industry to shift their attention and resources towards implementing lean construction and standardized onsite safety management systems. Providing a safe working environment in construction is paramount for a streamlined workflow and the avoidance of accidents and injuries. Lean construction concepts provide a platform for satisfying this ideal, as they aim to maximize value and minimize waste. Most of the respondents in the study agreed that the implementation of the lean construction concepts would enhance safety conditions, and would facilitate the achievement of the project in an effective and efficient way.

Lean construction is not applied in the Lebanese Construction Industry yet, as its concepts remain poorly recognized among the several project participants. Continuous training, open communication channels between participants, and the desire for change will be key for future implementation of lean construction. The analysis and discussion presented in the paper provide enough ground for establishing a link between lean concepts and safe practice. Such relationship should be a basis for construction and site management in the Lebanese construction industry. Further research is recommended to determine strategies and execution plans for overcoming the identified barriers. The proposed plans should then be tested and evaluated against quality and safety indicators.

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