5th South American Conference on Industrial Engineering and Operations Management
Bogota, Colombia, May 7-9, 2024
Publisher: IEOM Society International, USA DOI: 10.46254/SA05.20240241
Published: May 9, 2024

Enhancing Profitability in a Peruvian Construction Company: A Lean Manufacturing and Human Resources Approach

Claudia Rodríguez-Noe
Bachelor in Industrial Engineering
Facultad de Ingeniería, Universidad de Lima, Perú
20131157@aloe.ulima.edu.pe

Nicolle Rodríguez-Risco
Bachelor in Industrial Engineering
Facultad de Ingeniería, Universidad de Lima, Perú
20123067@aloe.ulima.edu.pe

Juan Carlos Quiroz-Flores
Research Professor
Facultad de Ingeniería, Universidad de Lima, Perú
jcquiroz@ulima.edu.pe

Abstract

This study targets enhancing profitability in a Peruvian construction company through the integration of Total Productive Maintenance (TPM), Lean Manufacturing and Human Resources Management tools. Historically, the construction sector in Peru has faced challenges such as material shortages, labor inefficiencies, and operational disruptions due to socio-political unrest, contributing to a profitability decline. This research responds to these challenges by proposing a model that applies Lean tools—Just-In-Time for material procurement efficiency, Total Productive Maintenance and Autonomous Maintenance for improved machinery reliability, and Standard Work and One-Point-Lesson for labor productivity. Additionally, a human resources strategy was designed to address the inadequate management and training of labor forces. The implementation of this model significantly improved operational outcomes, as evidenced by four key performance indicators: Profitability increased from 3.8% to the targeted 8%, Machinery availability enhanced, reducing downtime and operational delays, Maintenance compliance achieved 100%, and Labor productivity increased by 79%, demonstrating a substantial reduction in labor-related inefficiencies. These results underline the effectiveness of combining TPM y Lean Manufacturing principles with strategic human resources management to tackle the root causes of inefficiency in construction operations, positioning the model as a benchmark for similar companies in culturally and geographically analogous settings.

Keywords
Productivity, Lean Manufacturing, TPM, Standardized Work, Human Resources Management, Peruvian Construction Sector.

1. Introduction
The construction industry, which generates a total of USD 10.7 trillion globally, stands out as one of the most significant sectors in economic terms (Deloitte, 2023). It is important to note that, in 2021, the sector recovered to pre-pandemic levels. This growth is attributed, in part, to growth expectations driven by population increase (Eberhardt et

al., 2019). However, despite this favorable outlook, the industry faces considerable market uncertainty, characterized by inflation, high-interest rates, rising costs, supply chain setbacks, and material and labor shortages (Deloitte, 2023).

In the local context, between December 2022 and January 2023, the sector experienced a drop of almost 12% due to political-social conflicts, which generated unfavorable conditions for private spending (inflation, negative interest rates, and confidence) (CAPECO, 2023). Subsequently, a 9% decrease was recorded in the first half of 2023 compared to the same period of the previous year, reflected in a 6.1% drop in the sector's GDP caused by a lower execution of private projects and an increase in self-construction. In addition, there was a modest 0.2% growth in the construction sector's sales compared to the previous year. At the national level, the industry faces additional risks, such as high state obstruction, the negative impact of the El Niño phenomenon on the execution of works, and declining sectoral expectations (-1%) (CAPECO, 2023).

In this context, this article aims to investigate a company's operations in the construction sector in Peru to analyze the leading causes of low profitability. This analysis is intended to propose a model that integrates lean manufacturing tools, such as Just-In-Time, to address delays in materials procurement; Total-Productive-Maintenance to implement preventive maintenance improvements; Autonomous-Maintenance to implement an automatic maintenance plan; Standard-Word, to create standards of equipment use; One-Point-Lesson to train collaborators on machinery; A human resources plan to address the lack of a human resources management area, improve communication, implement training and incentive programs, and address the problems of low labor productivity and the limited availability of machinery and equipment.

This paper addresses a significant knowledge gap by focusing on improving profitability in a Peruvian construction company through a model that integrates Lean Manufacturing and human resources tools. Although the existing literature on the application of Lean in construction is extensive, most studies focus on conventional construction companies, leaving a gap in research on how this approach can specifically benefit companies in particular geographic and cultural contexts, such as construction companies in Peru. In addition, while numerous papers explore human resource management strategies in various sectors, more research must be used to integrate these strategies with Lean Manufacturing principles in Peru's construction context. The contribution lies in filling this gap by proposing an innovative model that combines Lean Manufacturing tools with a human resources plan tailored to a Peruvian construction company's specific needs and challenges, thus offering a comprehensive and results-oriented approach to improve profitability in this sector.

2. Literature Review

2.1. Lean Practices in Construction Sector

Lean Manufacturing originated after World War II in the automotive industry in Japan after the application of the Toyota production system (Saieg et al., 2018; Singh et al., 2018); subsequently, in the construction industry, it would focus on eliminating waste and improving efficiency at all stages of the construction process (Rekha et al., 2016; Koskela, 1992). Its application seeks to reduce costs, improve quality, and shorten lead times, thus improving the efficiency of construction projects (Jurik et al., 2020; Jamil & Fathi, 2016). Lean practices have shown that companies are three times more likely to achieve on-time delivery and twice as likely to meet budget (Aslam et al., 2020). Effective implementation of Lean in construction involves significant cultural and organizational change, where collaboration between all stakeholders in the value chain is critical (Sacks et al., 2018; Marhani & Jaapar, 2013). In construction, where projects are often complex and subject to constant variations, the application of Lean can be particularly beneficial to increase the profitability and competitiveness of companies in the sector. However, there is still a wide gap in applying this methodology, especially in small and medium-sized Peruvian companies (Heravi & Firoozi, 2017; Lopez-Uchuya, 2022).

2.2. Just in Time (JIT)

Just-in-Time (JIT) is a management philosophy that seeks to deliver needed materials, components, or services at the exact time they are required, thus avoiding unnecessary storage and reducing associated costs (Ogunbiyi, 2014). In construction, the application of JIT can help minimize lead times, optimize the use of resources, and improve efficiency in project execution (Hei et al., 2024; Enshassi et al., 2019). Studies have shown that JIT implementation in construction can reduce production times and excess inventory in raw materials, incomplete and finished goods, decreasing inventory costs (Kong et al., 2018; Phan & Athigakunagorn, 2022). However, its implementation in the construction industry presents unique challenges, such as managing the variability inherent in construction projects, effectively coordinating multiple activities and actors, and special training (Bamana et al., 2019; Moussaoui et al., 2021).

2.3. Total Productive Maintenance (TPM)

Total Productive Maintenance (TPM) in construction focuses on maximizing the efficiency of equipment and machinery by preventing failures and optimizing maintenance processes (Tsuchiya, 1992). Research led by Heravi et al. (2019) and subsequent studies by Cabrera et al. (2022) have highlighted the importance of implementing TPM in construction companies to reduce downtime, improve equipment reliability, and increase overall project productivity. Unlike the traditional practice of reactive maintenance, where one waits for failures before intervening, TPM promotes a proactive and systematic approach to prevent problems and optimize asset performance (Al-Aomar, 2012; Asay & Wisdom, 2002). In construction, where the intensive use of equipment and machinery is critical, implementing TPM seeks to reduce unplanned downtime, increase equipment availability, and improve production quality (Palomino-Valles et al., 2020).

2.4. Autonomous Maintenance (AM)

In the construction industry context, autonomous maintenance involves training field workers to take responsibility for maintaining and caring for their tools, machinery, and equipment used in construction projects (Cabrera et al., 2022). This is based on the understanding that workers directly involved in operations have detailed knowledge of the equipment and can identify potential problems early. Construction workers should be trained to perform tasks such as regularly cleaning equipment and tools to prevent the accumulation of dirt and debris that could affect their performance (Shin & Ahmad, 2011). In addition, they are taught to perform periodic inspections for signs of wear, damage, or malfunction and to take corrective action or report problems to maintenance teams as needed (Semrau & Horzela, 2021).

This approach not only helps to optimize equipment efficiency and reduce unplanned downtime on the job site but also promotes a sense of responsibility and care among workers towards company assets, contributing to improved productivity and quality in construction projects by ensuring that equipment is in optimal working condition (Amad et al.,2011; Burawat, 2019).

2.5. Standardized work (SW)

The lean approach to standardized work is based on establishing precise and uniform processes for each stage of the project, from planning to execution (Toussaint & Berry, 2013). This structure provides a solid foundation for improving efficiency, reducing waste, and ensuring the quality of the work performed (Monden, 2015). Recent research has shown that applying standardized work in construction leads to several significant advantages, including increased productivity, better resource management, reduced costs, and improved customer satisfaction (Fazing & Saffaro, 2016; Annosi & Bruneta, 2018). In addition, standardized lean work fosters an organizational culture of continuous improvement. By establishing measurable and transparent processes, construction companies can identify areas of opportunity and develop strategies to optimize their operations on an ongoing basis (Fazinga et al., 2018; Puvanasvaran et al., 2018).

2.7. One Point Lesson (OPL)

Lesson-in-point is based on learning from mistakes and challenges in real-time by fostering a culture of immediate feedback and corrective action; this tool allows construction teams to proactively address problems and avoid their recurrence on future projects (Miqueo et al., 2020). Existing research supports the effectiveness of the lesson-in-point in construction, highlighting its ability to reduce unproductive time (Szwedzka & Kaczmarek, 2018). Studies have identified lesson-in-point as a fundamental practice to drive continuous improvement in construction by facilitating the rapid identification of problems and the implementation of solutions; this tool contributes significantly to operational efficiency (Miqueo et al., 2020).

2.8. Human Resources Plan

Human resource planning in construction encompasses identifying, acquiring, and effectively managing the talent needed to successfully carry out construction projects (Fita & Bezo, 2015; Margherita & Bua, 2021). Studies led by Babalola and Aigbavboa (2022) have explored the importance of human resource planning strategies specific to the construction industry, considering the need for communication skills and workforce management in dynamic and often unpredictable environments. In addition, research by Adegbenga and Adebimpe (2019), Babalola and Aigbavboa (2018), and Cesário and Magalhaes (2016) have highlighted how effective human resource planning can contribute to improved productivity, talent retention, and job satisfaction in construction companies.

3. Contribution

3.1. Fundamental Contributions

The proposed model stands out for its ease of application, efficiency, and low cost. Its main objective is to improve the profitability of the construction company selected as a case study. This model integrates Lean Manufacturing tools, such as Just-In-Time, Total Productive Maintenance, Autonomous Maintenance, Standard Work, and One-Point-Lesson, together with a human resources plan to increase the productivity of the company's human resources and optimize the availability of machinery.

The model's approach was based on the company's diagnosis, which included interviews with collaborators and managers. This analysis elaborated on a tree of problems that synthesized the leading and root causes of the low profitability of construction execution projects.

This analysis identified two essential tools to address the company's profitability issues. First, Lean Manufacturing tools will help solve problems such as the low availability of machinery and equipment, multiple shutdowns due to a lack of spare parts, and the high rate of breakdowns. Secondly, other Lean Manufacturing tools are integrated with the human resources plan to optimize labor productivity, addressing problems such as the lack of human resources policies, low knowledge of machinery, low commitment on the part of employees, and inadequate use of equipment.
Figure 1 shows the proposed model, which describes a process-based approach. It begins with identifying the problem of low profitability in construction projects, which currently stands at 3.8%. Next, the first component is detailed, which proposes the optimization of equipment availability through the use of tools such as Just-In-Time, as well as the integration of predictive and autonomous maintenance. Then, the second component is presented, which aims to increase labor productivity through tools such as Standard Work and One Point Lesson, together with a human resources management plan. Ultimately, an improvement in profitability is expected to be achieved, approaching the 8% target.

Figure 1. Proposed Model

3.2. Proposed Model

The proposed model consists of two main components. The first focuses on optimizing the availability of machinery and equipment used in project execution processes. To achieve this objective, three Lean Manufacturing tools are implemented: Just-In-Time, which seeks to identify parts acquisition processes and establish relationships with reliable suppliers; Total Productive Maintenance, which improves preventive maintenance processes; and Autonomous Maintenance, which trains employees in inspections, cleaning and lubrication of equipment.
The second component seeks to improve human resource productivity through two Lean Manufacturing tools:

Standard Work, which generates standard documents on operating each machine from start to finish, and One Point Lesson, which trains employees on machinery and its main components. In addition, a human resources management plan will be implemented since the company needs an established area, policies, and communication channels.
It is important to note that the main objective of this model is to improve the profitability of a construction company in Peru. **Figure 2** provides a detailed explanation of the above.

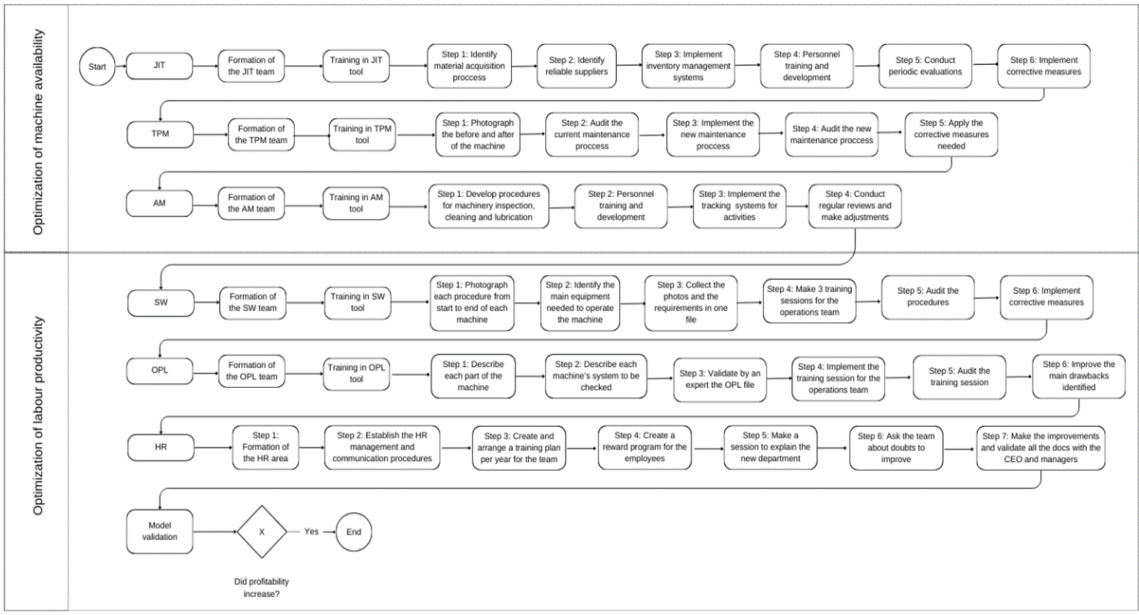


Figure 2. Flow diagram of the proposed model

3.3. Model Indicators

Below are the indicators used to verify compliance with the research objective, divided into three sections: general problem, leading causes, and root causes.

General Problem Indicator

First, the general problem, as mentioned above, refers to the company's low profitability, which the following indicator can measure:

$$\%\ Profitability = \frac{(Net\ Project\ Profit)}{(Total\ Project\ Cost)} \times 100$$

Indicators of root and leading causes

a) Low availability of machinery and equipment

The indicators associated with the most significant cause of low profitability, attributed to the limited availability of machinery and equipment, are presented below.

$$\%\ \text{Availability} = \frac{(Total\ Operating\ Time - Stoppage\ Time)}{Total\ Operating\ Time} \times 100$$

This root cause will be addressed through the use of three Lean Manufacturing tools: JIT, TPM, and AM, which will be evaluated through the following indicators.

i) To solve the problem of delays in the acquisition of materials, the Just In Time tool will be implemented with the indicator:

$$Spare\ Parts\ Acquisition\ Time\ (days) = Spare\ Parts\ Receipt\ Date - Spare\ Parts\ Order\ Date$$

ii) Likewise, for the problem of the low amount of preventive maintenance performed, the TPM tool will be evaluated using the following indicator:

$$\%\text{Maintenance Audit Compliance} = \frac{\#\ of\ compliant\ items\ audited}{\#\ total\ items\ audited} * 100\%$$

iii) Similarly, to address the lack of autonomous maintenance, the following indicator is presented:

$$\%\text{Downtime Rate due to Lack of Spare Parts} = \frac{\#\ of\ Downtime\ due\ to\ Lack\ of\ Spare\ Parts}{\#\ os\ Total\ Downtime} * 100\%$$

b) Low Labor Productivity

In addition, the second cause is related to low employee productivity and the following indicator is used to evaluate this:

$$\%\ MO\ Efficiency = \frac{Standard\ Time\ for\ Tasks\ Completed}{Actual\ Time\ Spent} \text{x}100$$

Two lean manufacturing tools, SW and OPL, will address this issue, along with a human resources management plan. These will be evaluated using the following indicators:

i) To resolve the lack of standards in the use of machinery, the Standard Work tool will be applied and evaluated using the following indicator:

$$Cycle\ Time\ (\text{sec}) = \sum(Time\ of\ each\ Activity)$$

ii) The One Point Lesson tool will be implemented to solve the lack of knowledge about the machinery on the part of the collaborators, evaluated with the following indicator:

$$Failure\ Rate\ (\%) = \frac{Number\ of\ Failures}{Total\ Number\ of\ Equipment}\ x\ 100$$

iii) The following indicator is considered for the human resources plan:

$$\%\ Turnover\ Rate = \frac{\#\ employees\ who\ left\ the\ company}{\#\ employees\ at\ the\ beginning + \#\ employees\ at\ the\ end} \text{x}100$$

4. Validation

4.1. Initial Diagnosis

The construction company under study has a 26-year track record in the market and has executed more than X projects throughout Peru. However, despite its extensive experience, the company is characterized by being family-owned and needs more efficient management, which has resulted in low profitability in the construction projects executed.

Following the diagnosis conducted through interviews and calculations, summarized in a problem tree, it was identified that 2023 profitability was 3.8%, while a target of 8% was expected to be reached. The leading causes of this situation are attributed to two main aspects. On the one hand, there was a low availability of machinery, which operated at 60% capacity.

Among the leading causes of this problem are shutdowns due to lack of spare parts due to delays in the acquisition of materials, with an average delay of 15 days and a cost of 405,136 PEN, representing 5. 35% of total indirect costs; high levels of breakdowns due to the lack of predictive and autonomous maintenance activity, with only 52% of maintenance carried out compared to the expected 100%; and inadequate use of equipment by operators since there are no standards or training on the parts and procedures for using the machinery.

On the other hand, low labor productivity, which barely reaches 42%, also contributes significantly to low profitability. This problem is attributed to the lack of a human resources policy, as the company lacks an area and established communication channels; the low level of knowledge of the machinery by the operators, with only 22% having higher education and only 10% of the operators being trained by the company; and the low level of commitment of the collaborators due to the lack of a rewarding process and labor instability, as most of the contracts are weekly, resulting in 2% labor stability.

To address these problems, tools will be proposed to optimize the profitability of construction projects in the company studied based on a detailed analysis of the causes and root causes identified in the problem tree. **Figure 3** shows the problem tree that summarizes the diagnosis made in the case study

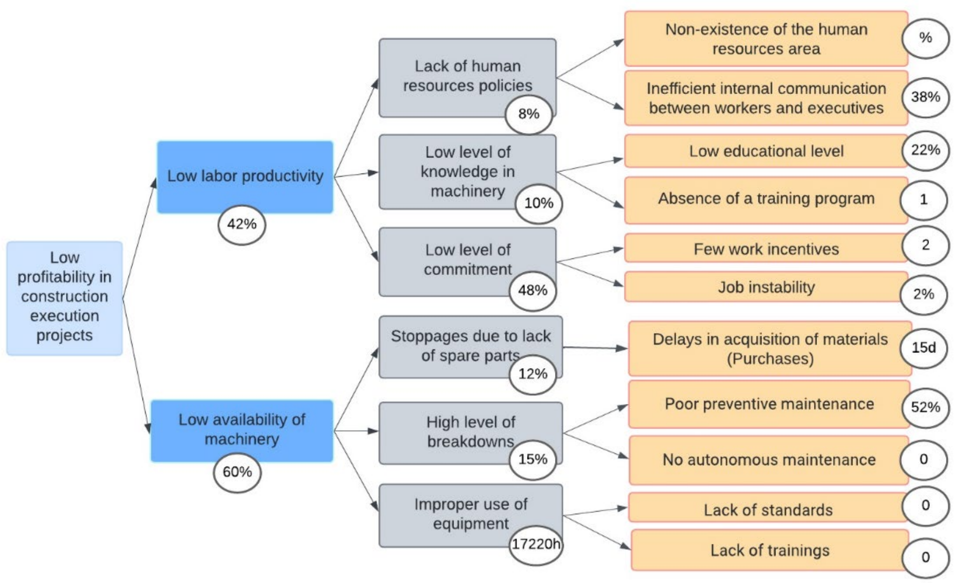


Figure 3. Problem tree diagram

The pilot implementation technique was developed over six months to validate the proposed model. The results of each implemented tool will be shown below.

4.2. Implementation of the JIT Tool

The Just-in-Time (JIT) tool addresses the problem of lack of spare parts due to delays in the procurement of materials, resulting in delays of up to 15 days and high spare parts costs. The implementation of JIT has demonstrated a significant reduction in the delivery time of materials needed for projects in the field.
Initially, a JIT team was formed, consisting of 2 employees from the operations area, followed by training with a subject matter expert.

Then, the materials required for each project were identified, including those of recurrent use, such as cement, coarse sand, crushed stone, and structural pipes. Reliable suppliers, such as Celima for cement, El Paisa for coarse sand and crushed stone, and Koplast for structural pipes, were selected to establish a weekly and monthly purchasing process to optimize delivery times according to each required order quantity.

Subsequently, a training program was implemented in the logistics area to inventory stored materials, thus facilitating the timely start of field activities and minimizing waiting times between material delivery and construction start. In the following months, the tool's progress will be periodically evaluated. The **Table 1** below illustrates the structure of the tool.

Table 1. Implementation of JIT Tool

Material	Supplier	Delivery Time	Ordering Frequency	Ordering Quantity	On-Site Projects
Cement	Celima	One day	Two times per week	20 bags	Fundo Pradera – Pachacamac
Coarse Sand	El Paisa	One day	Three times per week	10 m^3	Villa Alameda Lima Sur - Chilca
Crushed Stone	El Paisa	One day	Three times per week	$10m^3$	Villa Alameda Lima Sur - Chilca
Structural Pipes	Koplast	One day	One time per month	According to need	Sol de Ica XXVI – Ica

4.3. Implementation of the TPM Tool

Two main routes for implementing the Total Productive Maintenance (TPM) tool have been followed: autonomous and predictive maintenance. In the case of autonomous maintenance, a dedicated team was formed and received specialized training.

Subsequently, a document detailing the inspection, cleaning, and lubrication procedures required for the backhoe loader machine was prepared. In addition, a training campaign was carried out to train as many operators as possible in these tasks. A document compiling the five main autonomous maintenance procedures was created to facilitate their daily application and affixed as stickers on each machine. Finally, corrective actions were implemented to address any problems identified during the process. On the other hand, in the case of predictive maintenance, several key steps were followed. First, a dedicated predictive maintenance team was assembled and provided with training.

Figure 4 shows a photographic record of the condition of the machines before and after maintenance was taken using experts in the field. Two representative cases were selected to show the impact of autonomous maintenance: one related to a dirty air conditioner with 500 hours of use and another related to low pH refrigerant, changed every 12,000 hours. A comprehensive audit of the current maintenance process was conducted, and the new preventive maintenance process was implemented. Subsequently, a new audit was conducted to evaluate the effectiveness of the new approach. Finally, corrective actions were implemented to improve the process further.

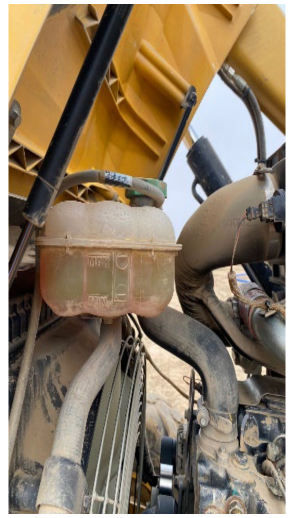
Before	After	Before	After
			

Figure 4. Implementation of the TPM Tool

Subsequent analysis revealed a significant improvement in equipment performance and a noticeable reduction in unplanned downtime. **Figure 5** shows the result of the maintenance audit, clearly shows the progress of the construction company's performance after the TPM tool.

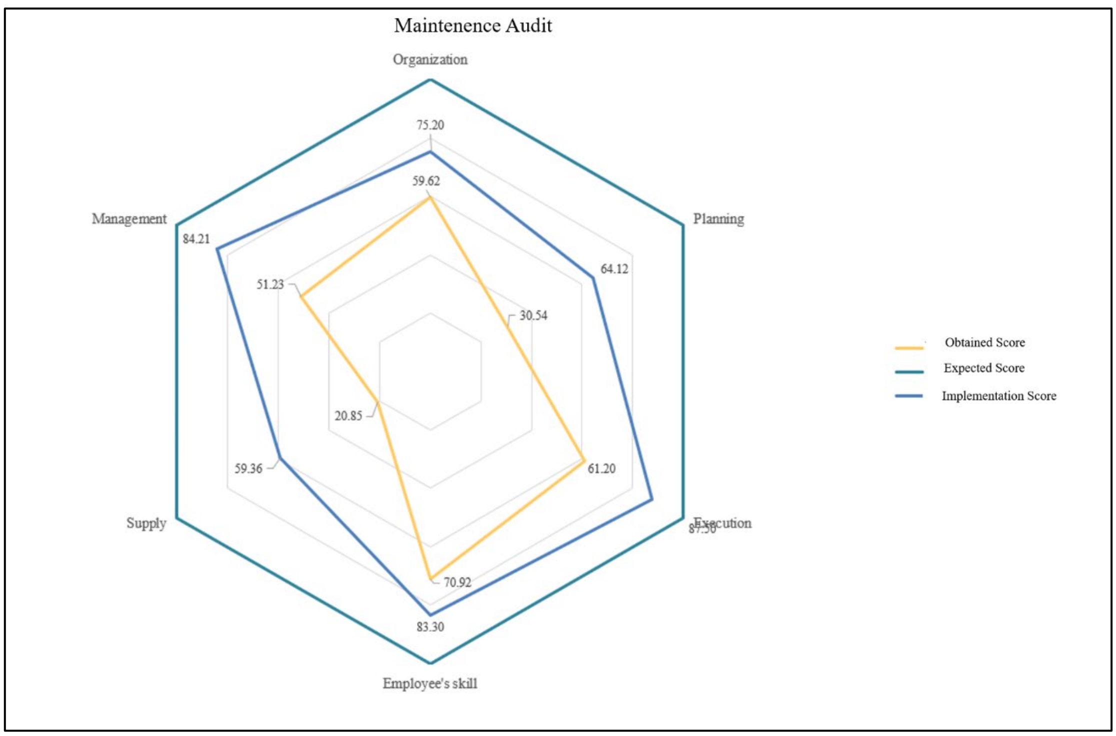


Figure 5. Before and after TPM implementation

4.3. Implementation of the SW Tool

A dedicated team was formed to implement the Standard Work tool, and its members received specific training. Next, each process, from start-up to shutdown of the backhoe, was photographed to document the steps required to operate the machinery correctly.

Next, the equipment needed to operate the backhoe was identified in detail. These photographs and specifications were compiled into a document serving as the operating standard. This document was used in three training sessions for the operators to familiarize them with the established procedures.

Finally, an audit was conducted to evaluate the effectiveness of the implementation, and all relevant observations were recorded for future improvements. **Figure 6** shows the processes and equipment required to operate the backhoe loader according to the established standard.

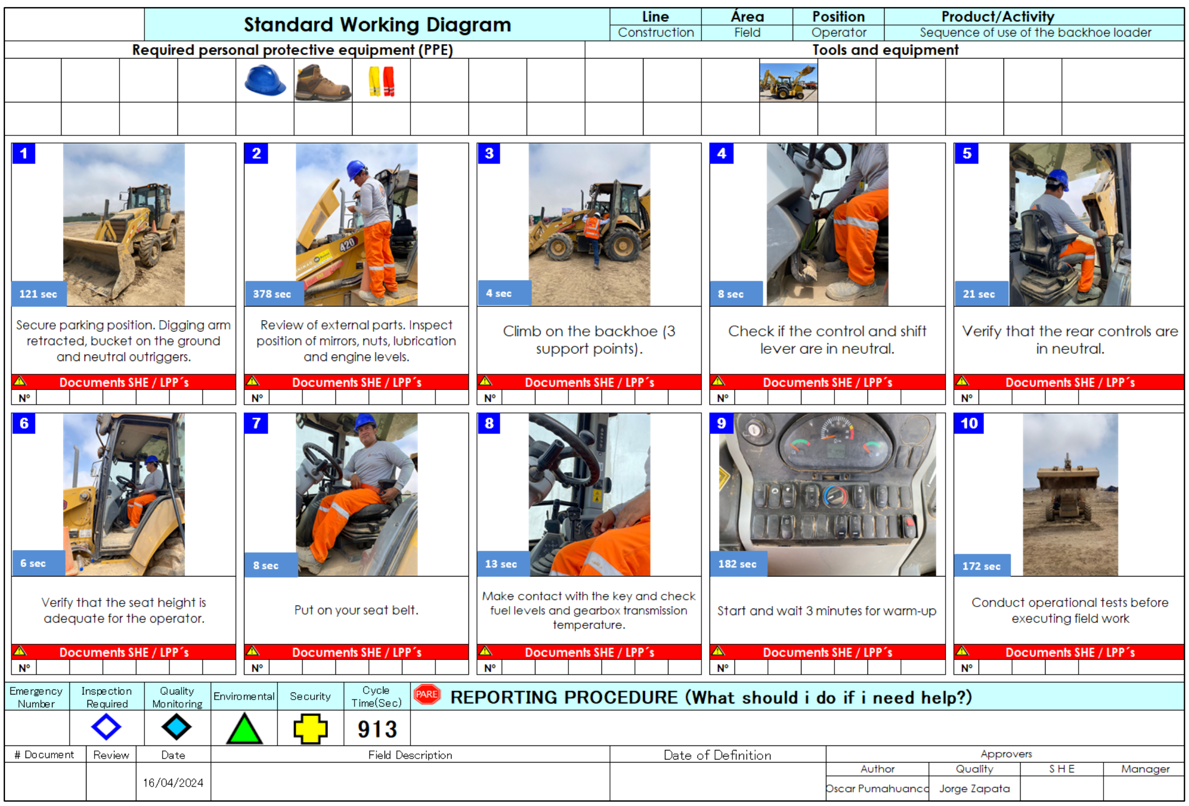


Figure 6. Standard work implementation

4.4. Implementation of the OPL Tool

A team consisting of a machinery expert and the safety manager was formed to implement the Lesson at a Point tool. This team received training on the tool to understand its practical application. A detailed document was then developed that identified and presented each part of the backhoe loader and the systems that must be verified before operating the machine. The expert validated each part and system to ensure accuracy and relevance.

Subsequently, a training session was designed and implemented for the operations area. It provided clear and practical instructions on properly using the backhoe, focusing on verifying critical systems prior to each operation. This training was conducted under the supervision of the expert team and tailored to the personnel's specific needs.

Once the training session was completed, an audit was conducted to evaluate its effectiveness, and areas for improvement were identified. Based on feedback received during the audit, adjustments and improvements were made to ensure the training was as effective as possible. **Figure 7** shows the Instructional Lesson Point of CAT Backhoe Loader inspection before use.

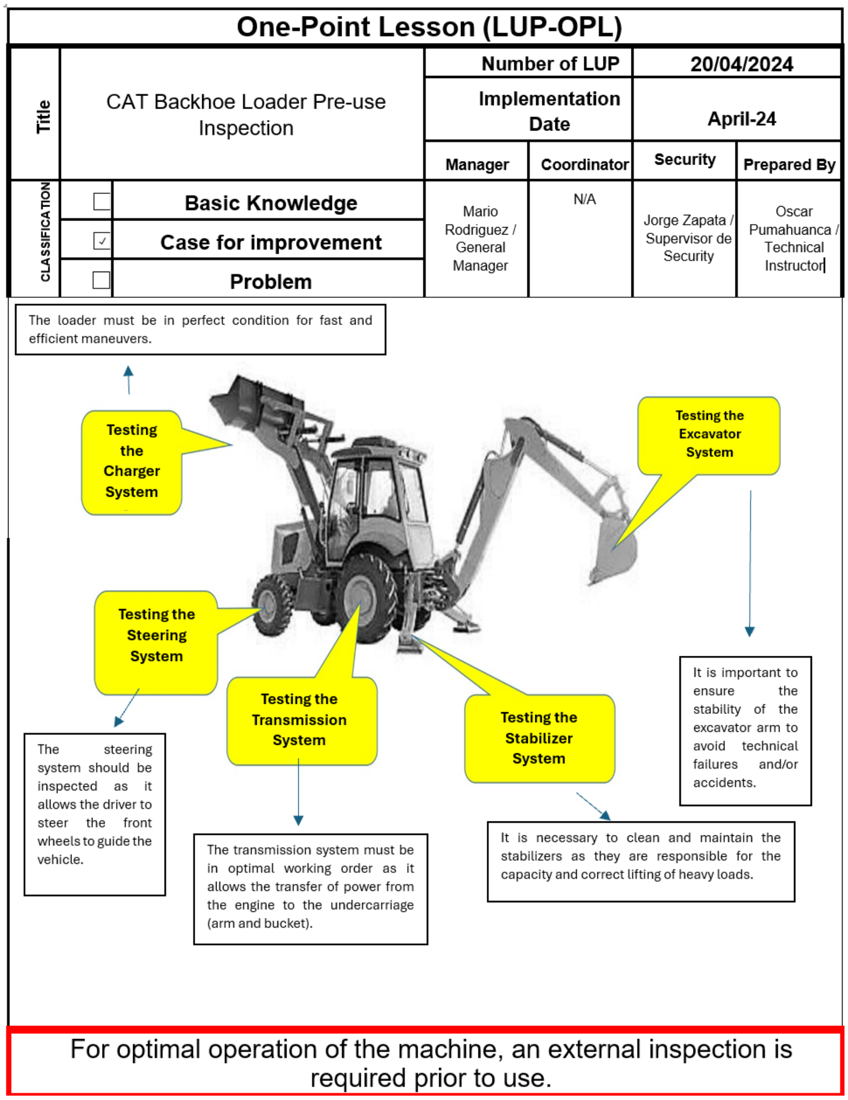


Figure 7. One-Point-Lesson implementation

4.4. Implementation of the HR Plan

The implementation of the human resources plan began with creating a detailed document establishing the basis for the formation of the human resources area in the company. This document included developing a clear and understandable organizational chart that defined the responsibilities and hierarchies within the department.
Subsequently, a human resources management plan was proposed and developed, outlining internal communication procedures and policies and practices related to human talent management in the organization. Particular emphasis was placed on transparency and fairness in the treatment of employees.

In addition, a comprehensive training program was designed for the management team and the operating personnel to provide them with the necessary skills and knowledge to perform their functions effectively and contribute to the company's success. These trainings were scheduled to take place over a year and address different aspects relevant to each level of the organization.

To motivate and recognize our employees' efforts, we created a rewards program to encourage outstanding performance and commitment to the company's values and objectives. This program included monetary incentives, public recognition, and other forms of recognition that would strengthen the sense of belonging and job satisfaction. Once the document with the human resources guidelines had been prepared, an informative session was held for all personnel, where the objectives and functions of the new department were explained. The active participation of the employees was encouraged, inviting them to express their doubts, suggestions, and comments to improve the implementation process.

Finally, comments were compiled, and the documents were validated with the approval of the CEO and company managers, ensuring their alignment with the organizational vision and strategy. This step guaranteed the endorsement and commitment of top management to the success and effectiveness of the company's human resources plan.

5. Results and Discussion

The results of the implementation showed significant improvements in the company's profitability. Engineering methodologies such as TPM tools and standardized work showed a lower consumption of resources and time. Profitability increased by 2.3%, reaching the company's expected target. In addition, the delay time for the arrival of spare parts to the project decreased by 20%, from 15 days to 7 days, through process optimizations in the procurement of materials. The implementation also showed decreased machine repairs since an audit of planned and autonomous maintenance was introduced for each machine, which was carried out on time.

Likewise, with the Standard Works methodology, it was possible to demonstrate that there is now a standardized process for using the machinery, thus reducing operator downtime. This went hand in hand with executing a human resources plan that focused on selecting trained operators, increasing labor efficiency by 79%. **Table 2** shows the results obtained from the indicators of the Proposed Model after the 6-month pilot.

Table 2. Results of the indicators of the Proposed Model

Indicator	Methodology/Tools	As Is	To Be	Results	Variation (%)
Project profitability (%)	**Modelo de operaciones**	3.80%	8.00%	6.10%	**61%**
Downtime rate due to lack of spare parts (%)	**Just Time**	22.50%	2.00%	8.12%	**-64%**
Spare parts acquisition time (days)	**Just Time**	15	7	8	**-47%**
Availability rate (%)	**TPM**	36.50%	5.00%	10.24%	**-72%**
Maintenance audit compliance rate (%)	**TPM**	49.00%	100.00%	76.00%	**55%**
Breakdown rate (%)	**OPL**	23.45%	6%	10.76%	**-54%**
Cycle time (min)	**Standard Work**	15	5	6.2	**-59%**
Labor Efficiency (%)	**Human Resources Plan**	45%	90%	80.40%	**79%**

6. Conclusions

It can be concluded that the model that integrates tools such as TPM, Lean Manufacturing, and the HR plan proves that through this case study, the business objectives were achieved, which has generated a contribution in the construction sector by being a replicable model in different processes.

One limitation of the case study was the tools' implementation time, which was only six months. To ensure the sustainability and effectiveness of what has been implemented for extended periods, this should be done through audits, training, and the standardized work described above. Another limitation is that it could only be developed in one company, so the results cannot be generalized.

Thanks to this implementation and the positive results that could be obtained in the operational part, a new line of research could be opened to complement the research in different areas, such as the administrative aspect and/or document control.

Finally, improving the construction processes in the field by reducing the delivery cycle time, implementing standard works, and creating a new area of human capital guaranteed the company's sustainability and profitability.

References

Ahmad R., Abdul I., Kamaruddin S. and Min C., Development of autonomous maintenance implementation framework for semiconductor industries. *International Journal of Industrial and Systems Engineering, 9, 2011*. DOI: 10.1504/IJISE.2011.043139

Al-Aomar, R., 'Analysis of Lean Construction Practices at Abu Dhabi Construction Industry'. *Lean Construction Journal*, pp. 105–121, 2012.

Annosi, M. C. & Brunetta, F., I am resolving the dilemma between team autonomy and control in a post-bureaucratic era: evidence from a telco multinational company. *Organizational Dynamics, 47*(4): 250-258, 2018. https://doi.org/10.1016/j.orgdyn.2018.03.002.

Asay, D. & Wisdom, L., *Kanban for the Shopfloor.* Productivity Press, 2002.

Aslam, M., Gao, Z., & Smith, G. (2020). Exploring Factors for Implementing Lean Construction for Rapid Initial Successes in Construction. *Journal of Cleaner Production,* 123295, 2020. DOI: 10.1016/j.jclepro.2020.123295

Babalola, H. & Aigbavboa, L., *Conceptual description of the critical attributes of human resource management practices in a developing economy.* In Human Factors, Business Management and Society. Proceedings of the AHFE International Conference, 56, 263-274. San Francisco, CA, USA, 2022.

Bamana, F., Lehoux, N. & Cloutier, C., Simulation of a Construction Project: Assessing Impact of Just-in-Time and Lean Principles. *Journal of Construction Engineering and Management, 145*(5), 2019. DOI: 10.1061/(ASCE)CO.1943-7862.0001654

Burawat, P., PRODUCTIVITY IMPROVEMENT OF HIGHWAY ENGINEERING, 2019.

Cabrera, O., Tejeda, J., Llontop, J., Mendoza, P., Alvarez, J., Sevillay, D., A validation model to reduce non-contributory time based on Lean tools: Case of a construction company in Perú. *Cogent Engineering, p. 10,* 2236838, 2023. https://doi.org/10.1080/23311916.2023.

Cesário, F. & Magalhães, S., Human resources management, citizenship behavior, and turnover intention in the Portugues public administration. *International Journal of Public Administration, 40,* 979–988, 2016.

Enshassi, A., Saleh, N., & Mohamed, S., Application level of lean construction techniques in reducing accidents in construction projects. *Journal of Financial Management of Property and Construction, 24*(3), 274–293, 2019. https://doi.org/10.1108/JFMPC-08- 2018-0047

Fazinga, Q., Saffaro, F., Isatto, E. & Lantelme, E., Implementation of standard work in the construction industry. *Revista Ingeniería de Construcción, 34*(3), 2019. https://www.scielo.cl/pdf/ric/v34n3/en_0718-5073-ric-34-03-288.pdf

Fazinga, W. R.; Saffaro, F. A.; Isatto, E. L.; Kremer, A., *Difficulties in Work Design in the Construction Sector.* In Proceedings of the 24th Annual Conference of the International Group for Lean Construction, 13-22. Boston: International Group for Lean Construction, 2016.

Hei, S., Zhang, H., Luo, S., Zhang, R., Zhou, C., Cong, M., Ye, H., Implementing BIM and Lean Construction Methods for the Improved Performance of a Construction Project at the Disassembly and Reuse Stage: A Case Study in Dezhou, China. *Sustainability, pp. 16,* 1–25, 2024. https://doi.org/ 10.3390/su16020656

Heravi, G. & Firoozi, M., "Production process improvement of buildings' prefabricated steel frames using value stream mapping". *The International Journal of Advanced Manufacturing Technology, 89,* (9–12), 3307–3321, 2017. DOI: 10.1007/s00170-016-9306-9

Heravi, G., Kebria, M. F., & Rostami, M., Integrating the production and the erection processes of prefabricated steel frames in building projects using phased lean management. *Engineering, Construction & Architectural Management, 28*(1), 174–195, 2019. https:// doi.org/10.1108/ECAM-03-2019-0133

Jamil, A. & Fathi, M., The Integration of Lean Construction and Sustainable Construction: A Stakeholder Perspective in Analyzing Sustainable Lean Construction Strategies in Malaysia. *Procedia Computer Science, 100,* 634–643, 2016. https://doi.org/10.1016/j.procs.2016.09.205

Jurík, L., Horňáková, N. & Domčeková, V., The application of smed method in the industrial enterprise". *Acta Logistica, 7*(4), 269– 281, 2020. DOI: 10.22306/al.v7i4.189

Kong, L., Li, H., Luo, H., Ding, L. & Zhang, X., Sustainable performance of just-in-time (JIT) management in time-dependent batch delivery scheduling of precast construction. *Journal of Cleaner Production, pp. 193,* 684–701.

Koskela, L., *Application of the New Production Philosophy to Construction, 72.* Stanford University, Stanford, CA, 1992. http://www.leanconstruction.org.uk/ media/docs/Koskela-TR72.pdf.

Lopez-Uchuya, K., Zamudio-Guido. & V., Altamirano-Flores, E., Lean Manufacturing and MRP will speed up the manufacturing of steel structures in the construction industry. 20th LACCEI International Multi-Conference for Engineering, Education, and Technology: "Education, Research, and Leadership in Post-pandemic Engineering: Resilient, Inclusive and Sustainable Actions", Boca Raton, Florida- USA, 2022. DOI: http://dx.doi.org/10.18687/LACCEI2022.1.1.749

Margherita, E.G. & Bua, I., The role of human resource practices in developing operator 4.0 in industry 4.0 organizations: A literature review and a research agenda. *Businesses, 1,* 18–33, 2021.

Marhani, M., Jaapar, J., Bari, N., & M. Zawawi., Sustainability Through Lean Construction Approach: A Literature Review. *Procedia - Social and Behavioral Sciences, 101*, 90– 99, 2021. DOI: 10.1016/j.sbspro.2013.07.182

Miqueo, A., Torralba, M., Ygue-Fabra, J. Lean Manual Assembly 4.0: A Systematic Review. *Applied Sciences, 10(*23), 2020 . https://doi.org/10.3390/app10238555

Monden, Y., *Toyota Production System: an integrated approach to just-in-time.* 3rd edition, Norcross, Georgia/USA: Engineering & Management Press, 2015.

Ogunbiyi, O.E., *Implementation of the Lean Approach in Sustainable Construction: A Conceptual Framework*. University of Central Lancashire, 2014.

Palomino-Valles, A., Tokumori-Wong, M., Castro-Rangel, P., Raymundo-Ibañez, C., & Dominguez, F., The TPM maintenance management model focuses on reliability and increasing the availability of heavy equipment in the construction sector. *IOP Conference Series: Materials Science & Engineering, 796*(1), 2020. DOI 10.1088/1757-899X/796/1/012008

Phana, T. & Athigakunagorna, N., Discrete-event simulation-based decision-making of Just-In-Time strategies for precast concrete supply chain using batch delivery and offsite inventory level. *Uncertain Supply Chain Management, 10*(3), 679-692, 2022. DOI: 10.5267/j.uscm.2022.5.007

Puvanasvaran, A.P., Ab. Hamid, M. N. H. & Yoong, S. S., Cycle time reduction for coil setup process through standard work: a case study in the ceramic industry. *ARPN Journal of Engineering and Applied Sciences, 13*(1), 2018.

Rekha, R., Periyasamy, P. & Nallusamy, S. (2016). "An optimized model for reduction of cycle time using value stream mapping in a small scale industry". *International Journal of Engineering Research in Africa, 27*, 179–189, 2016. DOI: 10.4028/www.scientific.net/JERA.27.179.

Sacks, R., Eastman, C., Lee, G. & Teicholz, P., BIM Handbook: A Guide to Building Information Modeling for owners, designers, engineers, contractors, and facility managers. *Wiley, 2018.* https://doi.org/10.1002/9781119287568.

Semrau, J., & Horzela, A., Using tools to improve logistics and production processes in a selected construction company: development strategy as an innovative tool for managing an organization. View project research on corporate social responsibility (CSR) in the context of cluster activities. View project using tools to improve logistics and production processes in a selected construction company. *European Research Studies Journal, 24*(1), 1211–1232, 2021.

Shin, C., Ahmad R., Kamaruddin S. & Abdul I., Development of autonomous maintenance implementation framework for semiconductor industries. *International Journal of Industrial and Systems Engineering, 9*(3), 268-297, 2011.

Szwedzka, K.; Kaczmarek, J., *One point lesson as a tool for work standardization and optimization—Case study*. Advances in Intelligent Systems and Computing, International Conference on Applied Human Factors and Ergonomics, 2018. DOI: 10.1007/978-3-319-60828-0_3

Toussaint, J. & Berry, L., 'The Promise of Lean in Health Care'. *Mayo Clinic Proceedings, 88*(1), 74-82, 2013. https://doi.org/10.1016/j.mayocp.2012.07.025

Tsuchiya, S., Quality maintenance: Zero defects through equipment management. Cambridge, MA: Productivity Press, 1992.

Biographies

Claudia Rodríguez-Noe Graduated from the University of Lima. Faculty of Engineering. With specialization in Project Management and Management Skills at the Pacifico University. And extensive experience in the Massive Consume and Construction sector.

Nicolle Rodriguez-Risco graduated from the Universidad de Lima, Faculty of Engineering.

Juan Carlos Quiroz-Flores holds an MBA from Universidad ESAN. Industrial Engineer from Universidad de Lima. Ph.D. in Industrial Engineering from Universidad Nacional Mayor de San Marcos, Black Belt in Lean Six Sigma. He is currently an undergraduate professor and researcher at the University of Lima. Expert in Lean Supply Chain and Operations with more than 20 years of professional experience in the direction and management of operations, process improvement, and productivity; specialist in implementing Continuous Improvement Projects, PDCA, TOC, and Lean Six Sigma. Leader of the transformation, productivity, and change generation projects. Able to form high-performance teams aligned with the company's "Continuous Improvement" strategies and programs. He has published journal articles and conferences indexed in Scopus and Web of Science. His research interests include supply chain and logistics management, lean manufacturing, Lean Six Sigma, business process management, agribusiness, design work, facility layout design, systematic distribution planning, quality management, Industry 4.0, Digital Transformation, and Lean Manufacturing. He is a classified researcher by the National Council of Science, Technology, and Technological Innovation of Peru (CONCYTEC) and a member of IEOM, IISE, ASQ, IEEE, and CIP (College of Engineers of Peru).