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Construction Model Based on Lean construction, MRP and SPL to Increase Compliance in a Construction Company.

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Abstract

The construction sector is a key economic driver in Latin America, but it faces serious problems such as cost overruns, delays and project stoppages. In Peru, for example, 2,298 public works projects were on hold at the end of 2023, representing a committed investment of over S/26 billion. The main causes of these issues are poor planning, contractor non-compliance, low productivity and delays in the supply of materials. To address these issues, this research proposes a model that integrates Lean Construction, Material Requirements Planning (MRP) and Systematic Layout Planning (SLP). The aim is to improve schedule compliance and optimise resource management. In a pilot test, the model reduced downtime, improved material planning and optimised workflow. Consequently, schedule compliance increased by over 15%, productivity by 12%, and penalty costs were reduced by 10%.

Keywords
Construction, lean construction, MRP, SLP and project compliance.

1. Introduction
The construction sector in Latin America is crucial for economic growth and job creation. Peru ranks seventh in the region for exports of construction supplies, achieving an average growth rate of 10.5% over the past five years despite occasional setbacks, such as in 2013–14. Bolivia is the main destination for Peruvian exports (22%), while Brazil and Colombia have both significantly increased their purchases. In contrast, Chile reduced its imports, while Panama increased them.

At a regional level, the construction sector faces delays and cost overruns due to various factors, including corruption (78%), exchange rate volatility (58%), subcontractor issues (28%), design changes (22%), low productivity (18%), poor planning (8%), climate (44%), and material shortages (7%).

The situation in Peru is more critical, with more than 2,200 public works projects at a standstill and a committed investment of over S/26.992 billion. The main causes are contractual breaches and financial constraints. Although the 'Works for Taxes' programme has proven to be more efficient, most traditional projects are seriously behind schedule.

1.1 Objectives
This research aims to implement an improvement model based on Lean Construction, MRP and SLP to enhance project compliance within a Peruvian construction company. The specific objectives are to: diagnose the main causes of non-compliance with execution schedules; implement Lean Construction tools to reduce waste, optimise processes and improve productivity; apply the MRP system to ensure a timely and efficient supply; design a layout using SLP to optimise material flow and reduce transfer times; and evaluate the model's impact on meeting deadlines, reducing costs and improving operational efficiency.

2. Literature Review
2.1 Compliance Index and the Construction Sector
In the construction industry, compliance with schedules is crucial for efficient project management. Delays and cost overruns can impact the sustainability of projects and the profitability of companies. Several recent studies have addressed this issue from different perspectives. Castaneda et al. (2025), for example, identified the underestimation of labour performance and inadequate labour planning in Colombian road projects as structural causes of non-compliance. Conversely, Aslan and Türkakın (2022) highlight the impact of the circumstantial factor of the disruption to the organisation of work in the sector caused by the pandemic.

Sheikhkhoshkar et al. (2024) propose an integrated planning and control framework which achieved significant improvements in productivity (15%) and waste reduction (20%). In Nepal, Erm, Koirala, and Shahi (2024) demonstrate that extreme weather conditions and poor site management cause over 50% of rural projects to be delayed. In the case of Peru, Romero and Esenarro (2024) used the Relative Importance Index (RII) to demonstrate that the main causes of non-compliance in public works are political factors, a lack of supervision, and poor monitoring, which generate high costs and place a burden on the national budget. Overall, these studies emphasise the importance of adequate planning and risk mitigation strategies. Despite their diverse approaches — structural, circumstantial or territorial — they all conclude that adopting collaborative, integrated and flexible frameworks is key to addressing the sector's challenges.

2.2 Compliance Index and SLP
Systematic Site Programming (SLP) has become a vital tool for enhancing operational efficiency and ensuring compliance with deadlines in complex projects. When implemented correctly, it optimises workflow, reduces travel times, improves safety and increases productivity. Several recent studies have explored innovative approaches to spatial planning. For example, Hammad et al. (2021) propose a model that integrates UAVs and BIM to automate real-time data collection, and RazaviAlavi and AbouRizk (2021) have developed a simulation tool that supports decision-making in situations of uncertainty. Kim et al. (2021) present a typological model for classifying constraints in temporary facilities. Meanwhile, Yang et al. (2021) use BIM alongside optimisation algorithms for prefabricated projects, achieving significant savings.

Other studies emphasise the importance of technological integration. For example, AlSaggaf and Jrade (2021) combined BIM and GIS to improve visualisation and conflict detection, and Tao et al. (2022) incorporated environmental aspects into site design to reduce pollution. Fathy et al. (2022), meanwhile, explore the use of visual programming and generative design, demonstrating greater efficiency than traditional methods. Taken together, these studies conclude that well-structured site planning, supported by emerging technologies, is crucial for improving project performance. The differences lie in their respective approaches to automation, uncertainty management, physical constraints, environmental sustainability and optimisation algorithms. Nevertheless, they all emphasise the importance of innovation in SLP for achieving more efficient and timely projects.

2.3 Compliance Index and Material Requirements Planning (MRP)
Material Requirements Planning (MRP) is essential for improving the performance of construction projects by optimising economic aspects and ensuring schedule compliance. When technological tools and automated approaches are used, its application allows for more efficient resource management. Recent studies, such as those by Awati and Putra (2024), emphasise the importance of balancing materials using systems like LFL (Lot-for-Lot) and POQ (Periodic Order Quantity). Meanwhile, Yıldız, Güne, and Kıvrak (2024) suggest a comprehensive approach to MRP that incorporates performance metrics and automation to enhance control in infrastructure projects.

Conversely, Reis (2023) demonstrates how tools such as Python can support MRP by integrating data and enhancing material forecasting. However, he also acknowledges the current low level of digitisation in this area. In contrast, Robles, Rangel and Sánchez (2022) take a systemic approach to supply management, focusing on collaborative logistics and strategic supplier management, achieving positive results in social housing projects.
Studies such as those by Cahyani and Putra (2024) and Xie, Chen and Chang (2021) incorporate optimisation techniques such as EPP (Economic Part-Period) and genetic algorithms. These studies demonstrate that, compared to traditional approaches, these methods can reduce costs and increase efficiency, particularly in modular construction and hospitals. Overall, the evidence suggests that, despite differences in mathematical models, logistics strategies and digital technologies, there is a consensus that effective materials management through MRP is crucial for meeting deadlines and reducing costs in construction projects.

3. Methods

This research project uses a case study of a construction company to evaluate the effect of an integrated management model on the compliance rate of the project portfolio. The model takes into account the official project schedule, material and input prices, labour productivity, equipment and tools, time lost due to unnecessary travel and inventory levels, as well as purchase orders.

The process combines three complementary approaches: Lean Construction, which standardises processes and minimises waste; Material Requirements Planning (MRP), which optimises inventory and production times; and Systematic Layout Planning (SLP), which improves construction site layout to reduce travel and facilitate workflow. Expected results include increased schedule compliance, reduced material and time wastage, increased equipment and labour productivity, and optimised supplier selection based on cost and delivery time criteria.

The rationale behind this method is that integrating Lean, MRP and SLP enables the simultaneous analysis of efficiency in planning, materials management and on-site distribution. This provides a systemic view that improves project control and ensures deliveries are made on time (Figure 1).

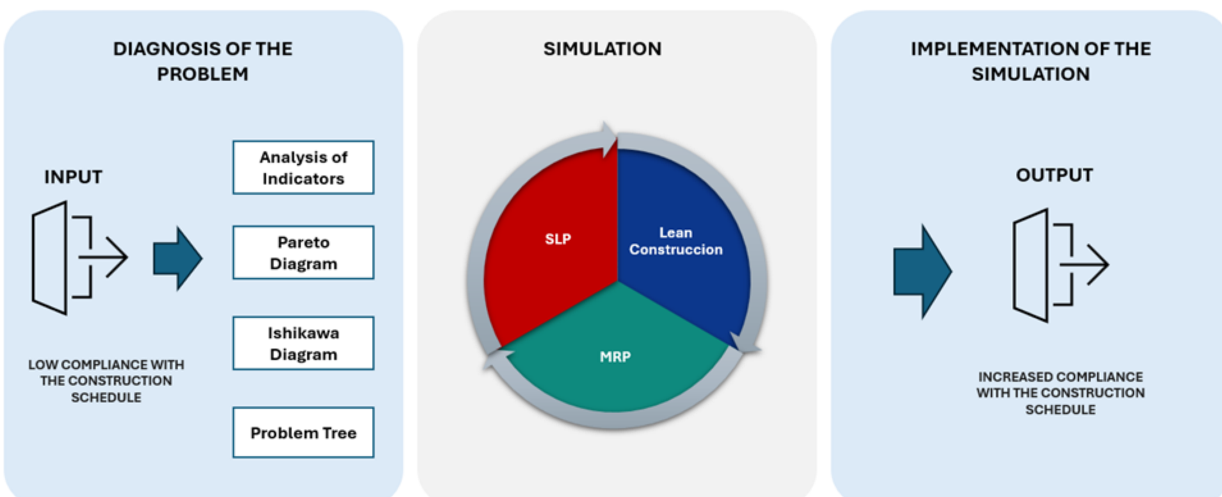

Figure 1. Proposed model

4. Data Collection

This research project uses a case study of a construction company to evaluate the effect of an integrated management model on the compliance rate of the project portfolio. The model takes into account the official project schedule, material and input prices, labour productivity, equipment and tools, time lost due to unnecessary travel and inventory levels, as well as purchase orders.

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To address these issues, a model divided into three components was implemented: the application of Lean Construction to standardise processes, reduce downtime and improve coordination between teams; the use of Material Requirements Planning (MRP) to calculate and control the materials required, size batches and avoid shortages or excess inventory; and the implementation of Systematic Layout Planning (SLP) to redesign the layout of the construction site, prioritising critical areas and optimising the layout of supplies and equipment. The time analysis revealed bottlenecks in activities related to coordination and temporary infrastructure, negatively impacting overall scheduling.

Concrete was identified as the most in-demand and critical material, so an MRP map was developed to plan for the requirements of cement, sand, gravel and water over an eight-week period. This included strategies to maintain adequate stock levels and avoid interruptions. Based on the material flow matrix and the coding of relationships between areas, the redesign of the layout placed the central area as a strategic node concentrating almost half of the total flow and located other key areas to minimise movement and facilitate operational coordination.

In addition, a Total Productive Maintenance (TPM)-based Operational Reliability Programme was proposed to address frequent electrical and mechanical failures causing prolonged downtime. The programme included awareness workshops for senior management and training for operators and technicians. Specific objectives included reducing unplanned downtime by 40% and increasing overall equipment effectiveness (OEE) to 85%. Daily checklists, operating standards and a prioritisation matrix were implemented to identify and address the most critical pieces of equipment, with specific actions assigned to each one.

Finally, the model integrated MRP and SLP tools to optimise the management of spare parts and maintenance logistics. Strategic locations for the warehouse were proposed to reduce travel times for technical staff. The programme's success will be monitored using key performance indicators such as MTBF, MTTR and checklist compliance to ensure continuous improvement in operational and production management (Figure 2).

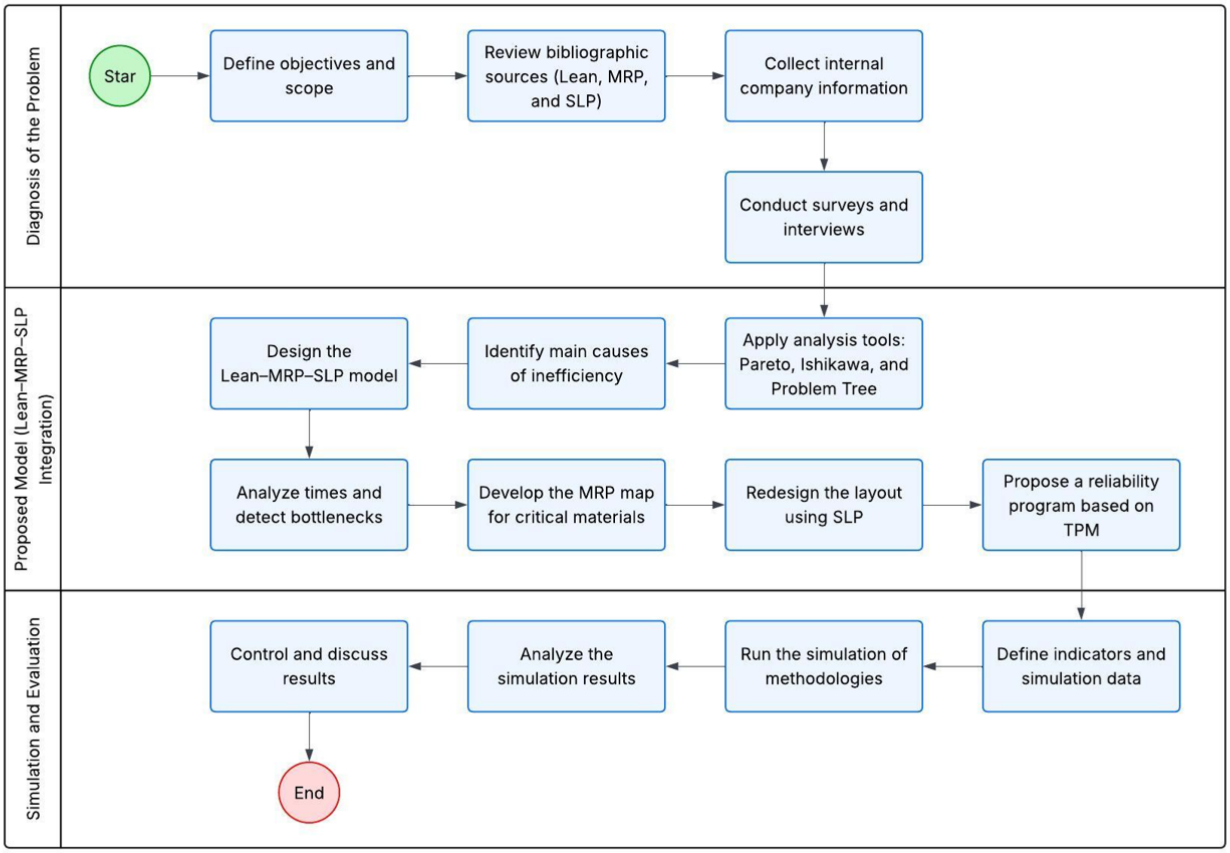

Figure 2. Diagram to achieve results

5. Results and Discussion

The proposed improvements were implemented through a three-week pilot test, during which the guidelines and strategies defined in the design stage of the model were fully applied. Key performance indicators (KPIs) were monitored throughout this period to evaluate the effectiveness of the implemented interventions.

The actions focused on optimising planning processes, inter-area coordination, and critical equipment maintenance. Similarly, operational continuity was guaranteed through the integration of Lean Construction, MRP (Material Requirements Planning) and SPL (System Productive Layout) methodologies, which aim to reduce waste and improve material flow and efficiency in resource management.

Analysis of the obtained data identified the 'Establishment of Temporary Infrastructure' activity as a critical factor in the project's overall efficiency. Prior to improvements being implemented, the average duration of this activity was four months, with variations between three and five months. After applying the MRP and SPL methodologies, execution times were reduced by an average of 75%, with an approximate duration of one month achieved in the pilot projects.

This demonstrates that collaborative planning and optimisation of material flow directly impact construction time. The implemented improvements included:
- Reorganisation of the site layout to minimise unnecessary movements;
- Joint coordination between the purchasing and construction departments.
- Use of prioritisation algorithms to identify critical material flows.

Implementing Total Productive Maintenance (TPM) on heavy-duty equipment, such as grinders, rotary hammers and pressure washers, also had a positive effect on operational availability and maintenance efficiency. The following notable results were achieved:

- 40% reduction in unplanned downtime
-OEE (Overall Equipment Effectiveness) increased to 85% through the implementation of daily checklists and autonomous maintenance.
-Spare parts planning and workshop reorganisation were improved, reducing internal travel by 30%.

These results demonstrate the significant contribution of integrating management and maintenance tools to strengthening operational reliability.

The proposed model was validated during a three-week pilot test in which Lean Construction, MRP and SPL methodologies were applied jointly. A comparison of the performance indicators before and after the intervention showed sustained improvement in all areas.

The following values were recorded for the main performance indicators:

MTBF (mean time between failures): greater than 200 hours.

MTTR (mean time to repair): reduction from eight hours to four hours.

Compliance with the daily checklist was greater than 95% (Figure 3- Figure 4).

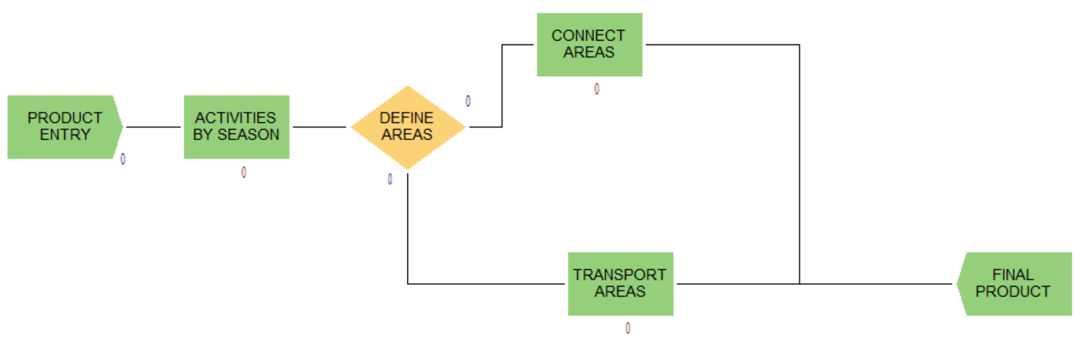

Figure 3. Simulation Model: Systematic Layout Planning

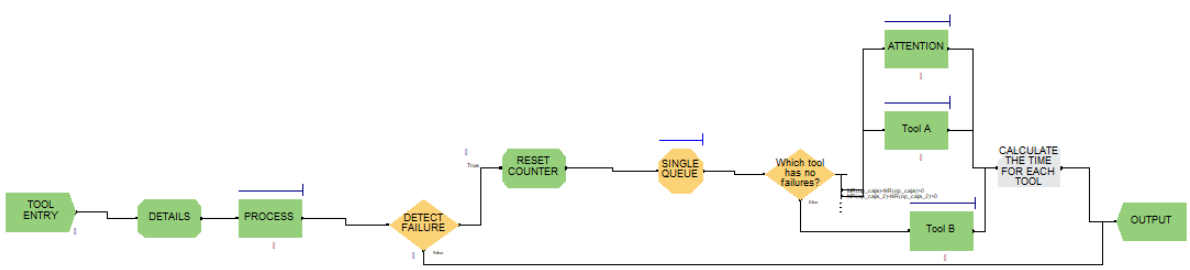

Figure 4. Simulation Model TPM

6. Conclusion

Integrating Lean Construction, MRP and SPL proved highly effective in optimising the performance of construction projects by improving planning, coordination and resource efficiency. Lean Construction reduced waste by 20% through process standardisation and the elimination of downtime. Meanwhile, MRP improved material management, cutting delays due to shortages by 35% using methods such as the Economic Order Quantity (EOQ) approach. Meanwhile, SPL increased logistical efficiency by 30% through the strategic relocation of warehouses and workshops. During the critical phase of establishing temporary infrastructure, project duration decreased from four months to one, thanks to the prioritisation of critical flows, improved interdepartmental coordination, and reduced planning times.

Furthermore, the implementation of Total Productive Maintenance (TPM) increased equipment productivity, reducing unplanned downtime by 40%, improving Overall Equipment Effectiveness (OEE) from 49% to 68%, and doubling Mean Time Between Failures (MTBF) from 120 to 210 hours while halving Mean Time To Repair (MTTR).

Overall, this integrated model sets a new standard for sustainable construction management in Latin America by effectively reducing work stoppages, preventing cost overruns, and enhancing productivity through strategic process integration and continuous improvement.

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