

Improving Service Level through the Application of ABC-Slotting and SLP Methodologies to Enhance Service Level in a Construction Industry SME

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Abstract

This article addresses the need to optimize the timely delivery of materials from the warehouse of a company in the construction sector. Currently, warehouse management causes delays in the delivery of resources, reaching 49.6%, which means that approximately half of the resources arrive later than planned. This problem directly affects the service level (SL) provided by the internal warehouse to the construction area, reducing it to 47.77%. These delays result in penalties, representing an economic loss of 25.77% of income due to noncompliance with construction progress caused by the lack of timely material delivery. The problem lies in the search times for orders, which reflect inefficient operations caused by the lack of material organization. Therefore, to improve service, a proposal was developed based on the rapid identification of key zones and materials, using ABC, SLP, and barcode-assisted picking tools. As a result, the service level increased to 88.04%, and search times were reduced from 54.52 minutes to 19 minutes.

Keywords

Warehouse and ABC distribution, organization or management and disorder, SLP, disorganized warehouses.

1. Introduction

The construction sector in Peru has shown a fluctuating trend in recent years, reflecting both the challenges imposed by the health crisis and signs of recovery and growth. After a modest growth of 1.51% in 2019, the sector suffered a significant contraction of 23% in 2020 due to the impacts of the pandemic. However, in 2021, a strong rebound was observed, with an increase of 35%, demonstrating the sector's resilience (Gamboa, 2023). Despite facing ongoing challenges, in April 2022, a growth of 4.9% was recorded (ComexPerú, 2022). On the other hand, in August 2023, the Ministry of Economy and Finance updated the Multiannual Macroeconomic Framework, projecting a contraction of 3.4% in the sector (CAPECO, 2023). In a challenging market, construction companies must adapt by seeking efficiency and cost reduction in resource management. The adoption of technology and improved storage practices is essential for their profitability and sustainability. According to the literature on different types of warehouses, especially hardware-related warehouses, which are essential for construction, problems have been identified regarding poor organization of materials, leading to low productivity and prolonged search times. On the other hand, several

articles emphasize that the service level according to OTIF should be at least 90%. This standard serves as a critical framework for evaluating and improving warehouse management practices (Granillo et al., 2020; Quiroz-Flores et al., 2022). Warehouse logistics management, which is crucial in construction, requires advanced technologies and comprehensive logistics services to optimize the supply chain and add value to the services offered (Calzado-Girón, 2020). To mitigate the problems identified in warehouse management, the development of specific engineering tools is proposed. The ABC Slotting methodology, which focuses on classifying materials according to turnover or demand, is the main proposed tool. In addition, Systematic Layout Planning (SLP) is implemented to optimize distribution and reduce travel times within the warehouse. Another strategy is the use of barcode-assisted picking, which speeds up material identification. Finally, classification by family or discipline is proposed, complementing the stratification of materials and facilitating their efficient handling. Together, these measures aim to significantly improve search times and overall efficiency in warehouse management.

1.1 Objectives

The research seeks to implement a continuous improvement model in the warehouse area with the purpose of streamlining the search and identification processes of materials, reducing delivery times or lead time, and improving operational efficiency. First, the slotting methodology with ABC classification will be used to reorganize materials according to their level of rotation, demand, and operational importance, allowing faster access to the most frequently used items. Secondly, a picking methodology supported by barcode identification and scanning will be implemented to improve material traceability, reduce search errors, and speed up the identification process. Thirdly, a material route planning strategy based on family distribution and Systematic Layout Planning (SLP) will be applied to optimize the movement of workers within the warehouse and reduce unnecessary travel times. Finally, a simulation model will be developed to evaluate the implementation of slotting and family-based distribution in material storage, measuring its impact on operational efficiency, lead time reduction, and warehouse productivity.

2. Literature Review

The authors point out that the warehouse area is one of the relevant components in the supply chain involved in the logistics network, since it acts as a regulating element in the flow of resources. Its purpose is to ensure the smooth delivery of materials required on site for the development of buildings and construction projects. On the other hand, they mention that one of the main problems in companies with warehouses is the failure to meet delivery times and deadlines, mainly due to prolonged material search times (Paucar-Apaza & Cartagena-Melo, 2023).

2.1 Warehouse Layout Using SLP

Studies demonstrate the use of structural design in warehouse spaces with the aim of accelerating transfer processes and movement routes, while avoiding unnecessary effort. Likewise, the authors mention that the SLP methodology allows for an efficient and effective distribution of warehouse space, facilitating the movement of materials and access to spare parts (Leon et al., 2022). In a study conducted in a Colombian company from the leather goods sector, the authors point out that an optimal layout not only allows activities to be carried out in the shortest possible time but also enables them to be performed safely. This methodology helps solve layout distribution problems by optimizing internal flows, improving monitoring, and minimizing delays in operations (Álvarez-Arias et al., 2022).

Other authors indicate that, in the warehouse of a company from the industrial fish sector, the application of SLP led to a warehouse redesign. The study showed improvements in transportation times, which increased management efficiency and reduced the costs generated within the warehouse. Likewise, the application of this methodology also showed an increase in storage capacity (De La Cruz-Bonifacio, 2020). This example illustrates how the implementation of advanced management techniques such as SLP can have a significant positive impact on different industrial sectors. The successful application of this methodology in the fishing sector suggests similar potential for its implementation in other industrial contexts

2.2 ABC inventory classification in warehouses

The studies analyzed consistently highlight the importance of adopting a strategic warehouse layout and effective picking methodologies in warehouse management, aligning with recognized best practices. ABC inventory classification emerges as an essential strategic tool for segmenting inventory items according to their importance. Implementing this analysis also facilitates stricter inventory management, as emphasized in the study conducted in the food sector. By strategically placing “A” products in easily accessible areas and assigning “C” products to less prioritized zones, space utilization is optimized and operational costs are reduced. This methodology not only

improves the overall efficiency of the warehouse but also adapts inventory management to the changing needs of the business (Granillo Macías et al., 2020).

Studies in the hardware sector indicate that the use of ABC classification helps locate products more quickly, achieving an 85% reduction in search times in one company. Likewise, it also contributed to an increase in product turnover. On the other hand, better organization within the warehouse was also observed, enabling more efficient operations and reducing picking time by up to 55% (De La Cruz-Bonifacio, 2020; Quiroz-Flores et al., 2022)

This study focused on determining the impact of implementing the ABC system in a dairy products company. As part of a broader set of tools designed to improve operational efficiency, ABC was selected after a thorough analysis of realistic constraints, being identified as one of the most effective solutions. The impact of this specific tool was evaluated through specific indicators, comparing simulated values with pre-established engineering standards. The implementation of ABC showed a significant improvement in inventory organization and contributed to an overall savings of 79.15% compared to previous losses (Añorga González et al., 2021).

2.3 picking methodology supported by barcode labeling

The article examines the interaction between identification systems, such as barcodes and radio frequency technologies, and their impact on supply chain management, with a focus on global applications and the Colombian context. Based on a review of books, scientific articles, and existing studies, key concepts related to these systems are explored, including their definitions, hardware and software components, and practical applications. The article highlights how companies of different sizes implement these technologies to improve operational efficiency. The study emphasizes the relevance of these technological tools in optimizing performance and traceability, simplifying operations, reducing costs, and accelerating the flow of information throughout the supply chain (Correa Espinal et al., 2010).

Several articles successfully addressed the need to minimize errors in material identification through the use of barcodes, with the aim of improving patient safety and optimizing logistics processes. This approach resulted in a significant reduction in both time and errors during material identification, improving operational efficiency and reliability within the supply chain. The implementation focused on inbound and outbound logistics areas, establishing a foundation for future improvements in production logistics (Medrano, 2014). In addition, the use of technology in picking processes was explored across different industries, concluding that it enables greater logistics efficiency (Grillo & Sembaj, 2017)

3. Methods

This article presents a case study based on a company from the construction sector. The research focuses on the materials management process within the warehouse area, where engineering tools are integrated to improve the organization, identification, distribution, and retrieval of materials. The proposed model considers poor materials management as the main input, reflected in inefficient use of storage space, delays in material identification, lack of prioritization according to demand, and difficulties in locating products. As an output, the model aims to achieve better material distribution, reduce penalties due to non-compliance, and improve material identification, contributing to shorter operating times. The improvement model is based on three tools: Systematic Layout Planning, Slotting with ABC classification, and the Picking methodology supported by barcode labeling. SLP is applied to optimize the warehouse layout and improve internal flow. Slotting with ABC classification prioritizes materials according to their demand, placing the most frequently requested items in more accessible areas. Finally, the Picking methodology with barcode labeling improves product identification, reduces picking errors, and strengthens traceability.

Therefore, the proposed model integrates layout planning, inventory classification, and technological support to address the main causes of poor materials management in the construction warehouse. The results will be evaluated by comparing the current situation with the improved scenario after the implementation of the selected tools, as show

in Figure 1.

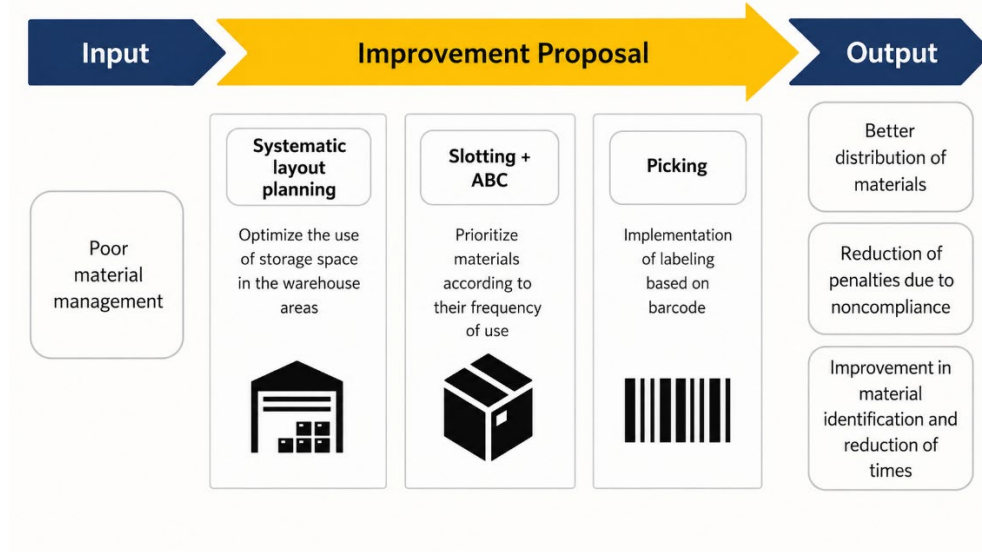


Figure 1. Proposed model

4. Data Collection

To collect data for the research, scientific articles and academic sources related to warehouse management, Slotting, ABC classification, picking, and SLP were reviewed. In addition, visits were made to the company's warehouse to directly observe the logistics process and gather information about problems in material distribution, identification, and search activities. Key performance indicators were also analyzed, such as resources delivered on time, complete deliveries, lead time, and urgent material requests. Based on these data, the main problem identified was the low service level, mainly caused by delays in material delivery and long search times in the warehouse. The study showed an average material search time of 55.7 minutes, which is much higher than the optimal standard of 10 to 13 minutes. Finally, the times for travel, identification, and location of materials were measured. With this information, a root cause analysis was developed, showing that the main causes were the lack of material identification, lack of knowledge about material locations, and inefficient warehouse distribution. This allowed research to validate the use of tools such as Slotting, ABC classification, SLP, and barcode scanning to improve the logistics process. Figure 2 shows the steps followed in the search for results.

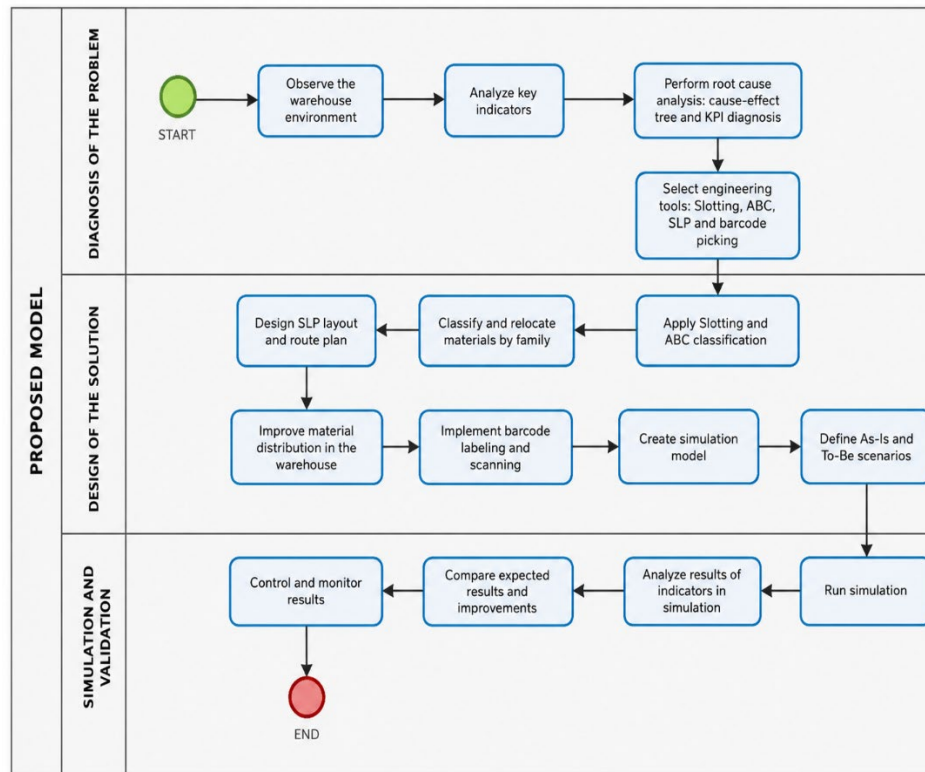


Figure 2. Diagram to achieve results

4.1 Implementation SLP, Slotting ABC, Picking methodology

To carry out the implementation, based on the literature review, the distribution approach was taken as a guide, with an initial focus on the Systematic Layout Planning methodology and the distribution by families as a starting point. In this sequence, essential tools such as Slotting and the ABC methodology were applied. This comprehensive approach is expected to result in a more efficient optimization of all operations related to storage and logistics. Finally, the Picking methodology was incorporated to further improve the system.

- For the Systematic Layout Planning tool, It is necessary to carry out an analysis of the current situation, as this will help determine the flow of materials, as well as the route followed by the personnel responsible for the warehouse. as shown in Figure 3

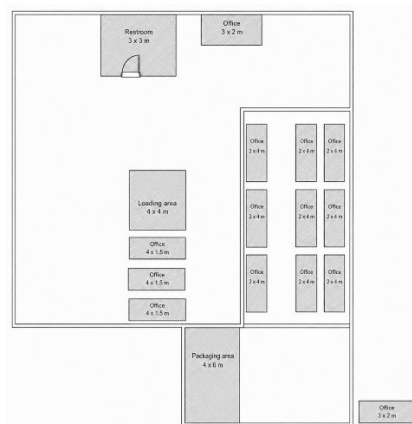


Figure 3. Current Layout

The information collected led to the classification of materials and the establishment of specific zones within the warehouse, facilitating the implementation of the SLP methodology. Previously, the lack of classification and zoning hindered operational efficiency. Figure 4 shows the new organization of the materials.

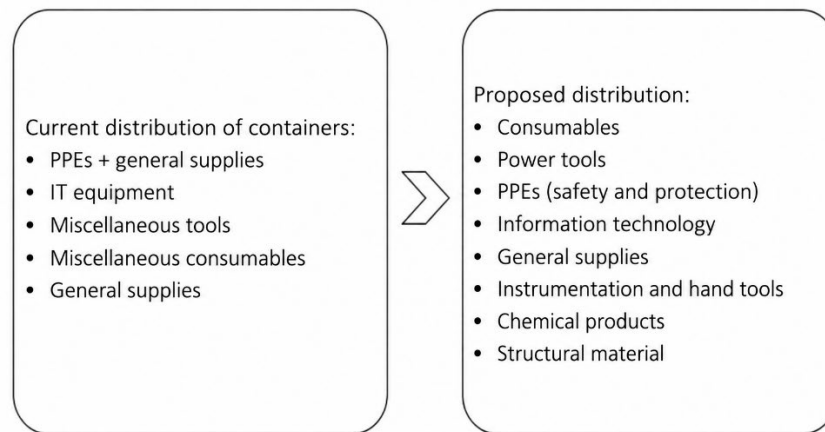


Figure 4. Material Family Classification

After defining the areas, the relational diagram was developed to determine the required space and the location of each area. The implementation covers not only the zoning of materials, but also the optimization of critical areas such as the dispatch area and the order preparation area. as shown in Figure 5.

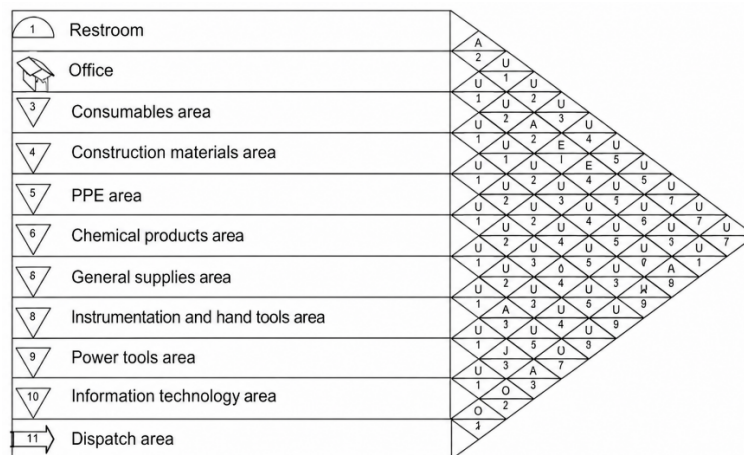


Figure 5. Relationship Diagram

Finally, the proposed layout is presented as follows, helping to improve access to the facilities and reduce travel times. The new layout is shown in Figure 6.

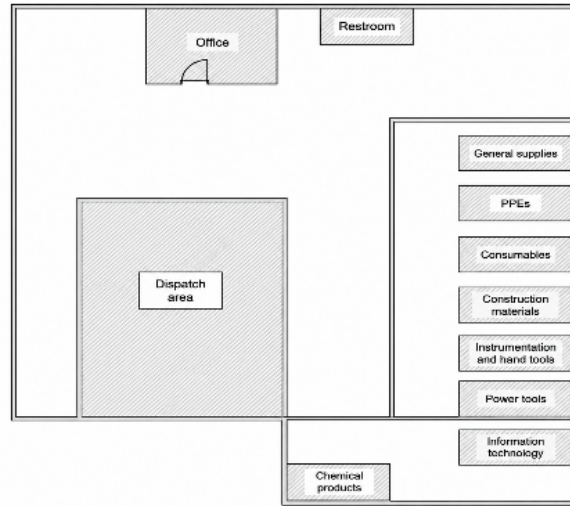


Figure 6. Proposed Layout

- For the Slotting and the ABC methodology tool, information on material demand was required, since, for a better development of the proposal, slotting was applied based on the demand of the different classes of materials. Table I shows the demand for orders by construction project.

Table 1. Order Demand by Construction Project

Description	Unit	Type
1" clamp for strut rails, conduit	69	Consumable
1" Omega-type clamp made of galvanized iron	70	Consumable
3/4" clamp for strut rails, conduit	20	Consumable
Clear-lens goggle-type safety glasses, CLITE model	20	Construction material
Dark-lens goggle-type safety glasses, Altimeter – MSA	20	Construction material
Abdominal dressing 10 x 10	2	Construction material
2" blind flange, carbon steel, Class 150 ASTM	1	Manual tool
3" blind flange, carbon steel, Class 150 ASTM	3	Manual tool
3" blind flange, carbon steel, Class 150 ASTM	3	Manual tool

After classifying the information by discipline, the materials were identified into categories A, B, and C. The materials were segmented into families, and the ABC analysis was applied to each one, thereby improving organization and reducing material location times. which is presented in Table 2.

Table 2. ABC Analysis by Material Family

• Consumibles

ZONA	Nº ELEMENTOS	% ARTICULOS	%ACUM	%CANT TOTAL	%CANT. ACUM
A	10	5%	5%	80%	80%
B	43	23%	28%	15%	95%
C	136	72%	100%	5%	100%
TOTAL	189	100%		100%	

• Herramientas eléctricas

ZONA	Nº ELEMENTOS	% ARTICULOS	%ACUM	%CANT TOTAL	%CANT. ACUM
A	3	5%	5%	74%	74%
B	2	3%	8%	19%	93%
C	55	92%	100%	7%	100%
TOTAL	60	100%		100%	

• Epps (equipos de protección)

ZONA	Nº ELEMENTOS	% ARTICULOS	%ACUM	%CANT TOTAL	%CANT. ACUM
A	6	10%	10%	78%	78%
B	9	15%	25%	16%	94%
C	46	75%	100%	6%	100%
TOTAL	61	100%		100%	

Thus, the tables show the elements corresponding to each type of material. In the case of consumables, the number of elements represents 10% of the total variety of materials in this category; however, despite the limited variety, this group accounts for 80% of the construction site orders placed to the warehouse. Likewise, this scenario is similarly repeated in the other material families, demonstrating the effectiveness of the practical analysis in relation to the theoretical approach.

- For the development of the barcode-assisted picking tool, the process is carried out as follows: information on the numbers assigned by the company is required in order to establish the barcodes, since the company has software called S10, which allows the integration of this technology. Table 3 to visualize the generated codes.

Table 3. Developed 14-digit codes

item code	item	unit	requested quantity
02041100080004	Hand protector (fingersaver),	unit	5
02070500040002	Round file 12"	unit	3
02070500500002	Flat file 12"	unit	3
02070500650002	Half-round file 12"	unit	3
0210010010032	Insulated Phillips screwdriver	unit	3
02070500400002	Round file 12"	unit	3
0210010030002	Ratchet cable cutter pliers	unit	2

With the updated inventory information, we will begin creating barcodes using the “Online Barcode Generator” software, ensuring that the new numbering is synchronized with the existing numbering to maintain system cohesion. The precise selection of the barcode type is crucial for identification and tracking. Effective management of materials. The integration of this system is expected to increase accuracy in the identification and location of materials. In addition, through the S10 software and its picking function, we will configure the location of each material in detail, thereby optimizing the storage process. After completing the entire implementation process, a sample was obtained, which is shown in Figure 7.



Figure 7. Barcode for the 12-inch round file

5. Results and Discussion

The results obtained after the application of the proposed solutions show a significant improvement in warehouse management, comparable to the optimizations reported in previous studies conducted in similar contexts. The simulation performed with 120 replications shows a reduction in the average search time, which represents a successful outcome. However, although the expected target for indicator 3 was not fully achieved, this indicator showed a substantial improvement of 63.53%. To provide better context for the simulation results, Table 4 presents the current situation, the expected outcome, and the results obtained.

Table 4. Comparison of Indicators

Tool	Indicator	unit	Current	Expected	Obtained
SLP	Total Search Time	min	54.5	25	19.88
Slotting + ABC	Round file 12"	min	18	4	5.75
Picking	Flat file 12"	min	20.5	8	10.66
	Half-round file 12"	min	72.60%	90%	88.04%

The implementation of improvements in warehouse management has resulted in significant progress. A reduction in the total average search time was observed, decreasing from 54.5 minutes to 19.88 minutes, exceeding the expected reduction. Similarly, the times for material location and preparation approached the proposed targets, with a notable decrease to 3.4593 and 5.7549 minutes, respectively. These efficiencies led to an increase in the Service Level, reaching 88.04%, which reflects substantial progress toward the 90% target. The results presented in Table 5 highlight the effectiveness of the implemented strategies in optimizing warehouse processes, although there is still room for continuous improvement.

5.1 Numerical Results

The indicators obtained after the simulation are presented below. It was simulated that the company works 6 days a week, from 9:00 a.m. to 4:00 p.m., and 120 repetitions were performed.

- Service level (%): $\frac{81.27\% + 94.8\%}{2} = 88.04\%$
- Search time: $3.4593 + 5.7549 + 10.6688 = 19.8830$

5.1 Graphical Results

Through the application of the tools, we were able to obtain the following graphic results (Figure 8):



Figure 8. Simulation indicators As Is and To Be

5.1 Validation

The proposed model was validated through a pilot test that lasted 1 month for the 5S tool and a simulation in Arena software for the other methodologies, with the latest information obtained after the simulation results, the calculation of the indicators was performed again. Table 5 shows the variation between the initial and final results.

Table 5. Comparison of indicators results between scenarios

Indicators	Initial Situation	Final Situation
Productivity Level (%)	78.12%	87.56%
Order Processing Time (min)	219.33	184.46
Defective Products (%)	7.47%	2.04%

With the results obtained for the indicators in the final situation after the simulation, it can be concluded that the main objective of the research was met, since all the indicators showed an improvement with respect to the initial situation, validating the improvement. However, if the model is implemented in the company, it may be open to further improvement.

6. Conclusion

This research successfully achieved the proposed objectives, demonstrating how the implementation of ABC classification systems, improvements in storage infrastructure, and the application of other engineering tools can significantly optimize inventory management and operational efficiency in the construction sector. This achievement not only validates the initial hypotheses but also addresses the challenge of internal warehouse management in construction companies, an area that, although not completely overlooked, has received relatively limited attention in the existing literature.

By focusing on the optimization of internal warehouses in companies from the construction sector, this research successfully met its goals, showing remarkable improvements in terms of operability and efficiency. This approach provides both practical and theoretical value to inventory management specifically applied to construction, while also enriching and deepening the existing body of knowledge in this specialized field. In doing so, it highlights the

importance of adapting and applying inventory management strategies that respond to the unique needs and challenges of the construction sector.

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Biographies

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