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Guide for the Optimization of Material Storage during the Structural Phase of Educational Projects through the Application of the ABC Methodology

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Abstract **-** This article presents a guide for optimizing material storage in educational infrastructure projects, specifically during the structural phase, using the ABC methodology. The study addresses the problem of poor management and placement of construction materials in warehouses, which negatively impacts operational efficiency and costs. A total of 172 stored materials were analysed in an October project, 86 of which were used. The materials were classified into three categories: A (11 materials), B (26 materials), and C (49 materials), representing critical values for prioritization and efficient distribution. The methodology includes an ABC analysis, a Pareto diagram, and warehouse modelling in Revit, demonstrating how redistribution improves access times, inventory control, and reduces the rate of obsolete materials. The results highlight the feasibility of implementing this guide in similar projects, promoting resource management.

Keywords**:** warehouse management, ABC methodology, educational infrastructure, construction materials, storage cycle, inventory classification, construction projects.

1. Introduction

In educational infrastructure projects, proper organization and management of materials in the warehouse is essential to ensure the efficiency and success of operations. However, it is common for there to be deficiencies in the administration and location of these supplies, which generates significant problems in the development of the project. These deficiencies in warehouse management cause delays in the execution of activities, as personnel spend additional time locating specific materials. This waste of time and the misuse of resources also generates cost overruns, especially when materials are not properly organized or are misplaced. In addition, the lack of an adequate distribution of space in the warehouse means that the available area is not used efficiently, which makes it difficult to meet the demands of the project in an agile manner and delays the progress of activities.

Materials in the construction industry account for 50 to 60 percent of project costs. Having control and good materials management is important for any company that wishes to complete a project successfully. [1] Ali et al. [2] note that proper management of materials in storage is essential to the project budget, as it ensures their availability and efficient use, while poor management can lead to delays and affect construction quality. In many construction projects, space in the work area is limited and its use must be carefully planned when developing material procurement and storage plans. [3] In this context, one of the most widely used techniques for efficiently managing materials is the ABC method, which classifies items into different categories according to their importance, thus facilitating better warehouse management and helping to reduce costs and optimize resources in the project. [4] The ABC method, widely recognized for its simplicity and practical applicability, organizes inventory items into three categories: A, B, and C. [4] Generally, between 5% and 10% of high-impact items are assigned to category A; the next 15% of moderate impact, are classified in category B; and the rest, with low impact, remain in category C. The choice of classification criteria is adapted to the specific needs of the management problem to be solved. [5]

This research proposes to implement the ABC methodology to improve inventory management in construction materials warehouses in educational projects during the structural phase. Likewise, by classifying materials according to their importance and frequency of use, it seeks to facilitate the organization and access to critical supplies within the warehouse. This approach allows a strategic arrangement of the most relevant materials, reducing search times, optimizing space and, ultimately, improving the operational efficiency of the project.

The contribution of this article is to offer a practical methodology adapted to the needs of the project during the structural phase. By classifying materials according to their importance, the ABC methodology allows for a more efficient management of resources, reducing operating costs and the risk of excessive storage. This represents a substantial improvement over traditional methods, which tend not to prioritize critical materials or identify those with slow turnover. In addition, the proposed methodology can be replicated in other educational infrastructure projects with similar logistical and operational characteristics, thus contributing to the development of more sustainable and productive practices in the sector.

2. Tools and methods

2.1. Tools

This research employs a quantitative approach to the classification of materials used during the structural phase in the warehouses of educational infrastructure construction projects, using the ABC methodology. The tools include spreadsheet software (Microsoft Excel), which allows for efficient organization and analysis of inventory data, as well as specific classification criteria aimed at identifying materials with the greatest impact on the project. In addition, AutoCAD and Revit software will be used to design the layout of the project's warehouse. The appropriate storage location for each material will be determined according to its classification in categories A, B or C, which will contribute to an accurate and prioritized management of resources, optimizing the use and disposition of stored materials.

2.2. Methods

This research provides a practical and detailed guide for the optimization of material storage in educational infrastructure projects through the application of ABC classification:

a. Data Collection

The Excel file with the inventory data is organized, recording each construction material used during the structural phase of the project (name, quantity, value and frequency of use).

b. Classification of Materials (ABC Methodology)

Materials are classified into three categories based on their impact and frequency of use:

- Category A: Critical materials representing between 5% to 14% of the inventory and 80% of the total value.
- Category B: Materials of medium importance, representing between 15% to 77% of the inventory and 15% of the value.
- Category C: Materials of low relevance, representing between 78% to 90% of the inventory with only 5% of the total value.

c. Warehouse Design

Using the information on the classification of materials in categories A, B and C, we will proceed to develop a plan in AutoCAD and Revit that represents the distribution model of the warehouse, allowing an efficient organization based on the priority of access and frequency of use of each material.

d. Warehouse Organization

Distribute the materials in the warehouse according to their category:

- Places category A materials in the most accessible and visible areas to optimize their handling.
- Assign category B materials in an intermediate area, easily accessible, but not a priority.

- Place category C materials in the least accessible areas, taking advantage of space without compromising access to critical materials.

e. Periodic review

A biweekly review of the implementation of the guide is carried out in order to evaluate its effectiveness in the organization and optimization of the warehouses. This review, commissioned by the site manager, includes verification of the correct location of materials according to their ABC classification, as well as analysis of any changes in the frequency of use or value of the materials that may justify a reclassification. This process ensures the validity and accuracy of the guide, allowing continuous adjustments to optimize both the accessibility of materials and the efficient use of warehouse space.

Fig. 1 shows a flow chart of procedures for the implementation of the Guide for the Optimization of Material Storage in Educational Infrastructure Projects through the Application of the ABC Methodology. In this way, it is visualized how the storage and classification operations of materials are optimized based on the ABC analysis.

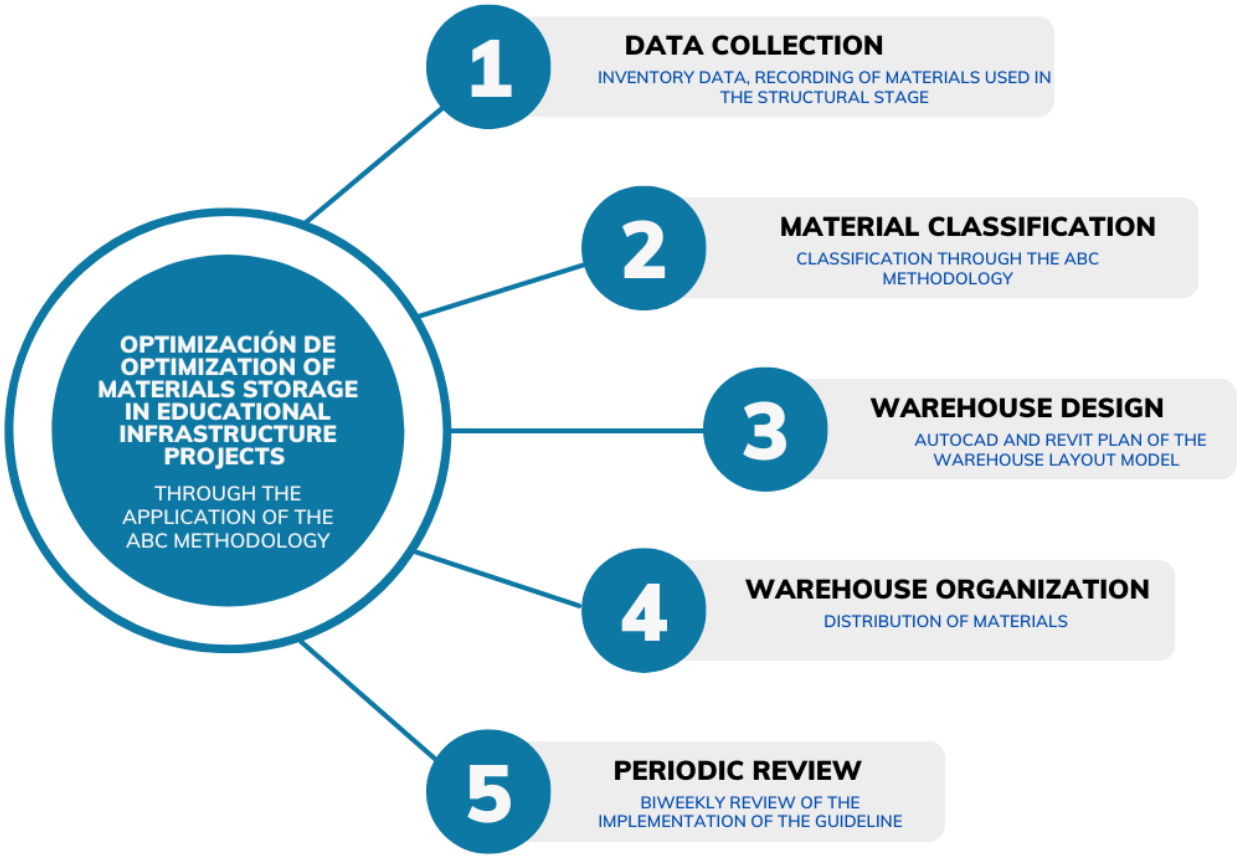

Figure 1. Flow chart of procedures for the optimization of material storage in educational infrastructure projects through the application of the ABC methodology.

3. Results

3.1. Application of the ABC Methodology

The ABC methodology was applied to a total of 172 construction materials stored in the warehouse of an educational infrastructure project during the structural phase. Of these, only 86 materials were used in the month of October and were included in the analysis. The materials were classified according to their value and frequency of use:

- Category A (High impact materials): 11 materials, representing 12.79% of the materials used, but corresponding to 79% of the total value, equivalent to S/ 31,433.80.
- Category B (Moderate impact materials): 26 materials, representing 30.23% of the materials used, corresponding to 16% of the total value, or S/ 6,244.40.
- Category C (low impact materials): 49 materials, representing 56.98% of the materials used, with a total value of S/ 2,001.47, equivalent to 5% of the total value.

Table 1 shows a summary of the above data.

Percentage	Category	Number of elements	% Articles	% Accumulated	% Investment	% Accumulated Investment
0-80%	A	11	12.79%	13%	79%	79%
80-95%	B	26	30.23%	43%	16%	95%
95-100%	C	49	56.98%	100%	5%	100%
Total	86					

Table 1. Summary of the application of the ABC methodology

3.2. Total value of materials

The total value of the 86 materials used in the month of October during the structural phase of the project amounted to S/ 39,679.67.

3.3. Pareto Diagram

The Pareto diagram shown in Fig. 2 clearly illustrates how a small proportion of the materials (category A) accounts for most of the total value of the materials. This diagram is a key visual tool that validates the theory that less than 20% of the elements generate 80% of the impact, which justifies the high importance assigned to the materials in category A.

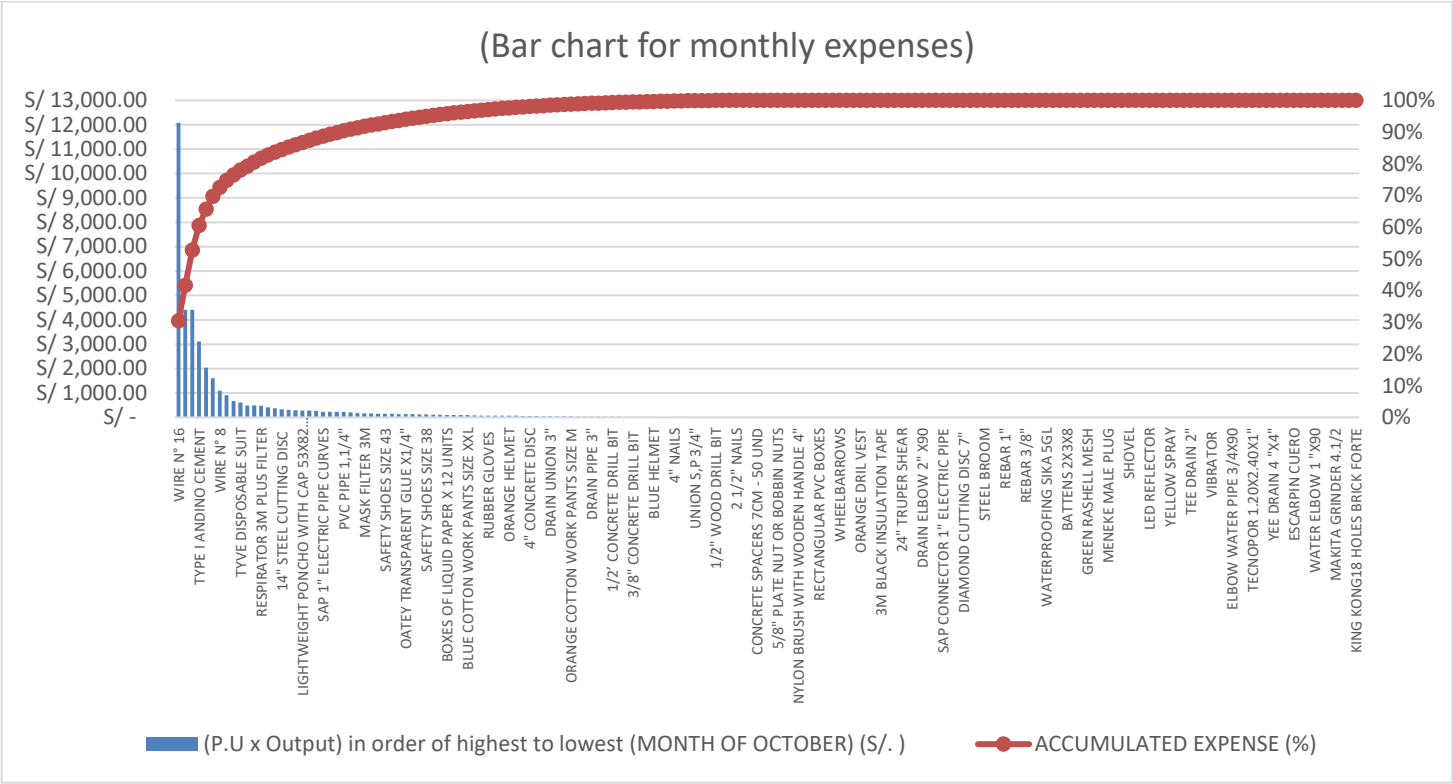

Figure 2. Pareto diagram with bar chart of monthly expenditures and line with markers that are the cumulative expenditures.

4. Analysis of results

- The application of the ABC methodology shows that, of the 86 materials used, 12.79% belong to Category A, representing 79% of the total value, indicating that they are key materials for the project and should be managed as a priority. Category B, with 16% of the materials, represents 30% of the value, suggesting a moderate impact on costs, while Category C, although it constitutes 56.98% of the materials, only represents 5% of the total value, indicating that these materials have a low economic impact and can be managed less frequently.
- Category A materials, which have a higher impact, have a high value and should be stored in easily accessible areas, while Category C materials, which have a low value, can be located in less accessible areas.
- The Pareto diagram presented in Fig. 2 reinforces the theory that a small fraction of the materials (category A) concentrates most of the economic value. This justifies the need to implement more rigorous management strategies for category A materials, which optimizes workflow and reduces operating costs.

5. Validation

5.1. Warehouse design

A model was developed in AutoCAD and Revit of the warehouse design for the efficient location of materials according to their ABC classification. In Fig. 3, Fig. 4 and Fig. 5, a visualization of the model is presented that facilitates the correct distribution of materials, optimizing the organization and access to them.

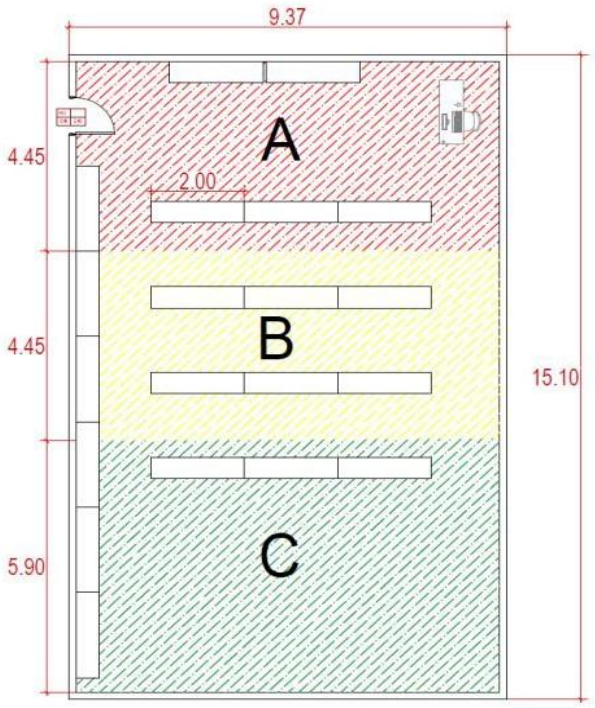

Figure 3. Plan view of the AutoCAD drawing of the warehouse measuring 15.10 x 9.37 meters.

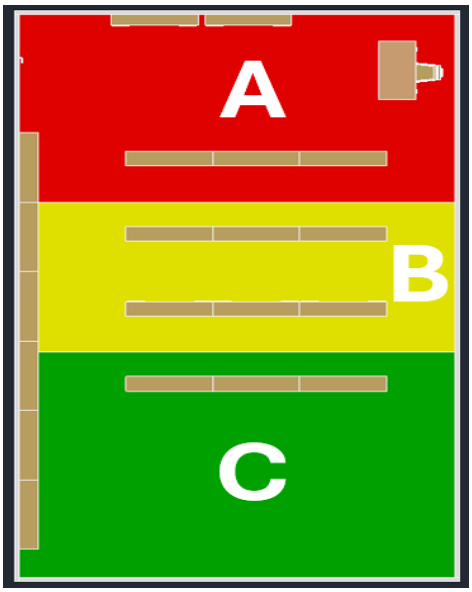

Figure 4. Plan view of the Revit modelling of the warehouse measuring 15.10 x 9.37 meters.

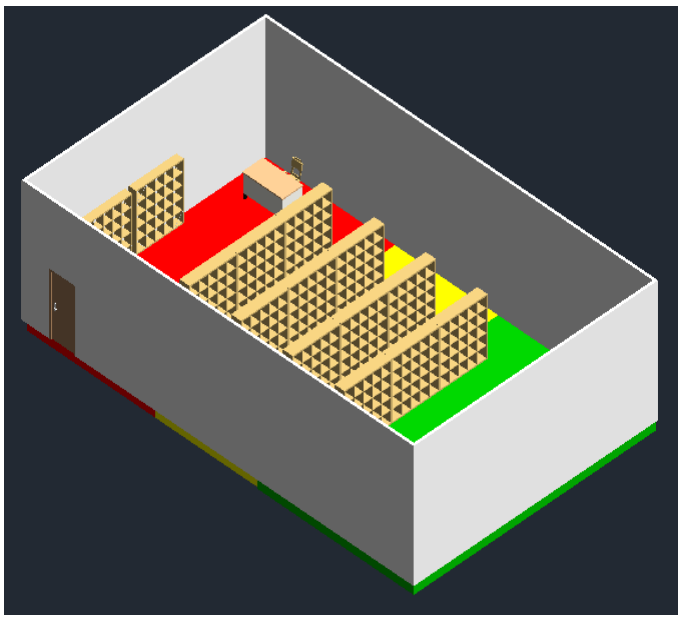

Figure 5. 3D view of the Revit modelling of the warehouse measuring 15.10 x 9.37 meters.

The AutoCAD and Revit model, shown in Fig. 3 and Fig 4, facilitates the optimization of the warehouse by allowing a clear visualization of the distribution of materials during the structural phase of educational infrastructure projects. This improves operational efficiency, reduces human error and optimizes access time to materials, especially high-impact materials.

6. Conclusions

The ABC methodology has proven to be a key tool for improving materials management during the structural phase of educational infrastructure projects. Its classification approach, based on the economic impact and frequency of use of materials, made it possible to organize the warehouse more efficiently. The most important materials were placed in strategic and easily accessible areas, while those of lesser relevance were stored in less used areas. This optimized the use of space, reduced search and handling times, and significantly improved the warehouse's operability, facilitating a more orderly and effective management.

Likewise, the Pareto Diagram clearly showed that a small quantity of materials represents most of the economic value in the warehouse. This made it possible to identify the most important materials and those that should receive the most attention in their management. By focusing on these higher-value materials, it was possible to optimize workflow, reduce costs and improve efficiency in the management of warehouse resources.

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