

# Current situation of construction material management at international Level

## Situación actual de la gestión de materiales de construcción en el ámbito internacional

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Fecha de Recepción: 19/11/2021

Fecha de Aceptación: 23/03/2022

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### Abstract

*The present research aimed to provide a broad overview regarding the management of construction materials. As a starting point, the conception of the set of actions that make up the materials management is described and its importance within the construction sector is pointed out; It also addresses the various obstacles that this sector currently faces when managing its materials, in a global scope, and which hinder the optimal development of the sector. Likewise, new management support technologies such as Radio Frequency Identification (RFID) web-based systems for materials management and data storage applications are described, offering a vision of the advantages and disadvantages involved in implementing these information technologies. In the same way, the most common support techniques for inventory control are outlined. It is concluded that the construction industry knows the concept of materials management, however, it still faces problems for the application of a correct execution of said concept; In addition, it is at an early stage in the adoption of new techniques and technologies to support the management of construction materials.*

**Keywords:** Materials management, building materials, RFID, ABC analysis, EOQ analysis

### Resumen

La presente investigación tuvo como objetivo proporcionar un panorama amplio referente a la gestión de los materiales de construcción. Como punto de partida, se describe la concepción del conjunto de acciones que componen a la gestión de materiales y se señala su importancia dentro del sector constructivo; se abordan también los diversos óbices que actualmente afronta este sector al gestionar sus materiales, en un ámbito global, y los cuales obstaculizan el desarrollo óptimo del sector. Asimismo, se describen nuevas tecnologías de apoyo a la gestión como Identificación por Radio Frecuencia (RFID) sistemas basados en la web para gestión de materiales y aplicaciones de almacenamiento de datos, ofreciendo una visión de las ventajas y desventajas que implican la implementación estas tecnologías de la información. De igual modo se reseñan las técnicas de apoyo para control de inventario más comunes. Se llega a la conclusión de que la industria de la construcción conoce el concepto de gestión de materiales, sin embargo, aún enfrenta problemas para la aplicación de una correcta ejecución de dicho concepto; además de que se encuentra en una etapa temprana en la adopción de las nuevas técnicas y tecnologías de apoyo a la gestión de los materiales de construcción.

**Palabras clave:** Gestión de materiales, materiales de construcción, identificación por radiofrecuencia, análisis ABC, análisis EOQ

## 1. Introduction

*Materials play a chief role in the execution of a construction project, thereby representing more than 50% of the total cost (Gulghane and Khandve, 2015); (Jusoh and Kasim, 2016); (Karoriya and Pandey, 2018); (Pal and Ahire, 2016); (Safa et al., 2014); (Solís et al., 2009). Therefore, it is necessary to further study the management of such considerable economic components, because the lack of adequate material management entails important problems, such as execution delays, excessive waste, low productivity and costs above those anticipated; thus affecting the project's overall performance (Gulghane and Khandve, 2015); (Jusoh and Kasim, 2016); (Kulkarni et al., 2017); (Majrouhi, 2012).*

*Recent studies have identified factors leading to deficiencies in construction material management. Soni 2015, points out issues derived from the communication among the persons who participate in the execution of the construction project, bad quality materials and lack of materials when they are needed (Soni et al., 2016). (Dakhli and Lafhaj, 2018), refers to problems concerning transport and deliveries, storage and inventory, and waste use and control (Dakhli and Lafhaj, 2018).*

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Since a company's material management is a key function for executing the project at a minimum cost (Soni et al., 2016), it is essential to mention and describe the components involved for its correct completion: planning, procurement, storage and control.

It is crucial to say that the correct practice of construction material management increases the productivity of a construction project (Gurmu, 2018). Likewise, (Gurmu, 2018), recommends the implementation of new management practices by using the latest technologies for improving the productivity. Therefore, and with the purpose of correcting certain irregularities of material management systems, some construction companies, with a more formal organizational structure, are starting to implement a number of new systems, techniques and technologies, always aiming at optimizing construction materials, which in turn improves the project's productivity.

Radio Frequency Identification (RFID) is among these new technologies, which is a wireless communication technology using a configuration system of tags and readers (Bryan et al., 2015) to improve the delivery, receipt and localization of construction materials (Majrouhi, 2012). Another one is Web-Based Material Planning and Control (WB-MPC), whose purpose is to rely on an interactive interface that allows constructors to calculate and store materials and, at the same time, to plan and control their use (Afolabi et al., 2017). Furthermore, Zoho Creator is an app based on data storage concerning construction materials, whose purpose is the access, management and edition of these data (Karami and Danesh, 2018).

Among the newly implemented techniques, the inventory control is worth highlighting as a support of construction material management. The first is ABC analysis, which refers to the 80/20 rule or least significant rule that analyzes the items corresponding to a small portion of the inventory (around 20%), but representing the highest economic value (approximately 80% of the total cost), and vice versa (Macías et al., 2019). The second technique is the Economic Order Quantity (EOQ) analysis, which refers to the order size that will yield the lowest ordering and transport cost of an inventory material (Pal and Ahire, 2016). When this technique is applied during the company's planning stage, it can reduce the lack of materials, so as not to interrupt the execution process, and also optimize their supply cost (Elmas, 2017).

It is a fact that new techniques and technologies have transformed the construction industry (Afolabi et al., 2017) and that their implementation allows giving sophisticated solutions to the difficulties that the industry faces in relation to material management (Kasim, 2011). However, it is also a fact that this implementation has been slow-paced (Afolabi et al., 2017), due to different factors that are worth outlining to make their identification and subsequent elimination easier.

## 2. Search Methodology

The present research is based on a large review of the literature addressing the construction material management worldwide, starting with the general concept, delving deeper into its components and offering a review thereof. Moreover, it deals with the use of information technologies (IT), their benefits, advantages, disadvantages, and obstacles for their implementation, among others. A description of the general scenario on the subject will help evidencing the progress made in the last years, but it will also allow examining what aspects have stalled the construction material management, thereby distinguishing the causes of this standstill.

The study period was limited to the past ten years, in order to offer the largest and most updated research possible.

The main key words used in the search were: "construction material management" whose search results gave 4,330,000 items; "material management" with approximately 5,020,000 results; and "building materials" with around 5,770,000 resulting documents. It is necessary to clarify that the information from all these results was filtered. First, priority was given to the publishing date, designating the results according to the 10-year period mentioned above. Likewise, the publication relevance, that is, the number of citations, was taken as a reference. Finally yet importantly, the journal in which the document was published was revised, thereby prioritizing the journals with greater impact at global level.

## 3. Definition of Construction Material Management

As a starting point, it is important to build an understanding of what **construction material management** is, and to know a little about the processes and actions involved. Therefore, a table (Table 1) has been generated to compare the definitions of different authors over the years.



**Table 1.** Definitions for Construction Material Management

<b>Author</b>	<b>Year</b>	<b>Definition</b>
Solís Carcaño, R.	2009	It can be defined in the following processes: planning, negotiation, ordering, receipt, storage, use, replenishing, payment and control. (Solís Carcaño, 2009)
N. B. Kasim	2010	Coordination function that is responsible for the planning and control of the material flow. In detail, it is a procedure comprising the procurement, delivery, waste manipulation and minimization, with the aim of guaranteeing the compliance with the requirements. (N. Kasim & Ern, 2010)
Khyomesh V. Patel	2011	Process that coordinates planning, assessment of the need, supply, procurement, transport, storage and control of materials, waste minimization and profit maximization by reducing the cost of the material. (K. V. Patel, 2011)
J. Majrouhi Sardroud	2012	Management system designed to plan and control all the necessary efforts to ensure that the adequate quality and quantity of materials and equipment are properly and duly controlled, and at a reasonable cost, and to ensure its availability when necessary. (Majrouhi Sardroud, 2012)
Calistus Ayegba	2013	Process for coordinating the planning by estimating the requisition supply, procurement, transport, storage and control of materials, reducing the waste and optimizing the profit by minimizing the cost of the material. (Ayegba, 2013).
Mahdi Safa	2014	Planning and control of the necessary activities to guarantee and confirm that the correct quantity and quality of materials and equipment are correctly specified, at a reasonable cost, and that they are available when needed. (Safa, 2014)
A. A. Gulghane	2015	Process that allows supplying the required goods and services to an organization in order to achieve their objectives of procurement, storage and movement of materials. (Gulghane & Khandve, 2015)
Harsh Soni	2016	Key business function in charge of coordinating the optimal planning, supply, procurement, transport, storage and control of material, in order to provide a customer a predetermined service at a minimum cost. (Soni, 2016)
Vikram Kulkarni	2017	Process providing the correct material at the indicated place and right time, and in the correct quantity, with the aim of minimizing the project cost, through planning, identification, procurement, storage, receipt and distribution of materials. (Kulkarni, 2017)
Zakair a Dakhli	2018	Optimal way to coordinate, plan, supply, procure and store the construction materials, and provide quality control. (Dakhli & Lafhaj, 2018)
A E Oke	2019	Process for material planning, tracking and coordination, as well as for material flow. (Oke, 2019)

The concepts coincide in four aspects that can be considered the most relevant ones: planning, procurement, storage and control (Madhavi and Varghese, 2013); (Phu and Aye, 2014).

According to Kasim & Anumba, the planning of materials provides the guidelines for the subsequent activities of the project, which has a great impact on the general plan. It is highly important to plan the access of materials to the site, in order to develop an efficient material management logistics (Kasim et al., 2005). That is where the relevance of this component lies, since the inappropriate planning of the material supply causes scheduling, cost and quality problems in the project (Chen and Nguyen, 2019).

Regarding the purchase of materials, a series of activities must occur successively and orderly for the correct execution: requisition of materials, consulting and comparing the suppliers, choosing the suppliers and negotiating with them, placing the purchase order and evaluating the supplier (Patel, 2011).

Storage is defined as the proper space, either closed or open, that is needed to provide security for the materials; this means protecting the materials against theft, loss or damage (Raibole and Waghmare, 2019). The place intended for storage must be located on a strategic point within the site to facilitate its access, because a badly located space has a negative impact on the project's productivity (Jusoh and Kasim, 2016).



The objective of the construction materials' control is to avoid generating a shortage and/or surplus of these materials on the site. This process is intrinsically related to the materials handling, distribution and use. The materials control can change according to how much the information technologies are actually used, since these technologies are capable of improving the process (Jusoh and Kasim, 2016).

It is imperative to manage the construction materials appropriately, because, in economic terms, these components represent more than 50% of the total cost of a construction project (Cengiz et al., 2017); (Georgekutty and Mathew, 2012); (Patel et al, 2015); (Patil, 2016). H. Nassir in 2010 affirms that a system that efficiently manages and controls the construction materials is able to increase the productivity of a project by up to 8% (Nassir et al., 2010).

### 3.1 Objectives of Material Management

The material management is important not only during the construction phase; it is also crucial to make a decision on the procurement of materials at the initial stage of the project planning and scheduling. Likewise, it is a key issue to rely on inventory management techniques during the execution phase, in order to supervise the material flow process periodically, and thus avoid losses, absences and delays (Patil and Pataskar, 2013). That is why material management pursues specific objectives, and their fulfillment allows an integral management process; these objectives are listed below:

- Efficient material planning
- Procurement
- Delivery and receipt
- Inventory storage and control
- Stock and waste control
- Material supply and distribution
- Quality warranty
- Good relationship with the supplier and customer
- Improving the department's efficiency
- Project cost reduction
- Time saving
- Project economics

In order to fulfill these objectives, it is important to establish coordination and harmony among those in charge of the material management department, who in turn must be integrated and coordinated with the employees of other departments within the organization, and thus achieve an optimal construction project (Pal and Ahire, 2016).

## 4. Information and Communications Technologies in Construction Material Management

When the task of identifying and tracking the materials is automated, it facilitates the obtainment of adequate and accurate information concerning the availability of materials. This implies a decrease of the waiting time for materials that are not used, as well as a reduction of inefficient decision making due to lack of information (Majrouhi, 2012), thus contributing to the material management process. The most common methods for localizing and tracking construction materials suffer from various limitations; therefore, it is necessary to incorporate new technologies (Kereri, 2018), such as Information and Communications Technologies (ICT). According to Sánchez Duarte, ICT are the technologies used for the management and transformation of information and, particularly, the use of hardware and software that enable the creation, modification, storage, protection and retrieval of this information (Sánchez, 2008). A correct ICT implementation can deliver a more competent and productive material management process (Kasim and Ern, 2010).

### 4.1 Radio Frequency Identification (RFID) in Construction Material Management

RFID is a general term referring to the technologies that use radio waves to automatically identify a person, object or other information (Ren et al., 2011). A RFID system is mainly composed of a reader (transceptor) connected to an antenna and a set of tags (transpondent), which store information. The reader communicates with a computer through an app, which manages the data stored in the tags. The function of the antenna is to establish



the communication between the reader and the tags. There are several types of antennas and tags, depending on the distance between the system and the objects to which the tags are attached (Valero et al., 2015), where readers can be at a range of up to 15 m from the tags. This technology is similar to the barcode system, but it differs in the sense that the RFID reader is capable to read more than one tag simultaneously and at a much larger distance, which makes it faster and more efficient.

The construction industry is applying RFID technology in different ways, but the most significant application is for material management (Hinkka and Tätilä, 2013). This approach consists in an integral GPS technology with RFID, with the aim of locating objects tagged in a real 3D plan. This means a great contribution to the material management process, because this tool is quite useful for facilitating and maintaining a real-time control of orders, stock of materials at the building site, entrance and exit from the warehouse, use, etc. (Lu et al., 2011). Likewise, the automated material management using this system replaces the traditional method with paper documentation, which can be tedious, inefficient and tardive. The application of this technology consists in using stationary antennas, which must be connected and installed in specific areas, such as in the entrance or exit of the warehouse, the construction site, among others. As soon as the tags attached to the materials reach the reading range of the readers, they are automatically identified and the information contained therein (including the GPS location of the corresponding reader) is transferred to a computer or server, where the project database is updated with the materials information, including their location (Majrouhi, 2012). There are also mobile or portable readers connected to the system, which can be transported by a person or mobile device to identify tagged items, either walking by or executing any other equipment. The main benefit of this integrated system is to ensure the availability of adequate materials in the right quantity, at the right place and when they are required, thereby reducing the search time for the materials, evaluating the inventory status, and reducing the waste of materials (Majrouhi, 2012). In contrast, the implementation of these technologies present certain disadvantages; one of them is the cost, which is a concerning issue for businesses. Moreover, the engineers, technicians and warehouse staff found that the implementation task for the new system was a little tedious, thus showing a certain reluctance and leaning towards the traditional material management system (Ren et al., 2011).

In 2012, studies were undertaken to evaluate the feasibility of these automated systems, and the results showed a saving of up to 3.1% of the total construction costs (Demiralp et al., 2012); this paved the way for implementing this system with new technologies. Such is the case for unmanned aerial vehicles (UAV), commonly called drones. A simple system was configured by installing a RFID reader on a drone, with the aim of tracking the materials located at the construction site, in order to control the material flow inside and outside of the warehouse and be able to rely on real time information about quantity, location, use, etc. The reader was a small device measuring 21 x 8.1 x 3.2 cm, whose weight was less than 500 g, which also provided a GPS positioning (Bryan et al., 2015). In relation to the selected drone, it had enough capacity to bear the weight of the RFID reader and its flight time was approximately 30 min.

The initial tests yielded positive results, that is, the combination of UAV and RFID technologies was successful; however, the researchers were faced with certain limitations such as the reading range of the RFID reader. The selection of a very small reader that could fly on top of the drone restricted the reading range, which was below 2 m. Furthermore, it was impossible to accurately control the speed and vision of the drone, thus making the task inside the site more difficult (Bryan et al., 2015).

#### **4.2 Web-Based Material Planning and Control Model**

The purpose of the WB-MPC model is to rely on an interactive interface based on the web, providing a tool for professionals in charge of construction materials that helps them calculate and store quantities of these materials, while simultaneously planning and controlling their use. The system was designed to show any deficit in the quantities of specific construction materials through periodical short texting systems or by E-mail. In this system, the construction project manager and certain users can access the form of the element by logging in to the webpage. The project manager or any other authorized employees have access to critical data or information dealing with the use of materials on the site, which contributes to the transparency of the project. The system also has a messaging network where users can send clarifications to the project manager regarding the works (Afolabi et al., 2017). (Figure 1) shows the design of the architectonic system.



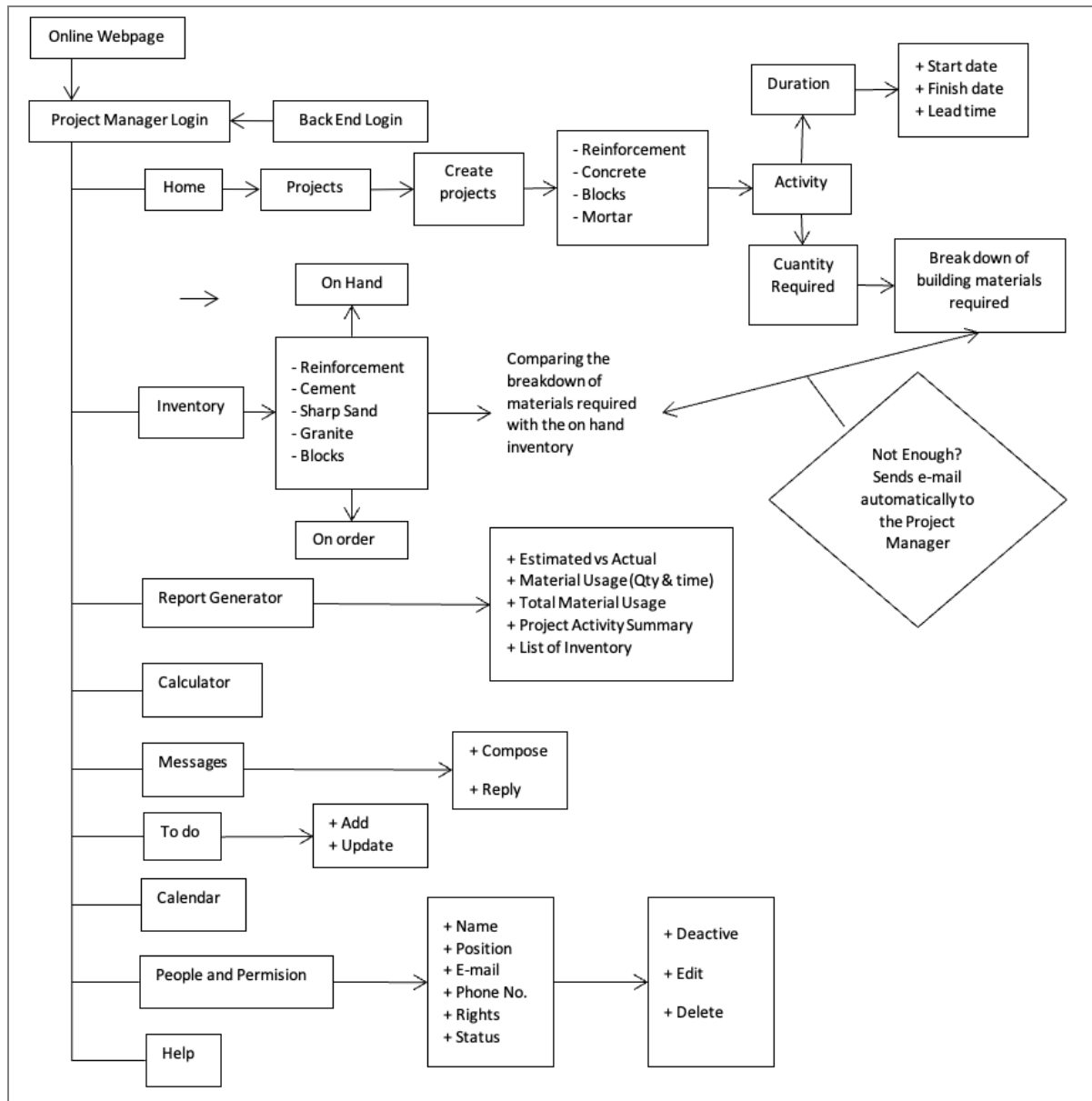


Figure 1. Architectonic design of the WB-MPC source (Afolabi, 2017)

### 4.3 Zoho Creator and its Material Management Application

Zoho Creator is a collaborative environment for making and using relational database artifacts, with regard to relations between entities and object-relational ones (VanZandt, 2017). This app is based on data storage, in this case, related to construction materials under predictable crisis conditions created by the app itself. It is a minimalist tool developed under an easy-to-use code. Its main objective is to easily access, manage and edit large quantities of materials data (Karami and Danesh, 2018). (Figure 2) shows the Zoho Creator's fields



Construction Material Management.		Search...																												
Dashboard	<table border="1"> <thead> <tr> <th colspan="2">Fields</th> </tr> </thead> <tbody> <tr> <td>Single Line</td> <td>Multi Line</td> </tr> <tr> <td>Email</td> <td>Rich Text</td> </tr> <tr> <td>Date.</td> <td>Date-Time</td> </tr> <tr> <td>Drop Dwon</td> <td>Radio</td> </tr> <tr> <td>Multi Select</td> <td>Checkbox</td> </tr> <tr> <td>Number</td> <td>Decimal</td> </tr> <tr> <td>Percent</td> <td>Currency</td> </tr> <tr> <td>URL</td> <td>Image</td> </tr> <tr> <td>Decision box</td> <td>File upload</td> </tr> <tr> <td>Lookup</td> <td>Add Notes</td> </tr> <tr> <td>Subform</td> <td>Zoho CRM</td> </tr> <tr> <td>Auto Number</td> <td>Formula</td> </tr> <tr> <td>Signature</td> <td>Users</td> </tr> </tbody> </table>		Fields		Single Line	Multi Line	Email	Rich Text	Date.	Date-Time	Drop Dwon	Radio	Multi Select	Checkbox	Number	Decimal	Percent	Currency	URL	Image	Decision box	File upload	Lookup	Add Notes	Subform	Zoho CRM	Auto Number	Formula	Signature	Users
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Subform			Zoho CRM																											
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Figure 2. Zoho Creator fields (reproduced by the author)

The app's main fields are dates and places in which the materials must be stored, according to the information facilitated at the working place and the decision made by the project managers. These fields are related to when and where the construction materials should be stored, and when and how many materials are to be used. This app certainly helps project managers to easily manage large amounts of data.

Two actors are needed for using the app: one of them is the person in charge of the materials in the warehouse, who receives the materials and accepts or rejects them according to the quality (the material's acceptance or rejection report can be generated in the app). The same person enters the necessary information of the materials (name, quality, quantity, supplier's data, etc.) in the Zoho Creator database. Once the data input is accomplished, they are immediately available for the second actor, the project manager, who will rely on the necessary information, in real time, for making decisions about how to use the materials, thus making their management easier, even when dealing with large amounts of materials (Karami and Danesh, 2018).

An evaluation of 21 app users (students of architecture and construction science) showed that the app fulfilled the expectations of the users by 85%. The drawback here is that the study was made with students, thus it is not possible to guarantee that the app used in real construction cases will be equally satisfactory.

## 5. Support Techniques for Construction Material Management

The inventory control is a key component of the material management process. It refers to a subsystem that guarantees the supply of the necessary inventory quantity and quality at the right time; in turn, this subsystem avoids superfluous inventory investment (Patil and Pataskar, 2013). Although there are different techniques to help in the optimal accomplishment of this inventory control, those considered predominant are ABC and EOQ analysis.



### 5.1 ABC Analysis

The ABC analysis is one of the most commonly used approach for classifying inventories (Desai and Patel, 2019). The analysis technique is based on the principle that a reduced portion of construction materials represents the highest monetary value of a construction project inventory; while the greatest amount of materials of this inventory represents a small part of its monetary value (Pal and Ahire, 2016). In order to calculate the cost or monetary value of the materials, you only need to multiply the quantity of material by its unit price.

- “A” classified materials, which make up for 5% to 10% of the inventory items, represent 70%-75% of the inventory cost.
- “B” classified materials, which make up for 10% to 15% of the inventory items, represent 10%-15% of the inventory cost.
- “C” classified materials, which make up for 70% to 80% of the inventory items, represent 15%-10% of the inventory cost (Mohopadkar and Patil, 2017).

The position of the elements in the different categories shows that “A” classified items must be strictly controlled, while “B” classified items could undergo a medium-level control; and “C” classified items can be controlled in a much more flexible way (Pande and Sabihuddin, 2015).

The case studies carried out demonstrated that the main advantage of this inventory control technique is that, compared to any other method or technique, it is the most inexpensive. The observed disadvantage is that ABC analysis does not provide the items’ critical nature with absolute certainty, that is, it only creates an idea about the inventory value (Shet and Narwade, 2016).

### 5.2 EOQ Analysis

The analysis technique of Economic Order Quantity (EOQ) refers to the order size that yields the most inexpensive total ordering and transport cost of an inventory material. The purpose of this technique is that construction companies do not place unnecessary orders, thus not generating superfluous or excessive ordering costs; and at the same time, that they do not generate a small number of orders with large quantities of materials to prevent storage and/or maintenance cost overruns (Pande and Sabihuddin, 2015).

The economic order quantity is calculated with (Equation 1).

$$Q = 2 * C_o * S C_u * I \quad (1)$$

Where:

$C_o$  = order cost,  $S$  = total consumption,  $C_u$  = item cost,  $I$  = inventory maintenance cost (Pande and Sabihuddin, 2015).

Using this tool has many advantages. In 2009, Deepak Karoriya stated that the cost of a construction project could be reduced with the EOQ analysis (Karoriya and Pandey, 2018). On the other hand, Mahant y Patil declared that the joint application of ABC and EOQ analysis techniques on a construction project produces cost savings and prevents material waste (Soni et al., 2016). In turn, in 2013 and following a case study on a construction project, Ashwini indicated that the total inventory cost was reduced after adopting EOQ analysis (Patil and Pataskar, 2013). In 2017, Elmas suggested that the application of this method during the planning phase could reduce sold out materials, thus not altering the process within the company, in addition to cutting down the materials’ supply costs (Elmas, 2017).

## 6. Obstacles in the Implementation of Construction Material Management

The currently used practices in the construction industry to manage the materials and procedures for controlling them are quite unsatisfactory, because they are labor-intensive, irregular and error-prone (Gulghane and Khandve, 2015). The project managers, who are responsible for the construction material management, show difficulties when it comes to solving problems with the current practices (Kasim, 2015). These situations lead to inadequate material management practices, thus causing many problems at the time of executing the system or process. (Table 2) lists the different problems that the material management encounters at international level.





**Table 1.** General diagram of the research methodology

Country	Author	Year	Problems Identified
Mexico	Solís Carcaño, R.	2009	<ul style="list-style-type: none"> <li>Poor material management due to improper development of software dealing with use of materials. (Solís Carcaño, 2009)</li> </ul>
Mexico	González, J. A.	2010	<ul style="list-style-type: none"> <li>Materials are not available opportunely.</li> <li>Material costs are higher than estimated. (González, 2010)</li> </ul>
United Kingdom	N. B. Kasim	2010	<ul style="list-style-type: none"> <li>Not enough storage space at the construction site. <ul style="list-style-type: none"> <li>Problems in the materials logistics.</li> </ul> </li> <li>Problems with the access to the site for supplying the materials.</li> <li>Operational limitations due to security issues.</li> <li>Problems with the congestion time in the loading area. (N Kasim &amp; Ern, 2010)</li> </ul>
Iran	Majrouhi Sardroud	2012	<ul style="list-style-type: none"> <li>Materials are required but not purchased; or else they are purchased, but not received or they do not arrive at the construction site on time.</li> <li>Materials are delivered in the wrong quantities or with the wrong characteristics.</li> <li>Inventory: stock data are not updated, thus generating shortages or overages.</li> <li>Storage: lack of enough space at the construction site; non-strategic location of the warehouse. (Majrouhi Sardroud, 2012)</li> </ul>
Malaysia	Yazdani Mehr and Omran	2013	<ul style="list-style-type: none"> <li>Difficulties to obtain the materials at the site where they are required in a timely manner. (Yazdani Mehr &amp; Omran, 2013)</li> </ul>
India	Madhavi and Varghese Mathew	2013	<ul style="list-style-type: none"> <li>Materials are inadequately obtained and stored and a lack of inventory control is perceived. (Madhavi &amp; Varghese Mathew, 2013)</li> </ul>
Myanmar	N. L. Phu	2014	<ul style="list-style-type: none"> <li>Unavailability of the necessary material.</li> <li>Material receipt does not comply with the specifications.</li> <li>Untimely receipt of the material (delivery ahead of time and delayed delivery)</li> <li>Not enough storage space and inefficient control thereof. <ul style="list-style-type: none"> <li>Material price fluctuations.</li> </ul> </li> <li>Lack of systematized control in the use of materials.</li> <li>Theft, robbery and vandalism. (Phu &amp; Aye Mya, 2014)</li> </ul>
Brazil	Francine Berghan Finger	2015	<ul style="list-style-type: none"> <li>Inadequate management of construction materials that entails low quality of the final product. (Berghan Finger, 2015)</li> </ul>
Pakistan	Anwar Zeb	2015	<ul style="list-style-type: none"> <li>Problems derived from storage: inadequate space at the construction site, which creates conflict between contractors and subcontractors and hinders the project productivity. (Zeb, 2015)</li> </ul>
United States	C. H. Caldas	2015	<ul style="list-style-type: none"> <li>The construction industry does not sufficiently invest to rely on satisfactory material management and control. (Caldas, 2015)</li> </ul>
Nigeria	B. Temitope Arijoleye	2016	<ul style="list-style-type: none"> <li>The works are not properly planned nor scheduled.</li> <li>Money flow to the contractors, vandalism and theft, and non-acceptance of the materials when they arrive at the site due to noncompliance with the specifications. (Arijoleye &amp; Akinradewo, 2016)</li> </ul>
India	Karoriya and Pandey	2018	<ul style="list-style-type: none"> <li>The construction industry has been facing problems related to the management and minimization of material waste, caused by the lack of competent planning and management. (Karoriya &amp; Pandey, 2018)</li> </ul>



Country	Author	Year	Problems Identified
France	Z. Dakhli	2018	<ul style="list-style-type: none"> <li>• Delay problems in the delivery of materials to the site, caused by traffic jams in urban areas, lack of space and logistic issues.</li> </ul> Problems regarding the storing facilities inside the construction site. (Dakhli & Lafhaj, 2018)
India	Sh. Raibole	2019	<ul style="list-style-type: none"> <li>• Organizational structure: problems such as no communication between the parties involved, non-conformity with the requirements, incomplete executive project.</li> <li>• Procurement: availability problems, delayed delivery, limitation and bad location of the storage areas and lack of communication between the persons involved.               <ul style="list-style-type: none"> <li>• Storage space.</li> <li>• Security problems: gradual stealing.</li> </ul> </li> </ul> Material availability in the market. (Raibole & Waghmare, 2019)
India	V. P. Vipin	2019	<ul style="list-style-type: none"> <li>• Material cost fluctuation.</li> <li>• Delayed delivery of materials.</li> <li>• Procurement of materials that does not fulfill the specified quality.</li> </ul> Risk management problems regarding the materials and the inventory. (Vipin & Rahima Shabeen, 2019)
India	R. Desai	2019	<ul style="list-style-type: none"> <li>• Storage remains the most important problem with regard to the construction material management. (Desai &amp; Patel, 2019)</li> </ul>
Chile	C. Santelices.	2019	<ul style="list-style-type: none"> <li>• Poor storage of materials.</li> <li>• Improperly manipulated materials.</li> <li>• (Santelices, 2019)</li> </ul>

## 7. Discussion

With the aim of achieving a competitive construction industry in the face of other sectors, it is essential to remain at the forefront in the implementation of new techniques and technologies for supporting the material management, regardless of the industry's business strata. However, it is not that simple to implement this in different business strata, because it is impossible to equate the facilities of medium and large business with those of micro and small business. The former rely on a more formal organizational structure, better human resource and greater capital investment, while the others have precarious organizational structures, less human resource and limited capital. Consequently, smaller construction companies suffer from underdevelopment in relation to the management of their materials.

It is noteworthy that the economic factor appears as one of the main barriers for adopting these new tools, but, on the other hand, the economic factor is also one of the greatest driving forces for establishing new methods of construction material management, because they allow optimizing the financial resources. Therefore, the economic capital plays the leading role in the optimization of a construction project by means of material management.

## 8. Conclusions

The construction industry has already consolidated the concept of material management, as well as its implicit processes. This is perceived in the definitions pointed out by different authors in different countries: they all agree with the fact that the main pillars for properly managing materials are: planning, procurement, storage and control. Nevertheless, despite knowing the concept and processes involved, it is clear that the construction industry has not been able to execute them to its full extent, because it faces different barriers that prevents it from achieving a satisfactory completion. At the international level, the predominant issues range from aspects regarding the logistics, organization, economics or investment to exogenous factors affecting the construction projects.

In the last decade, and for the sake of compensating these inconsistencies, the construction industry has started to bet on IT implementation and the use of new control techniques, which, although they do offer potential benefits, they are still in the development stage. The technologies such as radiofrequency identification, web-based



management models and data storage apps, as well as inventory control techniques such as ABC and EOQ analysis (which are not entirely new, but are gaining increasing importance) are the new tools used by construction companies, with the aim of overcoming the weak points in their material management processes.

There is no doubt that the construction material management has yet problems to solve, so it is crucial to emphasize the overcoming of these obstacles. First, in order to find a solution to any of the problems it is necessary to identify the causes generating them. Consequently, the present research leaves the door open for delving deeper into the factors originating these problems. This is feasible by undertaking case studies dealing with companies from the construction industry in their different strata, with the aim of detecting endogenous and exogenous causes that generate the existing problems when it comes to implement the material management within the construction companies.

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