جامعة الإسراء
Isra University

Materials Management on Construction Sites Using RFID Technique

Prepared by:

Osama Ali Ibrahem Ibrahem

Supervised by:

Dr. Ibrahim Farouq Varouqa

A Thesis

Submitted to Faculty of Engineering as a Partial Fulfillment of the Requirement for Master Degree in Engineering Project Management

January 2020

Committee Decision

This Thesis (**Materials Management on Construction Sites Using RFID Technique**)

Was Successfully Defended and Approved on 05 /01/2020

Examination Committee	**Signature**
Dr. Ibrahim Farouq Varouqa (Supervisor) Isra University	
Prof. Dr. Anas N. Al-Rabadi (Member) Isra University	
Prof. Dr. Sultan Abdulrahman Tarawneh (Member) Mutah University	

نموذج التفويض

انا اسامة علي ابراهيم، افوض جامعة الإسراء بتزويد نسخ من رسالتي للمكتبات او المؤسسات او الهيئات او الأشخاص عند طلبهم حسب التعليمات النافذة في الجامعة.

التوقيع:

التاريخ: ٢٠٢٠/١/٢٦

Isra University
Authorization Form

I'm Osama Ali Ibrahem, authorize Isra University to supply copies of my thesis to libraries, establishments or individuals on request, according to Isra University regulations.

Signature:

Date: ٢٠٢٠/١/٢٦

Dedication

This thesis is dedicated with all honor and gratitude to my beloved people who accompanied me on my long journey and they were the soldiers behind the scene.

To my father "Ali", my first supporter and motivator, whose effort and tiredness over the years have always inspired me to continue and thrive, no matter how suffering and struggling are; to make him proud and raise his name higher and higher. No words could ever explain the gratefulness and thankfulness for all that he gave me. A very heartfelt thank you dad.

To my beautiful mother, who without her warm words, encouragement and kindness this effort has never been accomplished. Thank you for getting me back in my weakness times and helping me regain my power when it was down. You taught me to believe in myself and my abilities and never let anything frustrate me whatsoever.

To brothers and sisters, very special thanks for being always there for me. I can't wait to see you gaining the upper hand in the battle of life.

To my friends and mates, thank you a lot for the precious time we spent together, the laughs and enjoyments and most importantly the trust you gave me that helped me refresh my soul and pushed me towards further success.

Acknowledgement

Special words of thanks and gratitude are due to my supervisor Dr. Ibrahim Farouq Varouqa, Faculty of Engineering at Isra University, for his profound support and consistent advice-giving. This thesis wouldn’t have been completed without his guidance by steering me in the right direction and encouraging me to unleash the best of what I have.

I would also like to thank Dr. Ibrahim A. Mohammad; whose doors were always open when I had questions or needed help during writing this thesis.

Besides, I want to thank the “Brain Tools” Company owned by Dr. Mohammad al-Natoor for supporting the idea and constructing the system of this thesis.

Finally, many thanks are extended to the respectful experts who participated in filling out the questionnaire and conducting personal interviews, as well as to all who contributed to making this work happen.

Table of Contents

List of Figures

List of Tables

Materials Management on Construction Sites Using RFID Technique

Prepared by

Osama Ali Ibrahem

Supervised by

Dr. Ibrahem Farouq Varouqa

Abstract

Traditional methods are still used in the world of material management, although they neither adequately meet site needs nor suits the overall management process. There is a consumption of labor's capacity, which affects productivity and is time-consuming in material reception and inspection. In addition, there is a difficulty in obtaining good inventory control and accurate information about items. While there are some large companies around the world that apply modern systems, the majority of companies do not pay much attention to this matter. Therefore, this research represents an attempt to develop a Radio Frequency Identification (RFID) system to solve the administrative problems facing material management construction sites and facilitate tasks for project managers. The methodology that has been adopted in this research included reviewing previous studies, a field survey and interviews with a number of site experts. Also, a questionnaire has been constructed to summarize the main problems of the management process. The results revealed that there is no application of modern systems, such as RFID. In addition, there are some problems facing material management on site, like time consumption, using excessive labor, poor inventory control, absence of databases and delay of receiving reports about material inspection.

The study recommends the application of Radio Frequency Identification (RFID) system, as using a very accurate system for managing materials on construction sites is essential to prevent problems that could affect the management process.

Keywords: Construction projects, Material management, RFID system, Tracking, Inventory control, Large and unique projects.

List of Abbreviations

Abbreviation	Meaning
RFID	Radio Frequency Identification
ICT	Information and Communication Technology
GPS	Global Positioning System
QAS	Quality Assurance System
BIM	Building Information Modeling
GIS	Geographic Information System
CMMS	Construction Material Management System
IC	Integrated Circuit
RF	Radio Frequency

1 Chapter One: Introduction

1.1 Background

Construction projects are somehow complex as they involve many participants, including clients, engineers, contractors, … etc. So, conflicts in different points of view are highly expected (Hujazzy, 2012). Therefore, the process of management should be perfectly organized. Material management is defined as the process of directing and controlling resources (Brownell, 2014). Another definition that has been suggested by the National Association of Purchasing Management states that *Material Management* is "an organizational concept in which a single manager has authority and responsibility for all activities principally concerned with the flow of materials into an organization". According to Arnold, and Champman (2011), these responsibilities include purchasing, planning, shipping, stock control, reception, and storing.

Material management has been defined by a business roundtable on modern management systems as the process of planning and controlling all operations related to quantity and quality of materials so that they are appropriately specified on time, obtained at affordable cost and are available when needed (Jusoh and Kasim, 2017).

Construction materials contribute between 50% and 60% of the overall budget of the project (Jusoh and Kasim, 2017). This percentage might reach to 70% in large and unique projects (Arijeloye and Akinradewo, 2016). This means that material management is a very important element in the project budget. So, planning at the beginning of a construction project must take into consideration the construction materials as a critical and essential issue. Also, poor material management has a negative affect on the overall construction time and quality. Material management aims to assure that the right materials are used in the right place and that appropriate warehouse is under perfect conditions and available whenever needed.

Phases of material management are multi-faceted. Therefore, they are susceptible to troubles in each phase. These phases include processes and functions, such as project planning, material take-off, purchasing, shipping, warehousing and material control. For example, receiving items not at the right time affects productivity, leads to loss and damage and so do poor material handling, placing materials not in the right place and deficiency in tracking items in and out of the stores.

Material management involves the three most important elements (cost, time, and quality), and these elements are always negatively affected when there is no real control of materials.

Most of recent research studies are focusing on the usage of Information and Communication Technology (ICT) tools and techniques for controlling and monitoring materials in order to make it easier to reduce losses by finding the best way for storing and handling materials. Information and Communication Technology (ICT) systems have played an effective role in managing and tracking inventories in contrast to traditional material management methods which are labor-intensive, time-depleting and erroneous. Using bar-coding technology in tracking materials or Radio Frequency Identification (RFID) and Global Positioning System (GPS) in material management will be the main concern of this thesis.

1.2 Research Problem

A fundamental problem in the management process is that there is insufficient importance given to construction materials on site, although they represent the bulk of the construction process. This is a problem more experienced by large projects than small ones. Conventional methods are most commonly used on sites, but these methods still have difficulties in controlling material management processes. There are late requests issued by the competent authorities related to the need for materials; i.e., there are requests which are unplanned in advance. This could impact storage space, delay time schedules, consume workers and stop work. Delay in receiving and inspecting materials as well as intensive labour consumption greatly influence productivity. There are also problems related to poor storage and distribution within warehouses and destruction or sometimes theft of materials. All these obstacles can not be controlled unless workers are continuously and accurately tracked. Drastic solutions based on integrated material management must be decided from the time materials arrive on the site until they are used. Therefore, the adoption of an integrated system using RFID technology leads to perform all administrative tasks to control materials through electronic technology, considering all the problems related to material management. This system will be discussed in detail later, along with all the accessories that can be used for better functionality.

1.3 Research Justification

Due to the importance of materials, specifically building materials, which account for about 70% of the overall budget of the construction project (Arijeloye and Akinradewo, 2016), which is a high percentage that pushes researchers to think that project managers are facing significant challenges. Therefore, this thesis will reconsider finding new technologies and strategies to compensate traditional methods. In addition, complexities facing construction projects especially huge ones will be addressed.

Justifications of this research can be summarized as follows:

1. Weaknesses in material management.
2. Shortage in smart systems for controlling and tracking materials.
3. Lack of achieving optimum flow of materials on construction sites, as a result of using traditional methods.

1.4 Research Hypotheses

The null (H_0) and the alternative hypotheses (Ha) of this research can be formulated as follows:

1. H_0: **A**. There are no factors that affect material management on site.

   B. There is no application of RFID systems on construction sites.
2. H_a: **A**. There are factors that affect material management on site.

   B. RFID systems are applied on construction sites.

1.5 Related Work

Many articles and studies have been conducted on material management. Jusoh and Kasim (2017) discussed how material management factors affect project performance. The factors obtained were as follows: s

1. Proper quality of materials which has impacts on (time, cost, and quality of performance).
2. Purchasing time.
3. Stock system and documentation which have affects on time and loss of materials.
4. Site of storage and site access which influence productivity and performance.
5. Appropriate material handling.

On the other hand, Kulkarni, Sharma and Hote (2017) investigated the factors affecting material management and recommended to use software in each phase of management. Also, attention must be paid to handling and storing of extra materials in order to prevent delay due to potential rejection of materials by the quality control team.

Furthermore, Arijeloye and Akinradewo (2016) explained the importance of material management in construction projects and indicated lack of good planning and scheduling. The study recommended that managers should improve their supervision on site and that materials should be adequately handled (handling process). Patel and Vyas (2011) studied material management on site by using a field survey and found that material managers should improve their control and tracking systems. In addition, it was found that an efficient Management Information System (MIS) is essentially required for effective management.

Besides, Kasim (2011) studied the effect of Information and Communications Technology (ICT) on material management and found out that with the availability of bar – coding technique and Radio Frequency Identification (RFID) system, the monitoring of material management will be impactful, thus improving material flow and tracking on construction sites.

Also, Kasim *et al.* (2012) focused on how essential ICT is for material management on site. They found out that lack in managing the site stock system will result in cost overruns, project delays and overall project performance deterioration.

Thus, there is a need for implementing ICT in construction projects. For example, using an RFID system in material tracking could simplify efficient material control in construction. Moreover, it is prospected to reduce overall costs, project delays and intensive labor to improve productivity.

1.6 Research Objectives

The research objectives and contributions can be stated as follows:

1. Identifying the problems and weaknesses in handling and transferring of materials on site.
2. Identifying the issues related to inspecting and storing materials as well as the tracking process.
3. Identifying the traditional methods of material management.
4. Improving the strategies of conventional material management methods.
5. Proposing an RFID system that regulates all movements of materials to assist in controlling and handling resources on construction sites.

1.7 Research Methodology

This research has two stages in terms of its methodology. The first is the theoretical stage represented by a comprehensive literature review. The second is the main survey that consists of identifying challenges facing project managers in managing materials on construction sites, taking into consideration strategies for advancing control and handling of materials by using the following tools:

1. Previous studies (secondary data);
2. Field survey: movement of materials on site and variables to be dealt with;
3. Questionnaire;
4. Personal Interviews with experts.

Figure (1-1) shows the process of methodology in detail.

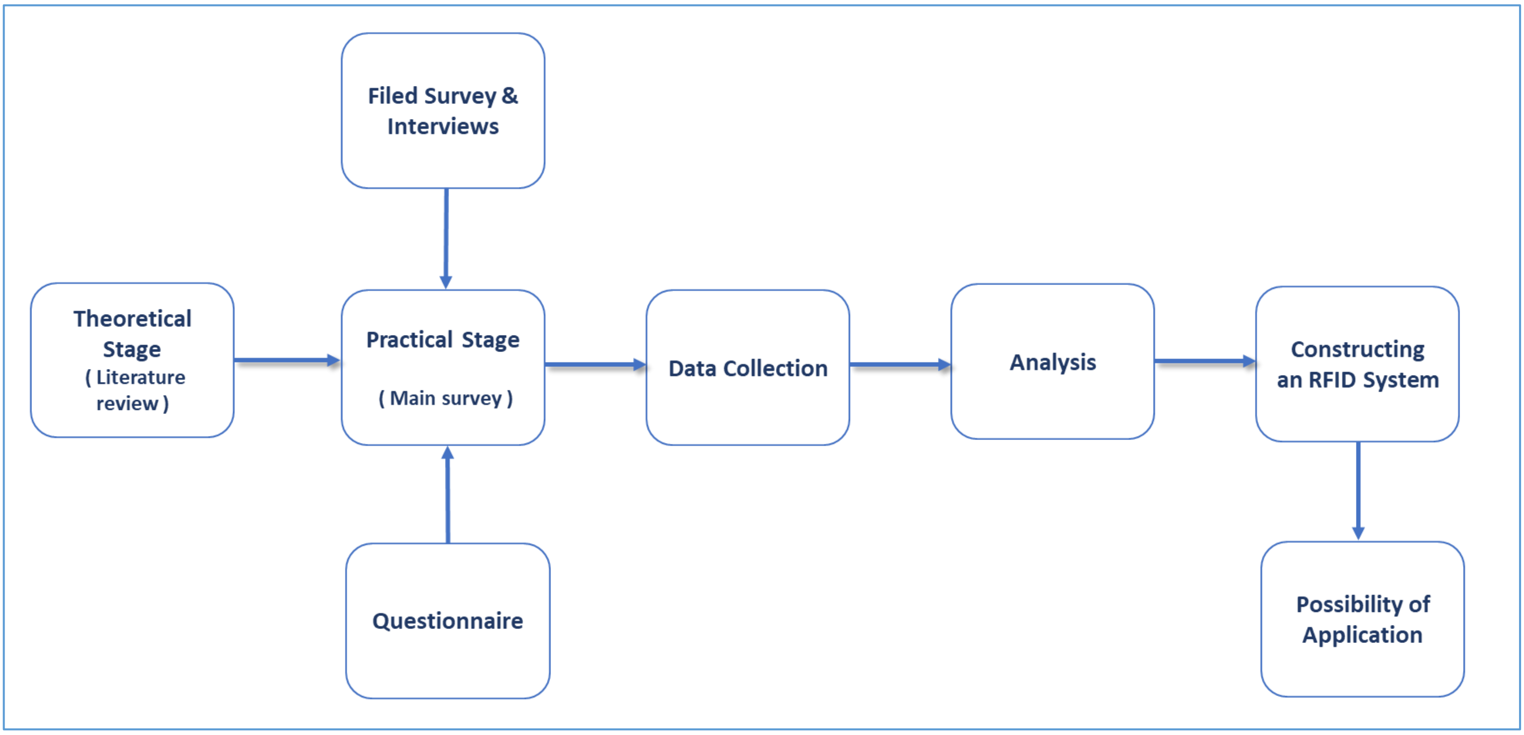


Figure 1-1: The Process of Research Methodology

1.8 Research Limitations

An RFID system will be constructed in this research, covering the whole material management process beginning with material reception and ending with warehousing. This process includes material inspection, handling and tracking. The proposed system provides all the necessary information in a very accurate manner.

1.9 Structure of Research

This research will be organized as follows:

1. **Chapter One**: includes background, research justifications, research hypotheses, research objectives, research methodology and research structure.
2. **Chapter Two**: provides the relevant previous studies divided into two categories: overview and RFID system.
3. **Chapter Three**: is concerned with managing of materials, including: classification, codification, reception, inspection and inventory control.

4. **Chapter Four**: presents the research methodology and data collection.
5. **Chapter Five**: data analysis and Radio Frequency Identification (RFID) system development.
6. **Chapter Six**: conclusions and recommendations, as well as suggestions for future Work.

2 Chapter Two: Literature Review

2.1 Introduction

Since the beginning of the technology revolution, the world is moving toward using Information and Communication Technology (ICT) in all specializations, as it provides easy and simple approaches focusing on time-saving and obtaining accurate and reliable results. This chapter sheds light on some previous studies that recommended using information technology in different scopes, specifically in operations of construction management, including the use of RFID (aiming at managing the movement of materials on construction sites). It also discusses the advantages of material management systems. The previous studies considered in this chapter give precious information and a comprehensive view that is reflected in the success of this research.

2.2 Overview of Previous Studies on Material Management

The beginnings of using technology in the world of material management were launched by Bell and Stukhart (1986) who discussed the essential elements in a material management system and how important it is to use computer systems irrespective of the complexity and cost of technology. They found out that a computer-based data system is essentially required to prevent shortages in materials, material surpluses, cash flow problems and labor delays. Poor management is a result of incorrect decisions. That’s what Dawood (1994) mentioned. He started that poor management contributes to late ordering and delivery of key materials thereby causing high wastage. The results revealed were as follows:

1. There are delays in the rejection of materials which cause obstacles in the progress of work.

2. Methods used to display material needs are not updated or not clearly understood, which causes shortages in materials.

Some authors, including Kasim, Anumba and Dainty (2005) argued that in fast-track projects, material purchase is in conjunction with the execution of construction activities; Therefore, material purchase definitely impacts the performance of projects. So, they suggested to use an ICT-based approach to manage materials in fast-track projects in order to reduce material waste and cost, in addition to increasing productivity.

On the other hand, Song *et al.*(2005) investigated recent advances in automated data collection technologies, particularly RFID and GPS, as well as the horizons of using such technologies on construction sites. Actually, only large companies are applying information technology in material management in order to control labor and material in construction projects, while Small and Medium Enterprises (SMEs) do not use information technology in project management.

Inventory management is one of the most important tasks that must be focused on in the process of material management. That is requires to know the availability of materials needed for the completion of construction activities. So, tracking materials is necessary. Studies conducted by Liwan, Kasim and Zainal (2013) in Malaysia, as well as by Kasim *et al.* (2012) requested project managers to identify the main problems facing them in the process of tracking materials and concluded that the material tracking process is based on manual methods and practices, including the use of paper documents which have many problems and disadvantages, such as losing materials.

Numerous companies and organizations suffer from poor profitability due to cost increase of raw materials, high labor consumption and costly fuels, which affect the cost of transporting materials to sites. Ogbadu (2009) argued that companies and organizations must take into consideration some factors to increase their profitability. These factors are as follows:

1. *Planning:* budgeting, value engineering, analysis and material specifications.
2. *Considerations of procurement*: determining quantities required, evaluation of suppliers, discussing and auditing contracts.
3. *Inventory control*: the responsibility of material manager; purchasing receipts, inspection, classification, codification and protecting materials from destruction and loss.
4. *Transporting materials.*
5. *Companies specialized in the production of raw materials*: production control and distribution.

On the other hand, Donyavi and Flanagan (2009) described how Small and Medium Enterprises (SMEs) can improve their performance in material management, through reducing cost and improving productivity by using information technology. Because of lack of workers, skills and finance, SMEs do not undertake detailed site activity planning. The study recommended using suitable and affordable technologies to improve material management on site, such as Internet, RFID and GPS.

One of the major problems in project implementation delays is poor management of materials and equipment. Patel and Vyas (2011) observed that there should be a material management team to realize coordination between site and organization, improve material tracking, and monitor the material management system.

On the other hand, Jusoh and Kasim (2017) discussed the effect of material management factors on project performance. The results of their study were as follows:

1. Appropriate quality materials have effects on (time, cost and quality performance).

2. Time of purchasing is a decisive factor which affects delays in project implementation.

3. Inventory system and documentation affect project time and loss of materials.

4. Site of storage and site access affect productivity.

5. Appropriate handling of materials positively affects project productivity.

Moreover, Kulkarni, *et al.* (2017) studied the factors affecting materials management and recommended using software in each phase of material management, as well as paying attention to handling and storing of extra materials for preventing delay due to rejection of materials by the quality control team.

Modern systems are not being applied in all companies. Sarowar, *et al.* (2018) studied the practices used in material management on site and figured out that only large firms use software for material management, while medium and small firms do not. This shows that the importance of material management has not yet been fully taken up by all firms and that there is still insufficient awareness in this area. Modern systems must be applied in all firms irrespective of firm size. Using traditional methods in material management can not be tolerated.

2.3 Radio Frequency Identification (RFID) Wireless System

A Radio Frequency Identification (RFID) wireless communication system depends on radio waves in the data transfer process. It is defined as a technique that depends on the use of electromagnetic or electrostatic coupling to identify objects by a unique code identification that the system can recognize and read. Information and details about items can be read from a specified rang *via* wireless connection. Items will be individually tracked from industrialization to consumption (Roberti, 2005). A chip (tag, also called Transponder) is connected through antenna waves to the reader, also called (Interrogator). The reader is also connected to a host terminal, also called (Middleware), which is a computer device to transfer information received by tags to be installed on. The RFID system can read several tags immediately and jointly without having to sort out the materials or set them apart. It is a good technique that is worth to be applied, because of its features that could serve in many sectors.

The beginnings of using RFID technology were in World War II (1940) by the US military Forces (Roberti, 2005), where this technology was used firstly to monitor and track aircraft and later on to distinguish between enemy and friendly aircraft. After about eight years, Harry Stockman has attributed this technology to himself as an inventor. In 1963, RF Harrington developed and formulated some new ideas and features visions that anticipated the important next stage of RFID systems. RFID systems were still in the development phase. Anti-theft devices were then constructed for commercial establishments using chips (Tags) in 1966.

Several years later, the reader (Interrogator System) was created on January 1973. In that year Charles Walton registered a patent for using the transponder in door locking without a key (Roberti, 2005). In 1975, Los Alamos published a research on the same technology, allowing it to be more popular and widely used by several companies in many service industries and in multiple areas. After two years, the first transmitting RFID license was issued. The first RFID payment system on roadways in Europe was used in 1987 and currently, such systems are widely used in many developed countries.

More than a thousand patents on RFID systems have been applied in many fields and institutions. Till this day, RFID technology has been used is still in a continuous development stage to serve even those specialties that have never been considered before. This is because of the accuracy of this technology as well as its ease of use. Since then, the use of this technique has become important in several areas and applications. This seeks to represent the profitability of applying RFID systems in material management on construction sites.

2.3.1 Components of RFID

This system is divided into three main components; the tag, reader and computer on which the program and database are installed Smiley, (2019)., in addition to the antenna that helps increase the network communication for providing wide-range waves for readers on construction sites.

2.3.1.1 Tags

Also called transponder, a tag is defined as an ambulant memory placed on a microchip, saving all dynamic detailed information about the item attached to the product (Smiley, 2019). It is read by a unique code, utilizing radio waves received by an antenna that then sends data to the reader. It can be stuck on products including:

1. Materials, apparel and baggage;
2. Vehicles;
3. Equipment;
4. Staff and laborers;
5. Computers, pets, … etc. This means that almost anything can be attached to and tracked by tags.

In addition, tags are obtainable in different shapes and sizes that suit the nature of the product for which they are used. They can be screw-shaped to be used with wooden items or credit card shaped for access applications. Besides, heavy tools like (heavy machinery, trucks, … etc.) use a rectangular tag with a specific dimension. Types of tags will be shown according to the storage space and radio frequency range used to cover working areas.

2.3.1.2 Passive Tags

A passive tag is consisting of two major components, which are the tag's antenna and the microchip or the integrated circuit (IC) Smiley, (2019). Passive tags have no internal power supply, which means that they are working according to the tag structure, specifically the tag's antenna part. The energy that moves from the antenna to the IC causes the chip to produce a signal that goes back to the Radio Frequency (RF) system. This process is called backscattering which refers to changes in the electromagnetic RF waves, which will then be discovered by the reader that detects and reads the information. Generally, passive tags are categorized into two main types: inlay tags and hard tags. Hard tags are sturdy and made of rubber, ceramic, metal or plastic with different sizes and shapes designed for a specific task, material and application.

Some kinds of RFID passive hard tags will be reviewed with their uses as follows:

1. Hight-temperature passive tags: these are designed to resist high temperature. They suit applications like healthcare and certain industries, as shown in Figure (2-1).

Figure 2-1: High Temperature Passive Tags (Smiley, 2019)

2. Rugged passive tags: some applications require tags that can resist environmental and external factors outdoors and can be stored in harsh conditions like snow, potential crushing under the wheels of vehicles and dust. Some rugged passive tags are shown in Figure (2-2).

Figure 2-2: Rugged Passive Tags (Smiley, 2019)

3. Size: tracking may be restricted by certain conditions; for example, tracking large or small goods. Here, the choice of tags depends on size.

4. Material: in case of tracking metal materials, metal-mount passive tags are required, as shown in Figure (2-3).

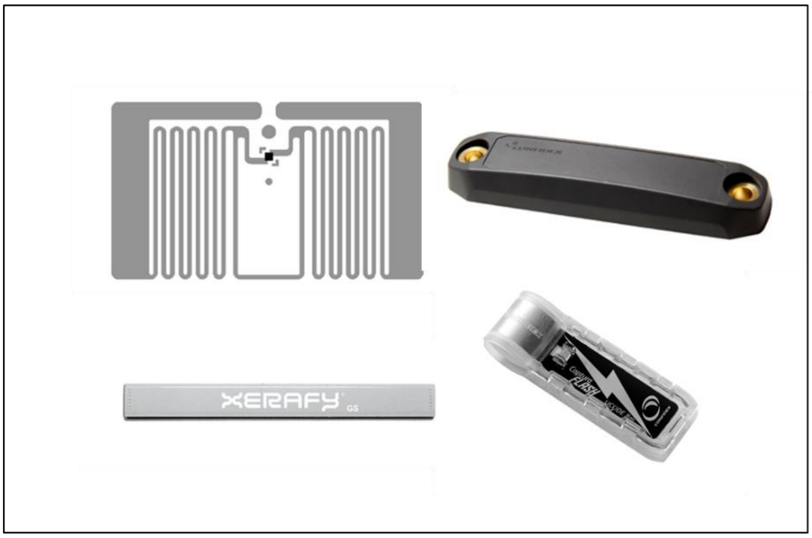


Figure 2-3: Metal-Mount Passive Tags (Smiley, 2019)

5. Passive RFID inlay tags: roll inlay passive tags are the cheapest RFID tags, but that does not mean that there is a relationship between price and performance. Roll inlay passive tags are shown in Figure (2-4).

Figure 2-4: Roll Inlays Passive Tags (Smiley, 2019)

6. Dry inlay passive tags: a dry inlay passive tag consists of a microchip and an antenna joined to a material named web, with no adhesive backing.

7. Wet inlay passive tags: a wet inlay passive tag consists of microchip and an antenna joined to a material with adhesive backing and can simply be glued to the item to be tracked, as shown in Figure (2-5).
8. Paper face tags: this type is used in applications that require numbers or logos to be visible on the item front to for easier identification, as shown in Figure (2-6).
9. Embeddable passive tags: some applications are associated with wear and tear problems. In this case, a coating can be applied to the tag, using materials such as epoxy. The embeddable type can fill in small cracks and fix problems.

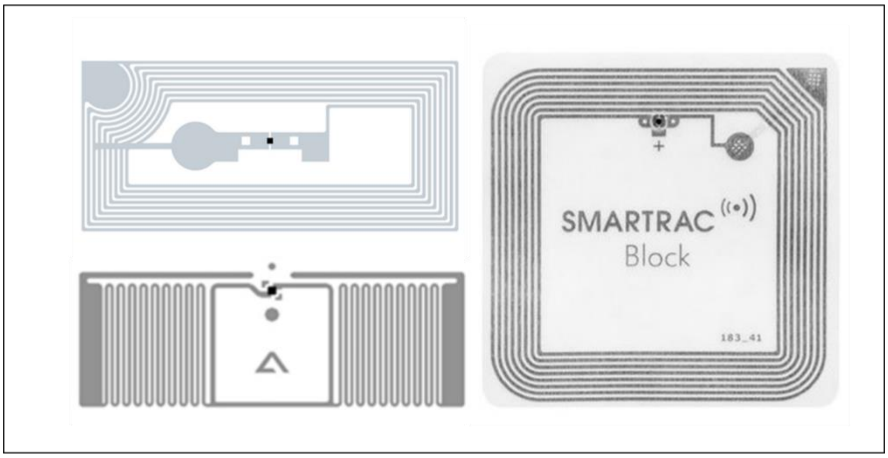


Figure 2-5: Wet Inlays Passive Tags (Smiley, 2019)

Figure 2-6: Paper Face Passive Tags (Smiley, 2019)

Frequency of RFID Passive Tags: Certainly not all passive tags run with the same frequency. There are three main frequency levels to be dealt with. Table (2-1) shows the various frequencies according to some terms.

Table 2-1: Different Frequencies of Passive RFID Tags (Smiley, 2019)

Terms	Low Frequency (LF)	High Frequency (HF)	Ultra-High Frequency (UHF)
Frequency	(125 – 134) kHz	13.56 MHz	(865 – 960) MHz
Wavelength	Extremely short	Medium	Extremely Long
Reading Range	(1 – 10) cm	1 up to 100 cm	(5 – 6) m Sometimes reaching 30 m
Application	Animals	Data Transfer, passport security	Tracking files (requiring more than one meter of reading range)

2.3.1.3 Active Tags

An active tag has three main components represented by the RFID reader also, called analyzer, the RFID antenna and the tag itself (Smiley, 2019). It is unlike a passive RFID tag, where an active tag has an internal power source which is a battery that usually lasts between three and five years. The battery can be helpful in enabling tags to have a very long reading range, as well as a large memory storage. In case of battery failure, the tag should be replaced. However, this is not the optimum solution; battery changing is better for saving costs. The size of an active tag is much larger than that of a passive tag, which is due to the large size of the battery and other internal ingredients. Active tags are commonly used for tracking high-value and worthy items, especially when these items are necessary for the success of a certain process. Types of active tags are shown below:

1. Beacons: a beacon sends a signal every three to five seconds without waiting for any signal issued by the reader. Beacons are widely used in oil and gas industries, construction and tracking applications. They have the potential to read information hundreds of meters away. But, this would be illogical due to the need to save the battery life. So, the reading range is reduced to a hundred meters only.
2. Transponders: these are highly efficient in serving the battery life when being out of the range of the reader. The most common areas in which transponders used are: secure access control and payment systems. Figure (2-7) shows an RFID active tag.

Figure 2-7: Active RFID Tag (Smiley, 2019)

Table (2-2) shows the features of active and passive tags according to size, price, flexibility, resistance to external conditions and lifetime.

Table 2-2: Features of RFID Tags (Smiley, 2019)

#	Passive	Active
1	Smaller size and lighter weight	Covering a scope of very long-range reading
2	Cheaper	Associated with modern technologies such as GPS
3	More flexible	Resistant to external conditions (Temperature, ice, dust, … etc.)
4	Long lifetime without battery	Providing accurate and efficient services

2.3.1.4 RFID Reader

Also known as (Interrogator) (Smiley, 2019), an RFID reader consists of an external scanning antenna that reads and records data *via* radio waves and then transfers it to the host terminal (computer). Reader types depend on the task performed, where a reader can be fixed at a fixed point such as (gate entrance and exit, warehouse or sale point) or handheld (portable type). Types vary in terms of readability range and use as well. According to Domdouzis, *et al.* (2007) an RFID reader can release radio waves that may reach a range of 60 m or more, considering battery power and frequency of radio waves used. Figure (2-8) shows different types of RFID reader.

Figure 2-8: Types of RFID Reader (Smiley, 2019)

2.3.1.5 Host Terminal

A host terminal is a computer device that stores a database for a specific organization. It is called (Middleware) (Smiley, 2019). Management software will be installed on it to input data received by the reader in order to be retrieved when requested. Several services can be provided by Middleware, such as filtering and improving data, monitoring and coordinating various readers in one single software.

2.3.2 Applications of RFID in Different Industries

The uses of radio frequency identification technology will be highlighted in this sub-section in order to identify the most important features of RFID systems, particularly those can be applied in the material management field. RFID applications will be reviewed, Tsai *et al.*(2008) utilized an RFID system in the process of managing nuclear materials, which was found to be very important in reducing direct handling of materials.

Recycling of waste materials is another RFID system application to identify recyclable materials. Abdoli (2009) classified a huge quantity of waste materials using an RFID system which was found to be very useful in this case.

In addition to scientific research and industrial management, RFID has an important role in healthcare area. Yao, *et al.* (2010) started that using an RFID system in tracking medical equipment to protect them from theft is very beneficial. It is also possible through using such as system to follow the patients themselves but this could be more complicated for the patients, because they think that this could violate their privacy. Another problem is that the frequency of the system may affect medical devices. Nevertheless, RFID systems still have the chance to be applied in this area to reduce medical errors, improve health services and have optimum access to patient’s information.

There are still uses of RFID system in many areas. RFID technology has been adopted in education. Dawood (2015) discussed how an RFID system works differently compared with conventional methods for inputting student’s information (name, number, …, etc.). Each student should have a smart card which contains a serial number and includes his/her information. So, this would be useful when taking attendance in classrooms without resorting to traditional methods like calling or signing on papers.

Transportation management systems, particularly smart parking, use RFID technology. Pala and Inanc (2007) investigated check-in and check-out of cars under RFID control. Tickets are no longer needed when using this smart system. Information of vehicles is inserted in a central database to facilitate identification of vehicles. For example, under normal conditions, if any vehicle checks in without RFID notification, it will not be able to check out. This software can be generalized and used to control parking areas in cities utilizing a tag reader.

Car anti-theft systems appley RFID technology according to Eze *et al.* (2018). Recently RFID system played a good role in this area as noted in previous studies. The system is based on integrated based on disabling the car’s engine to protect it from nonpermitted access. So, a secret code is required by the system if the engine is stopped to restart it.

According to Choi *et al.* (2015), an algorithm has been developed using RFID system in retail markets to meet customers' needs and manage stock. More clearly, in huge brands with hundreds of items the process becomes more complicated without sorting and locating items in order to identify what customers are looking for and where it is, in addition to identifying any shortage in these items. Due to rare and expensive jewelry pieces, an RFID system can be used for tracking jewelry. This kind of use needs intensive monitoring and tight security. So, RFID is suitable to have this process done (Wyld 2010).

There are still hundreds of fields related to the use of such smart systems, but it is difficult to harvest and collect them all. The applications mentioned above are preliminary indications of the importance and the intelligence of RFID technology.

2.3.3 Applications of RFID in Construction Projects

According to Lyu, *et.al* (2009) implemented a Quality Assurance System (QAS) to enhance the monitoring process, improve inventory management, facilitate decision making and reduce labor cost. Also, Wang (2008) explained that material inspection needs intensive labor for collecting, retrieving and analyzing information. However, modern systems such as RFID can help perform these missions more less time and cost.

RFID is getting into various fields, such as security, logistics, supply chain management, scientific research, … etc. According to Huang *et.al* (2011), RFID systems have not been widely included in construction projects. Therefore, it's mandatory to use an RFID system in equipment and material management to reduce time and cost and improving quality and safety at the same time.

The use of smart systems, such as RFID, in material tracking makes it easier to control and manage materials on site. Besides, such systems can help reduce problems of project delays, decrease working hours and improve labor productivity Kasim (2011) .

Traditional management of construction materials is still used in construction projects. It takes extra time, intensive labor and provides errors (Sardroud, 2012) and Costin *et al.* (2012). So, the time has come to use modern technological approaches, such as RFID and GPS. These approaches can facilitate work, minimize cost and maximize productivity. In addition, such systems are fully automatic so that they will provide high accuracy in data collection and material tracking.

An RFID system has been applied in water supply projects Ren *et al.(* 2011) gave some tips about it, reviewing its advantages as follows:

1. Maintaining all major materials.
2. Recording items received on site.
3. Analyzing reports on existing materials to prevent any shortage in material storage.
4. Tracking the locations of materials to ensure that quantities have been updated.

Improvements, such as long-range distance between reader and tags, should be adopted as a technical enhancement that will be very useful in the material management process. Construction projects should take into consideration the coding and flow of materials (e.g. building and infrastructure projects). Interference problems between different project management systems must be taken into account to ensure that there is no interference between input and output data of these systems.

Actually, when smart systems are integrated with each other, the results will be very good in terms of performance and accuracy, Valero and Adán (2016) mentioned uses of RFID with other systems, like RFID with total station, laser scanning, GPS/GIS and BIM (Building Information Modeling).

Conventional practices of material management are still implemented in construction projects and it's time to use RFID instead (Kasim *et al.* 2019). The results of this research showed a number of serious challenges faced by traditional material management methods which can be summarized as follows:

1. Time consumption;

2. Shortage in information;

3. Intensive labor resulting in more errors;

4. Paper-based usage.

5. Undelivered materials.

Recently, Ren and Li (2018) proposed an RFID system with the possibility of application in building construction projects, as well as a future overview for enhancing the system. But, before that, a detailed analysis of material management is needed. This analysis includes: (location of stores, quantities and criteria needed). This research is concentrated on the way how an RFID system is constructed, showing its components and how the whole material management process should take place, from receiving materials, until having them stored. It is worth mentioning that traditional material management methods include seven steps in sequence, while an RFID system can reduce them to four.

2.4 Summary

The most important key points mentioned in the literature review will be discussed for taking them into account in the methodology of this research.

1. From previous studies, it is concluded that the most important problems of material movement on site are represented in late purchasing, late delivery, bad storing, monitoring and tracking. These problems are attributed to huge quantities of items that can not be controlled easily by labor on site.
2. Most of previous research studies indicated that conventical material management methods are used in material management on construction sites nowadays.
3. It is recommended to incorporate new technologies in material management, such as RFID.
4. Information and Communication Technology (ICT) is used in large firms only.
5. There are many uses of RFID systems in different areas, but those systems are still not applied in construction projects.
6. Features of RFID system can be used and enhanced in order to develop material management systems.
7. The main benefits of using an RFID system are reducing time, decreasing errors and improving productivity.
8. There is an increasing chance to construct RFID system according to recently conducted studies and develop it to serve construction projects.

3 Chapter Three: Material Management and Movement

3.1 General

Materials are the core of the construction process irrespective of the type of construction. They account for a percentage of about 70% of the project cost (Arijeloye and Akinradewo, 2016). This shows that material management is an essential element in the construction process. This valid for most industries and not just for construction.

The concept of material management is defined as an integrated process that starts from the request of materials until their reception, flow on-site, storage and use (Bailey and Farmer, 2009). However, there are still several explanations and definitions that explain the administrative mechanism for material management more precisely. According to Dean Ammer (1991), it is the process of achieving the objectives of any organization by requesting materials form suppliers until they are incorporated and used. Plemmons et al. (1995) defined it as a comprehensive plan for all the activities of the project in order to ensure the appropirate quality and quantity of the materials.

However, there are still a number of problems like, deficiency in control, budget overrun, delays in schedule, poor performance of work, shortages and losses in materials, poor material handling and less productivity. Material management is defined as the process of planning, purchasing, shipping, receiving, inspecting, handling and storing of materials. There is a thoughtful concept in each phase that should be taken into consideration to get the operation successful. But, this is sometimes difficult due to the disability to guarantee that all stages will follow the optimum requirements. Therefore, this research is seeking to implement a system based on controlling these stages to obtain the best results that can develop the concept of material management.

In all cases, material management must be accomplished accurately to say that the administrative process has been realized. First of all, staff should recognize and understand the importance of materials, ensure the right quality and quantity of materials required, receive them at the right time, storing them in the right places and make them available when needed. Then, tracking will be the fundamental stage after fulfilling the pre-completion requirements to obtain the optimum flow of materials on site. This section will show the observations and functions approved in the material management field. The management phases will be discussed, including purchasing, inspecting and checking receipts to ensure that the quality and quantity of materials required are right. These phases also include the processes of material classification, codification and placing them in warehouses for later use.

3.1.1 Objectives of Material Management

Material management has several objectives that must be clarified. Based on Patel and Vyas (2011) and Kulkarni *et al.* (2017), these objectives can be listed as follows:

1. Effective planning of materials and identifying quantities required;
2. Setting time schedule plan, so that the purchased materials arrive at the right time;
3. Finding good and affordable suppliers;
4. Purchasing or ordering;
5. Shipping and receiving;
6. Inspection to ensure that the received materials conform to the required specifications;
7. Quality assurance;
8. Storing and stock control;

9. Process of handling;
10. Distribution of materials;
11. Wastage control and setting a plan to dispose of excess materials, whether by being sold or damaged;
12. Ensuring the use of materials according to the distribution plan;
13. Improving managerial efficiency;
14. Saving time;
15. Minimizing the overall budget;
16. Achieving economic competencies.

3.1.2 Main Issues of Construction Material Management

There are some major problems and challenges facing material management on construction sites. According to Ahmed (2017) and Sardroud (2012), these problems and challenges are:

1. Materials required but not purchased;
2. Materials purchased but haven't been received yet;
3. Materials received with wrong quality;
4. Materials received at the wrong time;
5. Material specifications that do not correspond to those in the purchase order;
6. Absence of information about the status of orders;
7. Shortage in updated information regarding the arrival of materials on site;
8. Deficiency in up-to-date information regarding site stock;
9. Lack or excess of materials;
10. The dimensions of storage areas being not satisfactory to contain materials;
11. Searching for materials and material tracking being time-consuming;

12. Project delays due to lack of timely availability of materials, which, in turn, impede project productivity;
13. Penalties imposed on contractors in contracts in cases of delay in delivery;
14. Increase in project costs as a result of payment of workers' wages during the interruptions in the work;
15. The problems related to agreed payments by clients due to non-conforming with the planned time schedule as a result of lack of materials on site.

3.1.3 Factors Affecting Material Management

There are some economic factors that have a significant impact on the material management process. These factors will be outlined below with the relevant legal issues and other considerations, according to Kulkarni *et al.* (2017)

1. Type of economic system; whether being a free market system or a planned economic system, as well as the possibility of importing materials from abroad;
2. Procedures adopted by the state in terms of procurement from abroad and custom control;
3. Import taxes and duty-free lists;
4. Restrictions on imported materials, noting that some countries rely on the use of local materials only;
5. Economic stability in the country and the inflation of price rates;
6. Technologies used in producing and using materials, both locally and globally;
7. The ease of delivery of items required to the sites by the transportation system available. This point is related to local and imported materials.

3.2 Construction Materials Management System (CMMS)

Generally, CMMS is one of the basic parts of the construction management system (Janin, 2013). This system includes the management related to all activities of the flow of construction materials, in terms of requesting materials from, receiving them and putting them in the final destination. This is actually what has been explained in the general concept of material management. There are two sub-systems of a CMMS the supply system and the utilization system. Figure (3-1) shows the details of the CMMS, which include the requirements (input) referred with regard to purchasing materials, as well as the relevant operations and the final destination related to the material reception process.

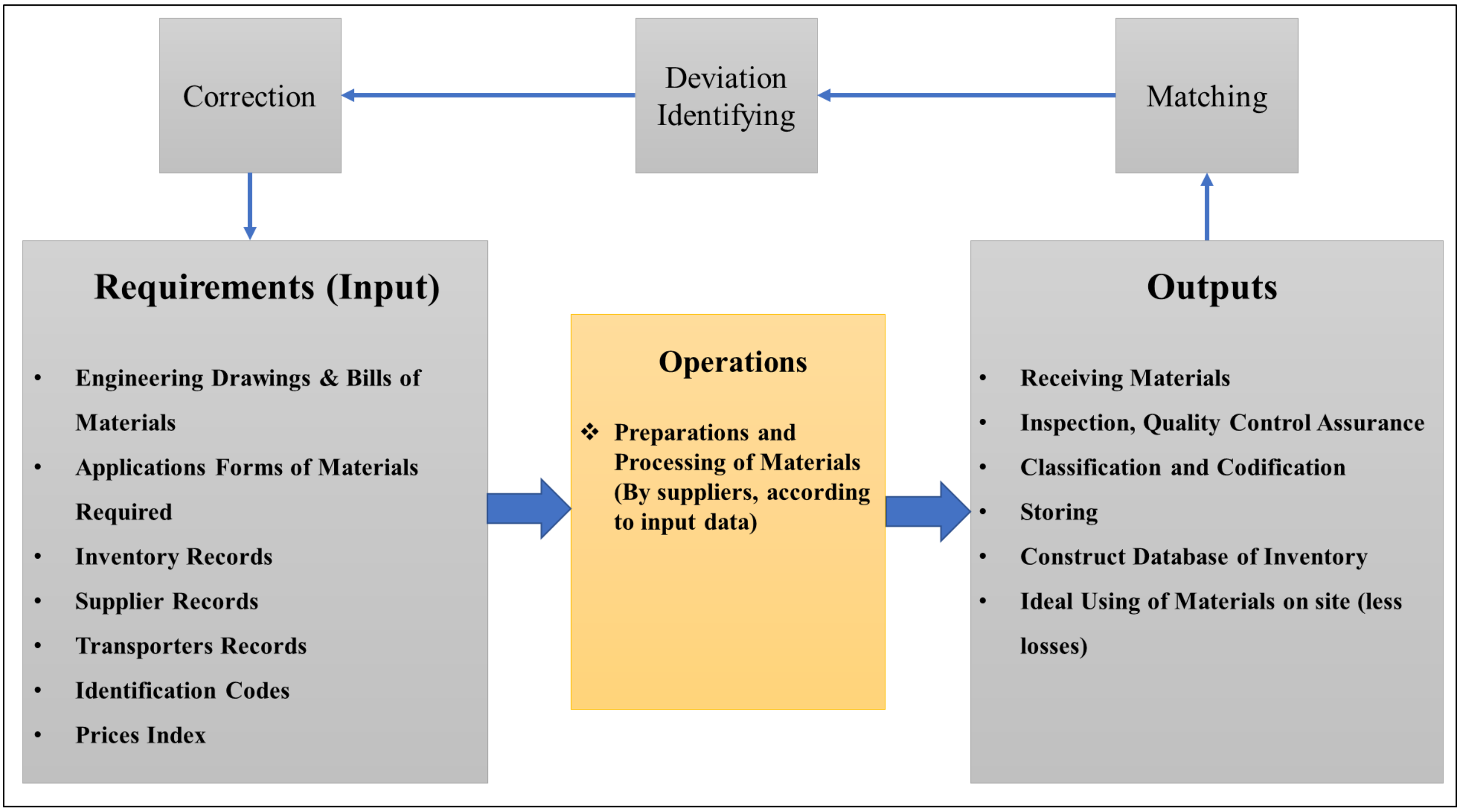


Figure 3-1: Construction Materials Management System (Janin, 2013)

3.2.1 Supply System

Supply system is a sub-system of CMMS (Janin, 2013), specialized in the processes related to the construction materials required. It is responsible for planning and controlling activities included in the construction project from the supplier to the site.

3.2.2 Utilization System

It is a sub-system of CMMS Janin, (2013), specialized of planning, controlling, receiving, inspecting, and storing materials on site, followed by tracking materials to their final destination. However, effective material management can not be divided easily, because of the interconnection between the stages related to the whole process. But, theoretically, such a division to facilitate understanding the proposed system. Figure (3-2) describes the process of material management on construction sites.

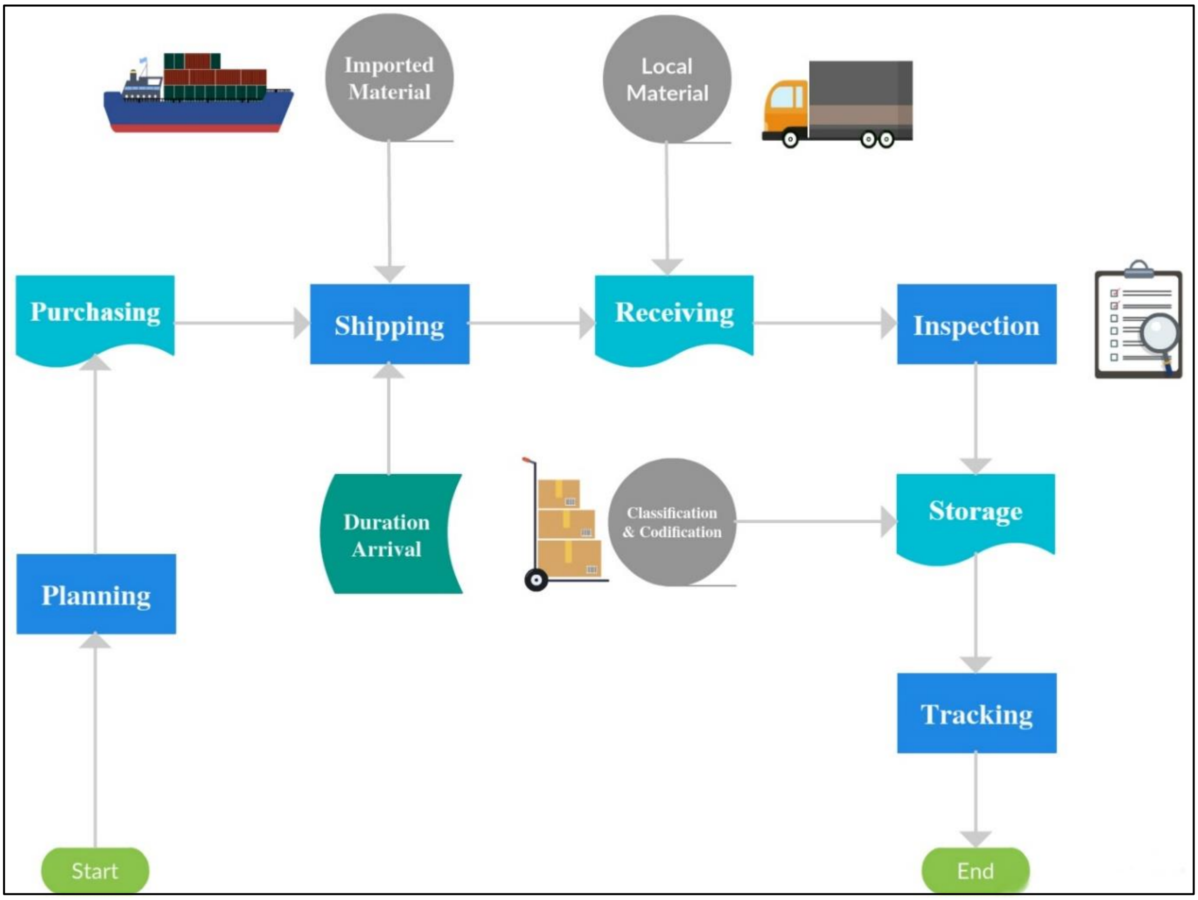


Figure 3-2: The Process of Material Management on Construction Sites

3.3 Classification of Materials

Classification refers to the division and distribution of materials under specific group Son *et al.* (2014), aiming to ensure a good and efficient stock control. Materials are separated and each group is placed in the right location in the store under the assumption that the warehouse consists of separate cells or sections. Classification is one of the most important tasks that must be carried out before making a purchase order. However, at present, with the development of modern systems, such as the RFID system, classification and codification of materials have become easier, because there is a tag chip that has a specific code equipped with the list of ordered materials to facilitate the processes of reception, checking and distribution.

The need for classification, identification and even codification of materials is due to the fact that large companies have large numbers and quantities of items. These items must be organized for easy handling. This is the responsibility of the material manager. Therefore, for effective inventory control, classification must be carried out accurately and correctly in order to avoid any problems. So, this research will discuss the most effective methods of material classification depending on importance, type, shape, supply source, being a local or imported material, … etc.

The next sub-section explains the classification of materials according to importance.

3.3.1 The ABC Method

This method classifies items into three categories (A, B and C) according to their importance, where A refers to the most important materials and C refers to the least important ones. Also, these classes are divided based on amount and price (Arnold, *et al.*

2007). Table (3-1) shows the annual consumption and the total percentage of inventory for each group, while Table (3-2) describes the considerations that must be taken into account for each set.

Table 3-1: Classifications of Materials "A B C" Group

Set	**Annual Consumption (%)**	**Total Inventory (%)**
A Vital	80	20
B Vital	15-20	30
C Vital	5	50

Table 3-2: ABC Purchase and Stores Management Considerations (Arnold *et al.*, 2007)

Term	**Set "A"**	**Set "B"**	**Set "C"**
Control	Strict	Moderate	Low
Safety Stock	No Safety Stock	Low	High
Ordering	Frequent	Once in Three Weeks	Once in Six Months
Reports	Weekly	Monthly	Quarterly
Analysis Value	Strict	Moderate	Minimum
Planning	Carefully	Estimated by Previous Data	Rough
Waste and Excess	Minimization	Quarterly Control	Annual Review
Lead Time	Max. Efforts	Moderate	Minimum

3.3.2 Classification According to Cost Accounting

This type of classification is based on the cost of each term of the contract, where there are direct and indirect material contracts.

3.3.2.1 Direct Materials

These are the basic materials required in the construction process, which are directly included in the civil work's list of materials, such as reinforcing steel, cement, sand, … etc., as well as any other materials that are noted in the terms of direct materials in the contract, also apparent in the engineering drawings (Janin, 2013) .

3.3.2.2 Indirect Materials

Unlike direct materials, indirect materials do not appear in the engineering drawings. A hidden material is an auxiliary material that is integrated with the direct ones (Janin, 2013). An example is wood frames for concrete casting. Many materials can be considered direct or indirect depending on the agreements made in the contract. To clarify more, steel wires used in the connection of steel bars are considered indirect materials.

3.3.3 Classification According to Supply Source

This type of classification is divided into three types based on how a material can be obtained (Janin, 2013).

3.3.3.1 Local Materials

A local material is simply expressed as a material that can be obtained locally from the public or private sector. Local materials are widely available.

3.3.3.2 Imported Materials

These are materials imported from other countries because of their unavailability locally, in terms of quantities or characteristics.

3.3.3.3 Special Materials

Special materials are those with special specifications and certain quantities, either imported or locally available.

3.3.4 Classification According to Material Movement

Classification here depends on the movement of materials and their demand for building construction (Janin, 2013). There may be a surplus of materials because of issues in the planning process at the beginning of calculating the quantities of materials required or due to delay in reception, where such materials have been dispensed of and replaced according to the relevant terms in the contract.

3.3.4.1 Fast Moving Materials

These materials are frequently used, daily needed and constantly requested.

3.3.4.2 Slow Moving Materials

These materials are ordered intermittently over varying periods of time, which means that these materials are not continuously used.

3.3.4.3 Non-moving Materials

These materials are surplus materials, which are rarely used requested over very divergent periods.

3.3.5 Classification According to Work Nature

One of the most commonly used classification methods depends on sorting materials based on the nature of work in the construction process (Janin, 2013). Materials grouped based on such classification are reviewed below.

3.3.5.1 Civil Materials

These include materials that are used to build the structure of a construction, like concrete, steel and sand. These materials also include finishing items, such as false ceilings, sandwich panels and wall varnish. However, sometimes, finishing materials are categorized under the architectural group.

3.3.5.2 Electrical Materials

These are materials used in electrical works; for example, electrical installations, lighting and electrical power systems including fire alarm and telecommunication systems.

3.3.5.3 Plumbing Materials

Plumping materials are those used in sanitary installations, sewerage systems and drinking water systems. Sometimes, fire extinguishing systems are added, but they are used with materials related to mechanical works.

3.3.5.4 Mechanical Materials

These materials are used in air conditioning and refrigeration systems. Fire extinguishing systems may be included in this group or integrated into the plumbing group, because they are identical in nature.

3.3.5.5 Temporary Materials

This type refers to tools that are used in the implementation of permanent works. These tools are removed after the completion of work and include steel and stone cutting tools, wooden frames for concrete casting and many more other necessary equipment.

3.3.6 Benefits of Material Classification

After identifying the most important classification groups of construction materials, it is necessary to clarify the importance and benefits of classification of materials (Son *et al.*, 2014).

1. Ideal use of storage space in warehouses by placing similar materials under a single group;
2. Easy identification of and quick access to materials by the inventory staff with the help of the unique coding number;
3. Classification according to the importance and value, which helps clarify how essential it is for the different material groups to be controlled and carefully tracked. This applied for other classification types to know well how to handle materials cautiously;
4. Avoiding storing surplus materials that are not needed, together with needed materials;
5. Small companies or enterprises may not notice these benefits which are more obvious in large ones. Therefore, we encourage all institutions to take these advantages into account.

3.4 Material Codification (Material Coding System)

Codification is an integral and complementary part of classification. Before technology evolvement and multiplicity of materials, the coding of products was done by description. Nowadays, codification has become more complicated in light of increasing types of materials. Therefore, it's necessary to find out new accurate methods for coding materials. Here, these methods will be discussed, along with clarifying the importance of material coding.

Coding is defined as the process of assigning a unique symbol using numbers and letters to each of the items (Vrat, 2014). This symbol should represent the material group, sub-group, type, size and shape. Symbols may be based on the nature or purpose of goods. They are very useful in tracking and checking materials in terms of damage, loss and theft. Codification will simplify inventory control to identify shortage and inform the procurement section.

3.4.1 Benefits of Codification

There are several benefits of material codification, which will be reviewed in the following points (Vrat, 2014).

1. Assorting similar items under a single group and ensuring confidentiality of materials;
2. Prevention of duplication and equivocation, as well as facilitating material recognition;
3. Effective inventory control;
4. Easy access to materials by clear and simple symbols;
5. Using a substitute of phrases that need more length to describe;

6. Effective handling;
7. The possibility of cost reduction, which is considered as technical matter;
8. Proving that the institution is working clearly and systematically in the material management process.

3.4.2 Considerations of Good Coding

There are major considerations for good coding, to prevent material losses and ensure easy access to materials (Vrat, 2014).

1. Numbers, letters or both must be as short as possible;
2. The coding system must be logical and appropriate for its purpose;
3. The coding system must be highly flexible to accept any future changes;
4. Each item must have a unique code that represents it and is different from codes of other items;
5. The code should be chosen carefully, especially in a system with mixable numbers and letters; for example, letter (O) and number (0) zero. This may confuse the person trying to read the code and record information about the material;
6. The code structure must be easy and understandable for various users;
7. Length of code layout must be equal; uses in this way (002 –500) are preferred over that way (2 -500).

3.4.3 Types of Codification Systems

Here three types of codification that are most commonly used in material management will be discussed.

3.4.3.1 Alphabetical Coding

This method is based on letters that are used for the codification of materials (Janin, 2013). For example, (CI = Civil Material, EL = Electrical Materials, PC = Portland Cement, CW = Copper Wire, … etc.). Full symbols that refer to materials and their working areas are shown in Table (3-3).

Table 3-3: Alphabetic Codification Symbols

Item	Group	Sub-Group	Code
Portland Cement	CI	PC	CI-PC
Copper Wire	EL	CW	EL-CW
Sewage System	PL	SS	PL-SS
Air Condition	ME	AC	ME-AC
Wood Frame	TE	WF	TE-WF

3.4.3.2 Numerical Coding

This method is based on numbers that are assigned to items, represent material class, type and specifications (Janin, 2013). To illustrate this method, some concepts will be clarified: in case that the company has (less than ten) major classes of materials, then one digit is needed for this case. For example, Civil Materials = 1, Electrical Materials = 2, …, etc. If sub-classes for each class are (less than ten) as well, then one digit is also needed, such as Cement = 8, Steel = 9, …, etc. If the items for each sub-class are (less than one hundred), then two digits are needed, such as Portland Cement = 04 and Ordinary Cement = 05. Finally, the whole symbol will be, for example, Ordinary Cement = 1805 and Portland Cement = 1804. This type of coding is more flexible and simpler than other coding types due to the possibility of inserting several digits. So, it is recommended to use numerical coding, especially when codification data is to be computerized. Numerical coding is shown in Table (3-4).

Table 3-4: Numerical Codification Symbols

Class	Digit	Sub-class	Digit	Sub-Sub-class	Digit	Code
Civil Material	1	Cement	5	Ordinary Cement	08	1508
Electrical Material	2	Fire Alarm System	6	Control Panel	09	2609
Mechanical Material	3	Air Condition	7	Compressor	10	3710

3.4.3.3 Combined (Alphabetical and Numerical) Coding

It combines the two previous methods using codes consisting of letters and numbers (Janin, 2013). Letters and numbers are assigned according to class and sub-class in a manner that serves the codification process. There are still several ways of coding materials, but this research has discussed the most important and popular ones that are used in construction material coding.

3.5 Material Movement

The optimum flow of materials on construction sites is debated in this section. The concept of material movement begins from reception, handling, storage and tracking materials into and out of the warehouse. Materials are purchased and received from suppliers, then request records are examined and matched to ascertain whether they meet the specifications and quantities required or not, while a report by the procurement department is prepared. The inspection stage will be followed by the material testing stage. Before getting to know all these details, purchasing materials will be defined.

3.5.1 Purchasing Materials

Purchasing can be easily defined as requesting the materials required to implement the project activities from their suppliers Janin, (2013), that can be achieved by engineering drawings and bills of quantities, which consist of:

1. Specifications, such as the quality of material;
2. Dimensions, like weight and volume;
3. Estimate of quantities for each activity;
4. Approximate pricing of quantities and activities.

A purchase request is basically form by which material quantities needed are requested in coordination with the department responsible.

3.5.1.1 Traveling Requisition

For repeated use, the demand for this type of requisition is continuous. It is usually used in manufacturing organizations, where storage levels are known and materials are directly requested from the stock.

3.5.1.2 Standard Requisition

It is a standard purchase requisition approved by an initiation. There is no standard data for this requisition type, but most of standard requisition forms contain the following points:

1. Request number and date;
2. Project title;
3. Account number and cost;
4. Work activity;
5. Quantities and specifications;

6. Classes and symbols of materials;
7. Delivery time.

3.5.2 Receiving of Materials

Receiving and examining represent the beginning of entry of items into the warehouse (Training, 2012) . Upon obtaining the, reception should be temporary until the inspection has passed and the required items have met the specifications needed. In addition, there are documents containing the preset date of receipt which is to be compared with the actual receipt date. If both dates do not match, fines will be imposed on the supplier. A temporary reception means that the supplier's responsibility has not ended yet. Each company sets its policies in receiving and examining materials according to the nature of its work and compliance with it. There are different forms of reception depending on the source of materials (supplier), whether the materials are bought from abroad (imported materials) or local materials. Types of reception are discussed below.

3.5.2.1 Partial Reception

Partial reception means receiving materials in the form of batches Training, (2012), according to the dates of delivery specified in the contract with the supplier. This agreement may be made from the beginning or during the period of the project, depending on emergency circumstances. The reasons for using this method can be lack of sufficient storage space or some problems that occurred in the implementation phase of the project. The receipt documents all belong to the materials actually received only, because there are still items that have not yet been delivered to the beneficiary. Financial payments shall be made by approval between supplier and purchaser.

3.5.2.2 Complete Reception

In this method, materials will be received in one batch Training, (2012). It is the most common method in the case of imported materials, due to reduction of customs and transportation costs.

3.5.2.3 Temporary and Final Reception

Materials that have arrived at the site are received temporarily Training, (2012); i.e., they remain within the supplier’s responsibility until they are tested and approved. Any materials received are not entered into the computer database, before they succeed in the inspection. Finally, when the specifications are verified, the receipt will be final. Materials are received temporarily in the following cases:

1. When taking samples of materials to be tested;
2. Purchasing equipment that need to be equipped and installed before use;
3. When the inspection process is required to go through more than one committee to issue final examination documents;
4. Any other administrative and technical problems requiring temporary reception.

3.5.2.4 Reception Procedure

Materials are received from the supplier, which is supposed to be on time; i.e. on the date mentioned in the procurement order Training, (2012). Relevant staff members receive materials, considering the following procedure:

1. Matching the descriptions of the materials with those stated in the procurement order, shipping documents and supplier invoices in terms of quantity, weight and size;
2. Matching in terms of overall appearance (good, bad, unrecognized);

3. Ensuring that there is sufficient time before the expiry of materials;
4. Issuing a provisional notice, which means that the materials are still in the testing stage;
5. Date of reception is stated as (day/month/year) to determine the fines due in case of delayed supply;
6. Issuing a final notice after the completion of inspection (final reception);
7. All internal measures should be taken into account; for example, sending copies of final receipt note to the financial department in order to pay the amount due to the supplier.

3.5.2.5 General Guidance on Reception

Some important recommendations for the best way of receiving and inspecting materials (Training, 2012) are shown as follows:

1. The competent manager has to inform the inspection committee before the date of material supply;
2. Supplier's agent or representatives should be notified of the data of testing. If they do not respond, the inspection procedure will be carried out and the committee's decision will be final;
3. The committee must clearly apply the principles of acceptance, where there is no confirmation of receipt of materials that do not match the requirements in any way;
4. In terms of materials rejected, the supplier should be notified to get them back during a period of (7 – 10) days;
5. Financial amount due depend on the type of receipt (partial or complete).

3.5.3 Inspection of Materials

As mentioned previously, inspection (test or examination, … etc.), aims at confirming the conformance of the received materials to the required specifications and ingredients of materials (Training, 2012). Whatever the confidence level of the supplier is, testing of materials must be carried out to avoid obstacles or troubles. Also, the dissatisfaction with any part belongs to the management chain. Some key points should be clarified to understand potential mistakes in the received materials. These points are stated below.

1. Material manufacturing errors due to uneven labor or machine efficiency;
2. Insufficient understanding of requested specifications by the supplier, resulting in delivering non-conforming materials;
3. Lack of effective control on the manufacturing process by some suppliers;

On the other hand, the examination benefits gained by the beneficiary (purchaser) as follows:

1. Avoiding getting materials that are not useful, which will be considered as a material wastage, in addition to preventing causing damage and problems to the construction later. All of these issues represent a financial loss to the organization;
2. When the supplier comprehends that his products will be subjected to inspection by the purchaser, this will motivate him to develop materials with good quality, in order that the purchaser continues ordering for the same supplier in the future.

3.5.3.1 Types of Inspection

Several types and forms of inspection will be debated in this sub-section. Inspection is carried out by within the same institution that ordered the materials, in addition to another inspection outside. The latter will be in two forms; the first is accomplished at the supply area, while the second is carried out by sending the materials to the competent authorities to get tested.

A. **Inspection Inside the Company:** In standard cases, materials are tested at the supply or storage area (Training, 2012). Factors that encourage and stimulate inspection in the same firm that purchased the materials (purchaser) are:
   1. Specialized department working for the same organization, meaning that a successful firm has to have specialists in this field;
   2. If the inspection is only concerned with checking a trademark or a specific brand name or ascertaining that product boxes are not damaged or harmed, it is sufficient to authorize the storekeeper to inspect the materials;
   3. Providing professional crew and special material testing expertise facilitates easy checking and quick decision making.

B. **Inspection Outside the Company:** Lack of experience and ability of companies to inspect materials requires intervention from outside to complete the inspection process (Training, 2012). This inspection may be carried out in the supplier’s company, where the inspection team is sent to the supplying factory. Reasons for applying material testing in the supplying factory are:

1. In case of a condition in the contract to inspect the materials in the supplying company, the inspection should be carried out there. This is also the case when shipping cost is very high;
2. Some materials requested may be expensive or need precision in the process of manufacturing. Such materials have to be monitored constantly;
3. If an outside crew is selected, the supplier and purchaser should agree that the final decision material testing will be the external specialist;

In the case of imported materials, some important controls should be taken into consideration to ensure that the materials arrive with the required quality and specifications. A specialized inspection company should be contracted to inspect and audit the materials in the same country of origin and issue the final inspection report. This company is a third party for the buyer and the supplier. This procedure is more beneficial to the beneficiary (purchaser) to avoid rejection issues.

3.5.3.2 Non-conforming Materials

When it becomes apparent that the materials ordered are not within the requirements included in the purchase order normally they will be rejected (Training, 2012). Here comes the role of the procurement department in the disposal of these materials. Legal interventions may be necessary to resolve such problems. In normal cases, the supplier is contacted to stop delivering any new material shipments until deciding on the rejected ones. Some people may think that the solution is simple, which returning non-conforming materials to the supplier, but trading transactions are not going that easy way. Steps taken in case of rejection are as follows:

1. Consultation with the technical staff on whether there is a possibility to use the rejected material or not before renegotiating with the supplier;
2. The supplier must be contacted after rejecting the materials and informed of the rejection reasons in detail. Usually, delegates are sent to observe the problem. The solution here is either to replace what can be replaced or reduce the previously agreed price;
3. Studying whether there's a chance of material editing, supervised by the technical team, provided that the costs of modification should be paid by the supplier;
4. Any alternative solutions that are satisfactory to both parties can be included, within the limits of achieving the target.

3.5.3.3 Nature of Inspection

This sub-section highlights the specific variables to describe the quality of materials, on which acceptance or rejection is based (Training, 2012). For example, material quality is measured by a trademark or brand name or even through outer appearance. Therefore, each institution follows a specific type of inspection, according to the nature and type of materials. Some materials need to be tested in the laboratory by taking a sample to satisfy the required quality. Another determinant is the type of manufacturing. In case of manual manufacturing, a very accurate testing method must be used. Some inspection methods are costly, which is also considered as a variable to determine the nature and type of inspection. Inspection can be carried out for all items of the same type or for some units that belong to the same product.

3.5.4 Inventory Control

The main goal of inventory control is to store and regulate materials, so as to ensure the continuity of each activity in the project (Training, 2014). Ordinarily, the inventory implicates several types of goods after being received, inspected and distributed within the warehouse. Controls and conditions needed for providing safety and preserving stock should be taken into account throughout the implementation period of the project. Based on the previous aims, some additional benefits of stock control are stated as follows:

1. Achieving balance between demand and supply, especially for materials that are available in certain seasons only or that require longer periods of manufacturing and preparation;
2. Protection against unexpected conditions that may occur, such as wars, economic crises, and other events that can not be controlled;
3. Achieving financial gains by keeping items the prices of which are expected to increase in the future;
4. Ensuring the continuity of work and avoiding interruptions due to shortage in materials.

Despite all these benefits mentioned, there must be a detailed study to indicate the need the warehousing, as materials may be exposed to risks and losses in stores. Furthermore, more efficient materials may be purchased at lower prices.

3.5.4.1 Inventory Responsibilities

The responsibilities and tasks of storekeepers vary according to the size of establishment and its functional tasks, in addition to the availability of an information system and modern ICT usage for inventory management (Training, 2014). Those responsibilities and tasks are stated below.

1. **Reception and Inspection**: these tasks are related to receiving and testing materials requested. It is worth to mention that these tasks are assigned to those responsible for managing stock, regardless of the considerations mentioned above about inspection.
2. **Classification and Codification**: materials are classified and codified based on an appropriate method which corresponds to the information system used in the company.
3. **Distribution and Storage**: these tasks are related to arranging materials and distributing them in the warehouse, considering optimum exploitation of space. The distribution method depends on some factors, like weight and size of items, space available in the warehouse and rate of movement and use.
4. **Inventory Records**: inventory records detailed information about all items and whether an item is obtainable or not in the store. This is helpful to determine shortages and requirements. Also, there are records related to financial and administrative control.
5. **Stock Control**: it refers to accurate planning that monitors the movement of materials (in – out – balance) and elaborates the storage levels (minimum – safe mode – maximum). Full control of documents and storage forms falls under stock control.
6. **Stocktaking**: it refers to sudden or periodical checks to inspect inventory and record its condition in terms of damage or deficiency, with the assurance of applying safety.

3.5.4.2 Procedure of Successful Storage

For the sake of achieving all the objectives of stock control represented by preservation of inventory (Training, 2014), periodical checks are necessary to keep all items valid for use, and maintain the level of storage, which serves the construction process. The following basic points should be followed:

1. Best suitable location of the warehouse. A detailed study should be conducted to determine the warehouse location in accordance with the nature of the stored materials;
2. Providing experienced and scientifically qualified employees to work in warehouses;
3. Adopting an intelligent system in the field of storage that reduces the dependence on human experience in classifying materials stored, accessing them or tracking their movement;
4. The internal arrangement of a store should rake the following issues into account:
    - Providing adequate space for the materials received, including those which are still in the inspection phase;
    - Allocating sufficient space near to the entrance of the warehouse for heavy equipment;
    - Utilizing the height of the storehouse for arranging materials;
    - Storing new items in the warehouse, while using old ones to avoid damages and losses;
    - Providing corridors and spaces suitable for material movement and automated handling;

- Distributing materials according to priorities; materials continuously required should be placed close to the entrance of the storehouse;
- Using wooden bases (foundations) for heavy-weight materials;
- Storing surplus items in special sections in order to be disposed of later.

4 Chapter Four: Methodology and Data Collection

4.1 Introduction

The methodology adopted in this research involves two stages, which are: literature review and questionnaire development. A comprehensive literature review was conducted through which learned most of the problems facing material management on sites and practical solutions which must be adopted to come up with an integrated solution. It was necessary to develop a questionnaire to know more about the situation of movement of materials on construction sites in order to reach the best way of material management.

4.2 Methodology and Research Significance

There is a philosophy concerned with the way of introducing a research methodology. According to Saunders (2011), the research has chosen to adope the methodology explained in Figure (4-1). The layers in the digram display the research strategies and data collection means. Regarding the importance of the research, it is essential to recognize the obstacles and problems associated with conducting this study. These will be identified by developing a comprehensive questionnaire, in addition to a number of personal interviews and a field survey to determine the factors that affect material management on construction sites and the variables that need to be considered in order to promote on-site material management.

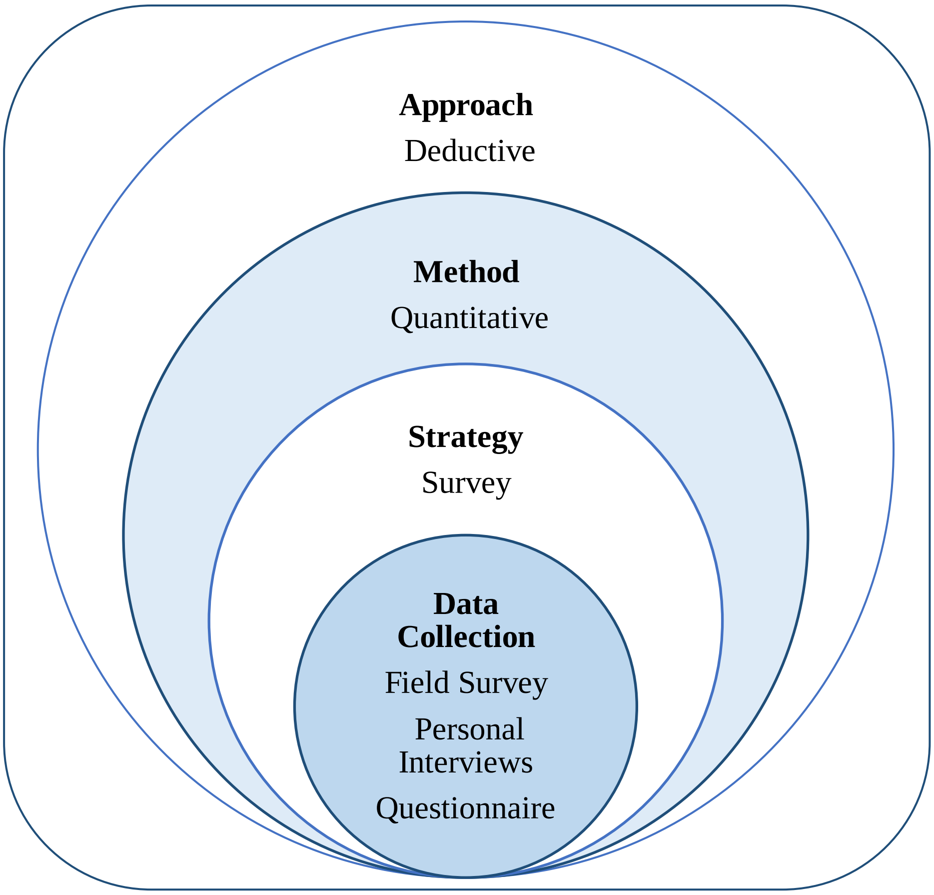


Figure 4-1: Diagram of Methodology

4.2.1 Research Methods

Two types of research methods have been found. Quantitative methods rely on numerical data and are based on statistical tools, concepts and methods in which numerical data is collected and analyzed and the results are shown through diagram. There are many patterns and forms of quantitative data collection, including questionnaires, online survey, face-to-face and phone interviews. On the other side, qualitative methods are related to exploratory research and used to take opinions, ideas and motives through which the hypotheses adopted in the research are accepted or rejected. Methods of data collection in qualitative research methods vary, where they may be semi-structured or unstructured. These include: observation, individual interviews and using a small sample for reaching a rich and accurate understanding, reducing generalizability in a particular case. This research here is quantitative, as it uses a questionnaire with a five-point Likert scale.

4.2.2 Research Strategies

Generally, there are several strategies that serve scientific research. But, this sub-section will focus on what have been used in this research.

- **Survey strategy**: it is a strategy that is usually correlated with the deductive approach. It is also used for of descriptive and exploratory research. It includes how much, how many questions, and some WH questions; (where, what and who). It is certified as a strategy to answer such questions. Therefore, it facilitates quantitative data collection analysis using statistical tools. In this research, a closed questionnaire has been used.

4.3 Procedure of Research Methodology

The flow chart in Figure (4-2) shows the research methodology in detail and illustrates the plan used to collect data for the development of the proposed system.

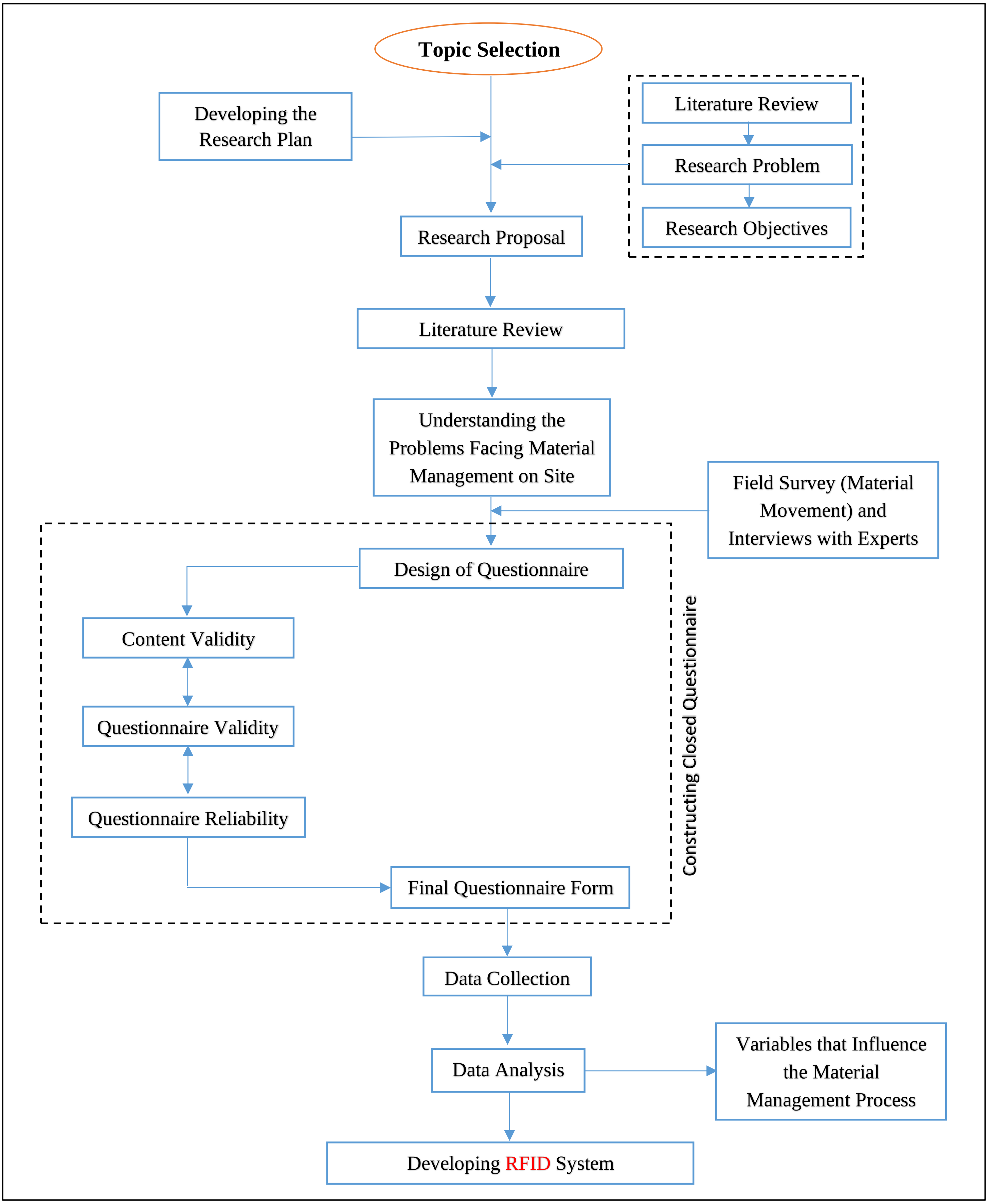


Figure 4-2: The Research Methodology

4.3.1 Questionnaire Construction and Design

As mentioned earlier, the closed questionnaire was selected. The population of this study was "150" civil engineers, including contractors, site managers and consultants, in addition to field experts working in large projects in the Hashemite Kingdom of Jordan.

Google form was used to prepare and construct the research questionnaire for easy and quick access to specialists. The questionnaire consisted of two main sections and six of sub-sections. The first section includes personal information, while the second one is about the strategies adopted for material management on site. This section aims to determine whether there are modern methods used for material management or traditional methods are still the most common material management methods used in projects. As for the other sub-sections are about procurement, reception, inspection, classification and codification and storing of materials. Each of these sub-sections includes a number of questions, where experts were asked to answer them in order to confine variables and figure out the best realistic solutions of problems facing materials management on construction sites. There were two copies of the questionnaire; one in Arabic and one in English, in order to make the questions clearer to the participants.

4.3.1.1 Questionnaire Validity

According to Saunders (2011), Pearson correlation coefficients are used and approved as a tool for measuring questionnaire validity. This is carried out by measuring the questions listed or determining the methodological errors included in the questionnaire. Table (4-1) shows the results of Cronbach's alpha and Pearson correlation coefficients for the statements (questions) of the questionnaire.

4.3.1.2 Questionnaire Reliability

Cronbach's alpha coefficients were computed to ensure whether the re-distribution of the same questionnaire under the same circumstances would give the same results. The reliability of the questionnaire can also be defined as the questionnaire application stability of the results, which means no deviations or significant changes in the case of re-distribution over a certain period of time.

4.3.1.3 Content Validity

Content validity is concerned with submitting the questionnaire to a competent committee to validate its questions and give their opinions and observations about them. A preliminary version of the questionnaire was developed and discussed with a committee composed of three specialists in engineering project management. Some of the listed paragraphs have been amended and a final version was adopted before distribution.

Table (4-1) shows the calculation results of Cronbach's alpha and Pearson correlation coefficients.

Table 4-1: Cronbach's Alpha and Pearson Correlation Coefficients

#	Questions	Pearson Correlation	Cronbach's Alpha
1	Modern systems are used in material management on site.	0.724	0.868
2	Systems include all phases of material management from receiving to tracking.	0.366	0.868
3	Conventional way is the most used one.	0.365	0.880
4	The conventional way provides suitable management.	0.152	0.876

Table 4-1 (continued)

#	Questions	Pearson Correlation	Cronbach's Alpha
5	RFID smart technique is adopted for managing materials on construction sites.	0.125	0.872
6	The use of modern smart systems saves time if applied compared with the conventional way.	0.517	0.874
7	The database enables requesting materials using a computer.	0.600	0.867
8	The procurement department orders materials using modern applications.	0.409	0.867
9	Materials are ordered when essentially needed.	0.450	0.874
10	There is a time schedule for requesting materials.	0.221	0.865
11	Printed documents are used for purchasing.	0.617	0.867
12	There is an electronic communication technology that connects the administrative department with the procurement department.	0.318	0.872
13	All materials ordered are local.	0.331	0.877
14	The ordered materials are being tracked electronically until delivery.	0.491	0.869
15	Matching documents of received materials with requested ones takes a very long time.	0.381	0.872
16	Losses of documents related to the required materials occur sometimes.	0.594	0.877
17	Final reception is carried out before inspection and ensuring that specifications are met.	0.410	0.870
18	Materials are received in batches when there is a storing problem.	0.309	0.868

Table 4-1 (continued)

#	Questions	Pearson Correlation	Cronbach's Alpha
19	In case of imported materials, there is a contracted competent authority for inspection in the country of origin.	0.344	0.869
20	There is an inspection outside the organization due to lack of staff experience.	0.452	0.875
21	Materials are inspected at the warehouse of the supplier before sending.	0.423	0.867
22	Some materials are examined (shape and trademark) by external appearance.	0.453	0.868
23	The rejected materials are returned back to the supplier and compensated.	0.164	0.868
24	In case of rejection, new agreements with the supplier are made.	0.367	0.869
25	Coding materials is done before ordering.	0.423	0.864
26	Coding materials is done manually.	0.512	0.869
27	Coding materials is done according to their functions.	0.222	0.867
28	There is a smart coding system being used.	0.502	0.868
29	Coding ways adopted are clear and facilitate easy access to stored materials.	0.575	0.864
30	If a smart system is used, the stores will be divided into cells to be more organized.	0.061	0.867
31	Materials are distributed based on importance and movement.	0.633	0.864
32	Materials frequently used are placed near the entrance of the store.	0.541	0.864

Table 4-1 (continued)

#	Questions	Pearson Correlation	Cronbach's Alpha
33	Materials are separated to provide corridors that facilitate the process of reception and distribution.	0.600	0.863
34	Mechanical handling is applied in the stores.	0.650	0.865
35	There is a monitoring software for storage (shortages or surplus materials).	0.520	0.864
36	When storing new items of the same type of those available, the old ones are used first.	0.412	0.864

Cronbach's alpha calculates the stability of the questions. It was found out that the average for all questions is (0.872). Based on Table (4-2), the stability of questions is in a good range. Also, Table (4-3) shows the Pearson correlation limits among the questions. There were negative values which indicate an opposite relationship between questions, while positive ones represent a high relationship.

Table 4-2:Cronbach's Alpha Limits

Cronbach's Alpha Limits	Status
0.00 – 0.69	Poor
0.70 – 0.79	Acceptable
0.80 – 0.89	Good
0.90 – 0.99	Excellent

Table 4-3: Questions Related to Pearson Correlation Intervals

Pearson Correlation Limits	Status	No. of Questions
0-0.3	Low relationship	4,5,10,23
0.3-0.5	Medium relationship	2,3,8,9,12,13,14,15,17,18,19,20,21,22,24,25,27
0.5-1	High relationship	1,6,7,11,16,26,28,29,30,31,32,33,34,35,36

4.4 Population and Sample Size

The population of this research consists of civil engineers working at the following institutions in the Hashemite Kingdom of Jordan: (Ministry of Public Works and Housing, Ministry of Water and Irrigation, Ministry of Municipal Affairs, Ministry of Tourism & Antiquities, Jordan Industrial Estates Company, Aqaba Development Corporation and Greater Amman Municipality).

Most of the large projects belong to the Ministry of Public Works and Housing. Therefore, the goal of this research was to take detailed information from experts working in this kind of projects.

The number of civil engineers working in large and unique projects of the Ministry of Public Works and Housing was about “150” (according to Ministry of Public Work and Housing and managers working at large and unique projects). These projects involve more than $100 million (Safa *et al.*, 2015).

According to Scheaffer, et al. (2010), Stephen Thompson’s equation is used to determine the representative sample of the population. This equation is shown below.

$$n = \frac{N \times p \times (1-p)}{(N-1) \times \frac{d^2}{Z^2} + p \times (1-p)}$$ *Equation (4.1)*

where:

n: sample size;

N: population size;

Z: standard score corresponding to the confidence level;

d: standard error of the sample distribution;

p: estimated value of the population proportion.

Table 4-4: Critical Values of "Z" (Sullivan and Verhoosel, 2013)

Confidence Level	Area for Each Tail ($\frac{\alpha}{2}$)	“Z” Value
90%	0.05	1.645
95%	0.025	1.96
99%	0.005	2.575

The estimated value of population proportion, based on McClave et al., (2014) in case of unknown value, p will be equal to (0.5). The confidence level is suggested to be (95%), then “Z” score value will be (1.96), as obtained in Table (4-4). The standard error of sampling is represented by “d” and has a value of (0.05), where “d” value is estimated with an acceptable sampling error range of (5% - 10%). Also, the population of civil engineers in large and unique projects of the Ministry of Public Works and Housing, “N” is equal to (150). By substituting values in Equation (4.1), the acceptable sample number will be as shown below:

$$n = \frac{150 \times 0.5 \times (1-0.5)}{(150-1) \times \frac{0.05^2}{1.96^2} + 0.5 \times (1-0.5)} = 109$$

4.5 Measurement Scale

Measurement levels are categorized into four forms. It is important to identify them in detail in order to choose the most appropriate method of data analysis.

1. Nominal scale: it simply consists of symbols to be assigned to variables (categorical variables). Variables may be numbered, where numbers are merely identifiable and do not interfere with any calculations of division or multiplication, in addition to that they have no order.
2. Ordinal scale: in this scale relationships are ordered from the lowest to the highest; i.e., from strongly disagree to strongly agree. Data that can be ranked fall under the ordinal scale.
3. Interval scale: it's a scale with units of the same difference. Generally, all data with meaningful division will be on an interval scale. For example, the difference of 5 degrees between 15 and 20 is the same difference between 100 and 105.
4. Ratio scale: the ratio scale is also an interval one, but it differs from the previous type in that it has an absolute zero, with no values below zero.

In this study, the ordinal scale is adopted, where a five-point Likert scale is used in the range (1-5), so that (1) refers to strongly disagree, while 5 refers to strongly agree. Table (4-5) shows the significance levels refer to interval of mean.

Statistical significance levels= $\frac{Max.value - Min.value}{Max.value}$ *Equation (4.2)*

Statistical significance level= $\frac{5-1}{5} = 0.8$

Table 4-5: Significance Levels

Level	Interval of Mean	Description
5	4.2-5	Strongly Agree
4	3.4 – 4.2	Agree
3	2.6 – 3.4	Neutral
2	1.8 – 2.6	Disagree
1	1-1.8	Strongly Disagree

4.6 Standard Normal Distribution

Normal distribution has been used for testing the research hypothesis. Z values related to all questions in the questionnaire were in the range (-1.96 to 1.96) for two tails, based on a confidence level estimated of 95%. Equation (4.3) below shows the calculation of "Z" value for each question.

$$Z = \frac{\bar{x} - \mu_o}{\frac{\sigma}{\sqrt{n}}} \qquad \textit{Equation (4.3)}$$

Mean of population $\mu_o = \frac{1+2+3+4+5}{5} = 3$

where:

$\bar{x}$: sample mean;

σ: standard deviation;

n: number of sample members.

4.7 Collection of Data

The required data was obtained through a closed questionnaire previously referred to as one of the methods used in the main survey of this research. Likert scale with the range (1-5) has been used as a measure to assist in the analysis process. (1) refers to strongly disagree, whereas (5) refers to strongly agree. The questionnaire aimed to identify the problems and weaknesses of the material management on construction sites to find solutions that help overcome these problems. The questionnaire was built electronically through Google form window to ensure easy access to it from any place and at any time. Appendix (A) shows the responses obtained and SPSS was used as a tool to analyze the data collected in order to decide on solutions that are appropriate to overcome problems associated with material management on construction sites.

The survey targeted civil engineers specialized in large and unique projects in the Hashemite Kingdom of Jordan, as well as four project managers from different sites in the industrial city of Tafilah and Jarash in Jordan for interviews, in addition to one of the managers of rapid bus service of Amman city, all with more than 10 years of experience. A field survey was also conducted to investigate how to deal with materials on construction sites of the projects mentioned above.

As pointed out by the filed survey conducted on the projects under investigation, there are deficiencies in dealing with materials on construction sites. There are no appropriate systems followed on construction sites to manage materials. There is unjustified time consumption in material reception, with the absence of special storehouses for materials, where it was noticed that materials are stored in unsuitable rooms in the same building to be constructed, causing material damage and spoilage and consequently financial losses. Through personal reviews, it was uncovered that there is no database that documents material reception, inspection or status. Furthermore, some project managers are not aware of the modern technologies adopted in material management and the benefits presented by modern management systems.

5 Chapter Five: Data Analysis and Developing RFID System

5.1 Introduction

This chapter consists of two main parts, the first of which relates to the statistical analysis of the data through SPSS tool to find out the main problems of material management on site, while the second one includes a full detailed study of the RFID system proposed and developed in this research, that is appropriate to be used as a modern material management technique, in addition to developing a database related to the system.

5.2 Statistical Analysis

The data was analyzed after having been collected from respondents to determine the statistical parameters, including means, standard deviations and Z-scores with respect to the confidence level of 95%. The equations adopted in this part for obtaining manual results are Equation (5.1) and Equation (5.2). Table (5-1) shows all results.

$$\bar{x} = \frac{\Sigma X_i F_i}{\Sigma F_i} \qquad \textit{Equation 5.1)}$$

$$S = \sqrt{\frac{\sum (X_i - \bar{x})^2 F_i}{n-1}} \qquad \textit{Equation (5.2)}$$

where, n: sample size;

x_i: Likert scale;

$\bar{x}$: mean of the sample;

f_i: frequency for each scale;

S: standard deviation of the sample.

5.3 Questionnaire Analysis

Most respondents were project managers who specialize in managing large and unique projects, which makes it easier to describe the current status of projects and how to devise appropriate solutions to control the research variables. Remember that the sample consisted of “109” specialists in the field of engineering projects. Figures (5-1) and (5-2) show the percentages of respondents according to their occupation and sector. Table (5-1) shows the respondents’ experiences, including those on construction sites.

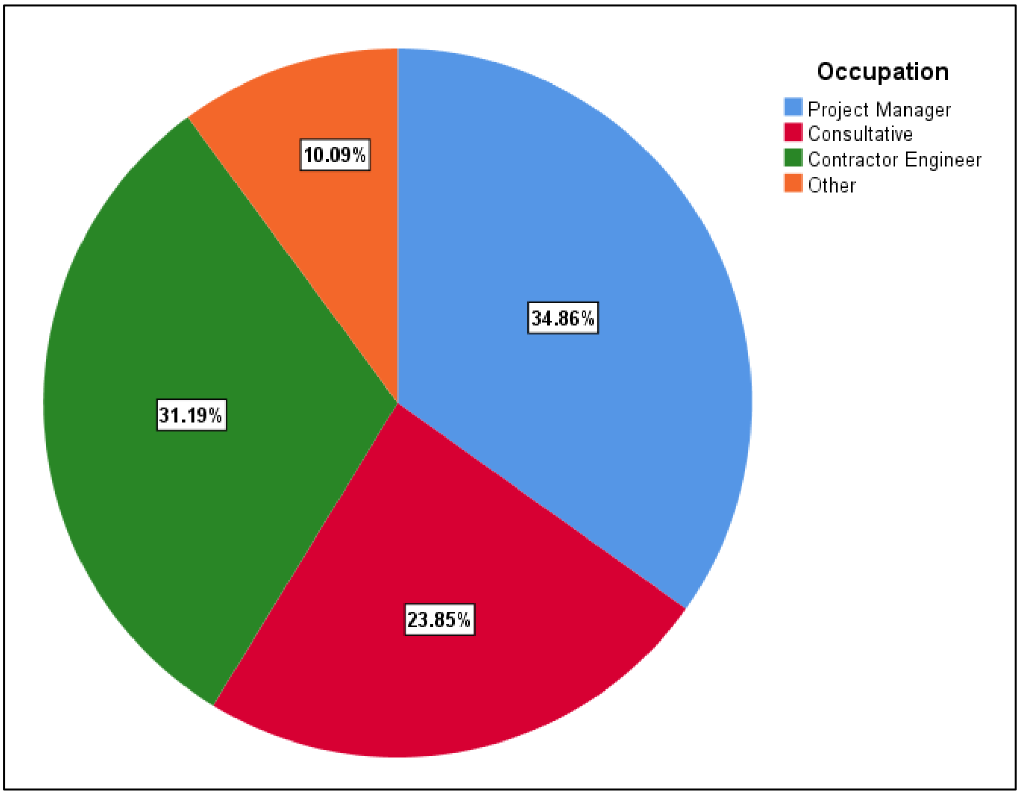


Figure 5-1: Occupations of Participants

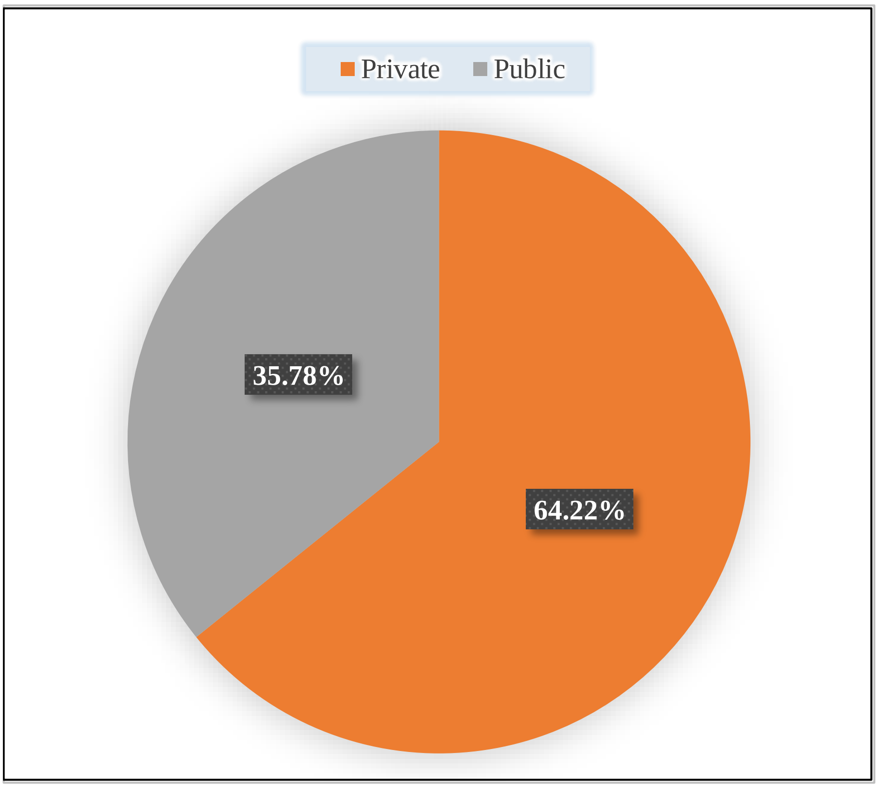


Figure 5-2: Sectors of Participants

Table 5-1: Years of Experience (Including on Construction Sites)

Years of experience	Frequency	Percentage (%)	Years of experience (on construction sites)	Frequency	Percentage (%)
1-5	16	14.68	1-5	27	24.77
6-10	16	14.68	6-10	33	30.28
11-15	42	38.53	11-15	29	26.60
16 and more	35	32.11	16 and more	20	18.35

The second section of the questionnaire was analyzed to find out the means, standard deviations and Z-values. The questions are ranked from the highest mean to the lowest one, which is very helpful in identifying the most influential variables on the process of material management, in order to propose appropriate solutions and recommendations later. Table (5-2) shows analysis results.

Table 5-2: Analysis Results

Rank	Questions	Mean	S. D.	Z - value
1	The use of modern smart systems saves time if applied compared with the conventional way.	4.23	1.060	12.11
2	If a smart system is used, the stores will be divided into cells to be more organized.	4.01	1.014	10.31
3	Materials are distributed based on importance and movement.	3.97	1.004	10.08
4	Materials frequently used are placed near the entrance of the store.	3.81	1.049	8.06
5	Some materials are examined (shape and trademark) by external appearance.	3.78	0.685	11.89
6	The materials are separated to provide corridors that facilitate the process of reception and distribution.	3.78	0.927	8.78
7	Printed documents are used for purchasing.	3.73	0.959	7.94
8	Conventional way is the most used one.	3.70	1.182	6.18
9	Mechanical handling is applied in the stores.	3.69	0.950	7.58
10	When storing new items of the same type of those available, the old ones are used first.	3.66	1.011	6.81

Table 5-2 (continued)

Rank	Questions	Mean	S. D.	Z - value
11	Materials are received in batches when there is a storing problem.	3.63	0.959	6.85
12	Rejected materials are returned back to the supplier and recompensated.	3.63	1.094	6.012
13	There is an inspection outside the organization due to lack of staff experience.	3.61	1.009	6.311
14	Materials are inspected at the warehouse of the supplier before sending.	3.51	0.909	5.58
15	Coding ways adopted are clear and facilitate easy access to stored materials.	3.38	1.016	3.904
16	In case of rejection, new agreements with the supplier are made.	3.36	0.996	3.773
17	In case of imported materials, there is a contracted competent authority for inspection in the country of origin.	3.35	1.040	3.513
18	Coding materials is done according to their functions.	3.31	1.060	3.05
19	There is a time schedule for requesting materials.	3.29	1.065	2.843
20	There is a monitoring software for storage (shortages or surplus materials).	3.19	1.110	1.787
21	Coding materials is done manually.	3.17	0.948	1.87
22	Materials are ordered when essentially needed.	3.11	1.074	1.070
23	Final reception is carried out before inspection and ensuring that specifications are met.	3.11	1.227	0.935
24	Matching documents of received materials with requested ones takes a very long time.	3.08	1.001	0.830
25	Coding materials is done before ordering.	3.01	1.032	0.101

Table 5-2 (continued)

Rank	Questions	Mean	S. D.	Z - value
26	Losses of documents related to the required materials occur sometimes.	2.99	1.206	-0.08
27	The database enables requesting materials using a computer.	2.92	1.073	-0.77
28	Systems include all phases of material management from receiving to tracking.	2.91	1.183	-0.79
29	There is an electronic communication technology that connects the administrative department with the procurement department.	2.82	1.195	-1.57
30	There is a smart coding system being used.	2.76	1.239	-2.02
31	The procurement department orders materials using modern applications.	2.71	1.048	-2.89
32	Modern systems are used in material management on site.	2.71	1.157	-2.61
33	The ordered materials are being tracked electronically until delivery.	2.65	1.181	-3.09
34	The conventional way provides suitable management.	2.61	0.903	-4.50
35	All materials ordered are local.	2.56	1.058	-4.34
36	RFID smart technique is adopted for managing materials on construction sites.	1.91	0.948	-12.0

The results were ranked according to the mean values, to show what strategies were being applied or not in material management on construction sites. Figure (5-3) shows the normal distribution curve for testing the research hypotheses, where the tail adopted was the right tail with a confidence level of 95%. Also, Table (5-3) shows the five categories of mean intervals.

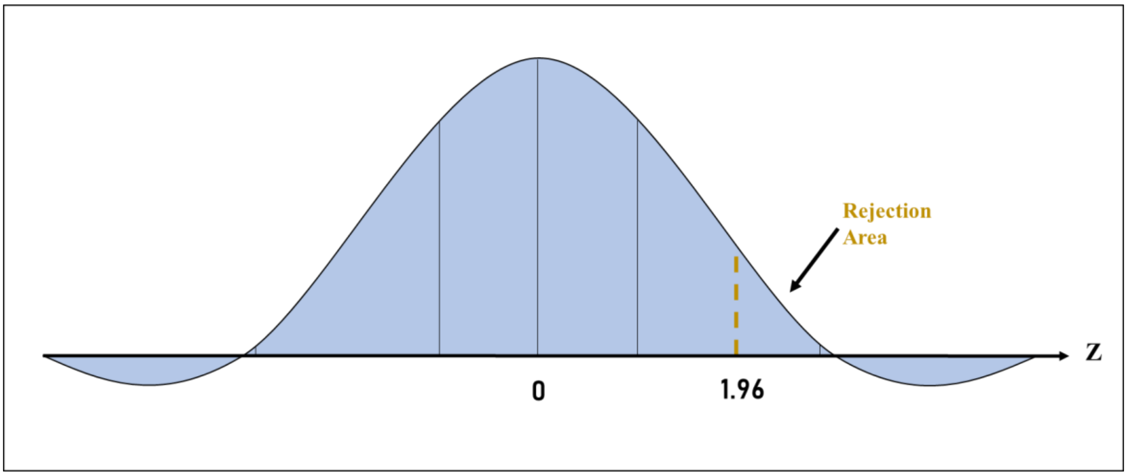


Figure 5-3: Standard Normal Distribution at 95% Confidence Level

Finally, based on the above results, strategies from 20 to 36 are not applied on construction sites, according to negative Z-score values and mean intervals shown in Table (5-3) that are not within the rejection area shown in Figure (5-3), especially the RFID system, despite the importance of its application. Also, there are influences and factors that are to be taken into account for proper management on construction sites. Most of the respondents strongly agreed that using a modern method reduces time if applied instead of the traditional method based on the mean intervals. Also, there is insufficient awareness of the concept of material management and its importance.

Table 5-3: Mean Intervals of Variables

Mean Interval	Status	Variables' Rank
≥ 4.2	Strongly Agree	1
3.4 – 4.2	Agree	2,3,4,5,6,7,8,9,10,11,12,13,14
2.6 – 3.4	Neutral	15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31, 32,33,34
1.8 – 2.6	Disagree	35,36
≤1.8	Strongly Disagree	-

Comparing the responses of participants to the research questionnaire, it was noted that contractors with a sample size of “34”, who are aware of and have direct contact to materials see that the main problems facing material management on construction sites according to the analysis results are shown in Table (5-4).

Table 5-4: Analysis Results of Contractors Sample

Rank	Questions	Mean	S. D.	Z - value
1	The use of modern smart systems saves time if applied compared with the conventional way.	4.29	0.938	8.01
2	Materials are distributed based on importance and movement.	4.24	0.890	8.12
3	If a smart system is used, the stores will be divided into cells to be more organized.	4.18	0.626	10.99
4	Materials are separated to provide corridors, that facilitate the process of reception and distribution.	4.09	0.793	8.01
5	Materials frequently used are placed near the entrance of the store.	4.06	0.983	6.28
6	When storing new items of the same type of those available, the old ones are used first.	3.94	0.983	5.57
7	Printed documents are used for purchasing.	3.88	0.808	6.35
8	Mechanical handling is applied in the stores.	3.88	0.844	6.07
9	Matching documents of received materials with requested ones takes a very long time.	3.88	0.977	5.25
10	Some materials are examined (shape and trademark) by external appearance.	3.76	0.496	8.93

Table 5-4 (continued)

Rank	Questions	Mean	S. D.	Z - value
11	Coding ways adopted are clear and facilitate easy access to stored materials.	3.71	0.799	5.18
12	Materials are received in batches when there is a storing problem.	3.65	0.981	3.86
13	Materials are ordered when essentially needed.	3.62	0.922	3.92
14	Conventional way is the most used one.	3.59	1.131	3.04
15	Coding materials is done manually.	3.53	0.929	3.32
16	Materials are inspected at the warehouse of the supplier before sending.	3.50	0.749	3.89
17	In case of rejection, new agreements with the supplier are made.	3.50	0.788	3.69
18	Coding materials is done before ordering.	3.50	0.896	3.25
19	Coding materials is done according to their functions.	3.50	1.022	2.85
20	There is a time schedule for requesting materials.	3.47	0.961	2.85
21	In case of imported materials, there is a contracted competent authority for inspection in the country of origin.	3.41	0.857	2.78
22	The database enables requesting materials using a computer.	3.38	0.799	2.77
23	There is an inspection outside the organization due to lack of staff experience.	3.38	1.015	2.18
24	Rejected materials are returned back to the supplier, and recompensated.	3.38	1.280	1.73
25	There is a smart coding system being used.	3.35	1.252	1.63
26	Final reception is carried out before inspection and ensuring that specifications are met.	3.21	1.095	1.11

Table 5-4 (continued)

Rank	Questions	Mean	S. D.	Z - value
27	The procurement department orders materials using modern applications.	3.18	0.968	1.08
28	Systems include all phases of material management from receiving to tracking.	3.18	1.114	0.94
29	There is an electronic communication technology that connects the administrative department with the procurement department.	3.09	1.164	0.45
30	The ordered materials are being tracked electronically until delivery.	2.88	0.977	-0.71
31	Modern systems are used in material management on site.	2.85	0.958	-0.91
32	Losses of documents related to the required materials occur sometimes.	2.85	1.048	-0.83
33	The conventional way provides suitable management.	2.76	0.819	-1.70
34	All materials ordered are local.	2.62	1.181	-1.87
35	There is a monitoring software for storage (shortages or surplus materials).	1.91	0.793	-8.01
36	RFID smart technique is adopted for managing materials on construction sites.	1.71	0.676	-11.1

According to the data analysis of the contractors who represent “34” of the total sample; it is found that the results are extremely close to the previous results which concluded that there is no reliance on any modern systems on construction sites and considered the conventional methods as the most reliable which does not meet the site needs and so there is no use of RFID system. In addition to some general problems related to time consumption and loss of materials documents. Also, there is no sufficient monitoring on storage. Accordingly, an RFID system will be developed.

5.4 RFID System Development

This research will construct and develop an RFID system based on the results obtained, stating that there is no use of this system on construction sites.

This system is divided into three main components; including the tag, reader and computer on which the program and database are installed, in addition to the antenna that helps increase the network communication for providing wide-range waves for readers on construction sites. Figure (5-4) shows the components of an RFID system.

Figure 5-4: RFID Components

5.4.1 System Database

The database is a component of the RFID system which is stored in the host terminal. C-shape and Visual Basic (programming language) are adopted to construct a program linked with a cloud website server to save the database.

Due to the amount and overlap of information at the same time and the number of tags used in the RFID system, a cloud has to be used to coordinate and organize information which can be easily accessed through web windows, so that the database is permanently connected to the internet and at any time and place, a user can access the server to request or enter any information. Figure (5-5) shows the login window of the program as an administrator or user depending on the responsibilities of the user.

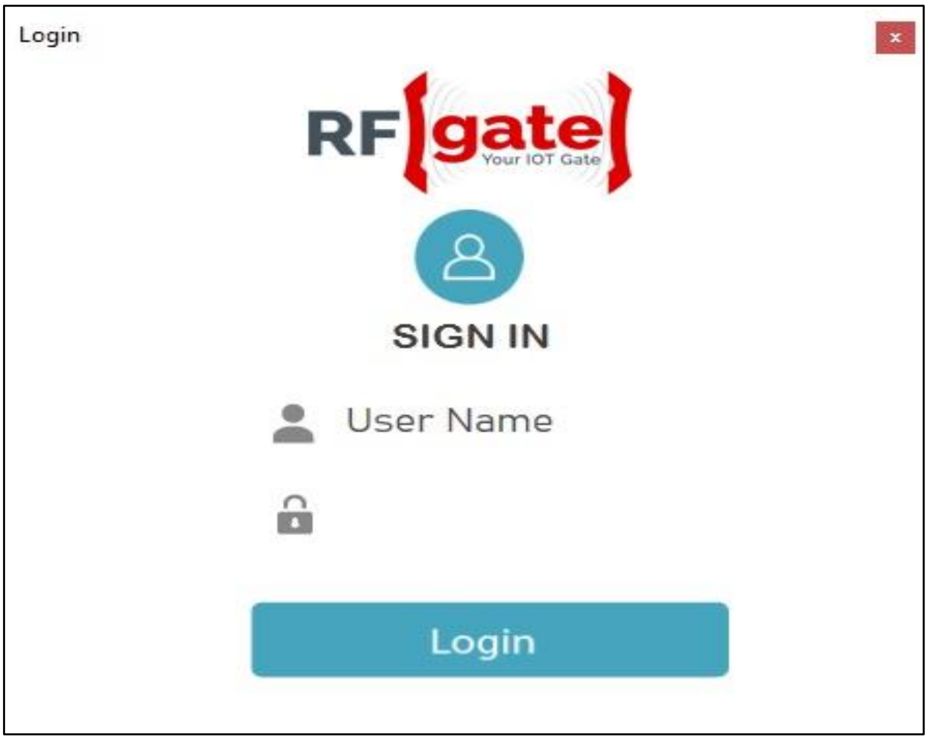


Figure 5-5: Program Login Window

Figure (5-6) shows the dashboard program, including the parameters of the items, such as category, price, dates of request and reception, weight, quantity and the unique tag code. Also, the destination of materials to the warehouse or construction site is included. There are some features that need to be considered such as minimum and maximum charges for material quantities in the warehouse to prevent any shortage or surplus. So, the system can send a warning message to fix this problem according to inventory records.

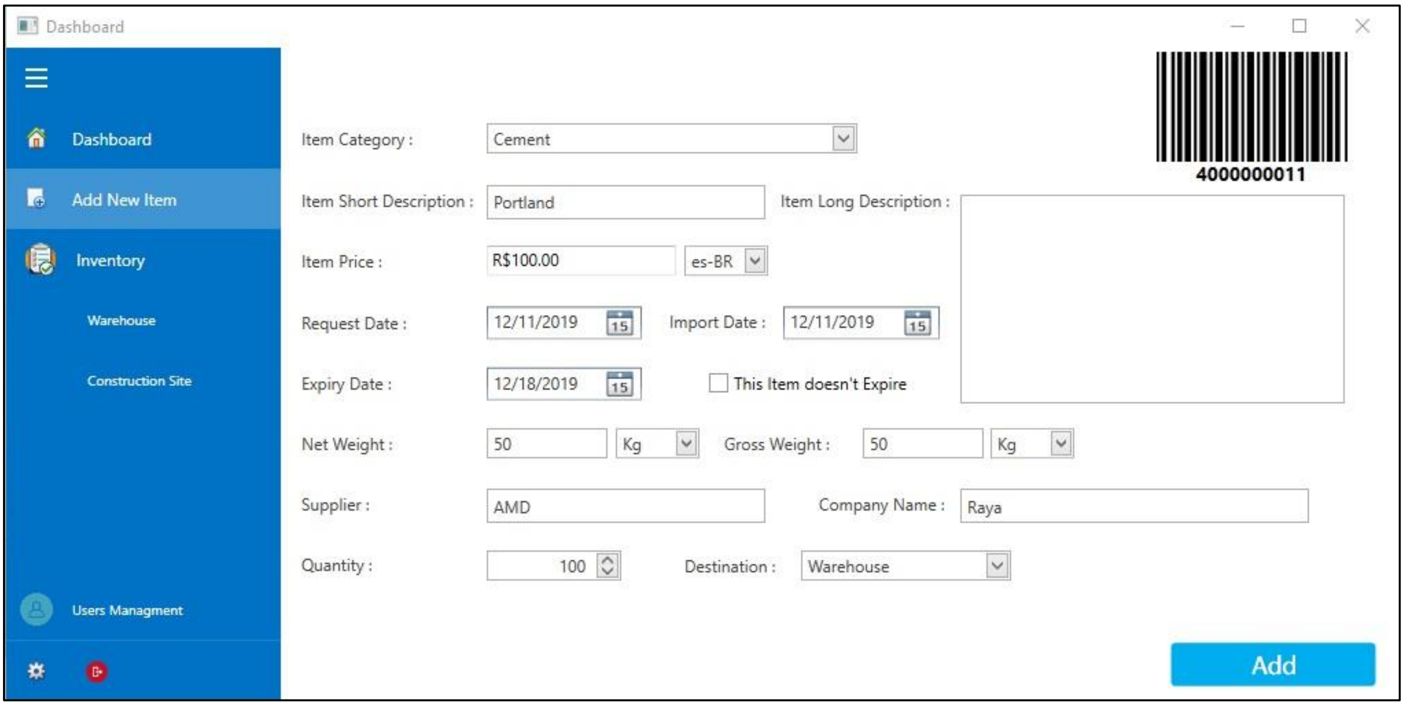


Figure 5-6: Dashboard Parameters

Figure (5-7) shows the details of the tag when the reader detects its code, which provides data editing feature.

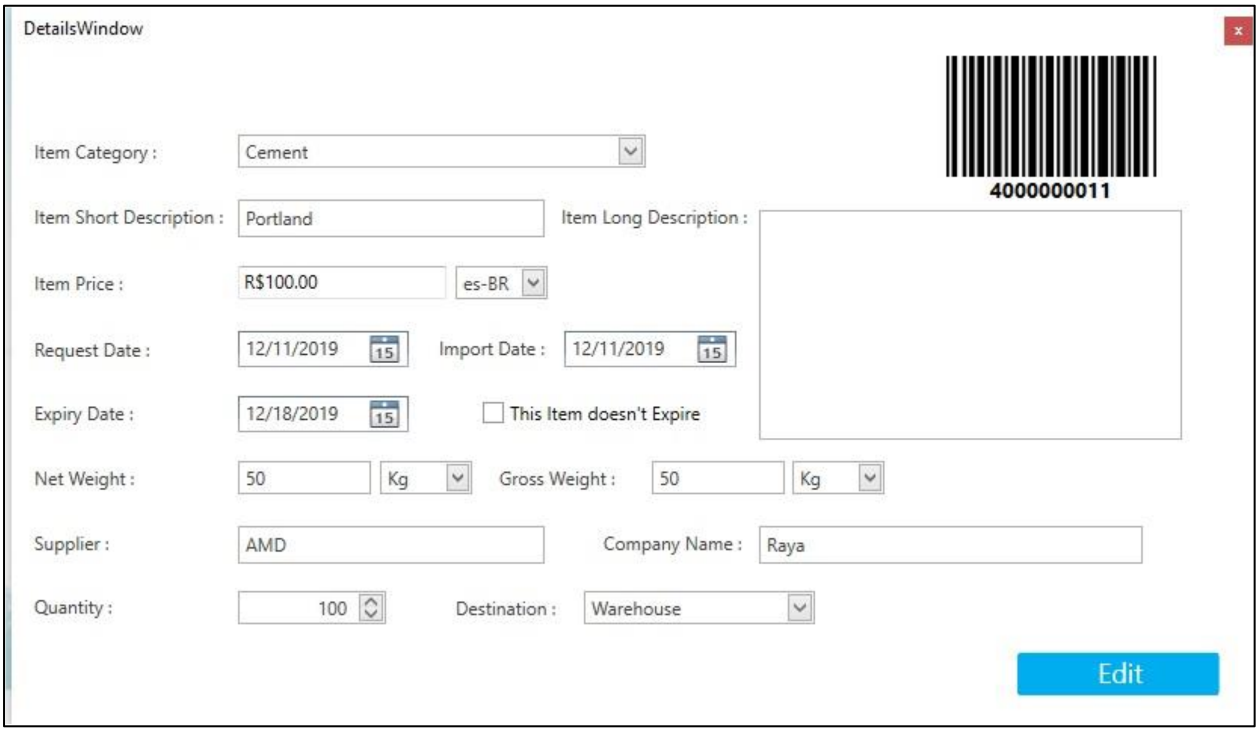
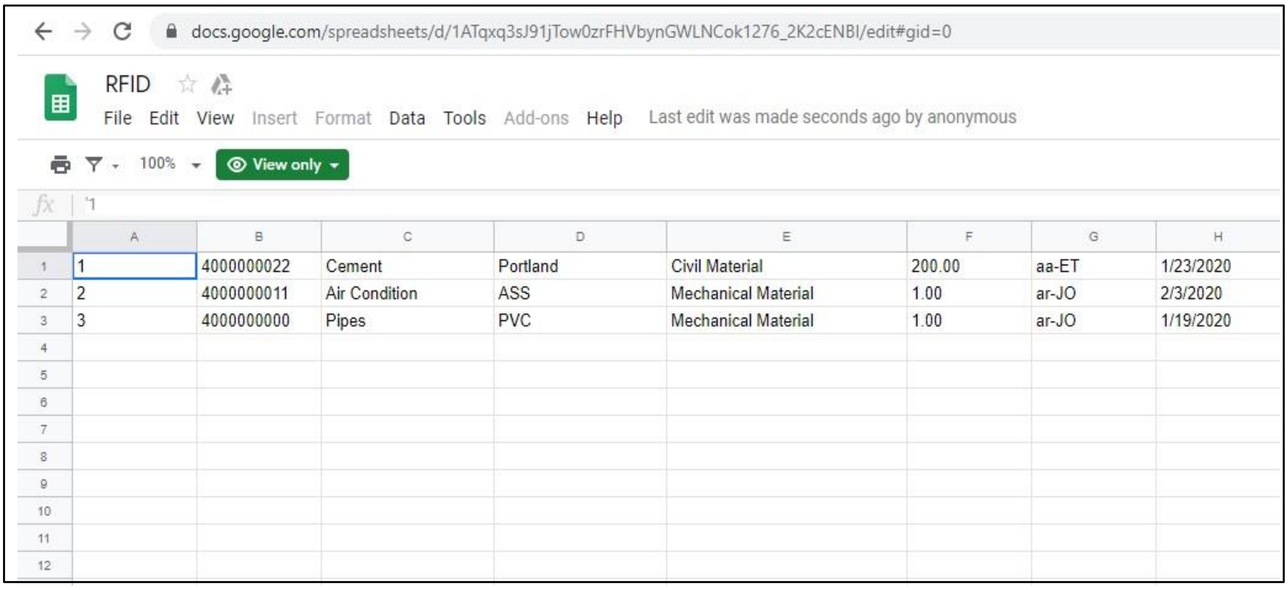


Figure 5-7: Tag Details

Figure (5-8) shows the server database of Google cloud linked with the dashboard of the RFID program, that can be reachable at any time and from everywhere. The database is secured by the Google cloud, which is just for easy viewing of a daily report of materials.



	A	B	C	D	E	F	G	H
1	1	4000000022	Cement	Portland	Civil Material	200.00	aa-ET	1/23/2020
2	2	4000000011	Air Condition	ASS	Mechanical Material	1.00	ar-JO	2/3/2020
3	3	4000000000	Pipes	PVC	Mechanical Material	1.00	ar-JO	1/19/2020
4								
5								
6								
7								
8								
9								
10								
11								
12								

Figure 5-8: Server Database (Google Cloud)

5.4.2 RFID Development Kit

The development kit equipped for this research consists of an RFID reader, an RFID antenna and 5 pieces of encoded passive tags. To complete the system so that it is ready for a, input and output data must be included. Figure (5-9) shows the RFID development kit.

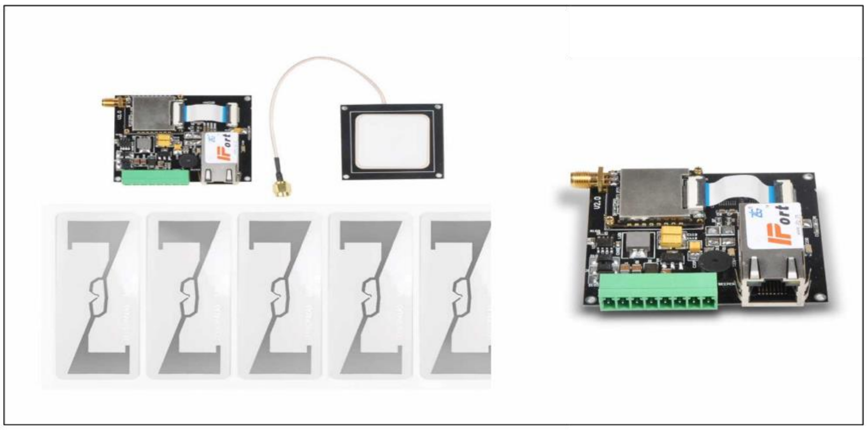


Figure 5-9: RFID Development Kit (Related to This Research)

5.4.3 Discussion

After determining the main problems associated with material management on construction sites through previous studies, field survey, personal interviews with experts and a questionnaire, an RFID system was developed to find solutions to these problems, in addition to studying the possibility of its implementation in construction projects. The proposed system was presented to a number of project managers and contractors to investigate their opinions with regard to adoption this type of system in construction projects. Their opinions were concentrated on the importance of holding specialized workshops on all advantages provided by the system, in addition to implementing an integrated network on site in order to obtain a complete and ready to implement system more accurately and clearly. In light of this, the proposed RFID system was compared with other methods followed in construction projects with the aim of adopting the proposed system in material management on construction sites.

On the other hand, with the availability of all components of the system, the system can be applied and used with much ease and effectiveness commensurate with the purpose for which it is used. Additional requirements will be provided to enhance the most effective use of the system; for example, antennas that help increase the reading range of the fixed or handheld reader.

6 Chapter Six: Conclusions and Recommendations

The conclusions which can be drawn from the findings of this research will be presented in this chapter, based on the study questionnaire, interviews with experts working at construction and field survey. This chapter also includes a number of recommendations for material managers, in addition to the possibility of developing the system to perform several tasks in the material management process.

6.1 Conclusions

First of all, since conventional material management methods used on construction sites are associated with problems impeding administrative work, it is necessary at least to make sure that they are applied correctly. Being indispensable in some cases, answering the questions asked in the questionnaire helps integrate traditional and modern methods to reach the best decisions.

According to the results of the questionnaire, field survey and personal interviews the researcher was able to determine the most important factors and considerations related to strategies adopted in material management on construction sites, including material purchasing, reception, inspection, classification and codification and stock control affecting the movement of materials on construction sites. Conclusion drawn can be presented as follows:

1. Traditional methods of material management are the most commonly used on construction sites, nothing that these methods do not provide material management;
2. These are difficulties in obtaining information due to loss of printed documents;

3. Conventional material management methods are time-consuming due to matching documents in the reception stage;
4. Labor capacity is intensively consumed in the inspection and reception stages, which will significantly impact productivity;
5. There are no warehouses leads to receive materials in batches or store them in unsuitable rooms in the same building to be constructed;
6. Final inspection of imported materials is approved only from a local authority. If the materials are rejected, this will cause delays in the implementation of activities on construction sites as well as financial loss;
7. There are delays in receiving of information about the status of material inspection in the lab and issuing the final report;
8. There is no electronic tracking of materials from the supplier to the site, although most of the materials come from a local destination;
9. There are no modern systems used except for some phone applications;
10. There are no RFID system uses on sites;
11. Some project managers see that RFID systems would be more effective if applied in large projects with wide materials diversity and implementation periods of 5-10 years;
12. Managers labor on construction sites are not familiar with RFID systems so, there is a need to promote using such systems in different ways.

Finally, the results showed that there is an appropriate follow-up of some phases related to traditional methods, which is good, but problems associated with these methods must be treated with appropriate solutions in order to make the management system integrated and properly applied.

6.2 Recommendations

The researcher suggests some important recommendations based on the results obtained. These recommendations are as follows:

1. There must be a realization of the importance of the materials as an essential element in the construction process. So, the best methods should be chosen and applied to appropriate material management;
2. Using more comprehensive systems, such as RFID systems, as they perform several administrative tasks;
3. Using modern systems to improve inventory management, which facilitates the process of monitoring input and output in addition to determining surplus and shortage;
4. Using more accurate and easier methods in the codification and classification of materials, such as RFID system;
5. Dispensing with traditional methods of receiving materials and appointing a specialist who can confirm the specifications electronically;
6. Paying more attention to that the schedule of requesting materials corresponds to the time of activity implementation for avoiding problems of work interruptions;
7. Inspecting materials before importing them by a specialized inspection company accredited by local authorities, to avoid the occurrence of problems later;
8. Selecting a staff of highly experienced material inspectors on the site and ensuring that materials are inspected at the supplier's warehouses before delivery;

9. Optimal selection of suppliers; for example, there are suppliers who do not adhere to required specifications and delivery times;
10. Popularizing modern systems to suppliers to facilitate electronic ordering of materials.

6.3 Future Work

After a detailed and in-depth study of material management in addition to investigating the possibility of linking several tools with the approved system, the points below show some possibilities for future research.

1. Using GPS with RFID in material tracking to ensure better material management;
2. Developing plans for firms that are classified as medium and small ones commensurate with the mechanisms of work;
3. Connecting a load cell (truck scale) to the system for uncountable materials, such as sand and aggregate, … etc.;
4. Applying the system in laboratories for the examination of materials, especially the inspection of concrete cubes;
5. Studying the possibility of utilizing the RFID system in most of the administrative stages of construction projects.

References

- Abdoli, S. (2009). 'RFID application in municipal solid waste management system'. *International Journal of Environmental Research (IJER).*
- Ahmed, F. H. (2017). 'Improving construction materials management practices in Construction Sites'. Universiti Tun Hussein Onn Malaysia.
- Arijeloye, B. T. and Akinradewo, F. O. (2016). 'Assessment of materials management on building projects in Ondo State, Nigeria'. *WSN World Scientific News*, pp. 168–185. Available at: www.worldscientificnews.com
- Arnold, J. R. Tony, Stephen, N. and Chapman, and L. M. C. (2007). 'Introduction to materials management'. TBS (2007), pp. 1–528. doi: 10.1017/mdh.2014.75.
- Bell, L. C. and Stukhart, G. (1986). 'Attributes of materials management systems'. *Journal of Construction Engineering and Management*. American Society of Civil Engineers, 112 (1), 14–21.
- Choi, S. H. *et al.* (2015). 'Item-level RFID for enhancement of customer shopping experience in apparel retail'. *Computers in Industry*. Elsevier, 71, pp. 10–23.
- Costin, A., Pradhananga, N. and Teizer, J. (2012). 'Leveraging passive RFID technology for construction resource field mobility and status monitoring in a high-rise renovation project', *Automation in Construction*. Elsevier, 24, pp. 1–15.
- Dawood, A. S. (2015). 'Automatic identification system based on RFID technology'. University of Technology.
- Dawood, N. N. (1994). 'materials management systems for the construction

industry'. *CIß TG 16, Sustainable Conslruclion*, pp. 735–743. Available at: http://www.irbnet.de/daten/iconda/CIB_DC24893.pdf.

- Domdouzis, K., Kumar, B. and Anumba, C. (2007). 'Radio-frequency identification (RFID) applications: A brief introduction', *Advanced Engineering Informatics*. Elsevier, 21 (4), 350–355.
- Donyavi, S. and Flanagan, R. (2009). 'The impact of effective material management on construction site performance for small-and medium-sized construction enterprises'. In: *Proceedings of the 25th Annual ARCOM Conference*. Nottingham, UK, pp. 11–20.
- Eze, P. C. *et al.* (2018). 'Anti-theft system for car security using RFID'.
- Hujazzy, A. (2012). 'Materials management on construction projects'. Damascus: Damascus University. Available at: www.academia.edu.
- J. R. Tony Arnold, Stephen, N. and Champman, L. M. C. (2011). 'Introduction to materials management'. pp. 30–46.
- Janin, (2013). 'Cnstruction material management for constructional projects'. pp. 1–20. Available at: http://keu92.org/uploads/Search engineering/Lotof Alla Janin.pdf.
- Jusoh, Z. M. and Kasim, N. (2017). 'A review on implication of material management to project performance', *MATEC Web of Conferences*, p. 01012. doi: 10.1051/matecconf/20178701012.
- Kasim, N. (2011). 'ICT implementation for materials management in construction projects: Case studies', *Journal of Construction Engineering and Project Management*. Korean Institute Of Construction Engineering and Management, 1(1), 31–36.
- Kasim, N. *et al.* (2012). 'Improving on-site materials tracking for inventory

management in construction projects'.

- Kasim, N. *et al.* (2019). 'Automatic materials tracking practices through RFID implementation in construction projects', in *MATEC Web of Conferences*. EDP Sciences, p. 5001.
- Kasim, N., Anumba, C. and Dainty, A. (2005). 'Improving materials management practices on fast-track construction projects', *21st Annual ARCOM Conference,* University of London. Association of Researchers in Construction. Management, pp. 793–802.
- Kulkarni, V., Sharma, R. and Hote, M. (2017). 'Factors affecting material management on construction site'. *International Research Journal of Engineering and Technology*, pp. 474–478. doi: 10.1128/JCM.00342-18.
- Liwan, S. R., Kasim, N. and Zainal, R. (2013). 'Materials tracking practices for inventory management in construction projects', *Proc. of 1st Faculty of Technology Management and Business (1st FPTP) Colloquium*. Universitiy Tun Hussein Onn, Malaysia. pp. 1–6.
- Lu, W., Huang, G. Q. and Li, H. (2011). 'Scenarios for applying RFID technology in construction project management'. *Automation in Construction*. Elsevier, 20(2), 101–106.
- Lyu Jr, J., Chang, S.-Y. and Chen, T.-L. (2009). 'Integrating RFID with quality assurance system: Framework and applications'. *Expert Systems with Applications*. Elsevier, 36(8), 10877–10882.
- McClave, J. T., Benson, P. G. and Sincich, T. (2014). Statistics for business and economics. Pearson, Boston.
- Ogbadu, E. E. (2009). 'Profitability through effective management of materials'. *Journal of Economics and International Finance*. Academic Journals, 1(4), 99–

105.

- Pala, Z. and Inanc, N. (2007). ‘Smart parking applications using RFID technology’. In: *2007 1st Annual RFID Eurasia*. IEEE, pp. 1–3.
- Patel, K. V and Vyas, C. M. (2011). ‘Construction materials management on project sites’. In: *National Conference on Recent Trends in Engineering & Technology*, pp. 1–5.
- Ren, Y. and Li, H. (2018). ‘Building materials management system based on RFID technology’. *International Journal of RF Technologies*. IOS Press, 9(1–2), 63–74.
- Ren, Z., Anumba, C. J. and Tah, J. (2011). ‘RFID-facilitated construction materials management (RFID-CMM): A case study of water-supply project’. *Advanced Engineering Informatics*. Elsevier, 25(2), 198–207.
- Roberti 2005, *The History of RFID Technology*, RFID Journal, viewed 13 July 2019, <http://*www.rfidjournal.com/articles/view?1338*>.
- Safa, M. *et al.* (2015). ‘Classification of construction projects’. World Academy of Science.
- Sardroud, J. M. (2012). ‘Influence of RFID technology on automated management of construction materials and components’. *Scientia Iranica*. Elsevier, 19(3), 381–392.
- Sarowar, Pratik P., Komal, S. and Surdkar, C. K. C. (2018). ‘Importance of material management on construction sites’. India.
- Saunders, M. N. K. (2011). Research methods for business students, 5/e. Pearson Education, India.
- Scheaffer, R. L., Mulekar, M. and McClave, J. T. (2010). Probability and statistics for engineers. Cengage Learning.

- Silverman, D. (2013). Doing qualitative research: A practical handbook. SAGE Publications Limited.
- Smiley 2019, *Active RFID vs. Passive RFID: What's the Difference?, AtlasRFIDstore,* viewed 5 August 2019, http://www. blog.atlasrfidstore.com/active-rfid-vs-passive-rfid.
- Son, H. *et al.* (2014). 'Classification of major construction materials in construction environments using ensemble classifiers'. *Advanced Engineering Informatics*. Elsevier, 28(1), 1–10.
- Song, J. *et al.* (2005). 'Locating materials on construction site using proximity techniques'. In: *Construction Research Congress*, pp. 5–7.
- Susan M. Brownell. (2014). 'Material management'.
- Training, G. O. for T. E. and V. (2012). Receipt and examination of materials in warehouses. Saudi Arabia: General Organization for Technical Education and Vocational Training. Available at: https://www.makktaba.com/2012/08/Book-receipt-examination-materials-warehouses.html.
- Training, G. O. for T. E. and V. (2014). 'Organizing of inventory'. Saudi Arabia: General Organization for Technical Education and Vocational Training. Available at: https://www.ust.edu/usty/images/open/library//mang/28/28.pdf.
- Tsai, H. C. *et al.* (2008). 'Applying RFID technology in nuclear materials management'. *Packaging, Transport, Storage & Security of Radioactive Material*. Taylor & Francis, 19(1), pp. 41–46.
- Valero, E. and Adán, A. (2016). 'Integration of RFID with other technologies in construction'. *Measurement*. Elsevier, 94, 614–620.
- Vrat, P. (2014). 'Material specification, codification, and standardization'. In: *Materials Management*. Springer, pp. 211–224.

- Wang, L.-C. (2008). ‘Enhancing construction quality inspection and management using RFID technology’. *Automation in Construction*. Elsevier, 17(4), 467–479.
- Wyld, D. C. (2010). ‘24-karat protection: RFID and retail jewelry marketing’. *International Journal of UbiComp (IJU)*, 1(1), 1–14.
- Yao, W., Chu, C.-H. and Li, Z. (2010). ‘The use of RFID in healthcare: Benefits and barriers’. In: *2010 IEEE International Conference on RFID-Technology and Applications*. IEEE, pp. 128–134.

Appendix A: Questionnaire

جامعة الإسراء
Isra University

(Closed Questionnaire) إستبانة مغلقة

Materials Management on Construction Sites Using RFID Technique

إدارة المواد في مواقع المشاريع الإنشائية باستخدام تقنية نظام تحديد الهوية باستخدام موجات الراديو

The questionnaire is one of the requirements for getting a master's degree in Engineering Projects Management

هذة الاستبانة من متطلبات الحصول على شهادة الماجستير في تخصص إدارة المشاريع الهندسية

Prepared by:

Osama Ali Ibrahem Ibrahem

Supervised by:

Dr. Ibrahem Farouq Varouqa

2019

Dear participants

It would be my pleasure to share this closed questionnaire with you. It aims to identify the problems and weaknesses facing the administrative process of material management on construction sites. Please, fill out, if you do not mind, as this will greatly help build a modern system that is concerned with all material management stages on site.

The degree of approval will be set from (1 to 5), where (1) refers to strongly disagree and (5) refers to strongly agree.

Note: The information here will be top secret. It is intended only for scientific research purposes. Thank you so much; your efforts are appreciated.

المشاركون الأعزّاء .. تحية طيبة

أرجو من حضرَتِكم تَخصيص دقائق من وقتِكُم والتفضل بالإجابة على الأسئلة المطروحة في هذه الاستبانة المغلقة التي تهدف الى تحديد المشكلات ونقاط الضعف التي تواجه العملية الإدارية داخل المواقع فيما يتعلق بإدارة المواد الإنشائية. وهي تهدف الى الأخذ بآرائكم وإعتمادها من أجل تطوير نظام حديث يهدف الى إدارة جميع العمليات الخاصة بإدارة المواد داخل المواقع الإنشائية.

ستكون الإجابات محددة من (1 الى 5)؛ إذ يمثل الرقم (1) عدم الموافقة بشدة أو فقرة غير مستخدمة في العملية الإدارية، بينما يمثل الرقم (5) الموافقة بشدة.

هذا، ونود إعلامكم بأن جميع المعلومات المتضمنة داخل هذه الاستبانة هي غاية في السرية، والهدف منها هو فقط لأغراض البحث العلمي المذكور عنوانه أعلاة. تقبلوا منا فائق الاحترام والتقدير.

First Part

<u>**Personal Information**</u> <u>**المعلومات الشخصية**</u>

1. **Occupation…………………….....** .1 **الوظيفة.......................................**
2. **Years of experience……………….** .2 **سنوات الخبرة...............................**
3. **Years of experience on site……….** .3 **سنوات الخبرة في الموقع.................**
4. **Sector** ☐ Private ☐ Public .4 **القطاع** ☐ خاص ☐ عام

Questionnaire

الاستبانة

Second Part

#	Terms	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A	**Strategies adopted in material management on site**					
1	Modern systems are used in material management on site.	17	37	21	29	5
2	Systems include all phases of material management from receiving to tracking.	12	35	23	29	10
3	Conventional way is the most used one.	7	12	19	40	31
4	The conventional way provides suitable management.	7	51	31	18	2
5	RFID smart technique is adopted for managing materials on construction sites.	40	51	8	8	2
6	The use of modern smart systems saves time if applied compared with the conventional way.	6	2	9	36	56
B	**Purchasing Materials**					
1	The database enables requesting materials using a computer.	9	37	20	40	3
2	The procurement department orders materials using modern applications.	15	32	35	24	3

3	Materials are ordered when essentially needed.	7	28	28	38	8
4	There is a time schedule for requesting materials.	7	20	25	48	9
5	Printed documents are used for purchasing.	2	15	11	63	18
6	There is an electronic communication technology that connects the administrative department with the procurement department.	15	35	23	27	9
C	**Reception**					
1	All materials ordered are local.	18	39	27	23	2
2	The ordered materials are being tracked electronically until delivery.	22	30	26	26	5
3	Matching documents of received materials with requested ones takes a very long time.	4	30	36	31	8
4	Losses of documents related to the required materials occur sometimes.	10	38	15	35	11
5	Final reception is carried out before inspection and ensuring that specifications are met.	13	25	20	39	12
6	Materials are received in batches when there is a storing problem.	4	11	20	60	14
D	**Inspection**					
1	In case of imported materials, there is a contracted competent authority	6	18	27	48	10

	for inspection in the country of origin.					
2	There is an inspection outside the organization due to lack of staff experience.	0	19	28	39	23
3	Materials are inspected at the warehouse of the supplier before sending.	4	10	30	56	9
4	Some materials are examined (shape and trademark) by external appearance.	2	2	22	75	8
5	Rejected materials are returned back to the supplier, and recompensated.	8	8	20	53	20
6	In case of rejection, new agreements with the supplier are made.	9	6	39	47	8
E	**Codification and Classification**					
1	Coding materials is done before ordering.	8	27	36	32	6
2	Coding materials is done manually.	4	25	33	43	4
3	Coding materials is done according to their functions.	4	24	28	40	13
4	There is a smart coding system being used.	17	34	30	14	14
5	Coding ways adopted are clear and facilitate easy access to stored materials.	7	8	45	35	14
F	**Stock Control**					

1	If a smart system is used, the stores will be divided into cells to be more organized.	6	0	19	46	38
2	Materials are distributed based on importance and movement.	2	10	14	46	37
3	Materials frequently used are placed near the entrance of the store.	2	10	30	32	35
4	Materials are separated to provide corridors, that facilitate the process of reception and distribution.	2	8	25	51	23
5	Mechanical handling is applied in the stores.	2	6	41	35	25
6	There is a monitoring software for storage (shortages or surplus materials).	8	21	35	32	13
7	When storing new items of the same type of those available, the old ones are used first.	2	10	38	32	27

Questionnaire of Contractors Sample

الاستبانة لعينة المقاولون

Second Part

#	Terms	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A	**Strategies adopted in material management on site**					
1	Modern systems are used in material management on site.	4	6	15	9	0
2	Systems include all phases of material management from receiving to tracking.	3	7	7	15	2
3	Conventional way is the most used one.	2	4	7	14	7
4	The conventional way provides suitable management.	0	16	10	8	0
5	RFID smart technique is adopted for managing materials on construction sites.	14	16	4	0	0
6	The use of modern smart systems saves time if applied compared with the conventional way.	1	0	5	10	18
B	**Purchasing Materials**					
1	The database enables requesting materials using a computer.	0	6	9	19	0
2	The procurement department orders materials using modern applications.	2	7	8	17	0

3	Materials are ordered when essentially needed.	0	5	8	16	5
4	There is a time schedule for requesting materials.	0	7	8	15	4
5	Printed documents are used for purchasing.	0	3	4	21	6
6	There is an electronic communication technology that connects the administrative department with the procurement department.	2	12	4	13	3
C	**Reception**					
1	All materials ordered are local.	6	12	7	7	2
2	The ordered materials are being tracked electronically until delivery.	2	10	14	6	2
3	Matching documents of received materials with requested ones takes a very long time.	0	5	4	16	9
4	Losses of documents related to the required materials occur sometimes.	2	15	3	14	0
5	Final reception is carried out before inspection and ensuring that specifications are met.	2	8	8	13	3
6	Materials are received in batches when there is a storing problem.	0	6	6	16	6
D	**Inspection**					
1	In case of imported materials, there is a contracted competent authority	0	7	7	19	1

	for inspection in the country of origin.					
2	There is an inspection outside the organization due to lack of staff experience.	0	9	7	14	4
3	Materials are inspected at the warehouse of the supplier before sending.	0	4	10	19	1
4	Some materials are examined (shape and trademark) by external appearance.	0	0	9	24	1
5	Rejected materials are returned back to the supplier, and recompensated.	4	6	2	17	5
6	In case of rejection, new agreements with the supplier are made.	0	5	8	20	1
E	**Codification and Classification**					
1	Coding materials is done before ordering.	0	6	8	17	3
2	Coding materials is done manually.	2	2	8	20	2
3	Coding materials is done according to their functions.	1	8	5	15	5
4	There is a smart coding system being used.	1	10	8	6	9
5	Coding ways adopted are clear and facilitate easy access to stored materials.	0	3	8	19	4
F	**Stock Control**					

1	If a smart system is used, the stores will be divided into cells to be more organized.	0	0	4	20	10
2	Materials are distributed based on importance and movement.	0	2	4	12	16
3	Materials frequently used are placed near the entrance of the store.	0	2	9	8	15
4	Materials are separated to provide corridors, that facilitate the process of reception and distribution.	0	1	6	16	11
5	Mechanical handling is applied in the stores.	0	1	11	13	9
6	There is a monitoring software for storage (shortages or surplus materials).	11	16	6	1	0
7	When storing new items of the same type of those available, the old ones are used first.	0	3	8	11	12

إدارة المواد في مواقع المشاريع الإنشائية باستخدام تقنية نظام تحديد الهوية باستخدام موجات الراديو

إعداد:

أسامة علي إبراهيم إبراهيم

المشرف:

الدكتور إبراهيم فاروق فاروقة

الملخص

لاتزال الطرق التقليدية مستخدمة في عالم إدارة المواد على الرغم من أنها لاتلبي احتياجات الموقع ولا تلائم العملية الإجمالية للإدارة. وتنطوي هذه الطرق على استنزاف طاقة العمالة، مما يؤدي الى التأثير سلباً في الإنتاجية إضافة الى استهلاك الكثير من الوقت في استلام المواد والتفتيش عليها. من ناحية أخرى، هنالك صعوبات في الحصول على سيطرة جيدة على جَردْ الموادّ وعلى معلومات دقيقة تخص المواد. وبينما يستخدم عدد قليل من الشركات الضخمة حول العالم أنظمة حديثة، فلا تلقي معظم الشركات الكثير من الاهتمام بهذه المسألة.

لذا، تأتي هذه الدراسة كمحاولة لتطويرنظام تحديد الهوية باستخدام موجات الراديو (RFID) لحلّ المشكلات الإدراية التي تواجة إدارة الموادّ في المواقع الإنشائية وتسهيل مهام مديري المشاريع.

اشتملت المنهجية المتبعة في هذه الدراسة على مراجعة الأدبيات والدراسات السابقة المتعلقة بموضوع البحث، والمسح الميداني، ومقابلات شخصية مع خبراء يعملون في المواقع الإنشائية. كما تم تصميم استبانة من أجل جمع البيانات حول أهم المشكلات التي تواجه عملية إدارة الموادّ.

وقد أظهرت النتائج غياب تطبيق الأنظمة الحديثة – ومنها النظام التي تسعى هذه الدراسة الى تطويره -، إضافه إلى عدد من المشكلات المتعلقة بإدارة المواد، مثل استهلاك الوقت، والاستخدام الزائد للعمالة، وضعف السيطرة على جَردْ الموادّ، وغياب قواعد البيانات، والتأخير في تسلُم التقارير المتعلقة بفحص المواد.

وتوصي الدراسة بتطبيق نظام تحديد الهوية باستخدام موجات الراديو نظراً لأهميته في إدارة المواد في المشاريع الإنشائية بدقه والتقليل من المشكلات التي تواجه مديري المشاريع في المواقع الإنشائية، وبخاصه فيما يرتبط بإدارة الموادّ.

الكلمات الدالّة: المشاريع الإنشائية، إدارة المواد، نظام تحديد الهوية بموجات الراديو (RFID)، التتبّع، السيطرة على المخزون، المشاريع الضخمة والفريدة من نوعها.