

The Role of RFID to Improve Materials Flow in Mega-projects Site

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ABSTRACT

In according to quantity of various consumption materials in construction sites of complex projects such as oil industry, infrastructure, and large scale commercial, management and monitoring of materials can affect on the final time and cost of project's activities. In today's world of rising labor costs and labor shortages, automated materials tracking can provide some advantage to improve activity execution and consequently reach to project's goals. Potential values of RFID technology in materials traceability and real time information can help us about status of materials to better management of them. In this paper, we categorize the materials management errors removable by RFID and show how RFID can eliminate these errors and simultaneously bring some other benefits to reduce time and cost in construction project sites.

Keywords

construction, RFID, errors, oil industry

1. INTRODUCTION

Material management is a key factor in project planning and control, since materials are main expense in construction, so efficient materials management will reduce the time and the costs of disposal. The report indicated that cost of materials and equipment usually makes up 60% of the overall project cost with construction labor cost contributing 25% to the overall project cost [1]. According to reports for a typical industrial facility, the cost for engineering design is 10% to 15% of the overall cost and the cost for equipment and materials is 50% to 60% of the overall cost [2].

Inefficient materials management can also affect on large and unnecessary costs during construction. First, if materials are bought very soon, capital may be tied up and interest charges incurred on the excess inventory of materials. Even worse, materials may deteriorate during storage or be stolen unless special care is taken. For example, electrical equipment often must be kept in water-

proof places. Second, delays and extra expenses may be incurred if materials needed for particular activities are not accessible. Accordingly, insuring a timely flow of material is an essential concern of project managers [3]. An efficient materials management system put in place on a construction project can increase productivity, avoid delays, reduce man hours needed for materials management, and reduce the cost of materials due to the decrease in wastage [4]. Therefore, the cost reduction is dependent on the accuracy information about exact place and traceability of materials to better consume of materials. These requirements are introduction of automated data collection in construction projects for efficient monitoring and control in real time.

One technology that has been gaining importance as an automated data collection is the Radio frequency identification (RFID) technology. Construction-site managers and subcontractors regularly attempt to retain accurate inventories of

their on-site equipment. If all items were tagged, an RFID reader at the construction site entrance could be used to mark the entry and exit of all tools and materials onto the site. The use of RFID technology in construction work processes was also considered for tracking precast concrete constituents and storing the information related to them through a supply chain [5]. The applications of automated data collection technologies in construction have been proved to have high benefits. These applications consist of quantity takeoff, field materials control, warehouse inventory and maintenance, timekeeping and cost engineering, purchasing and accounting, document control and office operations, simple and errorless data entry, construction materials and equipment management, and helping management in making informed decisions [5]. However, not many applications of RFID have been seen in construction practices, project managers may not have been fully aware of the uses of RFID in construction. All

advantages of the RFID enable a better real-time information visibility and traceability.

Many researchers have stated the requirement for investing in and automating materials management and control. In this paper, we categorize the materials management errors removable by RFID and show how RFID can remove these errors and bring some other gains to decrease time and cost in construction sites of complex projects such as industrial, infrastructure, and large scale commercial.

This paper is organized as follows: We start in Section 2 with a brief review of issues related to RFID in construction. In Section 3, we examine materials management in construction and discuss about automated materials tracking. Section 4 considers the introduction of RFID technology and its cost implementation. We present an analytical study in Section 5, where we classify materials management errors and RFID advantages to show how RFID can reduce time and cost in construction sites. The paper concludes with discussion and future research in Section 6.

2. LITERATURE REVIEW

To the construction industry, RFID technology is not new. Early in 1995, Jaselskis et al. [6] introduced its potential applications in construction provided information on RFID and its potential applications in the construction and lately Weisheng et al. [7] investigated various scenarios that can illustrate the uses of RFID technology in construction project management and showed how RFID can be used in the management of materials, men, and machinery for construction projects.

Song et al. [8] presented an approach to track materials on construction sites without adding any extra site operations. To develop models based on automatic, or semi-automatic, data collection for materials management and control. Domdouzis et al. [9] explored the applications of RFID technology in the construction Sites including automated tracking of pipe spools and other valued items, by comparing RFID with barcode system and magnetic strip system. RFID can store a relatively large number of data, encrypted to increase data security and possible to read data from multiple tags in one time. In addition to reading data, it is possible to write data back to the RFID tag, which greatly increases the interaction between items, system, and people processing.

Song et al. [10] expressed use of RFID technology to track uniquely identified materials through the supply chain as well Ergen et al. [11] put forward an automated system using RFID technology combined with the GPS technology for the tracking but not locating of precast concrete parts in a manufacturer's storage yard. They identified the high level requirements for an automated precast tracking system as: 1) No or minimal human input needed for data collection, 2) The accuracy of identification and tracking

of the materials should be higher than that with the existing systems, and 3) The proposed automated system should perform constantly under harsh construction conditions and in the presence of metal and concrete. Their research results indicated that the proposed automated tracking system worked satisfactorily, and the prototype system was successful in the data collection as well as semi-automated tracking

3. MATERIAL MANAGEMENT

In a comprehensive view, materials management is a planned procedure that encompasses the purchasing, delivery, handling and minimization of waste with the aim of ensuring that requirements are met [12]. It can produce what it should with the right quantities of the right material at the right time [13]. In construction sites we need some information such as: What materials have been fabricated? Whether materials have passed quality assurance? When materials have arrived on the jobsite? Which materials have been included into the structure? and so on. Hence, we discuss about the materials are consumed in construction sites and the issues related to position and tracking of them.

The materials for delivery to and from a construction site may be generally categorized as: (1) Engineered materials, (2) Bulk materials, and (3) Fabricated materials or units. The process of delivery, including transportation, field storage and installation will be different for these classes of materials. The equipment required to handle and haul these classes of materials will also be different.

3.1. Material Management Problem

Interestingly, many problems concerned management surface amongst local contractors even in developing countries. The problems normally differ in nature and intensity but are usually related to the inefficient management of construction resources including materials, labor, plant and subcontractors [14]. Few major materials management troubles were being identified in the construction industry in the UK and are summarized as below [15]:

- Lack of site storage space
- Problems with tower crane distribution
- Problems on logistic of materials
- Small loading region
- Problem with one site access point
- Difficulty in delivery of materials on site during aircraft operation
- Operation limitation as a result of security considerations
- Inadequate loading area at consolidation center
- Problems with congestion time at loading are

3.2. Automated Material Tracking

The major processes in an integrated materials management system are materials locating and tracking [4]. The main purpose of the automated materials tracking is to enhance efficiency, decrease data entry errors caused by human transcription, and reduce labor costs. There are a number of technologies that come under the Auto ID or ADC (Automation Data Collection) technologies.

In construction sites, automated materials tracking can provide some benefits as follow:

- Know the exact locations of all material and equipment anytime and anywhere
- Avoid costly delays caused by teams searching for construction materials
- Eliminate on-site delivery errors
- Get the right material to the workface faster

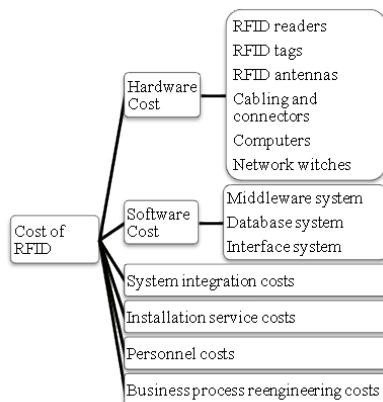
As is well known, RFID technology with to have possible advantages in the construction industry and particularly in materials identification, tracking, and locating is used to materials management. For example in situations such as heavy snow, sand, dirt, and heavy vegetation, it is often not possible to identify the materials using a manual approach [4]. Hence, in next sections, first we introduce RFID technology and its characteristics and then will explain how RFID can help to construction sites to improve their activities cost and time.

4.RFID TECHNOLOGY

Radio frequency identification (RFID) is an automatic identification and data capture technology which consist of five main components:

- 1) A RFID tag which could be either an active or passive tag.
- 2) A RFID interrogator [also called a Reader].
- 3) An air interface for wireless connectivity.
- 4) Processing architecture (middleware) such as a computer system.
- 5) Applications which could use the RFID information for further processing

Fig.1 RFID implementation cost tree [19]



A tag formed by a chip connected with an antenna; a reader that emits radio signals and receives in return answers from tags, and finally a middleware that bridges RFID hardware and enterprise applications [16].

RFID is these days usually related to the retailing and manufacturing industries, and it must also be acknowledged that these industries are driving development presently taking into account that major retailers such as: Wal-Mart, Tesco, Metro etc.

RFID is also widely used in facilitating electronic transaction (e.g. Toll collection in U.S., Octopus card in Hong Kong, or Oyster card in London), logistic and supply chain management (e.g. the internet of things), manufacturing and assembly (e.g. the assembly of cars), express service (e.g. American express), scientific research (e.g. tracing snakes and migratory birds), medicine (e.g. identifying a specific patient), and security (e.g. access control) [7]. In construction industry RFID technology is a promising technology that can be incorporated into systems that can track materials, identify vehicles, and assist with cost controls [17].

4.1.RFID Costs

The cost of acquiring, installing, and maintaining an RFID system is a key and influential factor in the use of this technology. There appears to be great variety and little quantitative information in the overall costs of acquiring, installing, supporting and retaining an RFID system. RFID system cost is made up of tags, readers, and processing and supporting information technology hardware and software. Higher adoption rates will cause system costs to drop and encourage more RFID users [18]. In Fig. 1., the cost due to RFID implementation and its related cost are classified.

5.RFID advantages in material management

Constructions sites are aggregation of activities, with vehicles dropping off materials, workers arriving and leaving, and tools being dropped off and picked up when they are no longer required. Activities must take place in carefully timed sequences to ensure each part of a project is completed as the next begins. The most conventional use RFID has seen so far in construction is in its ability to improve the efficiency of the materials management process. Large amounts of time and money can be saved when materials can be properly identified and located. In fact, in a case study conducted in their \$338 million Red Hills Project, time spent locating and tracking pipe supports and hangers was reduced by 30% (159 minutes per 100 hangers) as a result of the RFID system used. Also,

the inspection process was much easier and more accurate than that of the traditional manual process [20].

5.1. Classification of removable material management

One important factor in construction job sites management is exact information about materials. The information such as materials position and ability to track products from raw material to finished product. To examine RFID impact on cost and time reduction of activities execution in construction job sites, first we classify materials management errors removable by RFID in Fig. 2. and then we will explain each of them separately and will show how RFID affect on optimization of materials consumption by removing these errors.

1- Relocation errors: In an industrial project with a total installed cost in the range of \$200 to \$300 million, there can be around 10,000 pieces of individually tracked valves, fabricated steel components, pipe spools, and similar components [21]. So, when a huge number of materials are stored into warehouse or the stored materials are shipped for a construction activity, some errors such as shipping wrong materials and putting materials in wrong location may occur which take time and cost to be corrected.

After the materials are arrived on the site, they are sorted by the labors of the warehouse or workers of the contractor/subcontractor into grid marked areas by their physical characteristics and marked identifications codes materials having similar physical characteristics are grouped together. After the materials are sorted, the next step in the process is the storing of these materials in appropriate places so that they are readily available and identifiable when needed, and to keep them safe from an environmental and security point of view. In this process, a usual error that can occur is putting materials in wrong shelf. This occurrence is called misplacement of product.

Misplacement errors occur when some of the materials are not in their places, so they are not available to use. In according to the factors causing misplacement in retailer [22], we can introduce three sources that generate misplacement errors:

- 1) Staffs picking up materials and then putting them in another location
- 2) Labors not storing products on the correct shelf at the right time
- 3) Labors losing products in the warehouse

After the construction materials are shelved, the next step in the process is to ship them to the construction job site. Shipping means the transportation of the materials to the desired location either through road, air or water. Shipping includes all activities associated with transportation

such as rate analysis, method of packaging, transit time, and security. The mode of transportation depends on the types of materials being shipped, their size, weight, and lead times. Usually engineered and prefabricated materials, which are made in the same country where the project exists, are shipped through rail system or flatbed trucks using the highways. Large modules or materials which are not available locally near the job site are often shipped through sea or inland waterways and are received at the port before they can be sent to the job site [4].

Shipping errors can be very expensive; labors in construction sites have received wrong items and must pay double transportation costs to transport true materials. So, in this condition we paid additional time and cost to modify wrong shipment.

2- Inventory management errors: Inaccuracy problems in inventory management are important in construction sites. When information system inventory dose not adapt with physical inventory, an error series occur to receiving inventory. This can be due to the factors such as theft and shrinkage. Hence, we examine the factors which RFID can help us to control them.

Theft of cables, equipment, parts, tools, cranes, tractors and construction vehicles are ongoing challenges for construction sites and open-air depots. In addition to direct losses, the disruption to work schedules means further financial damage and inconvenience.

Inventory theft is defined as a combination of staffs theft, internal and external theft and employee fraud. According to the National Insurance Crime Bureau, approximately \$1 billion worth of construction equipment and tools are loss to theft each year in the U.S. construction industry. Usually, in construction sites we cannot use all materials that are bought. Because the factors such as: obsolescence and damage can decrease level of usable available inventory. But some of the occurred errors can be removed by RFID, so we discuss about the obsolescence.

Some of the materials shelved in warehouse of construction sites, may have not condition to consume. This condition can be the being out of guarantee or by spending much time of receiving date causing the materials not have appropriate quality to use. This situation can be due to existing of quantity of various using of them is difficult.

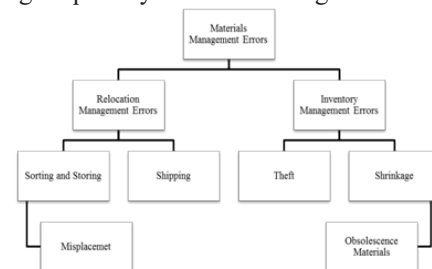


Fig.2 Materials management errors removable by RFID

5.2. RFID Application

As we saw, construction sites are challenging environments to manage with many critical questions to answer: How many parts ABC are currently on hand? Where is Partconsumption materials in warehouse and consequently, on time 123? and so on. To meet these challenges, more and a more construction companies and site contractors are benefiting by integrating RFID technology into their day-to-day operation of construction sites and projects. Efficient management of the materials used in construction projects can significantly reduce material costs and improve success in meeting project timescales. RFID technology with three major advantages can eliminate the errors of materials management and bring other benefits simultaneously which can lead to reduce time and cost in construction sites. We classify these advantages in Fig. 3. asfollow.

According to Avhad and Ghude [23] the basic benefits that RFID brings to the inventory management are automated data capture related to product information, status information, location and environment status information. As a consequence, in inventory information system of materials management, we can save costs related to manual operations and occurred errors of them as well as save time required to record data. In continues, some benefits that automation capture of data can bring to reduce cost and time in construction sites, are mentioned:

- Reduce labor costs for warehousing processes
- Increasing of data reliable
- Eliminate of paperwork errors
- Increase in warehouse processing accuracy and throughput
- Speed up physical inventory process

RFID allows to see the collection of data in real-time while one or more than one material is currently consumed. Hence, when we have access to visibilityin real-time, we don't need to search the construction site and warehouse to update information about status of materials that results in time saving. Also, information available in real-time helps to know about inventory level of materials which affect on the cost saving, because it reduced safety inventory of required materials to perform activities. The other profits of real-time visibility are in removing the errors due to theft and obsolescence. Therefore, RFID with this capability can provide some benefits such as:

- Time saving for information update
- Reduce excess / safety inventory

- Improved availability
- Removing the errors due to theft
- Decreasing of required materials shortage
- Better replenishment / re-order control of required materials
- Better control of materials consumption time to avoid obsolescence
- Better route planning

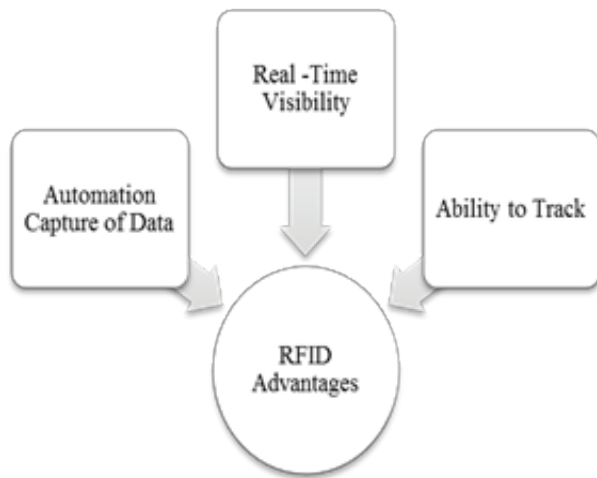
Maybe, the ability to track materials has been the most important advantage of RFID. Because when the materials are attached with the RFID tags, we can track them in all of materials transporting stages from receiving time to shelving in warehouse and shipping to use which help materials management. So, some errors like misplacement or wrong shipment can be removed. On the other hand, time and cost that must be spent to inspect and supervise materials flow for prevention of delay and doing works according to planning, can be saved. This advantage of RFID can improve time and cost consumption as follow:

- Elimination of wrong putting materials in shelves
- Tracking materials through construction site
- Pursuit of key products
- Prevention of wrong shipment
- Better handling of sensitive inventory
- Reduce costs of labors for locating and putting materials
- Avoid costly delays caused by teams searching for construction materials
- Compressed shipping times
- Enhanced security during shipping
- Get the right material to the workforce faster

6.CONCLUSIONS AND FUTURE RESEARCH

In this paper we have examined how RFID can reduce time and cost in construction sites of complex projects. For this objective, we first explained importance of materials management and automation tracking of materials. Then we have classified the materials management errors which can be removable by RFID. At last we have categorized RFID advantages in three groups and have showed RFID besides removing the errors due to materials management, RFID can bring some benefits to reduce time and cost simultaneously.

An interesting perspective would be considering the quality factor and examining RFID role in quality improvement. Also the major limitation of this research is a lack of trade-off between RFID costs and benefits which can be examined with return of investment (ROI) technique as future research. Also further research can extend RFID application to control of workers and equipments, and examine how RFID can impact on security and safety.



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