

Application of RFID Technology to Improve Material Management on Construction Sites

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Abstract – In construction industry effective inventory management is very much essential to define growth and success of a project. Recent researches have shown that even though construction materials and components contribute to 50%-60% of the total cost of typical project, conventional methods for managing them still rely on human skills. This leads to error-prone situations like counterfeiting, replenishment of stock and product misplacement. Because of these, emerging technology like RFID (Radio Frequency Identification) for real-time data collection is highly desirable. RFID facilitates the control on large number of materials which are required in every construction activity of building, from its planning to inhabitation. Case studies were done to identify existing problems and needs of industry. The findings reveal the demand for more sophisticated material management to improve material management processes. The paper presents the framework for RFID enabled inventory management system for real time tracking and identification of materials.

Key Words: Construction Industry, Material Management, RFID, Tracking, Automation.

1. INTRODUCTION

Effective inventory management is the backbone for all the construction companies in the new world. Each construction project is very unique in its nature and goes through various phases from its initiation stage to completion stage. The management of construction materials and components should be considered at all phases of a project. Most of the material management practices are undertaken manually and are time and labour intensive. Poor material management will lead to occurrence of problems like product misplacement, product theft, wastages, counterfeiting of products, etc. and finally can affect the overall construction quality, time and cost [1].

During last two decades, real-time information systems have become part and parcel in construction industry's inventory management. There are various modern tracking technologies available in the market which facilitates real-time tracking and identification of materials within no time. Among all the modern technologies available, one of the most extended and promising wireless non-contact systems is Radio Frequency Identification (RFID). Since the 1990's RFID has been applied in the field of construction [4].

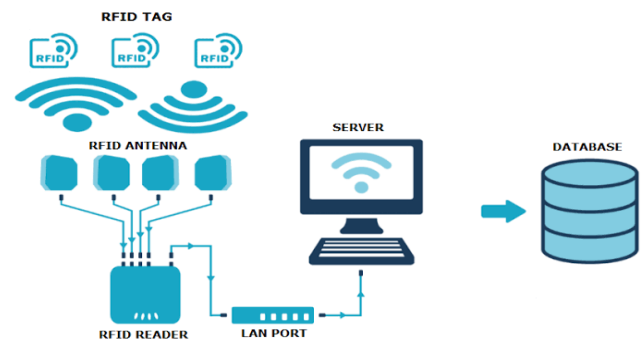


Fig -1: Typical RFID System

RFID system consists of tags (transponder) which are attached to an object, with each tag contain product information such as name, category, price, etc. and a reader with an antenna to read and access the data from tags. The data generated is sent to the controlling computer for record keeping. In this fashion, data collection is done automatically and correctly without having any human interference. RFID has a calibre to read several tags at a time through packaging or product itself and doesn't require a line of sight between tag and reader. Thus, we can get the data from mixed of materials almost instantaneously because of its ability to read large number of tags at a time [2]. Therefore, considering all the benefits of this system, this research work will focus on the potential employment of RFID technology in the resolution of specific problems related to material management in construction industry.

1.2 Objectives

The following are the objectives for current research work:

- 1) To identify existing problems in traditional inventory management practices.
- 2) To improve visibility and traceability of materials and components.
- 3) To propose a framework for RFID enabled material management system.

2. LITERATURE REVIEW

Anand Poojary and Dr. Satish Kumar (2014) [1] have extensively studied the RFID technology and explained significant advantages of it over manual methods. This type

of system provides managers with the ability to monitor and control the inventory in real-time. In this case study they came ahead with many benefits of using RFID for material management.

S. Prakash Chandar, Pashelpheta Anal and N. Ganapathyramasamy (2016) [2] have proposed the integrated RFID-GPS system as a step towards the automation in construction inventory management. They studied what types of materials will be suitable after applying this technology. They also have done the comparison between traditional and automated inventories. Precast members, marble, glass and sanitary items can be fully managed without having any human interference.

Narimah Kasim, Rozlin Zainal, Alina Shamsuddin and Nadira Che Kamarudin (2012) [3] have explained all the advantages the construction industry can get through implementation of RFID. The RFID applications like material detection, streamlined materials tracking, accurate material status, etc. were examined for their effectiveness, applicability and performance.

Enrique Valero, Antonio Adan and Carlos Cerrada (2015) [4] detailed out the use of RFID in wide variety of processes at different stages in the life cycle of a structure from its conception phase to its completion. RFID has been applied in construction industry since 1990's and new applications of it are still coming. The benefit to cost ratio of an effective material management could be up to 5.7 showing the clear advantages of paying attention towards material management.

Nan Li and Burcin Becerik-Gerber (2013) [5] have thoroughly studied a number of academic research papers on RFID. The case studies where actual implementation of RFID system were done includes sites in Ireland, Canada, Korea for equipment tracking, all assets tracking, personnel tracking respectively. The findings of study states that even in developed countries, RFID technology's application in the construction industry is not as widespread as in other industries like manufacturing.

3. RESEARCH METHODOLOGY

To identify existing needs and problems of industry regarding management of materials and components case studies were taken on residential and industrial construction projects. The data collection was done through questionnaire survey and interviews. The questions were categorized under broad headings as:

- 1) Practical problems in material procurement, handling and storage.
- 2) Approach to resolve problems.
- 3) Modern technology implementation and awareness about them.

Table -1: Case Studies

Case Study	Type of Project	No. of Projects	Respondents
A	Residential Building Project	5	Site Manager, Material Manager
B	Industrial Building Project	5	General Manager, Site Engineer

The results from the case studies are put together in below table:

Table -2: Case Studies Analysis

Factors for Analysis	Case A	Case B
Problems in Managing Materials	<ol style="list-style-type: none"> 1. Late Delivery 2. Logistics Problem 3. Site Access Problem 4. Product Misplacements 	<ol style="list-style-type: none"> 1. Late Delivery 2. Material theft 3. Inadequate Storage Place
Approach to Resolve Problems	<ol style="list-style-type: none"> 1. Constant Monitoring 	<ol style="list-style-type: none"> 1. Provide Enough Storage 2. Monthly Stock Checking
Use of Automated Technologies	No	No
Materials Tracking System	Manual	Manual

Generally, the facts collected from the case studies taken shows that the major problems related to material management practices are constraints on storage spaces, problems with material handling and distribution. Also material theft is one the noticeable issue. So, it is a need to find out the suitable alternative solution to manage construction inventory. As a result, this research work will develop a framework for RFID based inventory management to improve real-time material tracking and identification.

4. FRAMEWORK

The Framework consists of the following processes and elements:

4.1 Component Prefabrication, Storage and Delivery

Materials for a construction project can be classified into three categories: off-the-shelf components, made-to-order components and engineered-to order (ETO) components. [5]

4.1.1 Prefabrication and Storage

Different components in storage yard can be accurately identified and located. After manufacturing is done, tags are applied to the products before storing them.

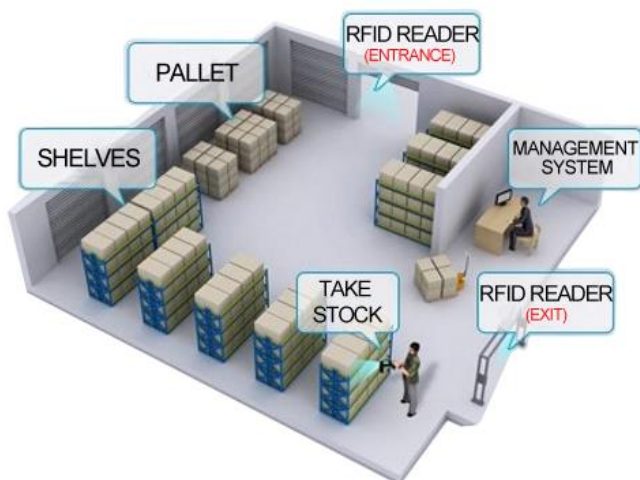


Fig -1: Storage yard with RFID System

4.1.2 Shipping

After prefabrication the tagged items must be shipped to construction sites. The items from the storage yard then loaded into the delivery trucks. The on-route locations of all the vehicles are tracked by the GPS receivers and data is sent to the system computers.

4.1.3 On-site Receipt

After receiving materials on construction project site, documentation is necessary. For these workers are sent for manual counting and checking of materials. This consumes lot of time. In RFID enabled system, when tagged items of delivery reach site, they get identified automatically and quantities of materials are get loaded into controlling computers. All these processes take only seconds of time. By this approach time can be saved and accuracy can be achieved.



Fig -2: Tracking & Identification at Site Gate

4.2 Construction Activities

Construction sites are complex in nature because of their constantly changing jobsite environments. Most of the material management work is done by humans which is insufficient and sometimes error-prone.

4.2.1 On-site Asset Tracking

The RFID readers are assembled at different positions as per the requirement such as main entrance and exit of construction site, storage yard's gate, etc. The tags continuously emit the radio frequency signals which are received by RF antenna. This identifies all the materials and components kept on site. If, when incorporated with GPS technology their locations can also be traced. RFID not only detects but also provide information about product units, price, weights, etc.

4.2.2 Locating Underground Assets

Locating underground assets is made possible through RFID, as RF waves can penetrate through soil underground components can be correctly identified.

4.2.3 Report Transmission

The main office will be involved in receiving all the materials' information from the site office to generate the data required to produce reports.

5. CONCLUSIONS

This research paper covers the potential benefits of RFID in material and component management and comes with a framework for RFID enabled material management system. The main benefits of RFID are improvement in component traceability and visibility, speeds up the processes, increases accuracy, reduction in material losses. RFID system can help material managers in better managing their inventory. As a result, this study encourages construction practitioners to look towards it as a best alternative which can provide better handling of materials and components to achieve overall performance of construction projects in terms of time, quality and cost. The fragmentation of the construction industry, temporary nature of relationships among project participants have slowed down the adoption of such modern technologies. But, by integrating RFID with existing systems

like GPS and GPRS, a more profound solution can be discovered to use this system to its fullest capacity.

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