# Automatic Materials Tracking Practices Through RFID Implementation in Construction Projects

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**Abstract.** Materials tracking for materials management play a vital role and contributed a major portion of the total cost in a construction project. In addition, the improper handling and storage of materials at the construction site has made it difficult to track and locate at the time are needed to carry out construction works. These problems subsequently contribute to the project delays and increase in the total project costs. Thus, this paper seeks to identify problems regarding current material tracking practices in materials management processes. In this paper, ICT and potential implementation of Radio Frequency Identification (RFID) for automatic materials tracking is also scrutinised. Data for this paper was obtained from the literature review and the case studies conducted in several construction projects. Semi-structured interviews with construction practitioners were carried out in order to gain insights into current problems, information and communication technologies (ICT) implementation, and RFID capability in assisting materials tracking practices. This paper reveals that construction projects in Malaysia are still using manual materials tracking practices, basic ICT implementation, and totally none RFID existence. Thus, there is a need for the application of RFID in order to facilitate materials tracking automatically for enhancing construction industry processes through IR 4.0.

## 1 Introduction

In construction projects, the cost of materials is a major contribution to the overall cost of the project. According to [1, 2], the overall cost of materials is 50-60% of the total cost of the construction project. This indicates that construction materials are required further intention due to the huge amount needed for construction projects. Therefore, materials management requires vigilant planning and control so that the building materials can be used effectively. Good construction material management is vital to ensure the success and competitiveness of a construction project. Hence, effective material tracking is essential in the management of materials. Material tracking activities are important especially when delivering materials to the construction site and storage areas.

[3] stated that materials' tracking in construction projects is important due to provide timely information on materials availability. There is also facilitate real-time measurement for controlling the progress of the project. Identification of materials tracking activities is important due to it is received an excessive alarm among key players in the construction industry. Therefore, the purpose of this study is to identify problems, and information and communication technologies (ICT) specifically radio frequency identification (RFID) implementation regarding material tracking practices in managing materials management for construction projects.

## 2 Literature review

### 2.1. ICT Implementation for Materials Tracking

Information and communication technology (ICT) implementation in construction could expedite the process of data transfer [4] and facilitate the effective and efficient control over materials on-site [5]. ICT plays an important role in construction, which is to make the sector more efficient and customer-oriented [6]. As ICT plays important role in construction, it is also important and the application of ICT could be implemented in materials tracking for the purpose of materials management. Previous research has shown the successful application of technology such Radio Frequency Identification (RFID), bar-coding, Global Positioning System (GPS), Geographic Information System (GIS) and others in materials tracking at construction sites.

Several types of research that have been conducted regarding the successful ICT application in materials tracking are as follow.

- RFID and GPS to track the precise movement and location of construction materials in lay-down yard [7].
- RFID to tracking tools and store pertinent operations and management (O&M) data regarding the tools on construction job sites [8].

- RFID and GPS technology in the identification and localization of engineering components on a construction site [9].
- RFID for real-time monitoring of construction materials on site [10].
- Integrated GPS, GIS, and RFID to track and locate construction resources on-site [11].
- Integrates Ultra-wide Bands (UWB) with RFID and GPS for asset tracking and safety assurance [12].

As ICT could expedite and facilitate the effective and efficient control over materials, it is important to implement ICT in materials tracking. ICT such as RFID application in materials tracking could assist the work and at the same time reduce the drawbacks caused by the manual method of materials tracking.

### 2.2 RFID Implementation for Materials Tracking

Materials tracking using RFID have been demonstrated by [13]. Base on his research, materials tracking in construction projects starts as early as the placing of purchasing orders from suppliers or manufacturers. The most common example is in the case of concrete ordering. In the construction site, usually, contractor sends in advance the purchasing orders which include the number of materials required together with their specifications via electronic e-mailing.

In the concrete plant, the site supervisor reviews the purchasing order and assigns trucks and trucks identification (ID) for delivery purpose. The truck was attached with RFID tags to record information related to job site location, concrete mix, admixtures time of loading and etc. The read-write scanner placed at the loading scans the truck tag and transfer information related to the concrete order from the plant computer to the tag. When the truck departs, the supplier sends electronically information related to the truck ID, time of departure and mix specifications to the construction site [13].

During arrival at the job site, a scanner at the entrance read the RFID tag attached to the truck. According to [14], the fixed scanner is always used at the entrance as it can monitor the flow of materials into and out of a construction site. A specific person was assigned to in charge during the concrete arrival. The person checked and compares information on the tag whether it is according to the purchasing order. When the truck departs, the scanner at the site entrance read the tag on the truck and information about the truck departure time was sent to the supplier, so that supplier can place another order related to that truck. Figure 1 shows the architecture for materials tracking at the main entrance using a stationary RFID reader.

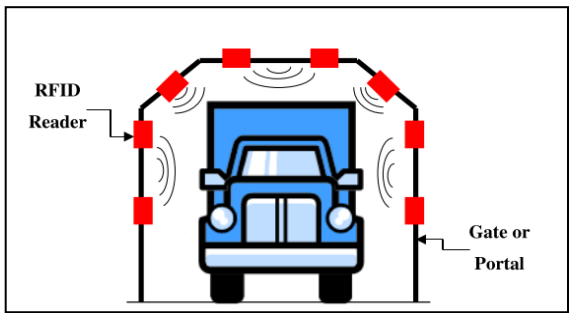


**Figure 1.** Materials tracking using RFID Reader [14]

However, at the storage; materials which delivered to the storage area were attached with RFID tags. It is the manufacturers or suppliers responsibility to equip the delivered materials with RFID tags. Relevant materials information such as date into the store, schedule date to install, the person in charge and others were input into the tags [15]. The inward and outward movement of materials within the storage were tracked by RFID reader installed at the entry or the exit points of the storage. Whenever material is moved from the storage, an alert is generated which gets updated in the system database. In addition, regular materials updates at the storage also are possible using the handheld RFID reader.

## 3 Methodology

This section presents several case studies undertaken among Malaysian construction projects. Objectives of the case studies are to investigate material tracking practices in construction projects and to identify problems regarding current practices. In addition, the case studies are important to identify potential implementation of ICT specifically emerging technologies (RFID, barcoding, wireless technology and etc.) in assisting materials tracking activities. It is expected that the suitability of emerging technologies implementation for Malaysian construction environments could be identified from case studies findings.

In order to understand current material tracking practices, the case studies explained material tracking undertaken in each case. Data for the case studies were collected based on semi-structured interviews with those respondents responsible for managing materials and overall site management (i.e. project manager, site engineer, site supervisors, etc.). Each interview session takes about 45 minutes to an hour. The interview questions were organised under several topics which consist of materials tracking problems, and ICT implementation. Data from the interview session was transcribed and involves both a single case and the cross-case analysis

The single case analysis was conducted in order to produce an individual case report and the cross-case analysis to make comparisons between each case. The cross-case analysis provides more robust findings compare with only a single case [16]. Details information on the projects involved in the case studies is presented in Table 1. There are variations in the type of project, respondents experience and the project cost. The differences provide an opportunity to explore variations in materials tracking practices and problems regarding materials tracking in each project.

**Table 1.** Project Background

| Case | Type of Project | Cost (RM) | Position | Experience (Years) |
|---|---|---|---|---|
| A | Agricultural Complex | 7.6 m | Site Engineer | 1 |
| B | School Building Project | 54.08 m | Site Engineer | 2 ½ |
| C | Housing Development | 12.8 m | Project Manager | 31 |
| D | Hypermarket Project | 118.8 m | Site Engineer | 2 ½ |
| E | Condominium Development | 46.3 m | Project Manager | 25 |
| F | Residential Development | 9.3 m | Site Supervisor | 1 |
| G | Public Infrastructure | 14.6 m | Project Manager | 12 |
| H | Residential Development | 40.2 m | Project Manager | 22 |
| I | Public Institution | 142.2 m | Site Supervisor | 3 |
| J | School Building Project | 38.0 m | Project Manager | 18 |

## 4 Results and Discussion

The result of the cross-case analysis among case studies is summarised in Table 2. Findings from the case studies revealed that manual method dominant for current material tracking practices in construction projects. However, the manual method of materials tracking which was practiced in construction projects has many drawbacks. From the case studies, the major problems regarding material tracking practices in construction projects are; time-consuming, lack of latest materials information status, extreme paper-based recording and reporting, labour intensive; and materials missing due to theft. The manual method of materials tracking is labour intensive as it requires human intervention to track materials during materials arrival and the issuance of materials in the storage area.

In addition, the excessive paper-based recording and reporting using the delivery order (DO) and log book make materials tracking more complicated. Furthermore, it is almost impossible to get the latest information regarding the status of materials as materials tracking was done manually and this is contributed by the fact that there are absentees of technology to assist in materials tracking. The implementation of materials tracking technology could automate the materials tracking. Hence, it is easy to get up-to-date information while at the same time decrease the dependency on manual materials tracking practices.

Regarding the ICT implementation, all case studies implement basic ICT tools in their projects. These tools include the e-mail system, fax machine, laptops, personal computers, telephone, internet connections and Microsoft Project. These tools can only perform the basic functions such as communication, purchasing and ordering activities, and in monitoring the work schedule. However, there are also a few cases which used WhatsApp, CCTV, and Microsoft Primavera to assist in the overall project management. The difference in the ICT tools used in every project is contributed by the fact that there are different needs for ICT implementation as a result of different project size and cost. However, findings from the case studies recorded that construction project did not implement emerging technology such as RFID to facilitate materials tracking. Although there is no implementation of RFID for materials tracking, however, all respondents are aware of the application of barcoding rather than RFID for automatic materials tracking.

The above discussion has discussed several problems regarding material tracking practices that happen in several construction projects in Malaysia. From the discussion, it can be concluded that manual material tracking practices has many drawbacks and it is important for construction projects in Malaysia to shift from the manual material tracking practices to the automated materials tracking using ICT. However, the basic ICT tools could not help assisting in materials tracking automatically. Therefore, sophisticated technology such as RFID should be implemented in order to assist and facilitate automatic materials tracking practices in construction projects.

**Table 2.** Cross-case Analysis

| Elements of Analysis | Materials Tracking Problems | ICT & RFID Implementation |
|---|---|---|
| Case A | • Extreme paper-based recording and reporting<br>• Time-consuming<br>• Lack of latest information<br>• Labour intensive<br>• Late delivery | • E-mail, fax, personal computers, telephone, wireless internet and Microsoft Project.<br>• No RFID implementation. |
| Case B | • Time-consuming<br>• Lack of up-to-date information<br>• Excessive paper-based records<br>• Waste of labour working hour<br>• Wrongly ordered materials<br>• Improper storage | • E-mail, fax, personal computers, laptops, telephone, wireless internet and Microsoft Project.<br>• Nor RFID implementation. |
| Case C | • Time-consuming<br>• Lack of up-to-date information<br>• Excessive paper-based record<br>• Inaccurate and subjected to error-prone<br>• Redundant work<br>• Theft | • E-mail, fax, personal computers, laptops, telephone, wireless internet and Microsoft Project.<br>• No RFID implementation. |

| | | |
|---|---|---|
| Case D | • Time-consuming<br>• Lack of up-to-date information<br>• Excessive paper-based record<br>• Defects | • E-mail, fax, laptops, telephone, wireless internet and Microsoft Project.<br>• No RFID implementation. |
| Case E | • Time-consuming<br>• Lack of up-to-date information<br>• Excessive paper-based record<br>• Theft | • E-mail, laptops, telephone, mobile internet, WhatsApp, and Microsoft Project.<br>• No RFID implementation. |
| Case F | • Time-consuming<br>• Lack of latest information<br>• Labour intensive<br>• Redundant work<br>• Theft<br>• Excessive paper-based record<br>• Late delivery<br>• Undelivered materials | • E-mail, fax, personal computers, laptops, telephone, wireless internet and Microsoft Project.<br>• No RFID implementation. |
| Case G | • Time-consuming<br>• Lack of latest information<br>• Labour intensive<br>• Excessive paper-based record<br>• Inaccurate & subjected to error-prone<br>• Failed to record materials<br>• Late delivery | • E-mail, laptops, telephone, mobile internet, WhatsApp, and Microsoft Project.<br>• No RFID implementation. |
| Case H | • Time-consuming<br>• Lack of up-to-date information<br>• Excessive paper-based record<br>• Failed to order materials | • E-mail, personal computers, laptops, telephone, wireless internet and Microsoft Primavera.<br>• No RFID implementation. |
| Case I | • Time-consuming<br>• Lack of latest information<br>• Labour intensive<br>• Failed to record materials<br>• Failed to order materials<br>• Excessive paper-based record<br>• Theft<br>• Wastage<br>• Delivered materials not according to the Purchase Order (PO) | • E-mail, fax, personal computers, telephone, wireless internet, CCTV and Microsoft Project.<br>• No RFID implementation. |
| Case J | • Time-consuming<br>• Lack of latest information<br>• Labour intensive<br>• Redundant work<br>• Excessive paper-based record<br>• Theft<br>• Wastage<br>• Materials not according to the Delivery Order (DO) | E-mail, personal computers, laptops, telephone, wireless internet, WhatsApp, CCTV, and Microsoft Project. |

## 5 Conclusion

This paper provides a review of ICT and RFID implementation in material tracking practices in construction projects. In addition, this paper also presents several case studies undertaken within the Malaysian construction environment in order to identify their problems, ICT and RFID implementation regarding current materials tracking. Therefore, findings from the case studies reveal that manual material tracking practices are still being implemented in Malaysian construction projects. Although current practices have several limitations, construction firms still rely on the current practices as it is flexible and does not incur additional costs. It is also found that all cases are aware of the potential implementation of ICT in assisting and facilitating material tracking. Therefore, the research concludes by suggesting construction projects should change from manual materials tracking to automatic materials tracking using ICT, particularly RFID for the effective and efficient materials management in enhancing construction industry activities through IR 4.0.

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