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DEVELOPING OF RFID AUTOMATION TECHNIQUE IN MATERIAL MANAGEMENT FOR VARIOUS CONSTRUCTION PROJECT

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ABSTRACT

In construction projects material management is one of the significant function that contributes to the success of a project. The problematic mostly occurring in the management of material is related to the shortage, availability, supply chain, inventory, handling, and the storage of material. Paper-based reports mostly to record and exchange information related to the materials within a supply chain and inventory which is error-prone, inefficient and time consuming. To overcome this error and problematic, real-time information visibility and traceability is highly desired and Radio Frequency Identification (RFID) technology can be implemented for this purposes. This paper starts with a literature review on material management and RFID technology potentially being employ was conducted. Further, a research methodology to identify potential employment of RFID technology for material management in a real construction project and what type of material will be suitable for implementing this new technology. The paper investigates a new approach for integrating the RFID technology in Information and communication technology (ICT) for real-time data collection in construction. In this approach, the combination of ICT, RFID, and global positioning system (GPS) technologies can facilitate extreme low-cost, infrastructure-free, and easy-to-implement solutions to identify uniquely and tracking of materials.

Key words: Construction projects, Material management, RFID, ICT, GPS, LSCM, Tracking, EPC.

INTRODUCTION

Construction materials account for 50-60% of the total project cost in the construction project. As the cost of materials is important the management of materials, especially at the inventory level and supply chain, are crucial for the successful project completion. Materials management is a vital function for improving productivity in

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construction projects. The management of materials should be considered at all the phases of the construction process and throughout the production periods. Poor materials management often affect the overall construction time, quality and budget. Many construction projects apply manual methods, not only for the tracking of materials but also for materials management as a whole, and this involves paper-based techniques and is problematic with many human errors. There are various advantages of adopting ICT in materials management; it has the potential to significantly improve the management of materials in the construction projects. This can eliminate the paper-based work, less productivity, idle of labor, operational cost, reduce cycle time and improve collection of real-time information. The previous method of construction, ICT is only used for material management for cost estimating through involving Microsoft Excel, and scheduling using Microsoft Project. However, there is not much use of modern ICT tools (e.g. wireless communications, RFID, GPS and GIS) to facilitate materials management processes in tracking material, erection and placing of material quickly, accurately, easily, and collection of real-time information.

Incorporate technologies such as RFID, GPS, wireless sensor network and Geographic Information System (GIS), wireless communications are expected to grow to support materials management practices in future. The main objective of this technology in the construction is to make sure that right information is always available at the right time in the right format to the right person to manage the right materials. These technologies have been successfully implemented in other industry sectors such as manufacturing, retail, and improving logistics and supply chain management (LSCM). In logistics and supply chain management (LSCM) using of RFID technology, such as real-time traceability and visibility, enabled at the upstream (e.g. manufacture) important for increasing the efficiency and quality of supply chain operations, especially towards the downstream (e.g. distribution, wholesale, and retail). However, little attention has been paid to the investigation of RFID technology in construction which is also an information based industry in addition to its labor, material, and capital intensive nature.

Radio frequency identification (RFID)

RIFD system consists of tags (transponder) with an antenna, a reader (transceiver) with an antenna, and middleware. The RFID reader acts as a transmitter and receiver and transmits an electromagnetic field that ‘‘wakes-up’’ the tag and provides the power required to the tag for operating. A RFID tag is a portable memory device located on a chip that is encapsulated in a protective shell and embedded in any object which stores dynamic information about the material. Tags consist of a small integrated circuit chip, coupled with an antenna, to enable them to receive and respond to radio-frequency queries from a reader. Tags can be categorized as Read-Only (RO), Write-Once-Read- Many (WORM), and Read–

Write (RW) in which the volume capacity of their built-in memories varies from a few bits to thousands bits. Tags are attached to vehicles and material components and encoded with an identification number (ID). As the vehicle approaches the antenna, the antenna broadcasts are received by the tag. The tag modifies a portion of the radio frequency (RF) signal and reflects it back to the antenna. This reflected signal contains the identification information for the object. After the antenna captures the signal, it is sent to the RF module where it is preconditioned and amplified. The signal pass to the logic module (part of the reader) for final decoding and processing. The reader logic interprets the ID code from the signal and validates the ID code based on user-defined criteria. It can also affix a time, date, and location stamp to the code. The reader finally transmits the code to the host computer or other data logging device. RFID has the potential to read a large number of RFID tags through the packaging or the product itself, almost instantaneously. Theoretically, this means that you could take a material of mixed products, all of which contain individual RFID tags, and RFID reader read all the tags within the fraction of time second, without having to move physically any of the materials or open any cases. RFID tags are reusable, less susceptible to damage and readable through a variety of substances, such as ice, snow, paint, fog, crusted grime and other visually and environmentally challenging conditions.

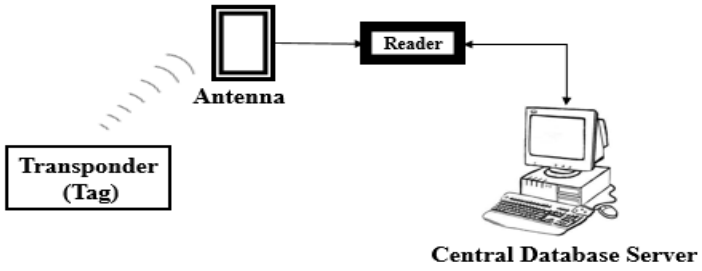

Fig. 1: RFID working mechanism

Construction material management

Materials management is an important function to improve productivity in construction projects. This is concerned with the planning and controlling process to ensure that the right quality and quantity of materials and installed equipment are appropriately specified promptly, obtained at a reasonable cost and are available when needed. Materials management involves the logistics of the materials components of a supply chain which involves the process of planning, implementing and controlling the movement and storage of raw materials, work-in-process inventory, and finished goods from point-of-origin to point-

of-consumption. The management of materials should be considered from the phases of the construction process and throughout the production period. Therefore, there is a need for an excellent managementsystem for handling materials.

Research methodology

The objective of this research is to identify the existing needs and problems and to define the corresponding objectives and scope of the technology. A comprehensive literature review including studies related to RFID applications in construction, automated material management systems and technologies was conducted. Selection of materials and components is carried out for feasible installation of the automation. The potential of the automation to adopt in the construction industry is studied and based on the suitable best technology available selection criterion is done. Based on this criterion, the different available automated data collection technologies are analyzed regarding their stability for materials identification and tracking.

(i) Precast member, tiles, marble, glass and related to the concrete components, etc. it can easily identify by the automation and tracking of materials can achieve without any interferences. The HF and UHF passive tag are more suitable; the materials are transparent which the signal can penetrate and enable to transmit radio wave and capture the data where about of the materials. It can identify and track the materials at different position and direction without direct line of contact. The long range reader along with antenna can be adapted to transmit the signal when it comes contact with the tag. The reader can identify and read the UHF passive and UHF active tag by the UHF reader only.

(ii) On the other hand, prefabricated steel member and iron bar etc. cannot be detected by normal HF and UHF tag since radio waves cannot penetrate due to the opaque nature of the material. The reader cannot detect the tag due to the position and direction in receiving the signal to identify and read the material. For such material UHF insulated metal tag along with long range reader can be preferred due to its ability of penetration and long range detection which is possible for easy identification and tracking of material. The insulation metal tag can also prefer for some expensive material and components for installation in the construction site. Fig. 2 showing the flowchart of research methodology.

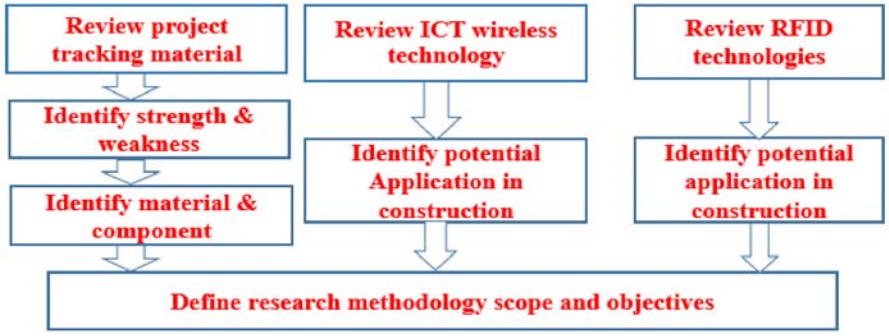

Fig. 2: Flowchart of the research methodology

Proposed of integrated RFID-GPS system

This research introduces the pioneering combination of GPS, and RFID technologies for tracking of materials to collect the real-time information. Even though each of them can be used as a stand-alone system in construction, their combination will significantly raise the consistency and reliability of the system as a whole, thus, greatly assisting the data collection process. When configured together, GPS and RFID receivers can establish their coordinates and quickly identify the presence of several tagged items. In this research, the RFID–GPS based mobile, a pervasive and ubiquitous system, was developed. This system is divided into two main parts, namely, hardware and server. The hardware mainly consists of two types of components namely:

(i) RFID technology (RFID tag, reader, and antenna): RFID is selected as the technology in the Identification segment, and RFID tag is used for identifying and monitoring objects by using the RFID reader, through the antenna which is connected to the system.

(ii) GPS technology (GPS receiver): GPS is selected for the positioning of location and tracking segment of the material. In order to track the location of materials, GPS was used for positioning equipment that transports materials, or positioning the location of the system. Fig. 3 showing the schematic of RFID-GPS system and data collection on the delivery and on-site of the material.

The server can consist of two parts: application server and database server (supplier database and project database). The application server could use different software for collecting, storing, updating, modifying, filtering, and sharing this data to act as a supply chain management, inventory control, materials location information, materials status, and

other applications. RFID tags are attached to any objects, such as materials, components, tools, equipment, and even labor etc. RFID tags is scanned when they come into each reader's reading range with the help of an antenna, and the information gathered from a RFID–GPS based system is transmitted to the server. If the object moved to a new location, this system can effectively track its location and movement. These advantages are due to the flexibility of the proposed integrated RFID–GPS based system. On the other hand, the collected server database is transformed into project database for modeling and scheduling of material management in the construction site.

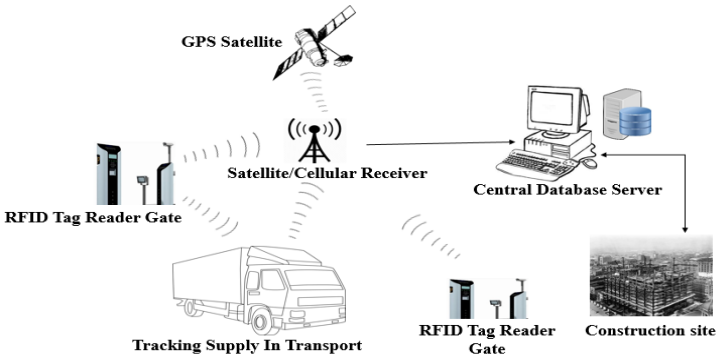

Fig. 3: Automated data collection on delivery & on-site

Developing framework and model

On the upstream level (e.g. manufacturer, production, and suppliers) materials and components are tagged with the RFID tag respective to the nature of material containing a unique ID and the object information. Another scenario for tagging materials and components could be carried out at the construction job site. Whereby, upon the arrival of materials, the RFID tag will be manually attached to materials and components. The reports of tracking information for a particular product are based on the identity of electronic product code (EPC). EPC is a sort of license plate with a unique number, which allows clear identification of a marked object. The manufacturer of the tag provides few spaces for the installation party to reprogrammed and add their ID or data related information to allow identify and track the material. Every item will have a description and a history of its movements, such as company name, product information, shipment date, and expiry date, and so on, recorded on a database accessible to authorized users.

The HF and UHF passive tag used for precast, tiles, marble and concrete components cost around (INR) Rs.17-35 per tag and the long range reader along with antenna which cost (INR) Rs. 2 Lakh. On the other hand, for opaque materials such as steel

member and iron member, metal insulated tag have to be preferred which cost around (INR) Rs.300-350 per tag and the long range reader along with the antenna, cost (INR) Rs. 2 Lakh. The above two different tags can be adopted depending on the nature of work and requirements of the construction material.

The reader along with antenna identify the tag and read the specifically related materials. The reader collects the data and information from the tag, and it stored automatically in the database without any input nature. The data can be visible and available throughout the entire project. During the tracking, it does not require direct contact with the material to locate and collect data.

Collective information is sent automatically to the project database, this means that all the information is available in one place so that construction players can access it in a cost-effective way, almost instantly. Thus, an electronic exchange of information is created in this research, which provides real-time information and wireless communication among all players, such as upstream parties and downstream parties to support project managers of each partner in monitoring and controlling progress in construction. The collection data and information is readily transferred to the construction site and project manager can access through Microsoft Project (MS Project) for modeling and scheduling of the material. Figure 4 showing the information flow from the supply of material to installation and erection of material on the construction site.

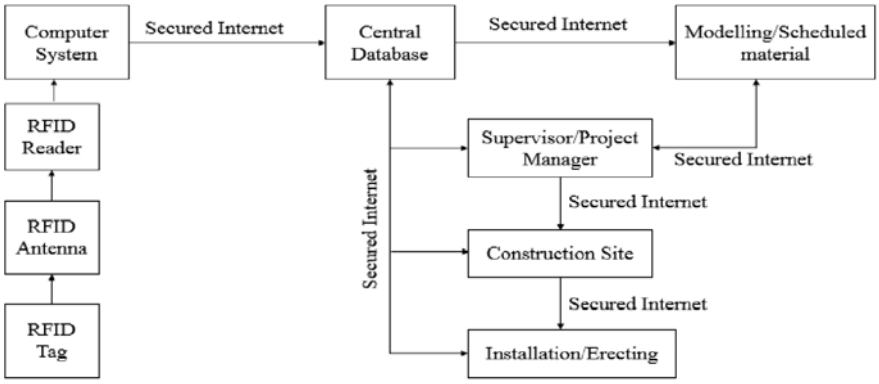

Fig. 4: The flow of information on the construction site

From the above development of framework, the technology extends the feasible amount of transformation in the construction industry, which readily can improve the efficiency of construction and increases the productivity and reduces the time of completion projects. Though the cost incurred during the initial stages of installation seems to be

expensive, later the technology proves to be more worthwhile than the initial cost. In the conventional and manual work process, though the cost incurred is comparatively less compare to the automated process, the efficiency is low, and productivity is very low, and the time consumption in the completion of the project is very high. The automated process proves to be high efficient, high productivity and consume less time for completion of the project. Looking at the different techniques and the work that one wants to execute, we can select the most appropriate method of doing the job. Keeping in mind the three parameters, the safety aspect of it should also be in consideration.

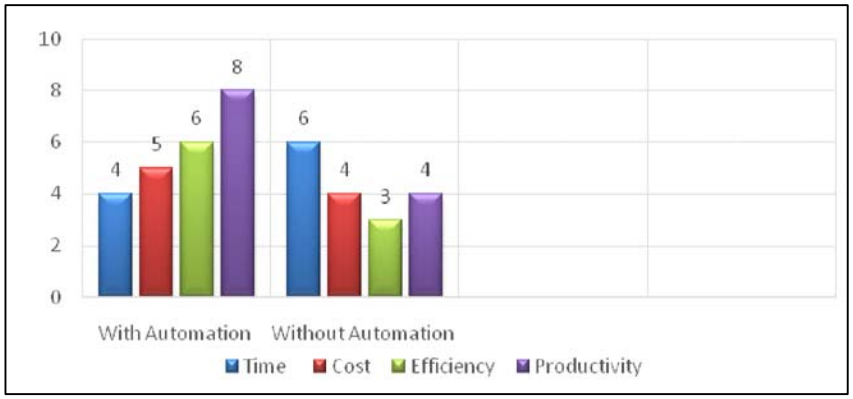

Fig. 9: Comparison of with automation and without automation.

Challenges and future research

RFID is used in various sector before the construction industry, owing to its different advantages. A pilot test is necessary to face challenges, by adapting the new technology in the construction industry. The new technology seems to give expensive in adoption, the cost incurred high only during the first installation of its hardware. But the future benefits outcome more from its initial installation. The technology will enable to give the real information and data of availability of the right materials, in the right quantity, at the right place, when they are needed. Implementation of RFID technology for material management will be relatively simple and offers easily capitalized benefits, if RFID tags would already be attached to at least certain types of products procured from the wholesaler, who is using RFID technology in its operations. Different RFID standards become a minor problem as upstream companies need to agree on the common industry-wide standards to use RFID tracking in their operations. The most significant drawback of adopting this automation may be the difficult detection and tracking of materials in case of opaque materials which require detecting the material in different direction and position, if not the reader may not able to read the tag. For such problematic arising metal insulated tag is the solution for such

material. On the other hand, in most of the construction industry still conventional materials and components such as brick, sand, steel, etc. are still used as compare the cost of the tag to be tagged on each material it does not prove to be economical but results in the escalation of the project cost. For adoption such new technology in the construction industry separate budget have to prepare and allocation of separate financial will be advantage for the possible implementation of this automation.

RFID technology is still relatively expensive although the cost has been reduced over the past years. Expensive tags are mostly preferred for reading the long distance, which makes the technology less competitive. Moreover, the upstream and the downstream party should collaborate and look forward to using the new technology. The construction industry must look forward to such new automation to increase its efficiency and productivity and in the near future.

CONCLUSION

This paper presented the benefits of the RFID technology in management of materials for the various construction project. The potential of RFID technology encourages in the construction industry to adopt in the near future to eliminate the error and problematic facing in the transferring of real-time information. It also envisages the importance of Information and Communication Technology (ICT) in the construction industry. The technology can provide intangible and comprehensive benefits in communication and labor utilization and time consumption to transfer information and avoided the paper-based recording in the material management. This paper also envisages the changes in the construction industry from its conventional method of practice to the new level of adoption new automation and technology to overcome the barriers and improve every aspects and stages to the construction.

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