Radio Frequency Identification (RFID) denotes a system with electronic devices that use radio waves or pulsating magnetic fields to communicate with identification units fastened to objects. The most referenced components in RFID systems are tags, readers and middleware. Tags are identification units attached to the objects to be localised. The RFID reader is via an antenna used for scanning the data content of the tags. The middleware is the software component which ties the RFID reader together with the other software components (e.g. an operation and maintenance system) in an IT system and, if necessary, also filters the data before it is relayed.

Radio frequency identification (RFID) have created emerging applications for tracking, sensing, and identifying various targets in wide-ranging areas such as supply chain, transportation, airline baggage handling, medical and biological industry, and homeland security. RFID systems with a variety of radio frequencies and techniques have been introduced. Among them, ultra-high frequency (UHF) band passive RFID systems...
that operate in the 860 – 960 MHz band have drawn a great deal of attention because of its numerous benefits, such as cost, size, and increased interrogation range. In particular, the interrogation range of the UHF RFID system is comparatively large, due to the use of a travelling electromagnetic (EM) wave to transfer power and data. The increased interrogation range makes it possible for UHF RFID systems to revolutionize commercial processes, such as supply-chain management.

Need of RFID In Precast Concrete Industry

A precast concrete manufacturer is liable for a component from the time that they cast the component until 25 years after installation. Precast components used in a facility are expected to maintain their original condition throughout its life cycle. Any problem that might have occurred during the manufacturing and erection of a component might not surface until late in service. Once a problem is detected during service, it is important to know the full history of a component to address the issue effectively. At the manufacturing phase, the material information about precast components should be documented during casting. After the components are cured, the information on where they are being stored should be documented to minimize the time-loss in locating components in a large storage area. At the construction phase, deliveries should be inspected to ensure that the components have the desired quality. Any problems during installation should be documented as part of a component’s history. Currently, critical information about fabrication and installation processes is not stored at all or cannot be accessed easily after the completion of a project, since they are mostly paper-based and stored at different locations. As a result, when a problem occurs with a component, it is hard to access the relevant historical data important to identify the cause of a problem. Part of material tracking problem, especially at the site or a large storage area is being addressed by barcodes. Even though barcodes provide an easier way to track components, it has been noted that barcodes are being damaged in the harsh construction environment. In addition, in some cases, it is difficult to access the tag for scanning (especially in storage areas) since one needs to be next to a barcode to be able to read the information. Finally, barcodes do not have any memory, and hence it would be impossible to store the history of a component on a barcode. Radio Frequency Identification (RFID) is another identification technology that uses memory chips attached or embedded to objects to transmit data about them. In this paper, we discuss the utilization of RFID technology to locate and track the precast pieces and to store information about them from their fabrication to installation. Our discussion revolves around a use case developed based on data obtained from a large-scale precast manufacturer. Refer Figure 1.

Background of RFID

RFID is a relatively new technology for automatic identification of objects using radio waves. RFID system has two main components, the tag and the reader. The tag is attached to the object we want to identify and the reader is used to read the tags information content. The tag has at least a unique serial number for identification, but many tags can have other information stored to their memory as well. RFID can be seen as a competitor to barcodes. Comparing RFID to barcodes, one can see a few advantages. Because RFID is based on electromagnetic waves, it doesn’t require a line of sight between the reader and the tag. This means that the tag can be hidden inside the identifiable object. RFID tag can also contain more data than a barcode. This makes it possible for each product to have a unique identifier, not just the identifier of product group or type. In many cases, it is not acceptable to have visible stickers on a product after it has been delivered to its final user. Furthermore, stickers with barcodes are not durable enough for many environments. Since RFID tag can be placed inside a product or even embedded inside products material, it can remain with the product during its lifetime without bothering the end user visually. RFID tag is an electronic label that stores data and is attached to objects. Readers, which send RF (Radio Frequency) signals for communication, are used to read data from these tags. A reader is composed of an antenna, a transmitter/receiver and decoder. Current RFID technologies use three frequency ranges: low (100-500 kHz), intermediate (10-15 MHz), and high (850-950 MHz / 2.4-5.8 GHz). Table 1 lists some of the unique characteristics of each frequency range. Low and intermediate frequencies are commonly used for inventory control, while high frequencies are used for railroad car monitoring and toll collection systems. RFID tags can be classified as either active or passive based on the power source. An active tag has an internal battery for power. A passive tag utilizes the energy generated by a reader/antenna. Active tags have a greater read/write range (up to 30 m.). However, they are larger in size, more expensive, and have a limited life span (5-10 years). Passive tags are cheaper.

Figure 1: Precast concrete members with RFID tags
smaller, lighter, and have unlimited life span. However, they require a more powerful reader and have shorter read ranges. Tags also can be read only (RO), read / write (R/W) or write once / read many (WORM). The principle of Radio Frequency Identification (RFID) has been known since the Second World War, but it has just recently become popular since the tags, and readers have become affordable to many solutions.

**RFID Technology Implementation Process in Precast Concrete Industry**

RFID technology can be used to locate each precast piece on a storage area without line of sight requirement, and ensure a reliable delivery schedule to a construction site. Additionally, information about manufacturing, inspection, and construction can be entered to a tag. When an owner places an order, the designers in the company designs the components, and assigns an ID for each piece. During the fabrication of each piece, passive R/W tags with unique IDs are attached to the pieces. During that time, all production-related information is entered to the tag. After 1-2 days when the curing is complete, the pieces are checked by the inspector. The inspector’s approval of the quality of precast components will also be stored on the tag before the components are sent to the storage area. A grid of transponders ("tags") is embedded in the floor of a storage area. When a piece is placed in a storage area, first its tag is read to retrieve its ID and all the other information, and then the embedded transponders are read to match the transponder’s code with the location in the storage area. This information in the reader is then sent to a supplier’s material database. This would enable quick identification of the member at the storage area and hence just-in-time delivery of the pieces to a construction site. Whenever the location of a piece is changed, the same process is repeated, and any new handling information will be stored in the tag as part of the history of a component. Once components that need to be delivered are identified, they are loaded onto a truck, which is also tagged with a W/R transponder. The IDs of the pieces are read and entered to truck’s tag by a handheld reader. When the truck departs, a reader installed at the exit records the components that are shipped. The date, truck ID, component IDs are sent to the supplier’s material database, and to the scheduler who works for the erector. Receiving this information, staging areas are determined on a site, and a crane is assigned for unloading. Additionally, during transportation of materials, the delivery truck can be tracked by GPS; thus, both the manufacturer and the erector can be informed about the real-time location of the truck and the components. At the entrance of a construction site, truck ID is read, components recorded as arrived in a database, which can be used for invoices and payments, and the manufacturer is notified that the delivery is completed. Another inspector who works for the erector company, checks the pieces, and enters any damage or defect that might have occurred during transportation. Finally, pieces are installed according to their IDs, and the current site conditions, and information about installation methodology are also stored in the tag as part of the history of components. As a result of this new process, delays due to locating materials at a...
manufacturing storage area and on a construction, site are minimized and all the important information about the history of a component is stored on a tag. This information can be retrieved any time after the installation of a component should there be a problem. As a result, a manufacturer can efficiently identify the cause of the problem, effectively manage the problem, and take precautions for similar problems that can be observed in other components. Refer Figure 2 and 3.

Test system

The system for identification of the concrete elements is built of the following parts:
- RFID tags
- RFID reader connected to laptop computer
- A laptop computer running the user interface for managing the data
- A server with database and a Web server for user interface

Figure 4 represents the test system. A RFID tag is embedded inside the element to be identified. Before embedding, the tag is read and its serial number is added to elements information in the database. The database, on the server, holds all the data connected to elements and implements a web user interface which can be used on any networked computer with a web-browser. The system for these tests was really simple and was only used for adding/modifying data concerning element in question and retrieving this information. Steps for adding new data and retrieving data are presented in Figure 5. The user is using a laptop with RFID reader connected through USB-port and a network connection. Adding and retrieving information happens with the help of a browser and a web user interface.

Benefits of RFID Over Other Tags

RFID tags are technically more advantageous than barcodes in material tracking and documenting the history of a component. RFID tags have capability of larger data storage. In addition, they can operate in harsh environments and do not require line of sight like barcodes. Besides, it is much faster to collect information about a batch of components using RFID since RFID technology allows collection of up to forty items per second. Data security is achieved in RFID tags with an optional password mode, which requires a password to enable read and write functions. Data in a tag can be locked by the user to prevent future modification.

Conclusion

The RFID system improves the efficiency of locating the components in storage areas in manufacturing plants. In addition, tracking the components during the delivery process is beneficial for just-in-time delivery. Finally, storing the necessary information in the tag helps the manufacturers to retrieve the history of a component quickly and identify the cause of any problem that might occur after construction.

Reference

- Embedded RFID In Product Identification, Tommi Kallonen and Jari Porras, Lappeenranta University of Technology, Department of Information Technology PO Box 20, 53851 Lappeenranta, Finland
- Utilizing Radio Frequency Identification on Precast Concrete Components – Supplier’s Perspective Burcu Akinci,Mark Patton, Esin Ergen