Applications of Radio Frequency for the Construction Industry

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SUMMARY

We present an overview of some current problems in the construction industry in Hong Kong to which applications based on Radio Frequency ID (RFID) can provide solutions.

A brief introduction to RFID is given along with a description of two solutions for concrete cube testing.

INDUSTRY OVERVIEW AND INTRODUCTION

Henry Tang’s Report,1 *Construct for Excellence*, highlighted some key areas of concern relating to quality control testing:

“The security arrangements for testing samples, including their selection, collection, identification, marking, transportation and dispatch of test results, practiced in the industry are (also) often found inadequate.” [para 4.40]

And

“Quality control tests and acceptance tests conducted on site should be closely supervised. There should be enhanced security procedures for the sampling and testing of construction materials, including sample identification and stock control, to prevent possible tampering.”[para 4.41]

In addition, the following major concerns of the construction industry in Hong Kong have been noted:

- **Conflict of interest** - if contractors are responsible for both construction material testing and works acceptance tests
- **Switching of test samples at site**
- **Integrity of test sample data**
- **Security on site**: illegal and inadequately trained workers working at project sites
- **Materials quality control**
- **Inventory control**

In response to these concerns, Intrare Consulting has developed solutions based on RFID technology.
WHAT IS RFID?

RFID (Radio Frequency Identification) is uniquely suited to the pursuit of automated testing, since it is a highly reliable way to electronically control, detect and track a variety of items using FM transmission methods. As a mainstream supply chain technology, RFID creates a dynamic link between people, objects and processes, and has fast become a primary technology in data collection, identification and analysis systems.

The competitive advantage to be gained comes from the continuous improvements to software systems and business processes that would be impossible without the RFID devices. The full potential of RFID technology has only just started to be realized, yet RFID

- Improves data integrity
- Reduces handling and labour costs
- Cuts cycle times
- Eliminates errors and put a wealth of data at your fingertips in real-time
- Works effectively in hostile environments where excessive dirt, dust, moisture and poor visibility would normally hamper rapid identification
- Provides a contactless data link without the need for line-of-sight between the transponder and reader
- Improves overall operations

The automation of concrete cube identification and the real time availability of quality test results will eliminate the manipulation of test data and human errors, promoting greater operational efficiency and discipline, thus improving the level of professionalism and quality standards within the industry. Historical records of concrete test data (from start of project till its final completion) can also be archived securely and permanently for future audit purpose.

The components of a typical RFID system are:

- **An RFID smart label or tag** – this can be ‘active’ or ‘passive’ and is from some manufacturers is a paper-thin identification label which contains a programmable integrated circuit (IC) and has an antenna connected to it. This communicates through radio frequency (RF) signals with a fixed-position or handheld reader/writer.
- **A reader**

The smart labels can be encoded with unique data which can later be read by a suitable reader; the labels operate by collecting energy from the RF field emitted by a reader device.

RFID is generally intended to automate logistical operations by providing machine readable and writable labels for objects. It is an enhancement of existing methods for automatic object identification and has:

- two types of RFID transponders: Passive and Active
- Read range from contact to >100m distance
- Frequencies – from 125KHz to as high as 2.45GHz

RFID is an industry-proven technology that is widely used in US, Europe & Asia
CONCRETE CUBE TESTING IN HONG KONG
Switching of concrete cube samples can happen almost anywhere, from the point of concrete pour to the point of delivery to the test laboratory

At present, the conventional practice is:
A sample of 2 cubes are made from each truckload of concrete delivered to site
Manual recording of test sample data at site by authorized tester
Test sample collection typically subcontracted (low cost)
Cost of collection and testing is low, yet cost of failure and data manipulation can be high

Key issues are security and integrity of sample data, the collection and delivery of large numbers of samples.

RFID technology can be applied to address these concerns:

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<thead>
<tr>
<th>Problems with conventional practice</th>
<th>A solution using RFID</th>
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<tbody>
<tr>
<td>• Paper-based, manual system</td>
<td>• Automates much of the data entry and data capture</td>
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<td>• Laborious, thus prone to human errors</td>
<td>• Can ensure data is entered by authorized persons only</td>
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<td>• Open to abuse</td>
<td>• Guarantees the identity of the test cube</td>
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<td>• No guarantee that the tester is qualified</td>
<td>• Protects integrity of test sample data</td>
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<td>• Test samples can be switched</td>
<td>• Direct match of sample ID and test data automatically and so protects against falsification of results</td>
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<td>• Same sample data are created twice – at the site and at the lab</td>
<td>• Allows due diligence tests by Central Laboratory staff on any test from any lab on samples submitted from any site</td>
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<tr>
<td>• Creates extensive and cumbersome paper trails when an exception is detected or during an emergency</td>
<td>• Automated test procedure means optimized use of manpower and other resources</td>
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RFID CONCEPTS FOR THE CONSTRUCTION INDUSTRY
RFID applications of great potential and interest to the construction industry should be:

• Construction industry related:
  - Concrete cube and lab testing
  - Inventory control (e.g. pre-cast)
  - Geotechnical testing (measurement of soil movement or ground water level, etc.)
  - Quality control (update on construction progress or product authentication)
  - Security control (site access, worker control/verification)
• Quality and process control systems: here we see potential for RFID tagging of prefabricated items at accredited manufacturers with subsequent item tracking through each step of the supply chain to inventory control
• Asset tracking
• Product authentication
• Security
Intrare Consulting’s has conceptualized two systems for concrete cube testing based on RFID technology:

**ACT.SYS™** - An improved, test lab-centered system to better manage concrete testing

**LCM.SYS™** - A web-based portal for central labs to effectively manage lab testing at the macro-level

We plan trials for both systems in Hong Kong. Label testing and durability under various conditions have been performed by MTR Project Laboratory.³

**ACT.SYS™** is an improved, test lab-centered system that:
- Makes full use of RFID smart labels to efficiently manage concrete cube testing
- Requires minimum hardware - RFID reader and disposable smart labels
- Can be installed and implemented cost-effectively
- Includes Order Taking, Task Scheduling to allow test labs to optimize resource allocation & to improve overall operations
- Flexible system platform that integrates test reporting for a project: allowing test labs to compile & tabulate other materials test results received in varied legacy forms for concise project reporting
- Preserves data integrity of test results

**LCM.SYS™** is a web-based portal solution for central lab to effectively manage lab testing at the macro-level. Its primary functions include:
- Working with contracted/subsidiary test labs for submitting and collecting test reports
- Monitoring individual lab test progress, checking and verifying test reports received
- Managing test results and producing integrated management reports (project-based)
- Requires minimum hardware - RFID reader and disposable smart labels
- Providing services of test analyses and other professional consultancies
- Ability to take input from the in-house **ACT.SYS™** or any other legacy formats

The benefits to a lab in using **ACT.SYS™** and/or **LCM.SYS™** are:
- Data capture via RFID smart labels ensures the integrity of test data & protects against falsification or manipulation of test data/results
- Central lab staff can perform due diligence testing on sample testing carried out at each contracted/subsidiary test labs, efficiently and accurately
- Automating test procedure = less manpower + a more cost-effective operation
- Wealth of information at your finger tips in real time for instant data analysis
- Complete data archive for future reference and audit purpose

Central laboratory management of concrete cube testing (**LCM.SYS™**) is a web based portal solution for the central laboratory to manage and monitor concrete testing conducted by contracted or subsidiary test labs in an efficient manner. Its primary functions include, in the first phase,

- Working with commercial and/or subsidiary laboratories for submitting and collecting test reports more efficiently
- Monitoring laboratory test progress, checking and verifying test results
- Managing test results and producing management reports, and
• Providing services of test analysis and facilitating other professional consultancies

\textit{LCM.SYS}^\textregistered provides two options – (1) test results submission from commercial laboratories to the central laboratory database, and (2) laboratory submission of test results and/or direct online data acquisition. It takes input from the in-house \textit{ACT.SYS}^\textregistered or any other legacy formats.

CONCLUSION
RFID offers an elegant way to solve a number of problems identified in the construction industry. However, any solution needs a combination of RFID domain knowledge and construction industry experience to succeed.

About the Authors
\textbf{Rachel Ho} has designed and executed highly successful business development and marketing activities for RFID applications for some of Singapore’s GLCs to automate concrete cube testing in the construction industry. The system is fully supported and endorsed by Singapore’s Public Utilities Board, Urban Redevelopment Authority and Building & Construction Authority in Singapore, with now more than 20 users in Singapore. She has made many presentations at conferences to HR Directors/Managers, senior management from MNC, and government officials on the advantages and prospects of electronic commerce, internet-based training and RFID related applications across industries.

\textbf{Ian Shelley}’s key strengths are in strategic planning, new business development, and sales & marketing management. He has implemented multi-million dollars of new business development in Asia, Europe and USA. Pioneer of two dotcom companies, with interests in content management, digital rights management, and various online business models, he now runs Intrare Consulting with a keen interest in RFID applications.

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REFERENCES


2 Richard Ho writing in HK Engineer Online, Legco News, notes: ‘…This may create a conflict of interest situation where the material supplier and the testing agent have a close business relationship and result in unsatisfactory quality control of the construction works.’

3 MTRC Report ‘A Comparison of Strength And Density on 100 mm Cubes With RFID Label Cast on Surface’, by Corey Ho of MTRC Labs, November 2002.