CONSTRUCTION MATERIAL QUALITY CONTROL ENHANCEMENT WITH RFID AND WEBSITE APPLICATIONS

FINAL YEAR PROJECT UG 2016

By

Muhammad Sunair Munawar – 198548 (G-L)
Salman Mazhar - 174285
Hassan Farooq - 177435
Danyial Babar - 191617

NUST Institute of Civil Engineering
School of Civil and Environmental Engineering
National University of Sciences and Technology, Islamabad, Pakistan

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This is to certify that the

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submitted by

Muhammad Sunair Munawar – 198548 (G-L)
Salman Mazhar - 174285
Hassan Farooq - 177435
Danyial Babar - 191617

has been accepted towards the requirements
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CIVIL ENGINEERING

_____

Muhammad Hasnain
Lecturer
NUST Institute of Civil Engineering
School of Civil and Environmental Engineering
National University of Sciences and Technology, Islamabad, Pakistan

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LIST OF ABBREVIATIONS

RFID - Radio Frequency Identification

QCM – Quality Control and Management

ISO – International Organization for Standardization

PRAT - Passive Reader Active Tag

ARPT - Active Reader Passive Tag

ARAT - Active Reader Active Tag

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ABSTRACT

A significant amount of time and effort is required in quality inspection and specimen track record monitoring. The data recorded manually using paper-based document leads to misinformation and delays. Many of the construction processes are plummeted from meeting deadlines and achieving client satisfaction. However, modern world is shifting towards innovative automated technologies in design, construction and monitoring. Construction automation subsumes the potential to ameliorate construction quality after extensive development in informatics tools. In order to contribute in enhancing efficient quality control for increasing construction operations, an automated RFID based Quality Control System is used. This Study involves the insertion of an RFID tag into the concrete specimen and analyzing the properties of the specimen such as strength, initial and final setting times, and curing time. Arduino Programming Language has been used for the coding of the RFID system. The resultant quality data is then uploaded to a Web Portal that is programmed through programming language 'PHP'. The data is then transferred to a web application. Real-time tracking of the Transportation phase (inventory to Construction site) is carried out via GPS facility on the web app.. It is expected that as a result of applying this automated scheme, the overall performance of the Concrete specimen Quality testing and tracking process will be enhanced. Performance involves increased efficiency, time and cost savings. The results demonstrate that application of RFID based quality control system is appropriate for material quality assessment.

CHAPTER 1

INTRODUCTION

1.1 General

Accurate, effective and efficient quality control becomes a first-hand task while attempting to achieve completion of a construction project in alignment with the baseline schedules and budgets. With the advancement of information and communication technology in the construction industry, data acquisition and dispatching among different stakeholder and participants has been facilitated and boosted. Presently and traditionally practiced methods of project related information and data collection, analysis, dispatching and monitoring control have turned out to be unreliable, ineffective, time consuming and require a lot of human efforts. Therefore, the proposed RFID based QCM system connects all the project participants, both on the client's end and the project manager's end. Thus, a significant amount of time, cost and efforts can be minimized by incorporating a such a system. Furthermore, the quality control data can be stored and updated periodically onto a safer and convenient interface which would substantially accelerate the problem-solving procedure, which would potentially diminish the chances of rise of a conflict.

1.2 Terminological background

The study would proceed towards a basic thorough reminder of the basic terms of the Quality Segment with reference to the International Organization of Standardization (ISO).

1.2.1 Quality

It can be defined as the extent to which a set of inherent characteristics of a product meet the requirements. Here the term ‘extent’ refers to the degree in terms of adjectives used to define the standards of work achieved. For instance, poor, bad, satisfactory, excellent etc. Characteristics can either be quality based or quantitative.

1.2.2 Quality assurance

The International Organization for Standardization defines quality assurance as "the activities of all plans and systems implemented within the quality system, which can prove that these activities can convince people that the product or service will meet the quality requirements."

1.2.4 Quality inspection

International Organization for Standardization defines Inspection as ‘The process of measuring, examining and testing to determine one or more than one characteristic of a product or service to carry out the comparison of these characteristics with the specified requirements to assure conformity’.

1.2.3 Quality control

International Organization for Standardization defines Quality Control as ‘The operational techniques and activities used to fulfill requirements for Quality’.

1.3 Technological description

RFID (Radio Frequency Identification) is a type of wireless communication technology that involves the use of electromagnetic or electrostatic coupling in the radio frequency range of electromagnetic spectrum for identification of an object.

An RFID system comprises of three main components; a scanning antenna, transceiver and transponder. The antenna and transceiver are embedded in the reader whereas transponder is installed within the tag.

An RFID tag comprises of following components.

- Integrated Circuit; for storing and processing information, modulating and demodulating radio signals
- A mode of gathering DC Power Source from the incident reader signal
- Tag Antenna; for acquiring and transmitting signal

Following are the main types of RFID tags

Table 1.1: Classification of RFID tags

Active RFID tags	Passive RFID tags	Semi-passive RFID tags
Require a power source(battery)	Receive power from reader's antenna	Circuit is run by battery
Read range: 10-100 m	Read range: 10mm-5m	Communication is powered by RFID reader

RFID systems are classified by the following types based on the types of a tag and a reader

- Passive Reader Active Tag (PRAT)
- Active Reader Passive Tag (ARPT)
- Active Reader Active Tag (ARAT)

The diagram below represents the working of an RFID system.

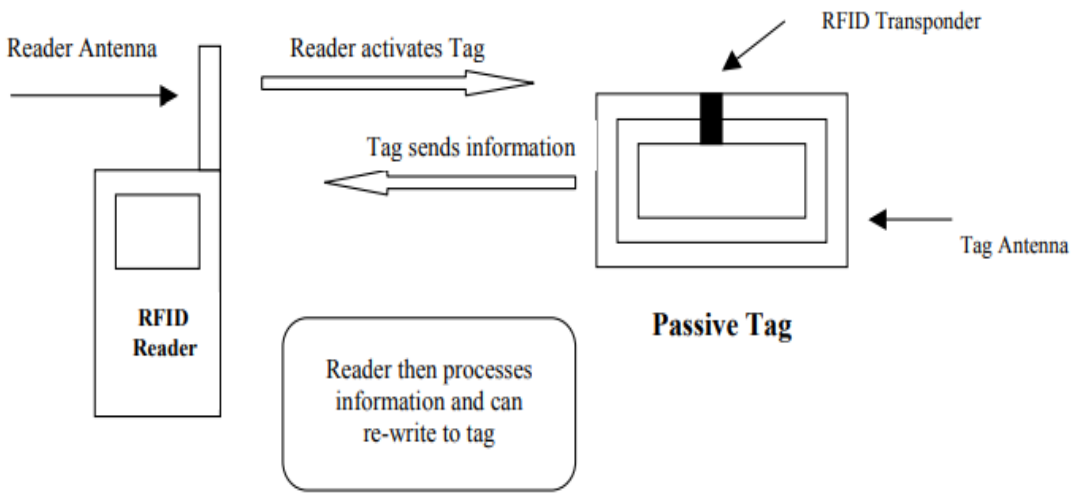

Figure 1.1: Communication flow in an RFID system

Characteristic	Low frequency RFID systems	High frequency RFID systems	Ultra-high frequency RFID systems	Microwave RFID systems
Band	120-150 kHz	3-30 MHz	300-960 MHz	2.45-5.8 GHz
Range	0-10 cm	10-100 cm	100-10000 cm	100-200 cm
Standard Frequency	125 kHz	13.56 MHz	433 MHz	2.45 GHz

Table 1.2: Frequency-based classification of RFID systems

Characteristic	RFID Tags	Standard Barcodes
Reading Requirement	Do not require a line of sight	Visible line of sight scanning and orientation sensitive
Mode of Scanning	Simultaneously Scanned	Marked and exclusively Scanned
Durability	Functional in severe conditions	Malfunction when disfigured and disjoined form their objects
Generic data Storage Capacity	20 data characters	8-32 mb
Mode of working	Rewritable	Read only

Table 1.3: Comparison of RFID with other tracking technologies

1.4 Problem Statement

Information acquisition problems occur in the testing laboratory, because most of the data and information are obtained from the testing laboratory and the central management department, which is an extension of the quality testing network. Laboratory staff usually use written documents, menus and specifications when working in the laboratory. As a result, due to the time interval between the distribution of data by the test laboratory and the retrieval of data by participants, it may lead to duplication of data and information, insufficient data and information, and related confusion. As a result, these methods of transferring information between the testing laboratory and the client and between all participants are ineffective and inconvenient. Therefore, in order to solve these problems, a full-featured RFID-based quality control system must be designed to enhance

the effectiveness and convenience of information flow, improve the efficiency of data collection, and provide real-time information to members. Since the test data will be uploaded to the portal immediately, and all stakeholders will be notified at the same time, you can immediately notice the results and possible updates. This is important because it prevents data fraud, because if you upload abnormal data, you can see it immediately.

1.5 Research Objectives

Conventional methods in practice require paper based documentation which is done manually in order to manage and track materials inspection through various laboratory tests. However, the information that is gathered by such comprehensive methods is not always accurate and the efficiency is also not up to the mark which makes the management of the inspection results very difficult. Moreover, these conventional methods require a lot of time and effort to input, store, retrieve, check and send data. Moreover, due to scammed reporting, conflicts may occur which can impact the relationship between involved parties negatively as well as significantly hamper the flow of the project.

Therefore, there is a need of a such system which helps in overcoming these problems by making the process digital. A system based on Radio Frequency Identification (RFID) quality control management can significantly help to improve accuracy and efficiency. The overall process of material inspection can be made much more flexible by combination of technologies like mobile devices (PDAs), web portal and RFID. In order to enhance efficiency and maximize cost saving RFID can be used in conjunction with some other technologies in the construction industry.

A Quality Control Management framework to enhance effectiveness and efficiency of construction projects will be required to make sure that project's current budget and

schedule are in conformation with the original budget and schedule decided in the beginning which is known as baseline budget and baseline schedule respectively. While performance of daily tasks QCM should be a very important factor in order to make sure the documentation of tasks is done and the maintenance of system is done on daily basis. In order to bring all the stakeholders on a same table, a digital platform like the one we are proposing (web portal) will greatly help in enhancing the efficiency and effectiveness of communication between the relevant parties and the access to data and data sharing will be made very easy for them. We aim to develop a system called RFID based Quality Control Management (RFID-QCM) System which will be a web based system for enhancing this whole inspection process in the construction industry.

All the problems involving communication of information will be minimized by this proposed system. A center management will be controlling this system and the aim is to provide all the relevant stakeholders with the inspection data quickly and to allow them to give their feedback on the data shared with them. Efficiency, accuracy and cost will all be improved by this system and it will also result in improving the overall communication and flow of information thus increasing the flexibility of the overall system. The conventional methods that are in use require the quality inspector to travel from one place to another in order to obtain information of the inspection resulting in waste of lot of time and effort. This RFID based system will enable the data to be uploaded on the web portal directly from the lab and all the stakeholders will have access to this data and they will be able to give feedback also on the results shared with them.

CHAPTER 2

LITERATURE REVIEW

2.1 Conventional Methods of Quality Control Management

Traditionally paper-based documentation is used for data collection and storage which has quite a few limitations and involve certain risks. (Birkett, 1988, Cummings & Masten, 1994)

When data needs to be retrieved it requires quite some time and effort to find the particular required data from all the stored data which makes the process very slow. Moreover, we also need to recheck for accuracy as there can be a human error while storing the data. (Reynolds-Haertle & McBride,1992)

The data entry by lab staff into some software like spreadsheet also require accuracy check as there is a considerable chance of error while entering the data. Professional services do this with high accuracy but they are costly to hire. (Roberts et al., 1997, Weber & Roberts, 2000)

2.2 Computerized Methods of Quality Control Management

RFID based system collects the data digitally which is way better alternative than the traditional method of paper based collection and it reduces the risks that come with the paper based techniques. Data is collected on computers and automatically coded and stored in a spreadsheet or statistical software for analysis. Some of the limitations that have been associated with this technique are the size of PC's that make them not suitable for every field situation and the volatile nature and size of the storage memory being used. However, the recent innovations in technology have solved these problems as the size which was

once an issue has been reduced to a hand held computer and tablets. The problems associated with storage and volatile nature have also been almost eliminated due to recent advancements in technology which have made the storage much more reliable and also provide an option for web storage and so many options for web back up. With such a system in place there is no need for additional people to handle this whole process of inspection as it happens when digitalizing any field. (Weber et al., 2004), (Birkett, 1988, Crombie & Irving, 1986, Irving & Crombie, 1986, Weber & Roberts, 2000).

2.3 Using PDA in Construction Sector

For field tasks in the construction field various types of mobile devices are used. In the construction industry PDAs have also been widely used. Some of the features of the PDAs include internet access via source such as a modem or some wireless source, internet browsing, contacts, data synchronization PC and PDA and it also provides option for additional software to be added.

On the other hand, the use of mobile devices in construction industry is very well known and understood by most. The use of mobile devices in field can be for any of the following reasons like acting as a source for information exchange, supporting a platform, capturing data for later use, use in construction supply chain management.

As the data of the tests is immediately uploaded to the portal and a mail is sent to all the stakeholders so they can immediately have a look at the results. This is important as it prevents scam because if something unusual is uploaded it can be seen immediately.

(McPherson, 2000) (D. Johnson, 2000) (Sunkpho, 2003) (H.M. Elzarka, 1997) (F. Pena-Mora, 2002) (M.J. Ward, 2003) (H.P. Tserng, 2005)

2.4 Using a Gateway in Portal Platform

The gateway collects information related to a specific theme and provides easy access to services and related information sources. Gates was first introduced in the late 1990s, and it is often complicated. The portal is an ideal platform for exchanging information through a web-based information management system. When using the portal, all state information is concentrated in the state database, which can only be accessed through the web interface. The portal also contains authentication and access control mechanisms to enable participants to access information according to user rights. However, it is more difficult in practice to exchange information between participants than at first glance. (F. Pena-Mora, 2002)

CHAPTER 3

METHODOLOGY

3.1 Basic Layers of RFID System

The QCM system work based on RFID system. We divided our system in for basic layers i.e. presentation layer, Application layer, Database layer and Backup layer. At first, RFID's were acquired from the market after which we moved towards programming phase of RFID.

3.2 Programming of RFID

Figure 3.1: Arduino UNO board

Arduino UNO board was used to program RFID, MFRC522 as module and jumping wires to connect RFID with board. Passive tag with active reader were used but active tag can also be used to obtain from some distance. The figure shows some part of the RFID programming.

```
        //Serial.print("read block: ");
        int sample_number = 0;
        sample_number = readbackblock[0];
        sample_number = (int)(sample_number - 47);
        Serial.println((String)"The sample " + (sample_number) + " is detected");
        for (int j=0 ; j<16 ; j++)//print the block contents
        {
          //Serial.write (readbackblock[j]);//Serial.write() transmits the ASCII numbers as human readable characters to serial monitor
          //Serial.print(strength[readbackblock[j]]);

        }
        //Serial.println("");


        //-------------------------------------------------------------------- WRITE HERE ---------------------------------------------------------------------
        Serial.println((String)"Name of sample is: "+ concrete_name[sample_number-1]);
        Serial.println((String)"Concrete strength of sample is: "+ concrete_strength[sample_number-1]+ "psi");
        Serial.println((String)"Final setting time of sample is: "+ final_setting_time[sample_number-1]+ " days");

        //Serial.println((String)"Concrete initidf of sample is: "+ initial_setting_time[sample_number-1]+ "psi");


        //-------------------------------------------------------------------- WRITE HERE ---------------------------------------------------------------------
}
```

Figure 3.3: A sample code

Different properties of concrete along with their specific assigned numbers were inputted. Now, when the Reader read specific tag it will show the properties of that RFID tag. (Figure 3.4)

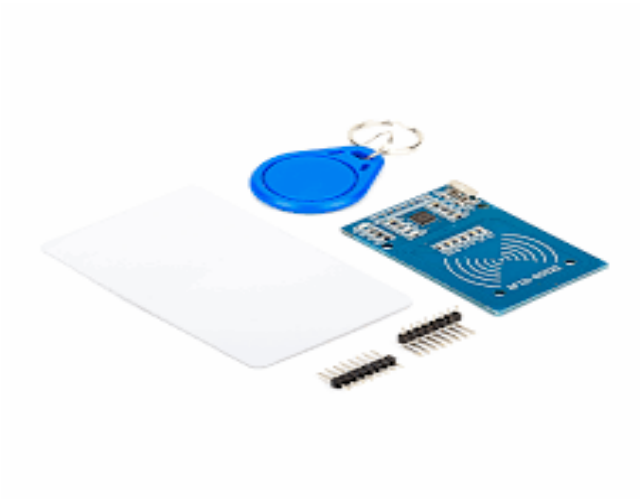

Figure 3.4: RC-522 RFID tag

3.3 Information Management

Information about construction equipment will be stored in RFID tag reader and to portal on web.

Figure 3.3: Login portal

Only verified persons will be allowed to change or edit data that can login to portal through their login ID. So first they need to sign up on portal giving all information and then they can login. All the information gathered from RFID reader will be stored on web portal. This web portal gathers information from RFID reader and give information to all participants signed up on portal.

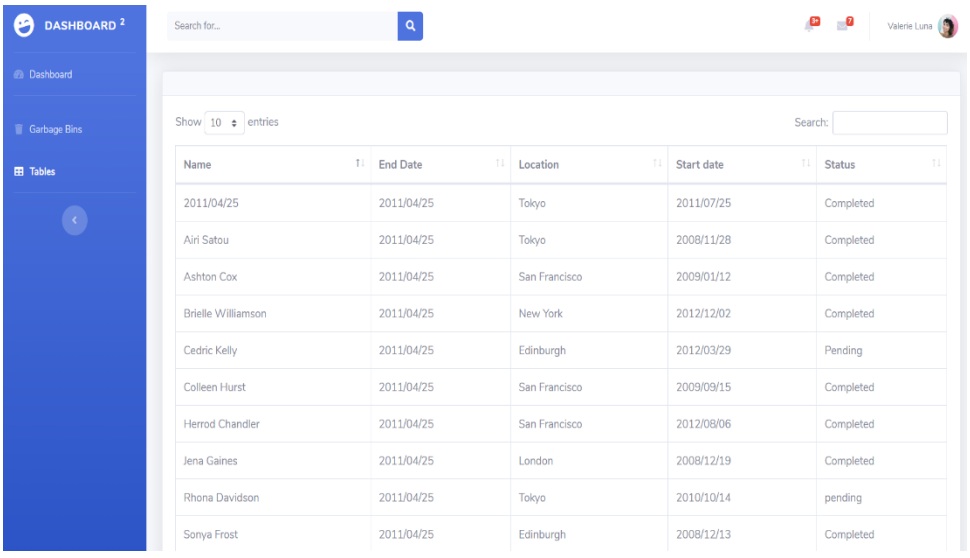

Figure 3.4: User management portal

Portal give complete information about inventory to supplier and costumer. All details about general tests and reports can be checked by general contractors. Also, portal will give all details about projects that are started and that are completed. Portal give all directions and optimized route to construction sites. This will be done by use of Google maps routing API.

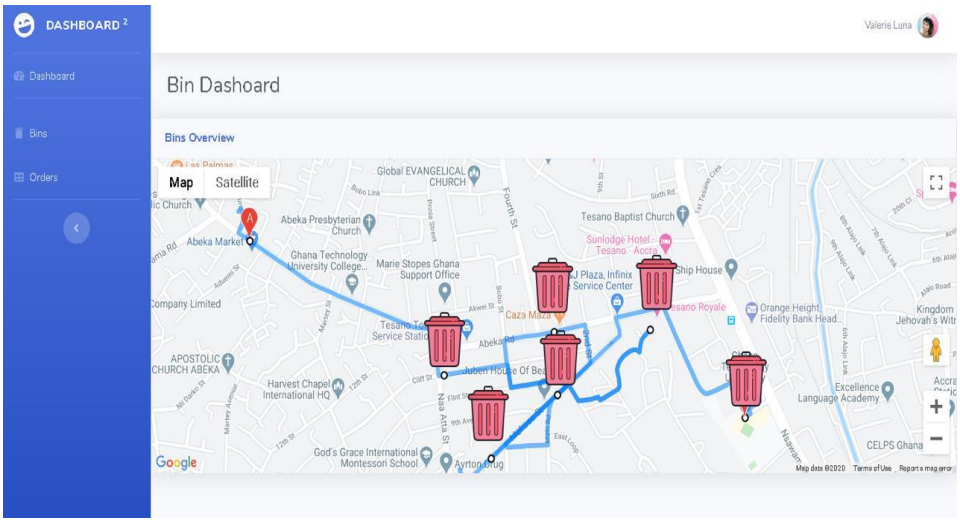

Figure 3.5: Google Routing API

It can be seen that optimized route from central locations to construction sites are given (Figure 3.6).

3.4 Front end and Back end work

Presentation layer is divided into different layers i.e. front end and back end. In presentation layer of portal, user can access though any browser like chrome or Firefox. Mostly this layer is operated by clients. The application layer is the website or portal on which user login. The database layer incorporates Standard Query Language (SQL) Server. First all data will be stored on database server and then it will upload to web-app.

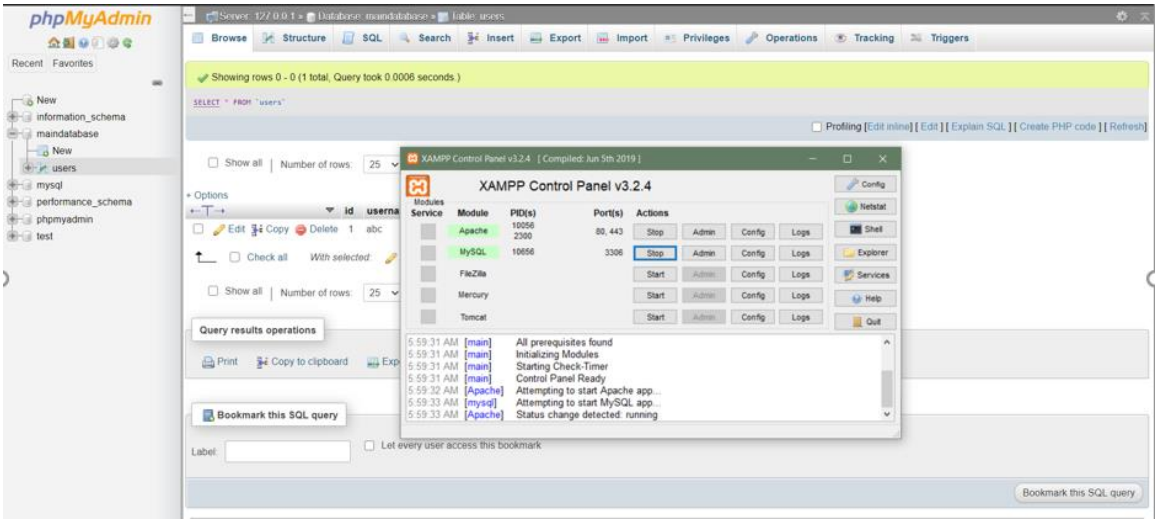

Figure 3.7: XAMPP Control Panel

So, all files will be saved using open database connectivity (ODBC). Whole web-app is written in php and html5. Web-app was local hosted through phpMyAdmin (Figure 3.7).

For backup layer google sheets are used to store all data uploaded from RFID. The Central Portal gives an answer including a single, brought together database connected to every practical framework with different level of access to information, in light of client job, both inside an association and across associations and different members.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 General

Due to unforeseen circumstances, the experiment under consideration had to be cut short and the results were most probably observed from questionnaires and literature review. Thus, neglecting the experimental phase.

4.2 Results from Questionnaire

In order to observe the effectiveness of the web portal and the QCM system, participators were asked to deliver their precious response by answering a questionnaire which was formed using Google Forms. Feedback was taken from lab staff, engineers, and relevant personals with sufficient experience. This questionnaire used a Likert Scale where responders specify their level of agreement to a statement in five points. One is referred as “not useful”, three “modest”, and five “very useful”. The results of this questionnaire showed a notable enhancement in safety of work and most of the concerned individuals considered this new proposed approach useful which is evident from an average mean score of 3.9 to 4.3 (see Table 4.1).

Table 4.1: Evaluation of the QCM system through Likert Scale

System Evaluation Result	
System Testing	**Mean Score**
Convenience	4.0
Ease of Acquiring Data	4.1
Accuracy	3.9
Reliability	3.9
System Capability	**Mean Score**
Reduce unnecessary time	4.3
Reduce unnecessary costs	3.9
Improves information sharing	4.1
Improves total work efficiency	4.0

The mean score is calculated from respondents' feed back on five scale questionnaire; 1(not useful), 2, 3, 4 and 5 (very useful)

4.2.1 Traditional to Proposed Approach

In this questionnaire, concerned individuals were asked whether it it time to move from traditional paper based data collection approach to a more refined approach in fields. Most of them were in favor of shifting to the proposed approach while some of them said that it depended on the type of situation one is working upon (see Figure 4.1).

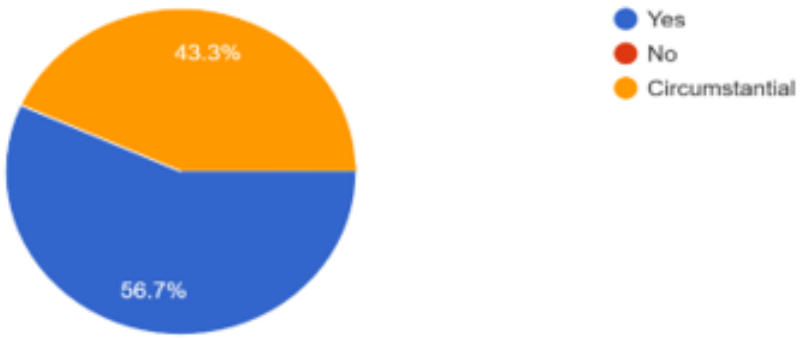

Figure 4.1: A pie-chart representing individuals that wants to shift to a new approach

4.2.2 Analysis of Quality Control System

A complete analysis of the QCM system was carried out in order to see the effectiveness of the system. In this analysis, specified personals were asked some questions about the system like whether this system was quick, easy to operate, convenient, expensive and useful. The analysis showed that the QCM system is very effective and constructive (see Figure 4.2).

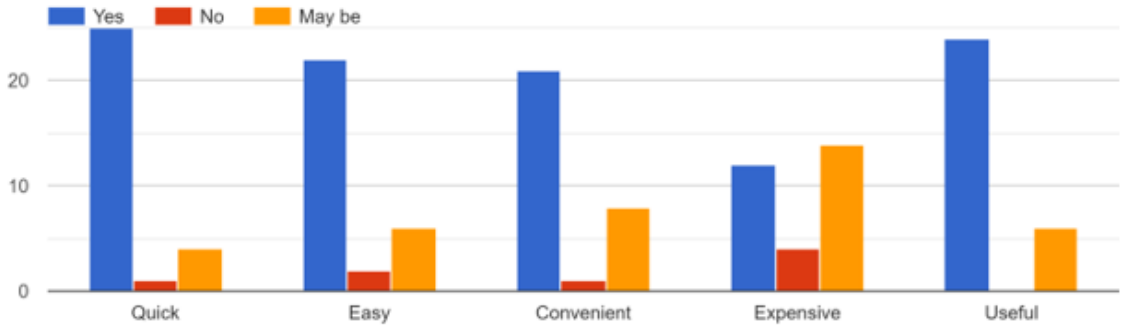

Figure 4.2: A bar-chart representing the analysis of the QCM system

4.3 Results from Literature Review

The RFID-QCM system improves the work efficiency, purchaser's satisfaction and at last it saves time in inspection operation.

4.3.1 Improving Work Efficiency

Through assimilating Web-based technology along with RFID to read and capture information will greatly help in improving the efficiency of the inspection process. For example, an RFID-aided web portal will help the lab staff to do more work in less time. Before they had to manually input data step by step but now through such a system lab staff would just directly input the data into the web-portal through their mobiles which will ultimately forward it to the QCM-system.

4.3.2 Improving Purchaser's Satisfaction

Customer's satisfaction has seen to be increased by a significant amount by real time sharing of results. The customer can track the stage and results of the sample quality inspection. In addition, customers can access the latest inspection results and get short reports directly from the Web. Thus, such quality control system is anticipated to greatly improve client satisfaction.

4.3.3 Saving Time in Inspection Operation

Tentative results show that such quality management system can significantly improve inspection. The proposed system sorts the inspection operations and arranges them to the appropriate personnel; and quickly and effectively manages laboratory operations and manages the travel sequence in advance. Inspection related operational time is significantly reduced by such a system as manual inspection activities are greatly reduced.

CHAPTER 5

CONCLUSION

This research has suggested an RFID-based quality control management system that assimilates Web with RFID technologies in order to improve the efficiency and productiveness of automatic data collection. Sharing of information among participants helps managers to control and monitor the schedule in laboratory. The projected RFID-QCM system uses RFID technologies to enhance the acquisition of inspection data and help monitor and control inspection progress. RFID technologies have the ability to effectively collect data through which all the relevant shareholders can benefit. Elimination of constraints regarding time and space in the laboratory and field has allowed them to seamlessly merge different workflows. Also, such reading helps to augment the accuracy along with speed of exchange of information, which as a result improves execution and performance capabilities. Furthermore, working ability of lower personals enhances which in turn increases the efficiency of the total work. RFID technology gives a much better response system from which every management personal can benefit from. Thus, QCM system used along with RFID technologies provide a much better platform for enhancing connectivity and workability.

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