IMPROVING MATERIALS MANAGEMENT ON CONSTRUCTION POJECTS

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IMPROVING MATERIALS MANAGEMENT ON CONSTRUCTION PROJECTS

NARIMAH BINTI KASIM

A thesis submitted in partial fulfilment of the requirements
of Loughborough University
for the degree of Doctor of Philosophy

January 2008

Loughborough University

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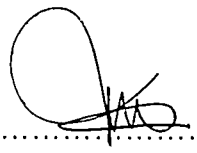

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ABSTRACT

An essential factor adversely affecting the performance of construction projects is the improper handling of materials during site activities. Materials management is made problematic by materials shortages, delays in supply, price fluctuations, damage and wastage, and lack of storage space. In addition, paper-based reports are mostly used to record and exchange information related to the materials component within a supply chain which is problematic, error-prone, and inefficient. Generally, modern technologies are not being adequately used to overcome human error and are not well integrated with project management systems to make the tracking and management of materials easier and faster. Thus, this research focuses on the development of a mechanism to improve materials management on construction projects through the integration of materials tracking and resource modelling systems.

A multi-facetted research approach was adopted. Initially, a literature review on materials management process in the construction project was conducted. This was followed by case studies involving six construction projects in order to investigate current practice in materials management to establish key problem areas and elements of good practice. The case studies also explored the requirements for integrating materials management and resource modelling in project management systems. The case study findings underpinned by literature results were used to develop a real-time framework for integrating RFID-based materials tracking and resource modelling.

The framework was encapsulated in a computer-based prototype system based on Microsoft Visual Basic.NET. The prototype system was developed by amalgamation of all the software and hardware chosen such as MS Access (database system), MS Project (resource modelling) and RFID (automated materials tracking) to provide the mechanisms for integrating materials management and resource modelling in the construction industry. Evaluation of the prototype system was carried out by a series of interviews with industry practitioners to assess its appropriateness and functionality. It also established the skills and other requirements for the effective use of the real-time materials tracking system. The evaluation established that the

prototype system demonstrated many benefits and is suitable for use in materials tracking and inventory management processes.

It is concluded that the prototype system developed can improve materials management on construction projects, particularly with regard to materials tracking and integrating materials utilisation with the resource modelling subsystem in project management applications. Adoption of the approaches suggested in the thesis will enable the construction industry to improve the real-time management of materials on sites, and hence improve project performance.

DEDICATION

I dedicate this thesis to

Almighty ALLAH,

My late beloved father (Kasim Radzuan), My mother (Sayanah Jaffar)

and

My husband (Amran Mahmud) who give me encouragement and love.

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First and foremost, I would like to express my gratitude to my supervisors, Professor Chimay J. Anumba and Professor Andrew R. J. Dainty, for providing me with invaluable guidance, inspiration and support for my research. My special thanks to Professor Chimay J. Anumba for being instrumental in helping me to realise my research project, and for being a mentor and supporter with his constant inspiration and encouragement.

I will also like to thank my Director of Research Dr David J. Edward; the Research Administrator, Ms Helen Newbold; all the academic, support and technical staff of the Department of Civil and Building Engineering; and the colleagues with whom I had constructive interactions and shared valuable moments together. I would also like to express my gratitude to my sponsor (Ministry of Higher Education, Malaysia), my employer (Universiti Tun Hussein Onn Malaysia, UTHM) for the study fellowship and financial support. I am also grateful to the organisations which participated in the research during the case studies and evaluation of the prototype system.

Finally, I would like to thank my husband, mother, brothers and sisters for all the love, understanding encouragement throughout the research period.

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LIST OF ABBREVIATIONS

Auto-ID	Automatic Identification
CC	Consolidation Centre
CMPS	Construction Materials Planning System
COME	Construction Materials Exchange
DS	Delivery Status
EAN	European Article Numbering
E-mail	Electronic mail
EPC	Electronic Product Code
ERP	Electronic Road Pricing
ESCAP	Expert System Advisor for Concrete Placing
FM	Facilities Management
GIS	Geographic Information System
GPS	Global Positioning System
GUI	Graphical User Interface
IC	Integrated Circuit
ICT	Information and Communication Technologies
IDE	Integrated Development
IEPC	Internet-based Electronic Product Catalogue
ITC	Information Technology in Construction
JIT	Just-In-Time
LC	Logistic Centre
LED	Light-emitting diode
MHESA	Material Handling Equipment Selection Advisor
MO	Materials Order
O&M	Operation and Maintenance
OAN	Japanese Article Numbering
OCR	Optical Character Recognition
PC	Personal Computer
PDA	Personal Digital Assistant
RFID	Radio Frequency Identification
RTM	Real Track Materials

SDK	Software Development Kit (SDK)
SI	Storage Information
UPC	Universal Product Code
VCMR	Virtual Construction Material Router

CHAPTER 1
INTRODUCTION

This chapter presents the context for this research. It starts with a brief background to the research, and then justifies the need for the research. It also states the aim and objectives of the research and the methodology adopted. Lastly, it describes the structure of the thesis.

1.1. Background

An important problem that adversely affects the performance of construction projects is the improper handling of materials during site activities. The inappropriate handling and management of materials on construction sites has the potential to severely hamper project performance (Ogunlana *et al.*, 1996). There are major issues which affect materials management activities such as constraints on storage areas, site logistics with regards to materials handling and distribution, and also ordering and delivery of materials to the construction site. Previous research has also highlighted materials management issues such as; improper storage (Canter, 1993), requirement for large storage capacity (Agapiou *et al.*, 1998), transportation difficulties and inappropriate materials delivery (Zakeri *et al.*, 1996). Other issues include; manual processes, and non-compliance with specifications (Dey, 2001), late delivery (Aibinu and Odeyinka, 2006), shortage of materials (Abdul-Rahman *et al.*, 2006).

There are several varieties of approaches, which are used to address materials management issues. These include: proper planning of materials logistics, Just-In-Time (JIT) concepts to resolve the problems of space constraints, and the implementation of Information and Communication Technologies (ICT) such as bar-coding for automatic tracking of materials. However, there is a paucity of positive examples of where such tools have been successfully used. An initial assessment of

the tools and techniques currently in use in materials management suggests that most of them are under development, with only a few being used on a commercial basis (BRE, 2005). The tracking of materials during delivery times and at the storage area is commonly undertaken manually. This can increase the scope for human errors (such as double handling) and the use of paper-based reports to exchange information related to the materials component within a supply chain can be problematic, error-prone and inefficient.

Generally, tracking technologies such as wireless, bar-coding and radio frequency identification (RFID) are not adequately employed in developing materials tracking practices on construction projects (Kasim *et al.*, 2005b). There is also insufficient support for the tracking and management of materials for operational efficiency in inventory management on site. Accordingly, there is scope for significant advantages if automated tracking technologies are deployed to overcome problems in manual practices, which is labour intensive and error prone (Navon and Berkovich, 2006). RFID has the potential to facilitate materials management processes for large scale projects, particularly with regard to the capability to store a large amount of data compared to bar-coding (Jaselskis and El-Misalami, 2003). It is expected that RFID can be beneficial in reducing paper-based requirements and can also be integrated with different applications such as project management systems (e.g. MS Project), to make tracking and management of materials easier and faster. Therefore, this research focuses on the deployment of RFID to improve on-site materials tracking, inventory management processes, and resource management.

1.2. Justification for the Research

Materials management is an important function for improving productivity in construction projects. The management of materials should be considered at all the phases of the construction process and throughout the construction and production periods. This is because poor materials management can often affect the overall construction time, quality and budget. Bell and Stukhart (1986) stated that it is important for planning and controlling of materials to ensure that the right quality

and quantity of materials and installed equipment are appropriately specified in a timely manner, obtained at a reasonable cost, and are available when needed. The scope of the research will focus on space constraints due to the logistics in construction sites and particularly in large and complex projects. 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 in the implementation of ICT in materials management, as ICT has the potential to significantly improve the management of materials on site. A range of opportunities for construction organisations to invest in advanced information technology and telecommunications systems are noted by Griffith *et al.*, (2000). In other areas of business, such as publications, advertisement and manufacturing the growth of ICT has been very rapid. According to a Building Research Establishment report (BRE, 2005), ICT applications in the construction industry are now commonplace for facilitating procurement, collaboration and knowledge management. For example, product procurement has such features as direct and indirect purchasing, electronic payment, and material aggregation which can be supported by ICT. This can eliminate paper work, lower product and operational costs, and reduce cycle times. ICT is used in materials management for cost estimating through involving a well known software such as Microsoft Excel (Sun and Howard, 2004). However, there is not much use of modern ICT tools (e.g. wireless communications, bar-coding and RFID) to facilitate materials management processes in tracking materials quickly, accurately, and easily.

In general, the current practices in tracking materials on construction projects are undertaken manually and are excessively paper-based. Previous research projects have demonstrated the successful use of automated tracking technologies such as bar-coding in helping improving materials tracking in the construction site. This includes the study of the use of bar-coding to provide instant and up-to-date information on quantities of materials exchanges between the storage keeper and the group leaders in term of the measurement of materials wastage (Chen *et al.*, 2002). Cheng and Chen (2002) have developed an automated schedule monitoring system to assist the managers to control the erection process for precast building construction

by integrating bar-coding and Geographic Information System (GIS). In another study, Moselhi and El-Omari (2006) present a data collection methodology that utilises both bar-coding and RFID technology to collect data (such as working hours and materials quantities) on construction sites and store the data in a central database for tracking project cost and schedule information.

All the above examples have shown the successful implementation of bar-coding in materials tracking processes. However, the use of the bar-coding system could involve many constraints such as it can easily be damaged, it cannot be read in direct sunlight, and it cannot withstand harsh conditions (Jaselskis and El-Misalami, 2003). Thus, incorporate technologies such as RFID and wireless communications are expected to grow in usage to support materials management practices (Kasim *et al.*, 2005a). These technologies have been successfully used in other industry sectors such as manufacturing, retail, and transportation in improving logistics. There is potential to apply these in construction practices (BRE, 2005).

Several papers have discussed the possibility of implementing RFID in the construction industry. Jaselskis and El-Misalami (2003) presented a procedure for helping construction industry owners and contractors to enhance their operations using RFID technology. It provided a flowchart to assist contractors and owners in selecting the most appropriate RFID system. Peyret and Tasky (2002) performed an experiment to trace asphalt quality parameters using electronic tags and Global Positioning System (GPS). This involved RFID for storing the data into electronic tags, and GPS for positioning the material parameters to trace asphalt quality with respect to the road-building project. The study of RFID utilisation on precast concrete components was carried out by Akinci *et al.* (2002) who developed a system to locate precast components in a storage area at the manufacturing plant. It also tracks the delivery of the components, and stores information on them from fabrication to post-construction.

Song *et al.* (2005) carried out a study on automatically tracking the delivery and receipt of fabricated pipe spools in industrial projects to determine RFID feasibility. Goodrum *et al.* (2006) developed a tool tracking and inventory system which is also capable of storing operation and maintenance (O&M) data using RFID tags and has