IMPROVING MATERIALS MANAGEMENT PRACTICES IN CONSTRUCTION PROJECTS

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ABSTRACT

Materials management is made problematic by materials shortages, delays in supply, price fluctuations, damage and wastage, and lack of storage space. 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, emerging technologies (such as wireless system, RFID) 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 paper reports on the early stages of research which is developing a new ICT-based approach to managing materials on construction projects. As a precursor to this work, a literature review on materials management process in the construction projects was conducted. This was followed by exploring the ICT tools and techniques currently being employ on construction projects. The findings from literature review reveal the need for more sophisticated materials management solution in order to improve tracking of materials efficiently. In conclusion, the paper suggests areas where additional applications might further enhance the management of materials particularly tracking of materials on construction projects.

Keywords: Construction Project, Materials Management, ICT, RFID, Tracking

1.0 INTRODUCTION

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.

2.0 MATERIALS MANAGEMENT

This section defines materials management and reviews materials management on construction projects.

2.1 Definition

Materials management is an important function in order to improve productivity in construction projects. According to Bell and Stukhart (1986) materials management functions include *"material requirement planning and material take off, vendor evaluation and selection, purchasing, expenditure, shipping, material receiving, warehousing and inventory, and material distribution"*. 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 in a timely manner, obtained at 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 of 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 construction period. Generally, construction materials are bulky, expensive and are supplied in large amounts to construction sites. Therefore, there is a need for an excellent management system for handling materials.

2.2 Materials Management on Construction Projects

The construction industry is the most significant industry in the economy and the successful measure with completion within time, budget, accordance with specification and satisfaction of stakeholders (Nguyen *et al.*, 2004). Construction is the process of physically erecting the project and putting construction equipment, materials, supplies, supervision, and management necessary to accomplish the work (Clough *et al.*, 2000). Construction projects are complex, with many organisations involved such as clients or owners, architects, engineers, contractors, suppliers and

vendors. This includes the heterogeneous and often complex process of producing unique, large and immovable products with a supply of the resources (money, equipment, material, and labour).

The management of materials in construction projects is an important function that significantly contributes to the success of a project. As projects grow in scale and complexity, materials management becomes more difficult, often requiring the use of appropriate tools and techniques to ensure, amongst other things, that materials are delivered on time, stock levels are well managed, the construction schedule is not compromised, and that wastage is minimised. Materials management is especially problematic for large and complex projects, where sophisticated tools and techniques are necessary. The management of materials in complex construction projects needs adequate consideration due to the various elements involved and the importance of the project. Furthermore, the implementation of appropriate ICT could facilitate new management processes for complex projects. For example, the potential of emerging technologies such as wireless technologies and tagging technologies could have a strong impact on materials management processes in the future.

The improper handling and management of materials on construction sites has the potential to severely hamper project performance (Ogunlana *et al.*, 1996). The result of improper handling and managing materials on site during construction process will influence the total project cost, time and the quality (Che Wan Putra *et al.*, 1999). The costs of materials management may range from 30-80% of the total construction costs depending on the type of construction (Muehlhausen, 1991). However, Kini (1999), accounted 50-60% of the total cost of construction projects is for construction materials and equipment. According to Stukhart (1995) materials are a major component on any project with value 50-60%. Therefore, there is a need for efficient materials management in construction projects. This is because poor materials management will affect the overall construction time, quality and budget. Therefore, an effective materials management system is required in order to avoid problems, such as delays in a construction project.

Delays in materials supply have been found to be a major cause of time overrun (Dey, 2000). Many factors accelerate the delay of project duration, however poor materials management can have a major effect on site activities. Ogunlana *et al.* (1996) suggested that the main reasons for project delays on housing projects in Thailand were incomplete drawings, material management problems, organisation deficiencies, shortage of construction materials, and inefficiencies in site workers. Dey (2000) also suggested that delays in materials supply was a major cause of time overrun. Thus, it would seem that materials delays are a major cause of delays in construction projects. There is also a need for an integrated material handling process from the design stage to the usage of materials. This could happen, with a good management system with the implementation of ICT in managing materials. Hence, a good materials management environment enables proper materials handling on construction sites.

3.0 MATERIALS MANAGEMENT PROCESSES

Materials management processes involve the planning, procurement, handling, stock and waste control, and logistics surrounding materials on construction projects. A good materials management environment enables proper materials handling on construction sites. In order to better understand materials management the following processes are discussed: planning, procurement, logistics, handling, stock and waste control.

3.1 Planning

The process of planning construction methods has been defined as "understanding what has to be built, then establishing the right method, in the most economical way to meet the client's

requirements" (Illingworth, 1993). This is a detailed scheme for achieving an objective for certain work tasks. In the case of materials, there is a need for an appropriate planning, which must be done concurrently with engineering, construction, and other project plans (Stukhart, 1995). Stukhart (1995) also mentioned material planning will provide guides for all the subsequent activities and can have a great impact on the project plan. The materials planning process covers setting up and maintaining the records of each part used in each plant to determine target inventory levels, and delivery frequency (Payne *et al.*, 1996). As a result, an excellent management of the materials record will help the flow of materials at the site in order to avoid several problems such as materials out of stock and materials that have not been delivered.

Stukhart (1995) mentioned that material planning would provide guides to all the subsequent activities and that this could have a great impact on the project plan. The materials planning process covers the set up and maintenance of records and determines the target inventory levels, and delivery frequency (Payne *et al.*, 1996). Planning of access and routing of materials within a construction site has an important implication for the development of an effective materials management strategy (Faniran *et al.*, 1998; Olusegun *et al.*, 1998) particularly in terms of increasing productivity and profit, and facilitating the timely completion of construction projects (Wong and Norman, 1997). The requirement for efficient materials planning is, to increase productivity and profit of the company, and facilitate the completion of construction projects (Wong and Norman, 1997). Thus, better planning of raw materials on site can help to eliminate project delays and reduces activity times, resulting in better service.

3.2 Procurement

The term procurement encompasses a wide range of activities that includes purchasing of equipment, materials, labour and services required for construction and implementation of a project (Barrie and Paulson, 1992). The objective of procurement in materials management is to provide quality materials at the right time and place, and at an agreed budget. Payne *et al.* (1996) stated that procurement is about organising the purchasing of materials and issuing delivery schedules to suppliers and following-up, to make sure that suppliers deliver on time. A failure in the purchasing process or in overseeing and organising the buying functions as listed by Canter (1993) could result in:

- Over-ordering of materials (wastage problems);
- Over-payments for materials (inadequate administration procedures);
- Loss of benefits (lack of skilled negotiating procedures); and
- Lack of knowledge (when and where the best service/source might be available at any particular time).

In order to avoid failure, it is important to know how the typical purchasing procedure takes place, and this is illustrated in Figure 1. Procurement of materials begins with defining the requirements of the project, followed by the selection of suppliers or subcontractors, and ends with the delivery of materials at the destination (Kent, 1991). Purchasing materials from the best source, at the right price and with timely delivery are challenges of many construction companies. Therefore, a control strategy is needed during materials procurement to achieve the targeted objectives. All requests for quotations and purchases must be initiated through a properly authorised requisitioning procedure normally controlled by the Project Manager. The Project Manager must ensure that the purchasing of materials follows the standard requirement, time and quality.

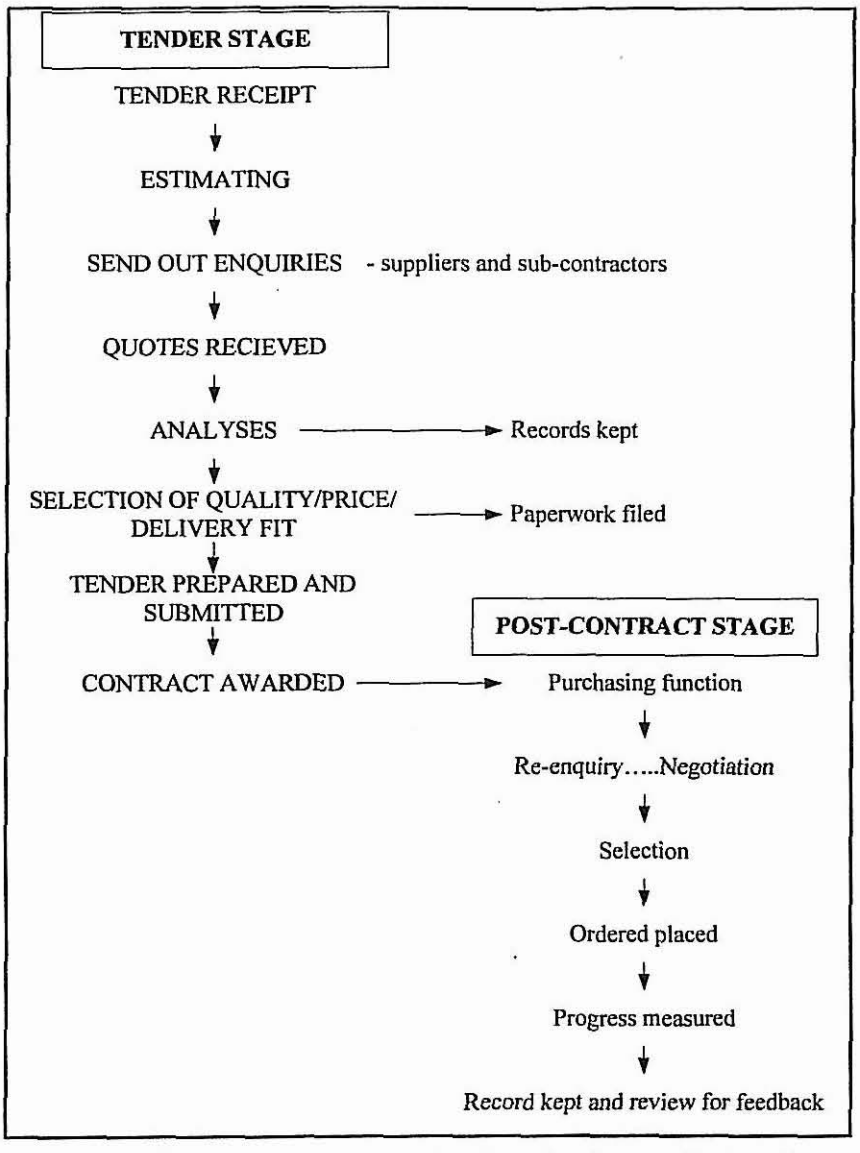

Figure 1: Typical Purchasing Procedure (source: Canter, 1993)

3.3 Logistics

Logistics is a concept that emphasises movement and it encompasses planning, implementing, and controlling the flow and storage of all goods from raw materials to the finished product to meet customer requirements (Stukhart, 1995). Raw materials for construction are usually varied, bulky and heavy and required proper handling in the supplying process. Consequently, the construction industry requires active movement of materials from the suppliers to the production area in both the factory and the worksite (Pheng and Chuan, 2001).

The primary focus of the logistics concept in construction projects is to improve coordination and communication between project participations during the design and construction phases, particularly in the materials flow control process (Agapiou *et al.*, 1998). They also mentioned that problems arise in the materials flow control process which includes delays of materials supply, due to some materials purchased just before they are required and waste of materials during storage, handling and transporting when procured in large quantities without complying with the production needs on site. The previous research suggested that, the routing of materials is one of the main causes which affect cost and time during construction projects (Varghese and O'Connor, 1995).

Hence, the factors that should be taken into consideration during the logistics process for effective materials management include:

- optimum forecasting of materials movement (Mahdjoubi and Yang, 2001); and
- planning of access and routing of material within a construction site (Olusegun *et al.*, 1998).

3.4 Handling

Tompkins and White (1984) define effective material handling as using the right method in providing the right amount of the right material, at the right place, time, sequence, position, condition, and cost. This involves handling, storing, and controlling of the construction materials. Therefore, materials handling provides movement to ensure that materials are located and that a systematic approach is required in designing the system. Handling of materials is the flow component that provides for their movement and placement. The importance of appropriate handling of materials is highlighted by the fact that they are expensive and engage critical decisions. Due to the frequency of handling materials there are quality considerations when designing a materials handling system. The selection of the material handling equipment is an important function as it can enhance the production process, provide effective utilisation of manpower, increase production and improve system flexibility (Chan, 2002).

The importance of appropriate handling of materials is highlighted by the fact that there are expensive and engages critical decisions. Estimated costs for materials handling may range from 30-80% (Proverbs *et al.*, 1999) and 10-80% depending on the type of facility (Tompkins and White, 1984) from total construction costs. Because of the percentage amounts, there are certain quality considerations in designing materials handling systems. The materials handling equipment selection is an important function in the design of a material handling system in order to enhance the production process, provide effective utilisation of manpower, increase production, and improve system flexibility (Chan, 2002). In addition, materials scheduling is also an essential part of handling material on site, which has several benefits (Che Wan Putra *et al.*, 1999) such as:

- showing the quantities involved in each particular operation;
- providing a key to the distribution of materials on site; and
- demonstrating useful way of checking quantities required by sub-contractor, etc.

Materials must be delivered to site undamaged and without any wastage. Most common problems associated with materials supply is inadequate unloading and handling facilities, which attribute a high proportion of wastage (Canter, 1993). Therefore, handling with safety during movement of materials at site, which reduce the percentage of materials wastage and finally foster significant improvement can often the total system productivity.

3.5 Stock and Waste Control

The European Construction Institute's Total Productivity Management report (ECI, 1994) states that *"materials delivery to site is a critical, productivity-related aspect which demands the introduction of a carefully developed system of monitoring and control as early as possible"*. Delivery of the bulk of the construction materials requires proper management of the stock control. Stock control is a technique to ensure all items such as raw materials, processed materials, components for assembly, consumable stores, general stores, maintenance materials and spares, work in progress and finished products are available when required (Prabu and Baker, 1986).

Construction activity can generate an enormous amount of waste (Teo and Loosemore, 2001) and materials waste has been recognised as a major problem in the construction industry (Formoso

et al., 2002). There are also mentioned that construction materials waste, in the USA contributes approximately 29%. In the UK it contributes more than 50% and in Australia it contributes 20-30%. This is evidence to control constructions materials in a good way during the construction process. The cause of waste in construction projects indicates that waste can arise at any stage of the construction process from inception, right through the design, construction and operation of the built facility (Faniran and Caban, 1998). Therefore, waste can be reduced through the careful consideration of the need for minimisation and better reuse of materials in both the design and construction phases (Dainty and Brooke, 2004).

Material storage on site requires close attention in order to avoid waste, loss and any damage of materials which would affect the operations on the construction project. Problems often arise during materials supply because of improper storage and protection facilities (Canter, 1993). Previous studies have identified that building materials often require a large storage capacity which is rarely available on site (Agapiou *et al.*, 1998). However, Stukhart (1995) suggested that there are a few considerations to be taken into account in the planning of the storage space such as timing of the initial buy, and historical information and experience. Materials management on site should seek to reduce loss of profit due to theft, damage and wastage, as well as running out of stock. Therefore, the requirements of storing space should be taken into consideration from the initial stage of the construction process.

4.0 MATERIALS MANAGEMENT PROBLEMS

There are many issues which contribute to poor materials management in construction projects. Zakeri *et al.* (1996) suggested that waste, transport difficulties, improper handling on site, misuse of the specification, lack of a proper work plan, inappropriate materials delivery and excessive paperwork all adversely affect materials management. Shortage of materials contributes to the cause of delay in managing materials in the construction site (Mansfield *et al.*, 1994; Ogunlana *et al.*, 1996; Abdul-Rahman *et al.*; 2006; Aibinu and Odeyinka, 2006). Late delivery of ordered materials is also problematic in materials management. Furthermore, Dey (2001) noted that the common issues relating to materials management are as follows:

- Receiving materials before they are required, causing more inventory cost and chances of deterioration in quality;
- Not receiving materials at the time of requirement, causing loss of productivity;
- Incorrect materials take-off from drawings and design documents;
- Subsequent design changes;
- Damage/loss of items;
- Selection of type of contract for specific materials procurement;
- Vendor evaluation criteria;
- Piling up of inventory and controlling of the same; and
- Management of surplus materials.

The traditional construction methods apply paper-based work during the construction process. This can produce excessive paperwork and contributes poor materials management in construction projects (Zakeri *et al.*, 1996). There is also give problematic, error-prone and inefficient in the recording and exchanging information of materials component within a supply chain. The implementation of ICT can help the management of construction activities to become more effective and faster. The emergence of ICT systems could transform conventional methods and improve materials management. The use of ICT has also increased with new software related to the construction industry and can support the effective management of materials practices. Therefore,

the ICT-enabled solution could help in order to overcome the problems. For example, improving materials supply management through an intelligent system to facilitate bidding, requisition and ordering of materials.

5.0 TECHNOLOGIES IN MATERIALS MANAGEMENT

The development of ICT in the construction industry can transfer information much faster globally than traditional methods. According to Björk (1997) that ICT as electronic machines and programs including computers and the software, other devices like the telephone, the photocopying machine and the telefax for processing, storage, transfer and presentation of information. Information delivery has traditionally been dominated by paper documents such as drawings and specifications.

The growth of ICT has been very rapid in other areas of business (such as publications, advertisement and manufacturing) to expand their business operations globally. In the construction industry, the development of ICT has improved through emerging technologies that can support any type of construction activities. Griffith *et al.*, (2000) stated that, there are great opportunities if construction organisations can spend their money on technology advancement in information and telecommunication. There are could also expand in ICT usage by powerful computer and better connectivity provided into construction industry (Sun and Howard, 2004). New information technologies could also improve materials management are develop and varies in construction industry.

5.1 Current Technologies

The implementation of ICT in materials management could facilitate the effective and efficient control of materials on site. Common use of ICT in materials management is in the cost estimating process by using software such as Microsoft Excel and Lotus 1-2-3 (Sun and Howard, 2004). The Internet is widely used for electronic mail (e-mail) and electronic commerce including electronic invoicing, payments and receipt of materials process (Harris and McCaffer, 2001). In order to improve productivity in ordering and quotation activities, contractors and suppliers could change their activities from conventional to more sophisticated or innovative tools and techniques. Accordingly, there is scope to make more use of computer-based systems to improve materials management on construction sites (Faniran *et al.*, 1998). For example, applications developed for this purpose by many researchers include the following:

- *Expert System Advisor for Concrete Placing (ESCAP)* – for assist in planning and controlling concrete-placing operations without much experienced personnel incharge (Alkass *et al.*, 1993);
- *Pen-Based Computer* – to automate construction field-data collection (McCulloch and Gunn, 1993);
- *Construction Materials Planning System (CMPS)* - for planning the use of construction materials to achieve the right materials in terms of quantities, time and meet the work programs (Wong and Norman, 1997);
- *Construction Materials Exchange (COME) (E-Commerce system)* – to improve efficiency and effectiveness of materials procurement process in construction (Kong and Li, 2001);
- *Internet-based Electronic Product Catalogue (IEPC)* – provide product information such as product category and other information related to the product by browsing or searching online (Kong *et al.*, 2001);

- *Virtual Construction Material Router (VCMR)* – to provides the decision-support system for materials movement for assisting site managers and planner in complex construction site (Mahjoubi and Yang, 2001);
- *Material Handling Equipment Selection Advisor (MHESA)* - for material handling equipment selection (Chan, 2002);
- *Bar-code system* - for material storage management (Chen *et al.*, 2002); and
- *Geographical Information System (GIS) and E-Commerce* – for construction materials trading (Li *et al.*, 2003).

Many computer software and Information Technology in Construction (ITC) tools have been developed recently and are widely used in construction to help the process of the activities. For example, like bar codes for managing materials on site to maintain inventory records purposes and wide use of the internet for electronic mail (e-mail) and electronic commerce (like electronic invoicing, payments and receipts of materials processes) (Harris and MacCaffer, 2001). Other examples are the cost estimating process for materials, the wide and successful use of spreadsheets like Microsoft Excel and Lotus 1-2-3, provide contractors and project managers with a powerful and a convenient analytical and presentation tool (Sun and Howard, 2004).

The use of ICT has increased as new software relating to the construction industry that supports the effective management of construction activities have been developed. Various opportunities for construction organisations to invest in advanced information technology and telecommunications systems are noted in Griffith *et al.*, (2000). Despite advances in the construction ICT development, an initial assessment of the tools and techniques currently in use in materials management suggests that most of them are under development with a few being used on a commercial basis. Therefore, more sophisticated solutions are expected to be used in the future such as wireless communication, bar-coding and RFID for tagging technologies. These technologies have been successfully used in other industry sectors for example manufacturing, retail, and transportation and logistics. There is potential to apply the same concept to construction practices (BRE, 2005). By using RFID technology, there is predicted that in the future the construction site manager will walk around the construction site where all the items will be tagged (Wing, 2006). For example, an RFID reader can check whether all the materials delivered by a lorry are at the correct construction site and if any components are missing. The use of electronic tags with combination cyber agents at the gates of the construction site in order to check the deliveries of different materials has been suggested by (Wing and Atkin, 2002).

5.2 Advantages of Current Technologies

Implementation of ICT in materials management could help create an effective and efficient controlling process of materials activities on site. Construction materials come in various sizes and types that require proper handling and management in order to achieve productivity. The traditional practices in managing on-site activities by paper documents are not practical in today's construction business. The contractor should implement more computer-based and electronic business (e-business) through the Internet in their activities in handling materials at site. In order to improve productivity in ordering and quotation activities, contractors and suppliers could change their activities from conventional to more sophisticated or innovated tools and techniques. Conventional communications between the main contractors and suppliers through paper document changed to electronic trading in their business activities (HMSO, 1995).

According to Construction Software (2005), much software can support construction activities on site including materials management as listed follows:

- *Construction Materials Management System* – link engineering, construction, accounting, vendors and other critical functions to manage the procurement, warehousing, delivery and reporting;
- *Material Management System QMS* – system for managing all phases of the material management process;
- *BARRICADE software* – saves time, manages inventory, generates invoices, and improves cash flow;
- *Best Estimate* – a fast, simple, pure estimator for renovators & remodelors general contractors;
- *BidWorx* – whether you need benchmarking, bid summary, detailed time and materials;
- *Builders Software* – general contracting business software the people, money, time and materials;
- *COMMANDconcrete* – batching system integration and financial management;
- *Estimate Builder* – for quick and accurate materials and labour estimates! Estimate Builder was created;
- *GoTakeoff* – complete material list for standard construction in a matter of minutes;
- *Power! Electrical Material Data Base* – Comprehensive electrical parts list; and etc.

Materials management is required to be efficient and effective, and is more complicated for large scale projects due to the vast amount and variety of construction materials needed. An application of the bar-code system for reducing construction waste can provide instant and up-to-date information of quantities of materials exchanged between the storage keeper and the group leader (Chen *et al.*, 2002). RFID has the potential to facilitate materials management processes for complex projects, particularly with regard to the capability to store a large amount of data compared to bar codes (Jaselskis and El-Misalami, 2003). For example, it is possible to use RFID in materials identification on construction projects in order to reduce the level of confusion regarding materials delivery from suppliers, and the relevant locations at the jobsite (Jaselskis *et al.*, 1995).

Several research projects have been undertaken on the potential implementation of RFID in materials management processes. The conceptual design of a RFID system has been presented by Jaselskis *et al.* (1995) to track material delivery vehicles, materials handling equipment, the material itself, and also to track concrete delivery vehicles. The concept of tracking delivery vehicles using RFID technology for quality control has been applied by Peyret and Tasky (2002) for plant mixed asphalt. RFID technology has also been proposed for use in tracking precast concrete pieces and storing information through the supply chain (Akinci *et al.*, 2002 and Ergen *et al.*, 2003).

RFID is on of the automatic identification technologies with the potential to improve materials tracking system specifically for the overall materials management processes on construction projects. There are advantages in employing the RFID system into materials management such as it is not easily damaged in the harsh conditions (e.g. construction sites). However, the consideration of the cost of the whole RFID system becomes an important factor especially on-large scale projects when required thousands of RFID tags are needed.

6.0 IMPROVING MATERIALS MANAGEMENT PRACTICES

In other areas of business such as publications, advertisements, manufacturing and many more, the ICT growth has been rapid (BRE, 2005). ICT has developed new software relating to the need of the construction industry in order to support construction activities and manage the effectively. Various opportunities for construction organisations to invest in technological advances in

information systems and also advancements in telecommunications have been noted (Griffith *et al.*, 2000). Therefore there are advantages for further development on what has already been developed to create a sophisticated, more reliable and affordable software. On the other hands, 'more powerful computers and better connectivity will provide a strong 'technology push' for wider use of IT in construction' (Sun and Howard, 2004).

According to BRE (2005), current implementation of ICT in materials management processes are under development and not many has been commercialised. IT 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. This can eliminate paper work, lower product and operational costs, and reduce cycle times. However, more sophisticated solutions to effective materials management in the future are expected to use wireless communications and tagging technologies such as RFID (Kasim *et al.*, 2005a). Consequently, this can give the construction industry opportunities in order to choose the appropriate technology to improve their materials management practices. Therefore this research will explore practical applications for these emerging technologies, particularly for facilitating materials management on construction projects.

7.0 CONCLUSION

This paper has presented a brief overview of materials management practices on construction projects. It is clearly important to manage all materials from design stage to the construction stage. Poor handling of construction materials affects the overall performance of construction projects in terms of time, budget (cost), quality and productivity. The wastage of materials should also be minimised during construction in order to avoid loss of profit for construction companies. There is a need to develop new approaches to materials management in construction projects in order to improve the efficacy of the production process. The potential of ICT applications provides a basis for developing an effective framework to support the improvement of materials management on construction projects. The next stage of this research will examine the extent and nature of automation of the materials management process and will develop new ICT-enabled approaches to improving materials management practices.

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