THE IMPACT OF EFFECTIVE MATERIAL MANAGEMENT ON CONSTRUCTION SITE PERFORMANCE FOR SMALL AND MEDIUM SIZED CONSTRUCTION ENTERPRISES

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Small and medium sized enterprises (SMEs) represent a large part of the construction sector. Large companies have the capacity and capability to use sophisticated information technology and management technology to control the labour and materials on projects. SMEs need help to implement control systems for labour and material that will improve performance on site. The research involves investigation of the impact of effective material management for SMEs on construction sites. Consideration is given to materials' flow through the supply chain up to installation on site. Materials can represent up to 70% of the project construction cost, hence any ways to reduce wastage and improve productivity will have major cost and time benefits. Now technologies can help in the management of materials flow and benefit contractors with lower costs and clients lower prices. The aim of this paper is to describe how SMEs can improve their performance in materials management, to reduce their costs, and to improve the project delivery. Case study and interview has been used as the research method to develop the ideas in this paper.

Keywords: materials management, planning, productivity, supply chain, technology.

INTRODUCTION

A construction project depends upon having the right people with right skills and equipment that are able to deliver the project on time and on budget. Having the right materials in the right place at the right time is equally important, and having the cash flow and capital to procure the labour and materials is also important. The materials on a project can represent anything from 30% to 70% of the cost of the work, yet materials management has not received a lot of attention from researchers. The research is based on three propositions.

1. SMEs tend to undertake little detailed construction planning of activities, they work to milestone dates which mean procurement and materials management is not properly scheduled with sufficient lead times for delivery.
2. Materials and component manufactures and suppliers, and builder merchants have invested heavily in developing IT based control systems to track their materials through the production, warehousing, and delivery process up to the point of delivery to site. The data and information are not then transferred to

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the SME and the delivery system fails to help the SMEs to manage materials on the site.

3. Significant savings could be made by SMEs with the better management of materials on site and the use of technology systems leading to reduced waste of materials and better site productivity through more efficient handling of materials with lower wastage.

Labour, material, tools, equipment and cash are the main parts of any construction project. Material management is the system for planning and controlling to ensure that the right quality and quantity of materials and equipment are specified in a timely manner. Materials should be obtained at a reasonable cost, and be available for use when needed. The cost of materials represents a large proportion of the cost. Our analysis of project cost for civil engineering projects showed the materials and plant component can be up to 70% of the project cost dependent upon the type of project and the extent of mechanisation and plant used, whilst on commercial building and housing projects the proportion is around 45%-50%. The sample size used was small, nine projects, however in interviews with estimators the findings were validated by professional judgement. A good management system for materials management will lead to benefits for construction. Cash flow has become crucial for the survival of any business, if materials are purchased early, capital may be tied up and interest charges incurred on the excess inventory of material. Material may deteriorate during storage or be stolen; also delays and extra expense may be incurred if materials required for particular activities are not available.

Despite the importance of the materials, very little research has been directed towards understanding the management of materials from order to production; most research is focused upon the management of the design and procurement process and on labour site productivity. Materials management, which includes procurement, shop fabrication, logistics, supply chain management, production on site, and field servicing, requires special attention to achieve cost reduction. The supply chain is a convenient term used to describe a complex web of activities. The use of new equipment and innovative methods of materials handling has influenced changes in construction technologies in recent years. Modern methods of material management have been embraced by the manufacturers across a wide range of industry sectors outside of construction. Some lessons have been learned from the automotive and retail sectors, like just-in-time deliveries. Containerisation, mobile craneage with grab loaders, and mechanised handling has influenced the design of lorries. However, small and medium sized construction enterprises have not embraced advanced methods of materials management, partly because of the fragmented and long supply chain, and also because of their size and ability to afford new practices and procedures. It is not that they are disinterested; many SMEs are highly motivated and very professional. Any improvement in the supply chain will result in higher efficiency of supplying materials, lowering the costs and increasing the profits.

THE SME IN CONSTRUCTION

An SME is classified according to the turnover and number of employees (ONS, 2008). SMEs play an important role in the economy, in construction with its proliferation of contracting and subcontracting, the SMEs will be found on very small and very large projects. There are also many small businesses in the informal sector where they are neither registered for VAT nor operating pay as you earn schemes.

The SME is project driven and always battling to reduce costs and to save money. They tend to win work on low bid price, rather than their technology. Bids are based upon resource estimating using knowledge and experience from previous projects. Cash flow is crucial to pay suppliers on time to ensure future materials supply. Materials are ordered 'just in time' to help with cash flow and storage limitations. Bulk buying is not appropriate. Site planning for the off-loading and storage of materials is frequently a random process. Delivery schedules are sometimes random leading to the inefficient use of labour.

The supply chain is a convenient way of describing a sequential linear chain of supply; the reality is that the supply chain is long, complex, and frequently not sequential. Consider the supply of pre-glazed timber windows delivered to the site shrink wrapped for protection. The lead time will be six to eight weeks from order. The delivery will be by the builders' merchant who placed the order, or a transport company employed by the window manufacturers. The lorry driver will have a delivery address, a preferred delivery time and a mobile phone contact. If electronic information of the delivery point could be transmitted to the delivery driver via a web camera it would help to plan the way the materials can be offloaded. Similarly, if the site could position the whereabouts of the lorry using a GPS/ GIS system it would help them to schedule the delivery. Both use straight forward and affordable technology, yet they are not used.

MATERIAL MANAGEMENT CHALLENGES ON CONSTRUCTION SITE

Materials management can be divided into five categories:

- The measurement and specification;
- The procurement and purchasing process where the order is transmitted to the supplier;
- Delivery to site and logistics of checking the order, off loading, and storing on site;
- The administrative and financial process of payment;
- Using the materials in production on the job site and removing the waste.

In terms of purchasing and supply of materials, not matching materials with the ordering purchase, forgetting ordering materials, over or less materials, early or late materials arriving, lack of JIT strategy, lack of training and adequate management, lack of communication and relation between contractor and supply chain companies are the main obstacles.

Some common problems on construction site are more obvious which are namely:

- Failure to order on time which delays the projects;
- Delivery at the wrong time which interrupts the work schedule;
- Over ordering;
- Wrong materials or error in direction of materials requiring re-work;
- Theft of materials from delivery into production;
- Double handling of materials because of inadequate material.

In terms of logistics, the main problems are wrong time of materials arriving to the site or even wrong quality, lack of information for materials arrival to the site or site stock, missing materials, unavailability of storage space, and waste of labour for materials searching on site.

The research has identified a gap between the procurement and ordering of materials and the delivery and use of the material on site at the production stage. This paper deals with this one aspect of materials management and focuses upon how technology can help to improve the tracking and delivery of the materials. Consideration is given to how GPS and GIS can be used to help SMEs in managing the process.

UNDERTAKING THEORY OF MATERIAL MANAGEMENTTHIS

There is a large literature on managing materials on site focused towards large projects and large firms, but there is a paucity of information on managing materials by SMEs for smaller projects. Because a company is small does not mean it is not innovative and forward thinking, or that it is reluctant to explore new ideas and technologies. Often SMEs are not restricted by layers of bureaucracy and management that must be consulted before good ideas can be implemented. They can make decisions fast and implement them quickly; the constraint is usually the availability of time and capital. Achieving efficient material management is important and a site layout design that reduces material travel time is very important in construction productivity. Ofori (2000) describe the, construction industry as being fragmented and having poor co-ordination; this was borne out by our interviews. Poor planning leads to inefficiency, low productivity, excessive waste, and health and safety problems. Supply chain management is one of the most important solutions for improving productivity and efficiency and preventing wasted time and cost. Planning and controlling of raw materials, components and finished produced are some obstacles for supply chain management for communication and feedback in supply chain management. The term supply chain describes the supply system from raw materials through to goods fixed in place. The linkage is between printed documents, purchases orders, receipts, invoices and emails which outline the specification, contract terms and delivery and customer details. The need for detailed information reflects the trust and relationship between the parties in the supply chain. An effective supply chain result to an efficient and productive project. Research must focus upon the people, the systems and process and how technology can help to improve the performance of the supply chain. Straightforward and affordable technologies are available but not fully implemented in construction. The research considered only on materials management and how technology can improve the process. For a proper flow of material installation on site there is a process from planning to use of technology. Planning is at the heart of having effective management systems to control materials, irrespective of the project size; all projects must have a plan.

A selected sample of small and medium sized general contracting enterprises was interviewed to understand how they undertake planning for their projects. The findings showed that small and medium sized enterprise undertake little planning the project and the more detailed the construction programme. Furthermore, the clients demand for construction planning was also an influence. Where planning was undertaken they were grant charts that used trades as the basis for planning.

1. Planning

Lack of planning is one of the major problems for construction on site. According to Faniran *et al.* (1994), there are lots of factors which have the capability for significant affect on improving construction planning such as consuming more time for planning before starting job, relationship between different parties, alternative plan and sufficient time, control time, revision interval and finally construction method control.

The project environment such as size, degree of uncertainty, complexity, competition, type of contract and also type of client have a direct impact on the project performance. In this case there are some uncertainties such as the design before beginning the project, the unpredictable weather and also availability of labour or equipment for project. By gathering more information and making flexible decision the rate of uncertainty in project will be decreased.

So as construction projects get bigger and larger and more complex then construction planning is getting more effective.

2. Materials classification

There are multi-facility problem for construction material management but by a realistic analysis this work out. Handling material, optimising location of haul roads and crane location problem are some sort of this kind of problems. To properly supply the materials we should have a good understanding of different type of materials. This will help us to order the materials according to their sizes, time of the usage on site and other factors.

2.1. Ordering system

What materials, quantity, volume and location or distance to the site are the main issues in terms of ordering and this information will be clarified from contract documents such as the contract bill of quantities. Classification materials into an ordering system are very important. Classification can be in terms of size and essential rate to the construction programmed and quality control into four ordering systems (Hiraki *et al.*, 1994).

2.1.1. Synchronised system

2.1.2. Prescheduled ordering system

2.1.3. Periodic ordering system

2.1.4. Non-periodic ordering system

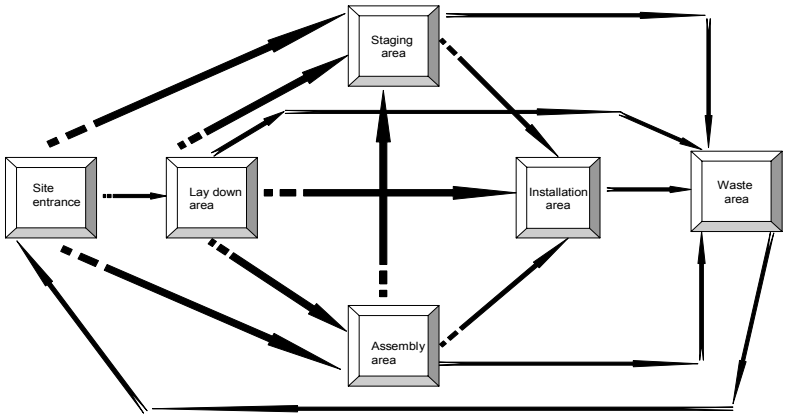
Ordering large components such as air conditioning system, steel work, called synchronised system. The next step, big volume material such as panels and door called prescheduled ordering system; these are not as big as the synchronised system. Such materials like cement, gravel, called periodic ordering system which is required at various stage of project. And at least the materials which are obtained at the circumstance of the project and those are small volume and large quantity such as bolts, nails are called non-periodic ordering system.

2.2. Site arrangement

Material flow on site is the process of moving materials from the site entrance through a set of function areas to the final installation areas. This can be through a model such as Tommelien (1994) has suggested which in these model six types of function area

are recognised: Site entrances, lay down areas, staging areas, assembly areas, installation areas, and wastes areas.

Lay down area is for the long term use for main material to their own lay down area for example steel or large panel formwork. For the frequency use of material if they are small volumes it should be shared with the same area. For short term temporary storage ‘’ storage area’’ is suitable. ‘’assembly areas’’ is the working area needed when materials are being placed when they finally remain and ‘’wastes area’’ are also needed for the waste material. ‘’Site entrances’’ which should be connected to the outside road system. Also ‘’non functional area’’ such as site offices or tools storage and worker changing rooms; and finally ‘’Unused area’’ which may be used for further work.



Basic material flow network

3. Work classification on construction site

According to Christian and Hachey (1995), by categorising the work into four groups the productivity will be increased in which, essential, essential contributory, idle and waiting are the four groups. Essential work influences the progress of the work, and work that has positive effect but indirectly such as movement of material or equipment for essential purpose is considered essential contributory. Idle time which represent a category in which the work could, but did not, progress because for example the worker doesn’t work, However if a worker can not perform just because of uncontrollable external delay then the lost time considered as waiting time, not idle time. Conventional methods of handling materials in which result in inefficient material management in SMEs have been long recognised. The potential technologies that can help to tackle these problems are already invented and in commercial use. The next section is dedicated to introduce such technologies and to explain how they can be used in SMEs to improve material management.

IMPROVING MATERIALS MANAGEMENT BY USING MORDERN TECHNOLOGY

Such basic technology like mobile telephony or laptop is the most common available at the moment. Some other technologies such as internet, RFID (radio frequency identification), GIS (geographic information system), GPS (global positioning system), tracking technology are available in which have the capability of tracking materials.

Use of IT has the capability for changing a cultural structure with an objective by reducing barriers between different functionality. IT also is a great opportunity for communication between different parties and different activities. Electronic data interchange (EDI) and Electronic funds transfer (EFT) are some other technologies in IT that enable a retailer to electronically do some functionality such as purchasing orders, paying invoices and processing credit checks. On site positioning and tracking technologies facilitate arranging for the arrival of materials just in time with right quality and quantity on construction job site while keeping the work in process inventory on the site to minimum the cost and time. Radio frequency base information and communication technologies, such as global positioning system (GPS), radio frequency identification (RFID) tags and Bluetooth have matured and become commercially available to potentially support resource positioning and tracking and automated data collection in construction. GPS technologies have the capability of tracking, managing and controlling earth moving and mining operations which occur in relatively open areas (Lu *et al.*, 2006).

SMEs want to use affordable, reliable, and available technologies to improve performance that are straightforward to use. One such technology is Bluetooth, which is an open wireless protocol for exchanging data over short distances from fixed and mobile devices, creating personal area networks (PANs). It was originally convinced as a wireless alternative to RS232 data cables. It can connect several devices, overcoming problems of synchronisation. So the Bluetooth technology is originally designed as a short range wireless connectivity solution for personal, portable, and hand-held electronic devices. The Bluetooth radio operates on a license-free, globally available 2.400-2.4835 GHZ industrial, scientific and medical (ISM) band, which is divided into 79 channels. In addition, Bluetooth employs a fast, frequency-hopping spread spectrum (FHSS) technology (with incremental frequency being 1600Hz) to avoid the interference in the ISM band and ensure the reliability of data communications. Bluetooth radio can be classified into three power classes by the RF transmission power. The typical working distance of Bluetooth ranges from 10m to 100m, depending on the power class of the device. At present, class 3 Bluetooth with a 10 m radius is embedded in most commercial applications of Bluetooth. A Bluetooth device assumes which the role of either a master or a slave. The master regulates which slave to transmit data and when. In some cases devices of two types share the common hardware structure and thus may swap their master slave roles only by altering the core programs. Bluetooth is an industry specification for ensuring compatibility in wireless connectivity of electronic devices, allowing one manufacture's device to control the slave device made by another.

PROJECT COLLABORATION TOOLS

A project collaboration tool allows a team to effectively assign and track projects, Share document and files and schedule meetings. A majority of team members are now involved in different aspects of a project. Often in different locations or even working for different projects or even different companies. The ability to share project information easily and securely via the web is a growing need among business worldwide.

By project collaboration, one share workspace for the entire team, release and iteration planning by adapting changing requirements. Tracking and reporting progress, real-time data for real-time decisions. Updating and accurate project visible to the entire

team is required. Program management, there is visibility across the projects with accurate reports and cross project reporting.

By investigating through UPS Company (united parcel service) for tracking parcels, there is a possibility to bring similar way for tracking materials to the site on construction projects. UPS have created ship quick, a proprietary package-delivery program in which GIS pre-sorts and loads packages at fulfilment centres which helps optimise UPS ground service for GIS clients. RFID tags are the current way for identifying the parcels. The service currently uses on-floor computers to generate specialised shipping tags, these UPS tracking tags utilise a UPC code and a UPS tracking code called a 1Z tracking number so they know where the package is, where it come from, where its going and how much is weighs, then they introduce RFID tags and what it needs is to install new printers and make minor software upgrades. By using tracking technology, UPS Company has the capability to track the parcels through different ways such as tracking by reference, quantum view manages, UPS signature tracking tool, UPS signature tracking tool, and wireless tracking. Due to the above explanation, for construction material delivery, this kind of technology is available, for example by classification materials as mentioned before and then giving a reference number for any kind of material there is possibility to check shipment through mobile or any other technology such as email or website or even cancel or asked for other option in terms of delivery. (http://www.ups.com/tracking/tracking)

By interviewing building component manufactures and suppliers and selecting a sample builders' merchants there was the view that they see the SMEs as a customer, however a requirement for their tracking systems as transferable to help the SMEs management of materials on site. There is therefore a gap between the requirements and needs of the SMEs and the supply chain.

CONCLUSION

Fragmentation across the supply chain is not unique to the construction sector. Similarly, the high concentration of SMEs is common across many industry sectors. Construction projects have a large number of different parties, skills and specialists; each forms an independent variable within projects. Good communication and coordination among the participants is a good way to overcome the gap between different parties and achieve the overall goals of the project. Project collaboration tools allow sharing of documents and files. There is the need to track and manage materials on all construction projects.SMEs do not undertake detailed site activity planning because of lack of people, skills and finance. Manufactures and suppliers schedule their deliveries and cause responsibility once the materials have been delivered. Also appropriate and affordable technology should be used to help with the better management of materials through the order process up to placing on site so new technology such as internet, RFID, GPS, tracking technology, extranet are instrumental and affordable in this process.

Better communication and flow information by using such a simple and affordable technology, make it more efficient. Global positioning system (GPS) is one of the few modern innovations which are now ubiquitous.

On-site and off-site construction activities should be use as a body to cover whole range of construction activities. Flow of information across their interface has an important affect.

The role of IT itself, and the role of technologies by an efficient planning have important affect for a productive construction management leading to a link between planning and technology. Use of IT has the capability for changing a cultural structure with an objective by reducing the barriers between different functionality. It is also a great opportunity for communication between different functionality. IT is now ubiquitous and more affordable and has the capability to be used in construction job site. Classification materials and classification construction work on construction job site as part of planning is also has important effect on construction. In complicated task integration planning and IT has the potential to remove lots of human error. According to improving communication and flow of information there are some other ability for IT on construction such as providing a competitive advantage by putting the company on a market, also Electronic Data Interchange (EDI), and Electronic Funds Transfer (EFT), are some other capability for IT technology that enable parties to electronically do some functionality such as purchasing orders, paying invoices and processing credit checks. Flow of material order, product, transportation and delivery of goods, strategic process service, support service, personnel and accounting from the business process, bring a better communication into the construction process between different parties from design to production to operation. A proper, accurate and timely information flow system has the capability to remove weakness.

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