REDUCING CONSTRUCTION WASTE IN HEALTHCARE FACILITIES: A PROJECT LIFECYCLE APPROACH

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The NHS has one of the largest property portfolios in the UK; comprising hospitals, clinics, dental offices, out-patient surgery centres, birth centres and nursing homes. Additionally, it is experiencing historic levels of growth with the largest programme of investment the country has ever seen where: 25 per cent of hospitals are being replaced or upgraded; 100 new hospitals to be constructed by 2010; and 3000 GP premises being built/replaced/refurbished. As a result, a significant number of environmental concerns and challenges need to be addressed, namely the reduction of energy consumption and waste generation. Construction waste generation is a global issue and several studies have been performed in different parts of the world to develop methods and tools for waste prevention, reduction, reuse and recycling. Many of these studies adopted a linear approach by focussing on a specific project phase, such as design, procurement or construction, however, a more integrated approach is required to holistically assess and evaluate waste causes and origins throughout the project lifecycle. An in-depth literature review has been conducted to identify the extent of the problem and provide a foundation for the PhD study that aims to develop a project lifecycle framework for reducing construction waste in healthcare facilities. The paper concludes that construction waste is generated throughout the project lifecycle covering design, procurement, construction and demolition. However, the literature review has revealed that there are a number of unique characteristics related to the construction and operation of healthcare facilities, when compared with other types of buildings, mainly due to their organisational and functional complexities. Hence, there is a need to develop a bespoke lifecycle waste mapping process for healthcare buildings.

Keywords: construction waste, healthcare, lifecycle, waste minimisation.

INTRODUCTION

In the USA, construction waste contributes approximately 29% of overall landfill weights in the UK it contributes more than 50% and in Australia it contributes 20–30% (Rogoff and Williams, 1994; Ferguson *et al.*, 1995; and EPA, 1998). The construction industry is responsible for producing several different waste streams, and the amount and type of construction waste depends on factors such as the stage of construction (Osmani *et al.*, 2008), type of construction work and supply chain practices (Dainty and Brook, 2004). The construction industry is thus under enormous pressure to minimise and better manage its waste production. Recently published UK government figures reveal that construction and demolition activities produce 120 million tonnes of waste every year (WRAP, 2007a), thus contributing to more than

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three times of household waste in UK (DEFAR, 2007a). The newly published Waste Strategy for England 2007 (DEFRA, 2007b) identified construction and demolition industry as the major source of waste in England. The National Health Service (NHS) is the largest public sector organisation (Tudor *et al.*, 2005) and one of the largest property portfolios in the UK comprising hospitals, clinics, dental offices, out-patient surgery centres, birth centres and nursing homes (Holmes *et al.*, 2006). It is now experiencing historic levels of growth with the largest programme of investment the country has ever seen in the UK where 25 per cent of hospitals are being replaced or upgraded; 100 new hospitals to be constructed by 2010; and 3000 GP premises being built/replaced/refurbished (SHINE, 2006). The increasing number of building projects in healthcare sector increase the total quantity of construction waste generation in UK, some of which are hazardous and have the potential to pollute the environment unless properly managed (Townend and Cheesman, 2005). Waste arising from UK healthcare construction is a pressing concern and urgent action is needed to properly manage and minimise its production.

Past and ongoing research work in construction waste management and minimisation focuses broadly on a number of waste minimisation approaches, such as: construction waste reduction through design (Keys *et al.*, 2000; Osmani *et al.*, 2008); construction waste quantification and source evaluation (Faniran and Caban, 1998; and Ekanayake and Ofori, 2000); on-site waste auditing and assessment (Chen *et al.*, 2002); and improvements of on-site waste management practices (McDonald and Smithers, 1998). Many of these studies have adopted a linear approach by focussing on a specific project phase, such as design, procurement or construction, however, a more integrated approach is required to holistically assess and evaluate waste causes and origins throughout the project lifecycle. Through a comprehensive literature review and analysis, this paper covers: healthcare facilities in UK, sustainable healthcare construction, types of healthcare waste, sources of construction waste, lifecycle construction waste mapping and the way forward as part of a doctoral study which aims to develop a life cycle construction waste mapping process for healthcare facilities.

METHODOLOGY

A comprehensive literature survey and review was conducted to: explore the main issues relating to construction waste generation and management in the UK healthcare sector; identify gaps that exist in current literature and research; and provide a foundation for a lifecycle framework to construction waste minimisation in healthcare facilities.

SUSTAINABLE HEALTHCARE CONSTRUCTION

Healthcare facilities in UK

The NHS is the largest business in the Europe (Holmes *et al.*, 2006) and the Learning Network for Sustainable Healthcare Buildings (SHINE, 2006) identified the following key environmental impacts associated with existing facilities and renovation and construction activities in the UK healthcare sector:

- 45 million Giga Joules of energy consumed per year;
- 40 billion litres water consumption per year;
- 3.4 million tonnes of CO2 emitted per year;
- 0.9 million tonnes of Carbon emissions per year;
- 350,000 tonnes of healthcare related waste generated per year (NHS only)

The ever-increasing consumption of natural resources and associated environmental impacts created by the healthcare sector in the UK emphasises the importance of sustainable practices in the design, construction and operation of healthcare buildings (SHINE, 2006).

Sustainable healthcare construction

Sustainable construction should maximise the benefits that the built assets can bring to the local community and economy whilst minimising the impact of the construction and operation phases on the environment (SHINE, 2006). It brings about the required performance with the least unfavourable environmental impact, while encouraging economic, social and cultural improvement (ISO, 2005). Hence, sustainable construction is the process of delivering healthy built environment based on resource efficient and ecological principles. Additionally, sustainable healthcare construction should enhance the long-term usability and value of the building, increase productivity of healthcare staff, improve user satisfaction, lead to more productive partnerships with local communities and organisations, and reduce environmental impacts (SHINE, 2006).

Specific targets were developed and implemented by the NHS to achieve cost savings and reduce the impacts associated with the operation of its existing assets and the construction of new buildings on the environment. These measures were mainly in the areas of: operational energy (reduction in primary energy consumption by 15 per cent by 2010 based on 2000 levels, and the use of 10 per cent of electricity from renewable sources by 2010); water (management of consumption); green transport; sustainable procurement; and waste minimisation and recycling (NHS Estates, 2005).

TYPES OF HEALTHCARE WASTE

Healthcare waste refers to any waste produced by, and as a consequence of, healthcare activities (DH, 2006). The NHS in England and Wales produces approximately 384,698 tonnes of combined waste per year (Material Health, 2004). The complexity of healthcare facilities is the origin of the variety of their disposed waste. Healthcare Waste Solutions (HWS, 2008) have classified healthcare waste into the following categories: solid waste; hazardous waste; recycled waste; electronic waste (E-Waste); pharmaceutical waste; pathology waste; chemotherapeutic waste; and construction and demolition waste.

Healthcare construction waste is defined as any waste that is generated as a result of some form of construction, demolition or renovation that is taking place in a healthcare setting (HWS, 2008). Several case studies undertaken by Waste and Resources Action Programme (WRAP, 2006; WRAP, 2007b) identified common construction waste material generated during healthcare related construction projects by monitoring waste arising during the end of the structural phase, the internal phase and the fit-out phase. Most common waste materials found from these case studies were plasterboard, metal, timber, plastic, concrete, packaging, ceramic, soil, bricks and blocks.

CONSTRUCTION WASTE MINIMISATION

Construction waste source evaluation

It is widely recognised that source reduction is the best way of minimising construction waste and has been defined as any activity that reduces or eliminates the generation of waste at the source, usually within a process (Begum *et al.*, 2007).

Previous studies on construction waste source evaluation have categorised sources of construction waste in different ways. Pinto(1989), Soibeiman *et al.* (1994), and Pinto and Agopayan (1994) related construction waste to material types such as steel, cement, concrete, sand, mortar, ceramic block, brick, timber, hydrated lime, wall ceramic tiles and floor ceramic tiles. Gavilan and Bernold (1994) went further to group sources of waste under design, materials procurement, materials handling, operation, residual and others. Additionally, Bossink and Brouwers (1996) extended the sources of construction waste further and identified respective causes. Furthermore, Faniran and Caban (1998) identified five typical waste sources: design changes, material scraps, packaging, design errors and poor weather; while Ekanayake and Ofori (2000) categorised construction waste sources under four main categories: design, operational, material handling and procurement.

Major construction waste sources can be related to the design stage, such as design changes, the variability in numbers of drawings and the inconsistency in the level of design details. Keys *et al.* (2000) classified origins of design and construction waste under the headings of manufacture, supplier, procurement, designer, logistics, client, contractor and site management. Osmani *et al.* (2008) conceptualised a lifecycle approach to waste source evaluation and compiled the main causes of waste, as identified by different authors, from project inception to completion of a project . However, the latter did not consider causes of waste during refurbishment and demolition phases. Although a number of studies reported that waste arises at all stages of the construction process (Gavilan and Bernold, 1994; Craven *et al.*, 1994; Faniran and Caban, 1998), very little research has adopted a lifecycle waste reduction approach.

Lifecycle construction waste mapping

There is a consensus in literature that factors causing construction waste span the project life cycle, including design, procurement, materials delivering and handling, construction and renovation, and demolition. This section summarises the key project lifecycle causes and origins of construction waste that were identified in existing literature (Figure 1).

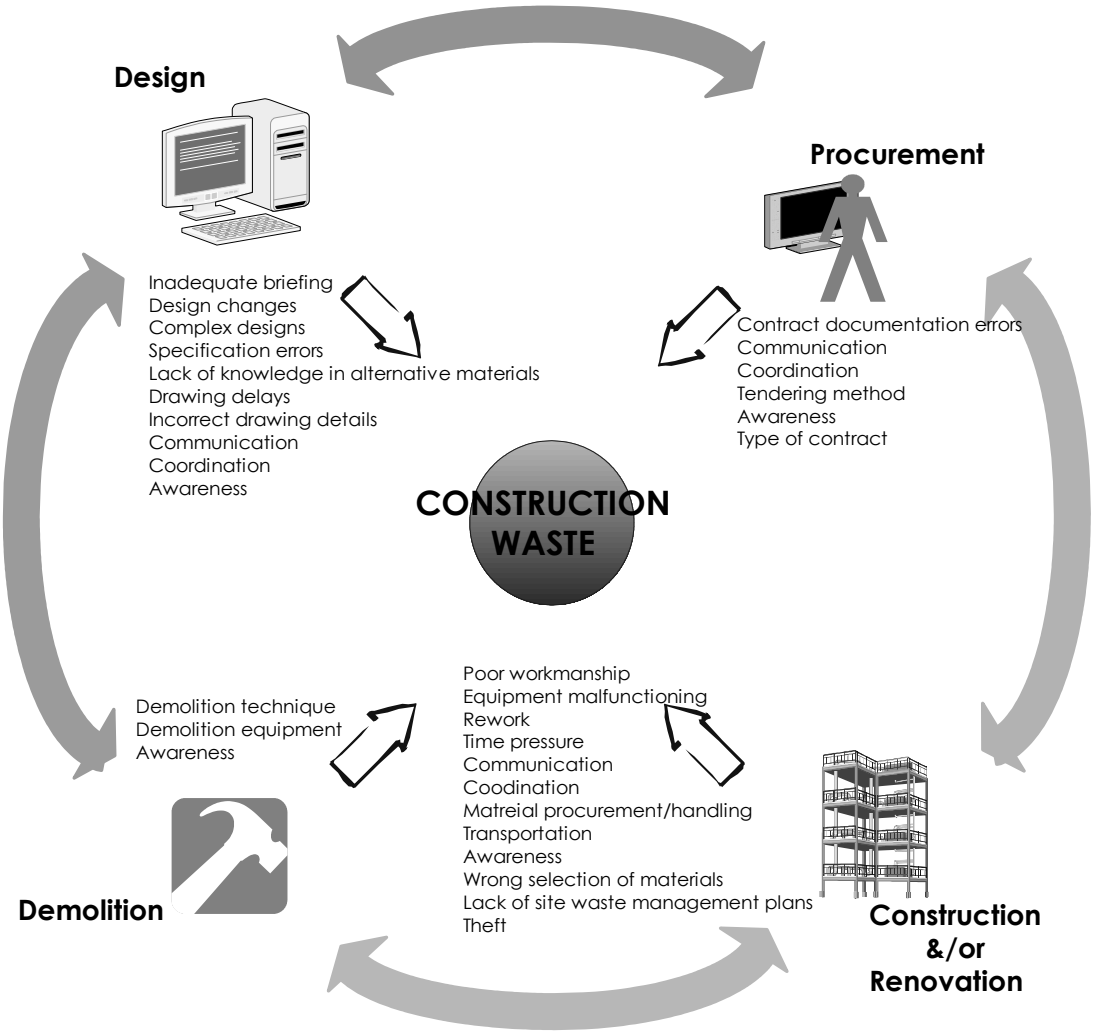

Figure 1: Lifecycle construction waste mapping (compiled from literature)

The design stage accounts directly or indirectly for a considerable amount of onsite waste (Osmani *et al.*, 2008; and Poon, 2007). As such, Innes (2004) reported that about one-third of construction waste could arise from design decisions. Furthermore, inadequate briefing at the initial stage of the project would lead to design changes and variations during site operations (Osmani *et al.*, 2008; Bossink and Brouwers, 1996; and Faniran and Caban, 1998). A designer's lack of construction process experience or poor understanding of material performance can also result in waste generation (Ekanayake and Ofori, 2000; Osmani *et al.*, 2008). Additionally, complex designs, over specifications and selection of non-standardised materials create waste (Ekanayake and Ofori, 2000; Osmani *et al.*, 2008; and Keys *et al.,* 2000). Keys *et al.* (2000) went further to report that a key origin of construction waste generation during the design process is a result of poor communication and coordination among project participants.

Procurement systems have different organisational structures and arrangements that can affect not only the design and construction stages of a project but, also cultural, managerial, environmental and political issues (Masterman, 2002). Ekanayake and Ofori (2000) stated that proper selection of a procurement system help improve decision making during the design and construction stages and reduced unnecessary

extra work and material waste. As shown in Figure 1, several studies (Osmani *et al.*, 2008; Bossink and Brouwers, 1996; and Ekanayake and Ofori, 2000) identified numerous procurement-related waste causes such as type of contract and tendering method.

The construction, renovation and demolition phases are where the most material waste is created. Causes of waste during construction are largely related to labour, equipments and materials used in the construction activities (Graham and Smithers,1996, Ekanayake and Ofori, 2000; Osmani *et al.*, 2008; and Bossink and Brouwers, 1996) and poor site waste management, transportation, material procurement and handling errors (Keys *et al.*, 2000; Osmani *et al.*, 2008; Ekanayake and Ofori, 2000). Even though this study is focuses on the causes and origins of waste in the whole lifecycle of a project, demolition waste is obviously very important. In addressing the impact of demolition waste, Poon *et al.* (2001) argued that its characteristics vary according to the types of structures demolished and the demolition technique used. However, very little literature address the demolition waste issues due to lack of landfill diversion strategies and lack of effectiveness of pre demolition audits.

HEALTHCARE FACILITIES LIFECYCLE WASTE MAPPING

Design

The design of healthcare facilities comprises functional and operationally interconnected built and technical elements that interact with several management systems, which makes them complex and somewhat unique. The complexities over human health implications make design briefing (Lawson, 2005), design decisions, material selection and product and equipment specifications more important for healthcare buildings than other types of construction (Vittori, 2002). Effective communications, poor scope definition, unique technical background of stakeholders, complex decision environments are major problems in pre-project phase of healthcare facilities (Lima and Augenbroe, 2007). Although these studies identified several pre-project phase inefficiencies, to date there has been little significant research into the causes and origins of construction waste related to all stages of healthcare construction projects.

Procurement

Many recent healthcare building projects in the UK have been funded through the private finance initiative (PFI) mechanism (Lawson, 2005). This is a system where by the private sector undertakes to finance the total procurement process on behalf of the public sector and payment being delayed until the project is completed and ready for occupation at handover (Bagnal, 1999). Consequently, the waste generation during the design, construction and maintenance phases have been heavily dependent on causes of waste related to PFI, however, new forms of procurement are emerging as the number of PFI funded projects reduces. Gamage *et al.* (2007) argued that there is a small but growing body of literature that attempts to explore the effects of the selected procurement methods on construction waste generation and minimisation. Similarly, McDonald and Smithers (1998) suggested that the future work should involve assessing the ways in which different procurement systems affect the generation of waste as a result of different interrelationships within the project participants due to alternative uses of procurement systems. Gamage *et al.* (2007) went further to acknowledge the need of mapping the causes and origins of waste under different

types of procurement system. WRAP recently completed case studies of several PFI projects (e.g. Derby City General Hospital, Great Western Hospital, Barts and The London Hospital, St. Bartholomew's and the Royal London Hospital) which revealed that a there had been considerable construction waste reduction and high levels of recycling achieved associated with the PFI procurement approach. In most of the above mentioned case studies, it was estimated that around 25%-30% of material can be recycled at no extra cost. Hence, the identification of the widely used procurement systems in construction of healthcare facilities other than PFIs and identifying the causes of waste specific to the healthcare procurement systems could help in the development of efficient waste minimisation during the construction of healthcare facilities.

Construction/ Renovation

Most of the causes of waste generation in the construction phase listed in Figure 1 are common to all construction projects irrespective of the nature and size of the construction. Healthcare construction can involve very large projects with significant investments and proper onsite waste management techniques are required to obtain the best value for investment. In the UK, most of the major healthcare contractors such as Yorkon, Skanska and Laing O'Rourke use off-site construction to reduce on site waste and expedite the construction process, which were successfully implemented in a range of projects such as Watford General Hospital, Walsall Manor Hospital, and Portsmouth St Mary's NHS Treatment Centre. This would suggest that offsite prefabrication could have a significant impact on onsite waste reduction. However, literature reveals that little has been done to identify the sources and origins of offsite construction waste. Additionally, the healthcare sector is subject to high rates of change during the operation phase, as interior spaces are reconfigured, remodelled and outfitted with new furnishings and equipment reflecting changes in management and delivery systems (Vittori, 2002) which also contributes to waste creation.

Demolition

Demolition waste is the highest proportion of waste in a project's lifecycle and approximately 92 per cent of all construction and demolition waste are from modification and demolition (Environmental Protection Agency, 1998). In the case study of Barts and the London Hospital (WRAP, 2007b), which is the largest PFI healthcare scheme ever to be signed in the UK, over 97 per cent of onsite demolition waste was either reused and recycled. This would suggest that proper onsite waste management plans can effectively reduce the total waste generation from healthcare building demolition.

CONCLUSION

This paper explores the construction waste paradigm within the healthcare construction industry in the UK and established the foundation for a doctoral research aimed at developing a lifecycle framework to minimise construction waste for healthcare facilities. There has been considerable building programme for healthcare facilities in the UK. This has given rise to significant environmental concerns, namely construction waste generation, which could increase due to the continued healthcare construction development. The extant of literature revealed that construction waste is generated throughout the project lifecycle, i.e. the design, procurement, construction and demolition phases. More importantly, the literature review little recent or ongoing research that focussed waste causes and origins specifically related to the design,

procurement and construction of healthcare buildings. Furthermore, there are a number of unique characteristics related to the construction and operation of healthcare facilities when compared with typical buildings, which is mainly due to their organisational and functional complexities. Hence, there is a need to develop a bespoke lifecycle waste mapping process for healthcare buildings. The next stage of this research will focus on preliminary quantitative and qualitative data collection with key healthcare construction stakeholders to identify causes and origins of waste. This would feed in the subsequent methodology stages that will lead to the development of a lifecycle waste minimisation framework for the healthcare sector.

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