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Taking Action on Construction Waste: An analysis of construction waste minimisation practices and their barriers.

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Abstract
Disposing waste in landfill sites is widely considered to have adverse effects on the environment and public health. In the UK the construction industry makes a considerable contribution to the total waste assigned to landfill. As a result the industry is under increasing pressure to adopt effective working practices at all stages of construction to initiate the reduction of construction waste. The general consensus in literature is that design has the greatest impact on waste minimisation. This paper analyses a number of actions required to minimise waste during the preparation, design and pre-construction phase. Further, key barriers associated with implementing these actions are identified as they conversely result in difficulties realising waste minimising practices. Recommendations to overcome these barriers are also discussed. It is concluded that the construction industry needs to do significantly more to divert construction waste from landfill as current measures are not sufficient.

Keywords: Waste minimisation; Construction waste; Key barriers for waste minimisation

1 Introduction

The construction industry in the UK is the largest contributing sector in terms of the consumption of natural resources and waste production. Reducing waste would thus have a major impact on improving the environmental performance of the built environment. This includes reducing raw material extraction and processing, CO_2 emissions from transport and manufacturing, and the demand for landfill. The latter is particular relevant as the UK has limited landfill capacity (Defra, 2011).

The reduction of construction waste can occur at various stages of a project life cycle (Osmani, 2011). Best practice approaches currently focus on the management of construction waste with emphasis on reduction, reuse, recycling and recovery processes. The general consensus in literature is however that greater focus should be placed on the earlier, design and pre-construction stages of building projects as this is where the largest environmental and financial savings can be made.

This paper focuses on examining current waste minimisation practices during the preparation, design and pre-construction phase; exploring the difficulties in realising their practical application within the UK construction industry; and proposing ways to improve existing occurring problems in implementing waste minimisation practices.

2 Concept of waste

Under the Waste Framework Directive (Directive 2008/98/EC) waste is defined as "any substance or object which the holder discards, intends to discard or is required to discard". The ‘holder’ can either be the producer of waste or be in possession of waste. This definition is mandatory for all member states of the EU and applies to all waste irrespective of whether it is destined for disposal or recovery operations.

3 Waste legislation in the UK

The UK government has employed various waste controlling measures that initiate the reduction of construction waste going to landfill. These include the introduction of the Waste Strategy of England (2007) which mainly focuses on recycling waste, the Strategy for Sustainable Construction (2008) that calls for the need to reduce waste at all stages of construction (Defra, 2008), a landfill tax with an ever so increasing rate to incentivise the increase in landfill diversion rates, site waste management plans (SWMP) which are compulsory for projects with a value in excess of £300,000 and the target for halving construction demolition and excavation (CD&E) waste going to landfill by 2012, relative to the 2008 baseline (Osmani, 2012).

4 Construction waste arising in the UK

The construction sector accounts for 35% of all waste arising in the UK which makes it the largest waste stream. Whilst there are no accurate statistics available confirming the amount of construction waste sent to landfill, WRAP estimates that an average of 25% of generated construction waste ends up in landfill every year (WRAP, 2009). In England the overall amount of CD&E waste being land filled increased from 13% in 2009 to 16% in 2010. It is stipulated that this increase is due to a rise in excavation waste being land filled. Consequently, it is feared that this increase is hindering the delivery of the UK government target of reducing CD&E waste to landfill by 50% by 2012 compared to the 2008. Thus, the industry's best efforts are currently focused on diverting excavation waste from landfill as this is regarded as the priority in halving all CD&E waste (Strategic Forum for Construction, 2012).

5 Origins of waste constructions

It is generally accepted that design decisions ultimately determine waste stream characteristics. Waste can be caused by the designer's inexperience and lack of knowledge in the method and sequence of construction, the lack of attention paid to dimensional coordination of standard building materials, the distribution of poor design information, the occurrence of design changes while construction is in progress and the difficulties for designers to integrate waste reduction measures into their standard design approach (Osmani, 2008, Parsanejad et al. 2010, Keys et al., 2000). Other factors, equally important for successfully minimising construction waste are discussed in only a few studies. These include the project procurement process (Gamage et al., 2009), contractual stage, training and knowledge in environmental issues (Greenwood, 2000), unclear waste legislation and the ability to forecast potential waste arising in a project (O'Reilly, 2012). Key waste sources within the pre-construction phase should therefore extend beyond design related matters. Waste sources are underlined by the lack of focus on preventing construction waste of being generated in the first place (Osmani, 2011) and the poor quality of up-to-date construction waste data in the UK. The latter is essential to provide benchmarks on waste generation against which the industry can set itself targets for waste reduction.

6 Waste minimisation practices

The effectiveness of waste minimisation practices is generally dependent on the willingness of individuals involved in the construction process to apply themselves or even change their attitudes. It is prudent to recognise that the clients' commitment to reduce waste can mandate the use of effective waste minimisation practices in a project (WRAP, 2009). Indeed, clients have started to incorporate sustainability as a part of their corporate social responsibility objectives and are increasingly demanding

the construction team to achieve major waste reductions and to obtain environmental ratings and accreditation (e.g. BREEAM). It is equally becoming more important for contractors, designers and members of the supply chain to attain the British Standard ISO 14001 accreditation to demonstrate their commitment to sustainable construction and good environmental management. It is also important to educate site personnel responsible for the physical handling of waste on site to waste minimisation (Greenwood, 2000).

Further, contractual responsibilities should be placed onto the design team, the contractor and members of the supply chain in order to set out targets and requirements for reducing the quantity of waste generated and maximising the amount that can be reused or recycled. The emphasis should be on the contractor to identify which potential waste streams to focus on, and the appropriate methods to adopt to reduce them. Then, targets for waste reduction and recovery can be developed in conjunction with the design team. For this reason, the early involvement of a contractor in a project is most beneficial. This is because the contractor is best placed to identify opportunities for improved performance and cost saving, given their position at the interface between the design and construction phases of the project, taking into account the supply chain that is to be employed. Early contractor involvement can be sustained through the use of an appropriate procurement method such as 'design and build'. It is considered more effective than a traditional procurement route (Gamage et al., 2009). 'Design and build' would not only reduce impacts during construction but would also cater for the consideration of buildability issues earlier in the design process, thus minimising opportunities for design changes that would usually generate more waste. Further there are financial benefits due to the realisation of shorter construction periods and improved efficiency. Another useful strategy is adopting a performance measurement system, in which businesses evaluate their processes against best practice to encourage better service provisions.

Key design actions to minimise waste include designing out waste in the first instance and understanding the consequences of design and the use of certain products in waste creation. In order to design out waste six different design strategies have been identified. For maximum effect these strategies should not be used in isolation and should be considered as part of the waste minimisation practices addressed above.

1. Use of fewer materials
   A simple structure has usually less waste than a complex structure. Fewer materials require to be cut to suit the design, resulting in less waste generation.
2. Use of reclaimed and recycled materials
   Full advantage should be taken of all opportunities for the recovery and reuse of existing building materials or components.
3. Design for deconstruction
   Designing structures for deconstruction at the end of their lives enables building materials and components to be easily removed for re-use or recycling.
4. Standardisation in design
   Building layouts can be designed to fit the manufactured dimensions of materials and components that will be used. This reduces the amount of off-cuts on site.
5. Adjustment of standard materials to suit the design
   This design-to-built strategy would require suppliers or manufacturers to supply materials that comply with the dimensions of the design.

6. Off-site construction methods
   Designing for the preferential use of prefabricated units can eliminate or reduce the site cutting and handling of materials, having dramatic effects on waste.

Throughout the site works design changes can often occur with the resultant rework usually generating considerable volumes of waste. Thus, freezing designs, the early distribution of a complete set of working drawings and effective communication and coordination can significantly reduce waste (and project costs). Conversely, where the contractor suggests that waste could be reduced if the design was to be amended then designers should be willing to explore these opportunities. In this case, the design should not be too prescriptive, allowing adjustments to be made on-site.

7 Barriers and recommendations to overcome them

Complete data on the amount of waste produced, recycled, recovered and land filled is required to draw a detailed picture of the current construction waste situation in the UK. However, current available data on waste quantities lack in quality and are outdated. There is an urgent need for waste data to be provided quickly to be current and accurate in order for the construction industry to make better use of the available data for setting realistic targets for waste reduction and to measure performances.

A range of design approaches have been developed in recent years to improve resource efficiency and incentivise waste reduction. This however is not enough on its own to encourage change. Despite the general acceptance and understanding of the need to minimise waste there still seems to be widespread ignorance amongst the industry with regard to the concept of waste reduction or the need to take personal responsibility. Designers often view waste minimisation as an additional, almost extraneous part of the design process rather than integral feature. They also perceive that many wastes are because of site operations and are therefore the contractor's responsibility. A further difficulty is that designers have to follow the design briefs provided by their clients, and sustainability and waste reduction do not often feature very highly as part of their requirements. Clearly, there is a need to inspire businesses to consider environmental issues, to demonstrate that waste reduction can deliver economic benefits and to provide knowledge and skill development for that purpose. In order to ensure that businesses integrate sustainability and waste reduction measures into their design processes the government must take the lead by imposing regulations. Further, incentives are required to encourage businesses to implement sustainable design and these should include prizes and awards that recognise those who have exceeded in adopting construction waste minimisation measures. Such incentives are especially important at times where regulations lack in driving waste minimisation. The current focus in UK legislation is more on recycling and recovery of waste that has already been generated rather than waste prevention and minimisation at source. Actions addressing the latter need to be identified and put in place without undermining the projects designed lifespan, energy consumption and emission, aesthetics, value, quality and purpose.

Design alone is unlikely to achieve sustainability without the involvement of manufacturers and suppliers of building materials and components for determining the treatment and optimum recovery of their material wastage. For instance, there is currently an increasing use of prefabrication and composite materials and components in the industry. Such products consist of a mix of materials that are very difficult to separate and recycle and consequently their waste is likely to end in landfill. Thus, innovative recycling processes need to be encouraged in order to deal with a wider

range of waste. New technologies, changes to production processes and innovative solutions to meet recycling needs can all play a significant role in reducing waste. Conversely, a lack of knowledge of material properties, poor business guidance, burdensome trade requirements and complex designs can impede efforts to reduce waste during the early phases of construction projects. Furthermore, additional cost and resource implications associated with designing out waste can equally act as obstructions for businesses, in particular small ones. It is important for the government to engage with the industry to enable businesses to invest in waste reduction strategies and to provide funding schemes for waste minimisation initiatives. Further, as material selection is a key part in designing out waste it is crucial that knowledge about sustainability of individual materials and products is sufficiently promoted and relevant information is made easily accessible for designers. Designers and contractors alike are especially reluctant in embracing the use of new materials as they lack confidence in their quality and performance.

The procurement phase can play a decisive role in reducing waste as it can enforce the working relationship within the project team. Although the 'design and build' procurement route is currently favoured as it enables an early contractor involvement it is criticised for operating a condensed project program whereby design and construction phases overlap. This complicates the management of the design process and moves waste minimisation to the bottom of the priority list. Further, during fast track projects it is unlikely that a complete set of drawings is made available before site work commences (Keys et al. 2000). Thus, it is prudent to consider the use of a partnering framework agreement as it is a more enhanced sustainable procurement practice that enables waste reduction. It is perceived to be most effective in facilitating good communication and information flow and coordination among the project team as its concept is based on a close working relationship between partners. Its benefits include that all partners have defined roles and mutual responsibilities in delivering set environmental targets. The partnering framework may be just the right approach towards tackling any miscommunication issues between project team members that could result in causing waste. Another viable approach to improve communication and coordination is the use of Building Information Modelling (BIM). It is an emerging technology within the construction industry that has significant advantages over the entire building lifecycle (Osmani, 2011). It is capable of modelling representations of the actual parts that are used for the construction of a building along with the geometry, spatial relationships, quantities and properties of building materials. The technology functions as a real-time interactive and collaborative communication system. Thus, it has the potential to help project stakeholders to collaboratively minimise the risk of occurring design changes and attain construction waste minimisation throughout the design and construction phase.

8 Conclusion

There is a general awareness within the construction industry of the need to enforce measures to control the current waste problem in the UK. However, waste quantities in England reveal that it is increasingly difficult to implement effective initiatives to decrease the production of construction waste. Whilst there are examples of good practice, in general terms the construction industry needs to do significantly more to encourage and implement waste minimisation practices.

Undoubtedly, current design initiatives such as the use of recycled and reclaimed materials, design for deconstruction, standardisation in design, and prefabrication are

a means of minimising construction waste and improving the environmental performance of the construction industry. However, there is a sense of reluctance from project stakeholders to embrace such sustainable techniques and methodologies due to lack of confidence in their performance, lack of knowledge and associated additional costs. It is crucial for the government to support businesses in the construction industry to implement waste minimisation strategies and to provide adequate funding to encourage stakeholders to adopt a more proactive approach. Assurance must be provided that each project goes through a waste minimisation procedure. Thus, it should be made mandatory for businesses to report their (project specific) progress with respect to environmental performance and more specifically on meeting their environmental targets.

With the increasing pressure to divert waste away from landfill and the UK commitment towards a zero waste economy (Defra, 2011), it is prudent to recognise that research into resource efficiency and novel processes must remain priorities to enhance opportunities for waste minimisation practices. There is urgency for new innovative solutions that are effective in not only diverting significant volumes of construction waste away from landfill but also in ultimately removing them completely from the construction process.

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