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Reducing waste to landfill in the UK: identifying impediments and critical solutions

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Abstract

Purpose – The UK construction industry produces up to one third of all waste to landfill. This study aims to identify specific project practices impeding the reduction of waste in construction projects as well as uncovering potential waste solutions throughout the project delivery process. The rationale being that for such a drastic reduction in waste to landfill, holistic and extensive measures would be required.

Design/methodology/approach – A two-way methodological approach was used. This comprised qualitative unstructured interviews and a quantitative questionnaire survey of three major stakeholders in the UK construction industry: clients, architects and contractors.

Findings – Design factors remain the major cause of impediments to waste reduction to landfill. Critical impediments include clients making waste prevention a top priority in projects, overly complex designs, waste taking a low priority compared to project time and costs, lack of concerns by designers for buildability, among others. Critical solutions include early supply chain involvement in design process, choosing materials for their durability, early communication of design changes to all parties, longer project programmes and better lead times, among others.

Practical implications – In all, the target of halving construction waste to landfill based on the 2008 benchmark is achievable but would require construction companies to take it upon themselves to implement the proposed solutions suggested by this study.

Originality/value – The value of this research is to provide UK construction companies with solutions to reduce waste and aid the reaching of the landfill target, as landfill is decreasing as a solution to waste. In addition the cost savings on reducing waste could be crucial for companies in this current economic climate.

Keywords Sustainability, Project management, Waste, Landfill, UK Government, Design, Construction, Landfill tax, Strategies, Challenges, Client, Architects

Paper type Research paper

Introduction

In general terms waste is unwanted material. Its original purpose has been met and the material is of no further use in its present state or location. WRAP (2011) found that the construction industry was responsible for a 120 million tonnes waste which was estimated as being a third of all UK waste. Waste management has generally adopted the approach of finding a way of moving and disposing of this waste through a series of processes. Historically most of the waste has ended up being disposed of via landfill.

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In the past this was a cheap option for waste disposal. There was adequate space available. This is no longer the case. Surrey County Council (2011) highlighted that in England and Wales landfill sites decreased from 3,400 in 1994 to 2,300 in 2001 with the present number of sites being around 1,500. At present, a high percentage of all waste produced in the UK is still sent to landfill sites. The volume is increasing to such an extent that other methods of waste management have to be adopted. The view of waste as a resource has further increased the shift away from landfill (Nick Herbert, 2009).

In 1996 the landfill tax was introduced to discourage use of landfill and to encourage recycling. The tax rates, which initially were set low, have subsequently been increased in order to strengthen its behavioural impacts, and more increases are planned. This tax has impacted on the construction industry. In 2000 the DETR found that 24 per cent of construction waste was disposed at landfills compared to 51.2 per cent. In June 2008 the "Strategy for Sustainable Construction" was created. It is a joint industry and government strategy with an overall goal of enabling England to be world leaders in sustainable construction. One of the key areas of the strategy is waste were the target is to achieve "By 2012 a 50 per cent reduction of construction, demolition and excavation (CD&E) waste to landfill compared to 2008". In the hope of aiding the reaching of this target the objectives of this research are to identify the main impediments within a construction project which create waste, as well as solutions to the waste

Literature review

There is a substantial amount of literature concerning waste within the construction industry. This research will look at waste management towards achieving the government initiative. An important sustainable strategy for waste management mentioned throughout literature is that waste prevention is best desired option when compared to minimisation, reuse, recycling, energy recovery (incineration) and disposal (land filling).

It is essential to understand the sources of waste within the construction process. Morris (2007) claim that one-third of all construction waste can be traced back to decisions at the design period. Ekanayake and Ofori (2000) identified three main categories of waste generation on a construction site namely, materials, labour and machines but highlighted material waste as being of more importance due to the construction industry using mainly virgin materials which are from non-renewable sources. Furthermore they found there to be four chief sources of waste in construction which were design, operational, material handling and procurement (material). In support of this Gavilan and Bernold (1994) identified six source categories of construction waste, with four the same as above. They are design, procurement, material handling, operation, residual and others. Causes of waste are rampant throughout the construction process, from inception to demolition. In terms of the waste hierarchy, waste can be prevented at both design and construction stages, whilst reuse and recycling strategies are more prevalent during the construction and demolition stages. This study will consider the causes and solutions at each of these stages.

Design stage

Osmani *et al.* (2007) discovered that architects believed most waste generated during a construction project to be the cause of contractors through such processes as misinterpretation of architects' drawings and specification and on-site logistical and operational activities. In all it was found that designing out waste was considered an

ad-hoc activity and architects would only be willing to work with contractors on this process if enticement was provided by clients, mainly through financial incentives. This approach of coordination is supported by WRAP (2008b) whom claim that "It is the contractor who sees where waste is generated on-site and who should be able to support the designer in looking for waste within the design".

WRAP (2008b) identified processes during the design stage to help minimise waste. These include preventing design variations through understanding the client's needs and the client providing "clearly defined objectives" and designing for site conditions. The need to minimise design changes is supported by Osmani *et al.* (2006) who found, through use of questionnaires that contractors and architects both agreed that late changes due to clients' requirements and design changes were the main causes of waste at the design stage. The increase in complexity of buildings also affects the amount of design changes. This is due to increased integration of components making it more likely that a change in one area of the design will require other areas to be redesigned (Keys *et al.*, 2000). WRAP (2008a) supports this by promoting standardisation of design to reduce complexity. If design changes are necessary all parties involved should be given appropriate and effective notice of them (Faniran and Caban, 1998). Most importantly the design stage should be considered as the stage which offers the greatest opportunity for waste minimisation (Keys *et al.*, 2000). Ekanayake and Ofori (2000) advocated the early involvement of the contractor during the design stage as a means towards waste reduction.

Construction stage waste prevention

One of the main causes of waste at the construction stage was considered by Jones and Greenwood (2003) to be "damage due to mishandling, weather and inadequate storage". Enshassi (1996) claims that having inadequate storage on-site can cause waste. However, he highlighted that contractors are not conscious of the rewards of providing proper storage. He also recommends having costly materials arriving on-site only when needed by providing safer off-site storage. A better material storage solution is just-in-time (JIT) deliveries. It facilitates a reduction in inventory level, overall building time, defects and costs (Akintoye, 1995). In order to apply JIT production trust and discipline is necessary between contractors and suppliers; this can be achieved through the building of long-term relationships and a willingness to share information (Akintoye, 1995). This highlights the need for supply-chain management in order to provide JIT production in the construction industry. Vrijhoef and Koskela (1999) state "The basic idea of supply chain management is to recognise the interdependency in the supply chain, and thereby improve its configuration and control based on such factors as integration of business processes".

One way to enable supply-chain integration is through partnering. CIB (1997) as citied in Cooke and Williams (2009), define partnering as "a structured methodology for organisations to set up mutually advantageous commercial arrangements, either for single projects or in long-term strategic relationships, which help their people work together more effectively". Furthermore WRAP (2008a) suggests that engagement with the supply chain can be used to minimise packaging on materials, encourage suppliers to reduce waste at source as well as aiding the setting up of "take-back schemes" enabling the contractor to return surplus materials to his suppliers. Tam *et al.* (2005) highlight another cause of material waste to be the use of the conventional construction method, which involves a lot of cast *in-situ* operations. They propose the use of prefabrication techniques as they found that the average wastage level between the

conventional method of construction to be much greater than that of the prefabrication method especially within the processes of concreting, plastering (up to 100 per cent reduction through prefabrication) and rebar fixing. Jaillon *et al.* (2009) discovered that prefabrication can provide numerous additional benefits such as a decrease in time to complete a project and an improvement in health and safety. Material handling was also identified as a construction stage waste contributor. To minimise waste from handling errors a monitoring system of wastage level should be enabling the contractor to have more knowledge of his material control plan which should include clear records of material usage (Poon *et al.*, 2004). In addition to this material handling can be improved through the use of the right piece of handling equipment for the conditions at that time (Cooke and Williams, 2009).

Reuse and recycling construction waste

Faniran and Caban (1998) state "Re-using and recycling waste refers to the reusing and recycling of waste materials, thereby reducing the volume of waste material to be disposed of and discharged back into the environment". To be able to make the most of both waste management techniques it is necessary to segregate waste. This view is defended by (Wimalasena *et al.*, 2009) who believe it is necessary to analyse construction waste so as to better understand the waste problem and help create "targeted recycling programmes". Site waste management plans (SWMPs) help to promote the segregation of waste which allows for the recuperation of materials and also provides a safer working environment (Hill, 2008). This is as an SWMP requires the identification of the likely waste to be generated during construction as well as the amount of each type of waste expected to be produced. SWMPs have now become compulsory on all construction projects of a cost $>$£300,000, within England from April 2008 (WRAP, 2008c). Furthermore WRAP (2008c) claims that the use of SWMPs has reduced the cost of waste management for contractors.

In terms of comparison between recycling and reuse of material waste it is better to reuse materials on-site than the recycling of materials off-site, though both are preferable to landfill disposal (Craighall and Powell, 1999). This is down to the facts that reuse on-site saves on transport costs and obviously the cost to recycle materials. A specific strategy to decrease the costs of recycling is to enter into an agreement with recycling companies who will remove waste from sites for recycling in a productive manner (Dainty and Brooke, 2004). A strategy to improve the potential of both recycling and reuse of waste is to evaluate the materials to be used at the design stage for the recycling and reuse opportunities they can provide (WRAP, 2008a).

Methodology

The approach chosen was to use a two-way research design consisting of a qualitative study preceding and leading to a quantitative study. Each is explained below.

Qualitative research

It was decided to use unstructured interviews as the qualitative information gathering technique. The reason behind this decision was to get insight knowledge beyond the literature review in terms on real-life waste management practices in everyday delivery of project operations. In order to get a balanced perspective it was decided to approach three key industry players of most construction projects; namely: the client, architect and contractor. Personnel with at least ten years experience were targeted. Over 50 people with these credentials were contacted with only five accepting the invitation to

take part in the study. Of these five interview participants, one was with an architect and two each were with clients and contractors. On average they have 14 years experience within the UK construction industry. The interviews last for a period of 55 minutes on average. Information from the interviews was tape recorded and later transcribed. Possible factors were identified from the transcribed data and used as a basis for developing a questionnaire survey for the wider industry participation in the study.

Quantitative research

This comprised a questionnaire survey. The target audience was again the three key players. The purpose of the questionnaire survey was to establish if the findings from the literature review and the qualitative analysis are supported by wider perception in the industry. The questionnaire was split into three sections. The first section (A) focused on the respondent's details. The second and third sections were split in accordance with the objectives of this study. The second section (B) was on the impediments and challenges which generate waste and lead to it being disposed of in landfill. The third section's (C) purpose was to identify methods and solutions which are effective at preventing and reducing waste. A Likert scale of 1-5 was used for sections B and C. Section B were impediments which generate waste and lead to it being disposed to landfill. The aim of section C was identify methods and solutions which are effective at preventing and reducing waste. Based on these, in section B, 1 represented strong disagreement and 5 represented strong agreement. In section C, 1 signified a proposed solution as not effective and 5 signified very effective.

The respondents were sourced through use of contact details on the WRAP web site of companies that have signed up to the halving waste to landfill commitment, as well as using contacts from the local construction industry. The total respondents numbered 27. Eleven were from contracting firms, 12 from architect firms and only four were from client organisations as shown in Figure 1. The return rate was less than expected with around with nearly 200 surveys sent out via e-mail (Figure 2).

Qualitative results

Five interviews were carried out, two each with contractors and clients and one with an architect. The two client interviews were combined as were the contractor interviews, leaving three maps. In general a substantial amount of information was harvested from the five unstructured interviews. To avoid repetition, the key findings from the interviews were condensed to results that were not identified in the literature review.

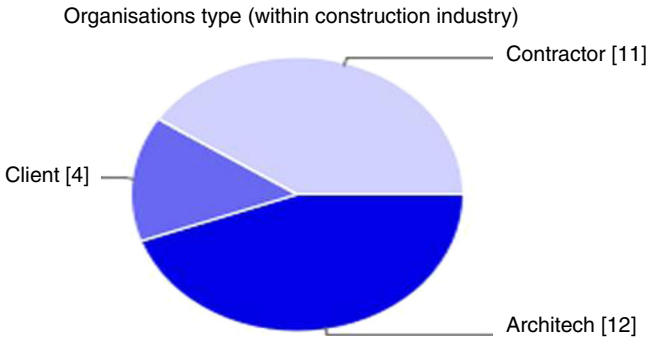

Figure 1.
Organisation types of respondent

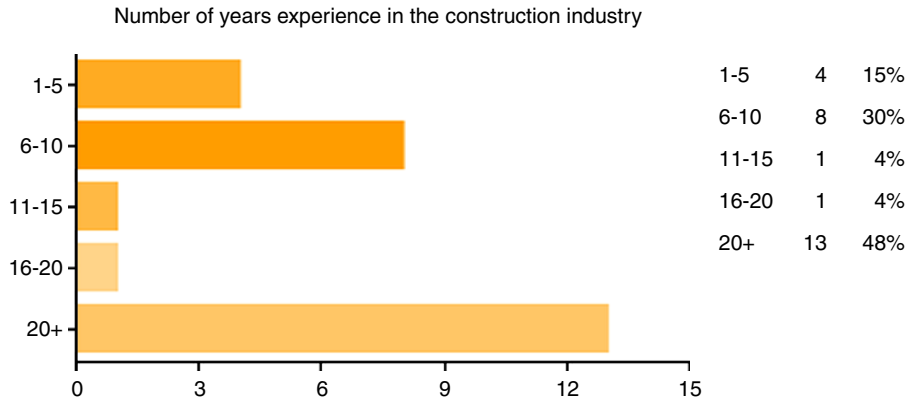

Figure 2.
Respondents years of experience in the construction industry

The interviews were also used to gather a plethora of first-hand information on the key player perspectives. This information was utilised in preparing the questionnaire. The new findings beyond those indentified in the literature are listed as follows:

- eradicating waste by sub-contractors through penalties and education;
- setting waste targets early;
- design and build procurement as the means of acquiring early contractor involvement;
- sites too small for effective waste segregation; and
- different parties with different goals.

All parties were aware of waste. The expected waste contributors scored high such as construction stage waste, poor design, etc. In terms of possible strategy unsurprisingly waste prevention was identified as the best approach.

Quantitative results and discussion

Tables I and II show critical impediments affecting reduction of construction waste to landfill and possible solutions, respectively.

Pre-design and design stage impediments

In order for waste prevention to be a major concern of the project design, it has been confirmed that it requires the client to demand it. To change the client's perspective requires persuasion or convincing of its cost benefits or be environmentally influenced or required to comply with government planning legislation. Teo and Loosemoore (2001) claimed that savings in outlay are the principal factor in the embracing of waste reduction behaviour. As is often the case the required design does not fit easily within the construction process due to its complexity. This could be resolved by a more standardised approach taken by the architect, with consideration of the complexities and designing them out as much as possible. In addition early contractor involvement could reduce complexity by using his knowledge of the problems it can create at the construction stage.

Construction stage impediments

Sub-contractors lack of commitment to waste targets was identified as the primary cause of construction stage waste. This finding is in agreement with

	Overall mean	Architects	Clients	Contractors
Design stage impediments				
1. Clients not making waste prevention a top priority in projects	4.37	4.50	3.75	4.27
2. Overly complex designs create waste (e.g. excessive amount of off-cuts needed)	4.11	3.92	4.00	4.36
3. Waste management and minimisation is a low priority for a project compared to cost and time	4.07	4.50	4.00	3.45
4. The lack of concern by designers for "buildability" of design generates waste	3.78	3.67	2.50	3.82
5. Waste minimisation practices are only implemented if they provide a cost benefit or are required by law	3.78	3.75	4.00	3.73
6. Poorly defined client brief's causes significant waste through the need for design changes	3.59	3.25	4.00	3.45
7. Architects do not "design out waste"	3.04	2.42	3.50	3.73
Construction stage impediments				
8. Sub-contractors are not committed to waste targets	3.67	4.00	3.50	3.36
9. Materials damaged during delivery to site is a significant cause of waste	3.52	3.50	2.75	3.73
10. Material handling on-sites is poor leading to waste	3.52	3.50	3.50	3.64
11. The poor quality of work by construction workers is a significant cause of waste	3.48	4.00	3.50	2.82
12. Inadequate on-site storage is a significant cause of waste	3.44	3.25	2.50	3.82
13. Materials come with excessive packaging	3.37	3.50	2.75	3.36
Reuse and recycling impediments				
14. Poor on-site management restricts reuse and recycling	3.48	3.00	2.25	3.82
15. Lack of recycling facilities in close proximity to a site increases the amount of waste disposed at landfills	3.41	3.17	3.00	3.45
16. Waste is inadequately segregated reducing the opportunities to reuse or recycle	3.33	3.75	3.25	2.91
17. Contractors believe it is cheaper to landfill than recycle	3.11	3.25	2.25	3.27
18. The sizes of sites restrict the ability to segregate and therefore recycle	3.04	2.75	2.25	3.82

Table I.
Impediments affecting reduction of construction waste to landfill

Shen and Tam (2002) who found through interviews with contractors that they found it extremely difficult to manage sub-contractors' environmental performance. McDonald and Smithers (1998) proposed a method to improve sub-contractors commitment by having the main contractor and sub-contractor evaluate the sub-contractors likely waste output and in accordance with this evaluation set practical targets for recycling and reuse of waste. Another means of reducing sub-contractor waste is to penalise them for poor waste performance. Materials damaged upon delivery can be resolved by ensuring that appropriate care is taken when materials are loaded onto their method of transportation as well as when offloaded on-site. This can further be enabled through collaboration with suppliers, manufacturers and contractors, to ensure that materials are adequately packaged, loaded and transported in the manner required by the site conditions (Poon *et al.*, 2004). Poor material handling has been realised as a

Pre-design and design waste solutions	Overall mean	Architects	Clients	Contractors
1. Early supply chain involvement in design process, giving waste reduction a top priority	4.37	4.50	4.50	4.18
2. Choosing materials for their durability	4.19	4.25	4.50	3.55
3. Longer project programmes and better lead times	4.15	4.17	3.75	4.09
4. Making the Site Waste Management Plan (SWMP) part of the pre-design stage	4.04	3.75	3.25	3.64
5. Submission of Deconstruction plan as part of planning permission application	4.00	2.83	4.00	4.45
6. Training for clients on the benefits of a well defined clients brief	4.00	4.08	3.50	3.36
7. Setting targets for the recycling and reuse of waste	3.96	4.00	3.25	3.55
8. Using partnering as a vehicle for implementing waste management and minimisation practices	3.74	3.42	3.75	4.00
9. Use of supply chain to influence manufacturers to reduce materials waste (i.e. packaging)	3.59	3.58	2.75	3.82
Construction and demolition waste solutions				
10. Using off-site prefabrication	4.33	4.50	3.75	4.09
11. Early communication on design changes between all contract parties	4.15	4.17	3.75	4.18
12. Use of design freezes	4.07	4.33	3.25	3.73
13. Use of quality management to reduce defects	3.93	3.83	3.25	4.00
14. Use of modular construction	3.93	4.17	3.75	3.64
15. Waste efficient procurement (i.e. materials logistic plan just-in-time delivery, etc.)	3.81	4.08	3.75	3.55
16. Instigation of take-back schemes with suppliers for surplus materials	3.74	3.75	2.00	4.00
17. Ensuring the correct handling equipment is available for diverse weather conditions	3.67	3.75	2.00	3.82
18. Using deconstruction instead of demolition	3.33	2.83	4.50	3.45

Table II.
Solutions to help reduce waste to Landfill

major cause of waste. One measure is to ensure the proper handling equipment is equipment is available as well as laying out areas for storage with room to manoeuvre. JIT delivery can reduce material handling waste by decreasing the time materials are stored on-site (Dainty and Brooke, 2004).

Reuse and recycling impediments and solutions

For recycling and reuse to be adopted throughout a construction project commitment to managing waste has to be shown by management who need to supply the facilities to aid it (Teo and Loosemoore, 2001). This can be through providing areas for segregation, the setting of waste recycling and reuse targets and in general having the on-site supervisor championing the need for better waste management. The lack of recycling facilities nearby will also produce wastage. This is if the transportation and recycling costs outweigh the disposal costs, landfill will become more favourable. One resourceful way of dealing with this issue is to reach an agreement with recycling companies to pick up the waste that is of benefit to them (Tam *et al.*, 2005).

The only solution to improve recycling and reuse of construction and demolition waste that was recognised as being effective by all the key players was the use of SWMPs. These plans improve recycling and reuse as they require each sub-contractor and main contractor to identify their expected waste streams. This then enables the

planning of what can be recycled and when. It also allows for the planning of reuse of materials. Furthermore if the SWMP is integrated in at the design stage it will allow for better evaluation of waste and can allow for greater reuse of waste within the design. In addition Tam (2008) found that if it is integrated at this stage it can help identify areas where waste can be reduced.

Pre-design and design stage solutions

In terms of overall solutions to the design stage it has been found that waste reduction should be considered early in the design process. This will require an increase in priority, which is unlikely to happen unless it is required by law, provides substantial cost benefit or demanded by the client. In terms of cost benefit it should be highlighted that prevention reduces the amount of waste produced and therefore should fabricate cost savings by reducing costs of unnecessary waste. The choosing of materials for durability is a simple measure in theory. In terms of the client this was the highest ranked solution to waste. This is logical as more durable materials will last longer requiring less change to the clients building and therefore less disruption as well as less expenditure. The increasing of time available for a construction project is unlikely to happen as discussed earlier, though it would most definitely reduce waste production. Shen and Tam (2002) found that due to heavy penalties for time overruns imposed by the client, contractors are diverted from investing time into environmental management. Lack of segregation of waste, has already been mentioned as an issue impacting on recycling and reuse. However, it seems that contractors need to be educated on the benefits as well as the unquantifiable benefit of improving their corporate social responsibility (Tam *et al.*, 2005). It is accepted that in some cases segregation is not feasible such as small sites or small projects. In these cases it will be inevitable that waste that could be recycled will end up in landfill.

Construction stage minimisation solutions

The greatest generator of construction waste is the concreting process so any lessening in the amount of on-site concreting equals a reduction in waste (Baldwin *et al.*, 2009). One method of reducing traditional *in-situ* concreting is to make use of off-site prefabrication. This has been verified by this research with architects, clients and contractors, agreeing that prefabrication are a very effective means of reducing construction waste. Prefabrication is a manufacturing process which takes place in a factory designed for it and thus allows for better control. The repetition of prefabricated units also allows for waste to be removed through refining the process. Furthermore Jaillon *et al.* (2009) found that a 70 per cent time saving could be gained through the use of prefabrication techniques in comparison to *in-situ* construction. Prefabrication is not without its problems. Due to size of units they are not suitable for small sites. They may be damaged during delivery and more time is required at the early stages of a project to design for prefabrication and allow for production (Baldwin *et al.*, 2009). However, this extra time taken before construction can commence could be used to implement proper waste management throughout the project as well as allowing for time to further reduce waste through design. In full traditional methods of construction need to be reduced as much as possible which is further supported by findings that modular construction was ranked fifth as an effective method of waste prevention.

The second and third ranked methods of reducing construction waste concern design changes. It has been identified at the literature review, the interviews and

validated by the questionnaire as a large cause of waste. The solutions provided to reduce the effects of design changes are the early communication on design changes between all contract parties as well as the use of design freezes. In support Latham (1994) found that if an effective communication network was not defined, then bad practice would continue throughout the construction industry. Therefore it is important to ensure effective lines of communication are set up. Also the use of partnerships would encourage better relations between disciplines and therefore better communication and understanding. The late changes to designs during the construction phase could be reduced through design freezes. This is otherwise known as design fixity. Cooper *et al.* (2005) explains that design fixity is where the design elements for certain processes are signed off upon agreement and from this point cannot be changed. Design fixity therefore provides the contractor with certainty over the construction process and project which will reduce waste as well as keep the project on schedule.

Conclusion

This research has shown that whilst only just over one-third of questionnaire respondents signed up to the commitment, all displayed an awareness of the issues of waste within construction. To move from awareness to action may require additional government intervention.

The research highlighted that the client is the predominate player in the construction process and proposes that the client needs to be made aware of the benefits of waste control. The architects can contribute to reducing waste through less complex designs and increased "buildability" through use of various techniques including prefabrication. Another factor which could reduce waste could be the involvement of the contractor at this stage. Waste was identified at all stages of the construction process, on referring back to the waste hierarchy on prevention being the best cure it was concluded that the design stage could be the most important part of the construction process for the reduction of waste. Other waste contributors were highlighted throughout the construction stage including sub-contractors not committed to waste targets, materials damaged upon arrival and poor handling of materials, poor site management, lack of on-site storage, the logistics and economics of recycling and reuse. Potential solutions were the incentivising of sub-contractors, quality management, use of SWMPs and collaboration with suppliers. Furthermore the best solutions to construction waste overall were prefabrication, improved communication and use of design freezes. In regards to reuse and recycling of construction and demolition waste segregation and SWMPs have been found to be effective. In addition SWMPs should be considered at the design stage. Deconstruction should be used instead of demolition were time permits.

Landfill space is running out. If the target is not a success then stronger measures will have to be implemented by government. However, this should not be the case as there are enough opportunities and solutions that can be utilised to prevent the disposal of waste at landfill. In addition if such methods are adopted cost savings can be made which could be especially significant in these current times where construction companies are making a loss on projects just to keep their cash flowing. Prevention is the best cure and can also provide the most benefits but does require collaboration between the key players in the construction industry. Reuse and recycling is easier to implement and may be the uncomplicated answer to fulfilling the commitment.

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