

CONSTRUCTION WASTE MINIMISATION IN THE UK HEALTHCARE INDUSTRY

N. Domingo, M. Osmani and A.D.F. Price

Department of Civil and Building Engineering, Loughborough University, Leicestershire, LE11 3TU, United Kingdom.

Over recent years, there has been considerable growth in healthcare infrastructure investment throughout Europe where billions of Euros are invested in new and refurbished healthcare facilities. In the UK, capital expenditure on healthcare has increased from around £1.1 billion in 1997/98 to around £5.5 billion in 2007/08; an increase in real terms of almost four times the expenditure in 1997. As a result, several environmental concerns and challenges, including construction waste generation, have emerged. There is a consensus in the literature that factors causing construction waste span the project life cycle, however, healthcare facilities have different features compared to other buildings due to functional and operational complexities. By means of a questionnaire followed by interviews with construction industry practitioners specialising in healthcare facilities, this paper aims to identify the level of importance given in the healthcare industry to minimising construction waste; recognising the effect on construction waste generation due to complexity and special features of healthcare facilities; exploring causes of waste particular to the healthcare lifecycle and to examining the waste minimisation strategies used in the industry. The findings revealed that lifecycle waste mapping in healthcare facilities is similar to other types of buildings. Results also indicate that waste management is not treated as a priority in the briefing and design stages of most healthcare facilities and is still seen as the responsibility of the contractor. Initiating waste minimisation practices at the construction stage inevitably results in losing a number of effective waste reduction opportunities at the beginning of the project. The findings from this research contributes to a growing body of literature on sustainable healthcare construction and to support NHS policy on 'greening the environment' through reduction of construction waste. This paper concludes that a more integrated lifecycle approach is required to effectively reduce healthcare construction waste.

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

INTRODUCTION

Each year, across Europe billions of Euros are invested in new and refurbished healthcare facilities. In the UK, the National Health Service (NHS) is the largest public sector organisation (Tudor *et al.*, 2005) and has one of the largest property portfolios (Holmes *et al.*, 2006). Over recent years, there has been considerable growth in healthcare infrastructure investment in the UK, where capital expenditure on healthcare has increased from around £1.1 billion in 1997/98 to around £5.5 billion in 2007/08; an increase in real terms of almost four times with an average annual increase of over 10%. Along with this healthcare building boom has come an emphasis on sustainable building construction that uses less energy, less CO₂; less water and less waste to reduce the overall building impacts (Brannen, 2007; SHINE, 2006).

Domingo, N., Osmani, M. and Price, A.D.F. (2009) Construction waste minimisation in the UK healthcare industry. In: Dainty, A. (Ed) *Procs 25th Annual ARCOM Conference*, 7-9 September 2009, Nottingham, UK, Association of Researchers in Construction Management, 1021-30.

Construction waste generation is a serious issue in the UK since the sector generates 120 million tonnes of waste every year (WRAP, 2007), which is approximately 32% of the total waste generated in the UK. 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). Being one of the largest property portfolios in the UK government, healthcare sector has a considerable level of responsibility to support the UK's sustainable construction strategy (HM Government, 2008) which sets targets: to reduce construction, demolition and excavation waste to landfill by 50% in 2012 compared to 2008; and to achieve zero net waste by 2015 at construction site level and zero waste to landfill by 2020. Past research has highlighted that waste can arise at any stage of the construction process from inception, right through the design, construction and operation stages and ending with the demolition of the built facility (Gavilan and Bernold, 1994; Craven *et al.*, 1994; Faniran and Caban, 1998). Moreover, there seems general agreement in the literature that the construction of healthcare facilities is different and very complex (Chinyio, 2005). This paper discusses the level of importance given by the healthcare sector to: minimising construction waste; recognising the effect on construction waste generation due to complexity and special features of healthcare facilities; exploring causes of waste particular to the healthcare lifecycle and to examining the waste minimisation strategies used in the industry.

METHODOLOGY

This study comprised nine interviews: three client representatives; three designers and three contractor representatives in healthcare projects. A pre-interview questionnaire was sent to these nine interviewees before the interview and the questionnaire answers were discussed in more detail during the interview. The interview template and pre interview questionnaire was based on literature review on healthcare construction and construction waste generation. Both had three sections to identify: individuals and institutional background information; causes and origins of construction waste in healthcare facilities and waste minimisation practices in the healthcare industry. The data gathered from the pre interview questionnaires were analysed using basic descriptive analysis method considering respondents counts and the interview data were analysed considering contents in the responses and by comparing similarities and dissimilarities in their answers.

UK HEALTHCARE INDUSTRY

The UK healthcare industry is currently experiencing historic levels of growth with the largest programme of investment the country has ever seen. Changes in medical technology, the difficulty of attracting and retaining registered nurses, a more competitive business environment, a more informed and demanding patient population and concerning data about the quality of care in hospitals are the driving factors for the healthcare construction boom (Kimball and O'Neil, 2002; Bogenstatter, 2000). With regard to the Hewitt (2007), since 1997: one third of the acute and general NHS estate (i.e. excluding PCTS) has been replaced; major hospital schemes (67 PFI and 21 public capital) worth over £4.9 billion have opened and 111 new major hospital schemes will be open by the end of 2010 (worth £8.5 billion).

Nearly 90% of all patient contact with the NHS happens in primary care and almost half of the buildings are either adapted residential buildings or converted shops. In addition, around 80% are below the recommended size (Holmes *et al.*, 2006). Hence, they often have very little room for expansion or improvement. Therefore, parallel to

the major (acute) hospital construction and refurbishment programme, there is a remarkable trend in the building/refurbishing/replacing of primary/GP premises. The government had already made a commitment to substantially refurbish/replace 3000 GP premises by 2004 and 750 Primary Care Centres by 2008 (Hewitt, 2007). The above statistics on capital investment strongly confirm that there are huge investments in healthcare buildings in the UK at this moment, which will tend to increase in future.

SUSTAINABILITY IN UK HEALTHCARE CONSTRUCTION

The increasing pace of healthcare construction projects will inevitably have a significant impact on the environment and hence requiring sustainable practices, which uses less energy, less water and produces less waste (Domingo *et al.*, 2008; Brannen, 2007). As such, the Department of Health has set several targets to minimise the environmental impacts of its huge construction programme. These targets mainly consider the areas of: primary energy consumption with a reduction by 15% or 0.15 million tonnes of carbon from 2000 to 2010; 60% CO₂ reduction by 2050 (1990 base year); use 26-32% renewable energy sources by 2020; reduction of energy consumption by 20% by 2020; use of 10% bio fuel for transportation by 2020 and; waste minimisation and recycling (a reduction in construction, demolition and excavation waste to landfill by 50% in 2012 compared to 2008, achieving zero net waste by 2015 at construction site level and zero waste to landfill by 2020) (Holme, 2008; HM Government, 2008)

HEALTHCARE CONSTRUCTION WASTE MINIMISATION

Construction waste minimisation is one of the most important requirements in the UK sustainable construction strategy since the construction and demolition activities are renowned to be the largest waste generators in the UK (DEFRA, 2007). As the largest public sector organisation with a huge property portfolio, the UK healthcare sector has a considerable responsibility to support this national strategy. In addition to this responsibility, there are a number of benefits the healthcare industry can achieve through waste minimisation, such as: reducing the environmental impacts from disposing of waste; complying with NHS policy on 'greening the environment' and statutory obligations and reducing current and future costs for waste management. In the waste minimisation hierarchy, reduction of waste at source is ranked by the Waste and Resources Action Programme (WRAP) as the best option to minimise construction waste. In the recent past, a number of researchers (Osmani *et al.*, 2008; Poon, 2007; Ekanayake and Ofori, 2000; Keys *et al.*, 2000) have sought to identify the sources and origins of waste in the different stages of the project lifecycle. A study by Domingo *et al.* (2008) mapped and classified the causes of waste in the project lifecycle. Furthermore, this study highlighted some unique features in the healthcare facility lifecycle such as: functional and operational interconnectivity; frequent changes in the management systems; the complex nature of the design; the use of special procurement methods; and the use of modern technology. As these features could affect the origins of waste, the above study emphasised the need for a further research to customise this lifecycle waste mapping to the healthcare facilities. In addition, case studies conducted by WRAP (2007a) revealed that by using waste minimisation strategies such as offsite products; waste segregation; the use of recycled materials and effective material control systems, healthcare construction waste can be reduced significantly. However, these studies focus only on the waste minimisation strategies used in the construction stage. Hence, this paper is part of a research project that aims to identify the level of importance given to minimising waste in the

healthcare sector; the causes and origins of waste particular to the healthcare facility lifecycle; and the waste minimisation strategies used throughout the healthcare facility lifecycle. Two distinct research activities: pre-interview questionnaire and interview, have collected data from the construction industry practitioners and are described in the next section.

SURVEY FINDINGS

This section presents the findings of the pre-interview questionnaire and interview regarding: the importance of construction waste minimisation in healthcare; special features in healthcare facilities and their effect on waste generation; causes and origins of construction waste in the healthcare project lifecycle and construction waste minimisation strategies in healthcare construction.

Importance of construction waste minimisation in healthcare

The respondents were asked about the level of importance given to minimise construction waste in their current healthcare projects aiming to identify the importance of construction waste minimisation in healthcare. Six respondents (out of 9) agreed that construction waste minimisation is very important in healthcare construction and they further mentioned that this level of importance is increasing rapidly over time. Moreover, they agreed that they considered construction waste minimisation since they aimed to obtain BRE Environmental Assessment Method (BREEAM) "Excellent" for new projects and "very good" for existing facilities as it is a national regulation. However, even though they agreed that construction waste minimisation is important, contractors argued that the majority of clients and designers still do not address this issue properly and that their level of importance given to it is very low. Furthermore, respondents reported that the lack of engagement of clients and designers is due to the difficulty of waste management in complex projects and the use of non-traditional contracts permitting less influence by the designers during the construction stage. Conversely, contractors stated that they all give a considerable level of importance to the minimisation of construction waste in healthcare projects as it affects the sustainability targets of their projects. One contractor said that they "very much think on sustainability of projects" and "the most important environmental issue is the minimisation of waste". Furthermore, all the contractors stated that they have sustainability policies for their companies, including construction waste management practice. However, none of these companies have sustainability policies particularly for healthcare projects.

Special features of healthcare facilities and their effect on waste generation

The respondents were asked whether healthcare facilities are complex compared to other buildings and special features in healthcare facilities affect on construction waste generation. The aim of this question was to obtain the healthcare industry construction practitioners' views regarding: the complex nature of healthcare buildings; the special features in the facility; and the effect on construction waste generation. Except for one designer, all the other interviewees agreed that healthcare facilities are complex compared to other buildings. One contractor stated that "it is far more complex than other buildings". They identified several features in healthcare buildings such as the complex nature of the mechanical and electrical services; the use of the building by various people; frequent changes to a building throughout its lifetime; the need for 24x7 operation of the facility; high levels of wear and tear on the building and the requirement for different types and shapes of rooms. Furthermore,

they highlighted that the density and numbers of materials required for healthcare buildings are higher compared to other types of buildings. Also, unlike other buildings, in healthcare the requirements vary from one project to the other. They further believed that this non-standardisation of requirements and the use of a large number of materials considerably affect construction waste generation in healthcare. Hence, the majority (8 out of 9) accepted that these special features and the complex nature of the facility create more waste from healthcare construction compared to other constructions. However, one client held an opposite view to this, arguing that the shell is basic for all the projects and the things that go into the shell are same.

Causes and origins of construction waste in the healthcare project lifecycle

The aim of this section is to present the views of the healthcare industry construction practitioners regarding the causes of waste particular to the healthcare project lifecycle. In the pre-interview questionnaire, the respondents were asked to identify the causes of waste particular to the healthcare facilities from the generic waste causes found from the literature. More elaborative reasons were obtained regarding their views on relevant waste causes during the interview.

Pre-design

As shown in Table 1, more than 7 (out of 9) respondents acknowledged that incomplete briefing, lack of client awareness of the construction process, inefficiencies in communication and coordination and non-embedding of waste minimisation issues in contractual clauses are the causes for waste generation in the pre-design stage. According to designers and contractors, incomplete briefing can be found frequently in healthcare construction and the main reasons for this are the client's lack of experience in healthcare and the failure to understand the requirements properly at the beginning of the project. They further stated that there are chances for miscommunication at the pre-design stage due to the large number of stakeholder involvement and a lack of understanding among them. Most of the respondents (7 of 9) believed that the client's lack of knowledge of construction processes, especially choice of material and site activities, have an effect on waste generation. However, two clients held an opposite view and declared that clients do not necessarily need to be aware of the construction process. The majority of designers and contractors suppose that clients do not usually worry about waste generation unless it costs them. Whereas, clients believe that contractors are better at managing waste and they do not need to embed waste minimisation clauses into the brief.

Design

As shown in Table 1, more than 7 (out of 9) respondents agreed that: design changes; complex designs generating off cuts; lack of knowledge on alternative materials; over/under specification; inefficiencies in communication and coordination; delays in drawing; incorrect drawing details and lack of awareness about the waste generation are causes of waste in the design stage of healthcare facilities. One contractor pointed out that the health building notes (HBN) and health technical memoranda (HTM) published by the Department of Health as the main barrier to choose innovative material and thus have innovative designs. Moreover, they mentioned that there are high chances for design changes in healthcare due to the client's changes of mind and complexities due to the number of interfaces. However, by implementing change-management procedures, better communication through building information-modelling systems and partnering procurement system arrangements they believed that these effects are minimised to a certain extent. Other than above said causes

respondents highlighted late involvement of the contractor, lack of standardisation and rationalisation, lack of kit approach and poor interface design as the causes for waste in the healthcare design stage.

Table 1: Causes of construction waste in healthcare facilities

No	Waste causes	Relevant				Not Relevant			
		c	d	co	to	c	d	co	to
Pre Design									
1	Inefficiencies in communication and coordination	3	3	3	9	0	0	0	0
2	Incomplete briefing	1	3	3	7	2	0	0	2
3	Lack of client's awareness on construction process	1	3	3	7	2	0	0	2
4	Waste minimisation issues not embedded in contractual clauses	2	2	3	7	1	1	0	2
Design									
5	Lack of knowledge in alternative materials	3	3	3	9	0	0	0	0
6	Incorrect drawing details	3	3	3	9	0	0	0	0
7	Complex designs generating lot of off cuts	2	3	3	8	1	0	0	1
8	Over/under specification	2	3	3	8	1	0	0	1
9	Inefficiencies in the communication and coordination	2	3	3	8	1	0	0	1
10	Design changes	1	3	3	7	2	0	0	2
11	Delays in drawings causing time pressure during construction	1	3	3	7	2	0	0	2
12	Lack of awareness about the waste generation in construction	2	2	3	7	1	1	0	2
Procurement									
13	Inefficiencies in the communication and coordination	3	3	3	9	0	0	0	0
14	Inconsistencies in the contract documents	1	3	3	7	2	0	0	2
15	Type of contract varying the responsibility towards waste	1	3	3	7	2	0	0	2
16	Tendering method varying percentage allowances for waste	1	2	2	5	2	1	1	4
Construction/ Renovation									
17	Poor workmanship causing rework	2	3	3	8	1	0	0	1
18	Inadequate communication and coordination among parties	2	3	3	8	0	0	0	0
19	Lack of a site waste management plan for every project	2	3	3	8	0	0	0	0
20	Material handling and storage facilities onsite	2	3	3	8	0	0	0	0
21	Damages to materials during transportation	2	2	3	7	0	0	0	0
22	Ordering wrong materials	2	2	3	7	0	1	0	1
23	Equipment malfunctioning causing rework	1	2	3	6	1	1	0	2

(c=client; d=designer; co=contractor; to=total)

Procurement

Table 1 shows, more than 7 (out of 9) respondents agreed with the causes inconsistencies in contract documents and type of contract varying responsibility towards waste where as they all (9 out of 9) agreed with the waste cause inefficiencies in communication and coordination. All the designers and contractors had similar

views regarding these waste causes where clients had contrasting views. A wide dispersion can be seen among the views of respondents regarding the cause 'types of tendering varying the percentage allowance for waste', where only 5 (out of 9) respondents agreed it as a waste cause.

Construction/ Renovation

All the respondents agreed with the waste causes material handling and storage facilities onsite; damages to materials during transportation; lack of a site waste management plan for every project; ordering wrong materials; and inefficiencies in communication and coordination among parties. Furthermore, majority of the respondents pointed out that these waste causes vary tremendously from site to site and project to project depending on the partners. Moreover, they stated that complexities in healthcare facilities make designs more complex and increase the tendency to create off cuts and thus generate waste. However, one client stated that doing things correctly the first time, as mentioned in the Egan report, can make a huge difference in waste generation. All the respondents commonly believed that there is no considerable difference in the renovation stage compared to construction and thus apply all the causes of waste to the renovation stage as well. Nevertheless, four respondents acknowledged that due to the reusability of the materials there can be some differences. Additionally, they judged that these depend on the type and nature of the building, knowledge of materials in the building and the potential for reuse.

Construction waste minimisation strategies (WMSs) in healthcare construction

The aim of this section is to present the waste minimisation strategies used in the healthcare industry. In the pre-interview questionnaire, participants were asked to tick against the WMSs currently implemented in their healthcare projects and during the interview it was asked to mention the most effective WMSs for healthcare projects. As shown in the Table 2, a wide dispersion of the use of WMSs can be seen during the pre design and design stages among the respondents compared to construction/ renovation stage. According to the questionnaire results, less than 5 (out of 9) respondents use WMSs such as: embed waste issues in the brief; insert contractual clauses to minimise waste; design for deconstruction and corrective actions to reduce waste when a change has occurred. Also, there is a considerable dispersion among clients and designers regarding 'embedded waste issues in the brief' and 'insert contractual clauses to address waste issues', where clients said that "they often do it" and designers said that "they have never seen it". Contractors mentioned that, even where clients stated it automatically, their main focus is cost. However, majority of the respondents use all the waste minimisation strategies (WMSs) shown in Table 2. Other than these strategies, one client said that they consult with product manufacturers during the pre-design stage and one contractor said that they use the kit approach and shell in core approach and work with designers to make the design less wasteful and improve adaptability and flexibility. According to the respondents, avoidance of late changes at critical stages, off-site prefabrication, training of staff workers, adoption of low-waste modern technologies, early involvement of product manufacturers and making subcontractors responsible for the disposal of their waste are the most effective WMSs for healthcare projects. Furthermore, respondents had a huge variation regarding the stage at which they implement WMSs, where the answers referred to the pre-design, design, procurement and construction stages. Additionally, they all accepted that waste minimisation should be considered and implemented as early as possible.

Table2: Construction waste minimisation strategies used in healthcare construction

No	Waste Minimisation Strategies	Use				Not Use			
		c	d	co	to	c	d	co	to
Pre Design									
1	Insert contractual clauses to address waste issues	2	0	3	5	1	2	0	3
2	Embedded waste issues in the brief	2	0	1	3	1	2	1	4
Design									
3	Avoidance of late changes at critical stages	3	3	3	9	0	0	0	0
4	Early involvement of product manufacturers	2	3	2	7	1	0	1	2
5	Designing for deconstruction	1	2	1	4	2	1	1	4
6	Corrective actions to reduce waste when a change has happen	0	3	0	3	3	0	1	4
Construction/ Renovation									
7	Effective communication.	2	3	3	8	0	0	0	0
8	Separation of all wastes into different	2	2	3	7	0	1	0	1
9	Regular site inspection for waste minimisation	1	3	3	7	1	0	0	1
10	Training and education on waste concepts to all staff	1	3	3	7	1	0	0	1
11	Pre demolition audits	2	3	2	7	1	0	1	2
12	Usage of offsite products and components	1	3	2	6	1	0	0	1
13	Effective supply chain practises.	2	1	3	6	1	1	0	2
14	Adequate site supervision and control.	2	2	2	6	0	0	0	0
15	Adoption of low waste modern building technologies.	1	3	2	6	2	0	0	2
16	Effective materials control schemes.	1	1	3	5	1	1	0	2
17	Making sub-contractors responsible for waste disposal	2	1	2	5	0	1	0	1
18	The practice of lean construction.	0	2	3	5	2	0	0	2
19	Transparency and teamwork	1	1	2	4	1	1	0	2
20	Proper documentation of all incidence of waste on site.	1	1	2	4	1	1	0	2
21	Adequate planning to stabilise work process on site.	1	1	2	4	1	1	0	2
22	Site waste management plans for every projects	0	1	3	4	2	2	0	4

(c= client, d=designer, co=contractor, to= total)

DISCUSSION

Having targeted clients, designers and contractors specialising in healthcare construction, the first section of this paper seeks to identify the level of importance given to construction waste minimisation by the healthcare industry, as DEFRA (2007) classified the construction sector as the highest waste generator in the UK. Nevertheless, the findings of the study clearly indicated that except for contractors, both clients and designers do not consider it as a priority or their responsibility, even though they believe it to be important. The majority of the respondents agreed that healthcare facilities are complex and have special features compared to other

buildings, reinforcing the findings from the literature review by Domingo *et al.* (2008). Moreover, a majority of them acknowledged that these complexities and special features create more waste from healthcare constructions and support the need stated by Domingo *et al.* (2008) for a further study to identify the causes of waste particular to healthcare facilities. Even though there are special features and complexities in healthcare facilities, it is interesting to note that there is no significant difference in the causes of waste throughout the healthcare facility lifecycle compared to other buildings, which strengthens the findings of the studies by Osmani *et al.* (2008), Poon (2007), Ekanayake and Ofori (2000) and Keys *et al.* (2000) regarding the causes and origins of waste in different lifecycle stages. In addition to the causes of waste published in the above studies, respondents stated that late involvement of the contractor, lack of standardisation and rationalisation, lack of the kit approach and poor interface design were all causes of waste in the healthcare design stage. Furthermore, it should be noted that all the respondents agreed that inefficiencies in communication and coordination in all the stages as a cause of waste. Furthermore, strengthening the results obtained by WRAP (2007a) case studies, respondents agreed that the healthcare industry uses WMSs such as offsite products, waste segregation and effective material control systems very effectively. However, they mentioned that avoidance of late changes at critical stages, training of staff workers, the adoption of low-waste modern technologies, early involvement of product manufacturers and making subcontractors responsible for the disposal of their waste are the most effective strategies for healthcare construction.

CONCLUSIONS

The aim of this paper was to identify the level of importance given by the healthcare industry to minimising construction waste; recognising the relationship between complexity and special features in healthcare facilities with construction waste generation; exploring the causes of waste particular to the healthcare lifecycle and examining waste minimisation strategies. The findings revealed that respondents think construction waste minimisation is important as the law says to implement SWMPs and the national regulation to obtain BREEAM "Excellent" for new healthcare buildings and "Very Good" for existing facilities. However, it is not treated as a priority by healthcare clients and designers and is still thought to be a responsibility of the contractor. Results further highlighted that there are special features and complexities in healthcare facilities and healthcare industry practitioners believe that these complexities generate more waste compared to other buildings. However, results indicated that causes of waste span over the healthcare project lifecycle and are similar to other buildings irrespective of these special features and complexities. Additionally, the findings indicated that there is a wide variation of views about the use of WMSs in healthcare projects where some respondents implement them at the start of the project while others consider them during the construction stage. Since the causes of construction waste span across the healthcare project lifecycle, this study concludes that a more integrated lifecycle approach is required to effectively reduce healthcare construction waste.

REFERENCES

- Bogenstatter, U., 2000. Prediction and optimisation of life-cycle costs in early design. *Building Research and Information*, **28**, 376-386.
- Brannen, L., 2007. Waste Management for Healthcare Facilities. Hospital Engineering and Facilities Management.

- Chinyio, E., 2005. Private Finance Initiative in the healthcare sector: trends and risk assessment The Authors Akintola Akintoye, School of the Built and Natural Environment, Glasgow Caledonian University, Glasgow, UK. *Engineering, Construction and Architectural Management*, **12**, 601-616.
- Craven, D.J., Okraglik, H.M. and Eilenberg, M., 1994. Construction waste and a new design methodology. Sustainable Construction: *Proceedings of the 1st Conference of CIB TG16*, Tampa, FL, 89-98.
- DEFRA- Department of Environment, Food and Rural Affairs, 2007. Waste Strategy for England 2007. The Stationery Office, UK.
- Domingo, N., Osmani, M, Price, A.D.F, 2008. Reducing construction waste in healthcare facilities: A project lifecycle approach, *Association of Researches in Construction Management*, 2008, Cardiff, Wales.
- Ekanayake, L. L. and Ofori, G., 2000. Construction material waste source evaluation. *Proceedings of the 2nd Southern African Conference on Sustainable Development in the Built Environment: Strategies for a Sustainable Built Environment*, Pretoria
- Faniran, O.O. and Caban, G., 1998. Minimising waste on construction project sites, *Engineering, Construction and Architectural Management*, **5**(2), 182-8.
- Gavilan, R.M. and Bernold, L.E., 1994. Source of evaluation of solid waste in building construction, *Journal of Construction Engineering and Management*, **120**(3), 536-52.
- Hewitt, P., 2007. *Rebuilding the NHS - New generation of healthcare facilities*. Department of Health
- HM Government, 2008. *Strategy for sustainable construction*.
- Holme, L., 2008. NHS -Sustainable Healthcare- Defining the agenda and practical implementation, LIFT Sustainability Summit, Department of Health.
- Holmes, J., Capper, G. and Hudson, G., 2006. LIFT: 21st century health care centres in the United Kingdom. *Journal of Facilities Management*, **4**, 99-109.
- HWS, 2008. Waste streams. Healthcare Waste Solutions. Available at: <http://www.hwsusa.com/2minute.asp>, Accessed on: 19 March, 2008.
- Keys, A., Baldwin, S. and Austin, S., 2000. Designing to encourage waste minimisation in the construction industry , CIBSE National Conference Dublin, Republic of Ireland.
- Kimball, B. and O'Neil, E., 2002, Health Care's Human Crisis: The American Nursing Shortage, The Robert Wood Johnson Foundation, Princeton, NJ, available at: www.rwjf.org/files/publications/other/NursingReport.pdf.
- Osmani, M., Glass, J. and Price, A.D., 2008. Architects perspectives on construction waste minimisation by design, *Waste Management*, **28**(7), May 2008, 1147-1158.
- Poon, C.S., 2007. Reducing construction waste. *Waste Management*, **27**, 1715-1716.
- SHINE, 2006. SHINE Learning Network for Sustainable Healthcare Buildings. Available at: www.shine-network.org.uk, Accessed on: 10 March, 2009.
- Tudor, T.L., Noonan, C.L., Jenkin, L.E.T., 2005. Healthcare waste management: a case study from the Cornwall NHS, UK, *Waste Management*, **25**(6), 606-15.
- WRAP, 2007. Halving construction waste to landfill by 2012. Available at: http://www.wrap.org.uk/downloads/Halving_waste_to_landfill_briefing_note.803d673.pdf, Accessed on: 11 April, 2009.
- WRAP, 2007a. Waste recovery quick win case studies. Available at: http://www.wrap.org.uk/construction/construction_waste_minimisation_and_management/wrqw_case_studies.html, Accessed on: 21 March, 2009.