Achieving Sustainability in the UK Construction by Reducing Waste Generation

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Abstract
The construction industry in the United Kingdom has been the highest contributor to construction waste (62%) as compared to other sectors. Such waste has a direct impact on the environment and causes poor air quality, increases CO_2 emissions, etc. The reduction of waste will play important part in achieving the environmental and economic sustainability in this important sector. According to Defra statistics, the UK is producing an average of 110 million tonnes of construction waste every year since 2010. While EU aims to reduce the construction, demolition and excavation waste (CD&E) by up to 70% by 2020. This paper will identify and discuss the key factors that contribute to the generation of construction waste. Relevant data was collected from different construction sites. The data was then analysed by assessing the site waste management, material procurement, material management, material usage and wastage, in addition to the average amount of waste transported and the volume of re-used materials. For economic and environmental perspectives, the reduction of the maximum amount of waste from any construction project will contribute to:

- Decreased removal and landfill taxes,
- Reduced labour cost for the transportation of waste, and
- Minimising waste going to landfill will benefit the environment efficient waste disposal.

The findings of this research project will help better understanding of the major factors that can reduce the construction waste within the forecasted targets and contribute towards achieving sustainability in construction waste management.

Keywords: Construction Waste Management, Sustainability, Economic Development.

1 Introduction

Over the past few decades, the construction industry has been experiencing a serious issue of waste generation. Although, many researchers are working on this issue and different sets of frameworks are being proposed almost every year in order to control waste generation, there has been no major breakthrough so far. Some strategies that have been proposed, do work to some extent, such as, Site Waste Management Plan (SWMP). However, this plan is only implementable on site, when the project has moved from the design to the construction phase. This indicates that there is a need to identify and reduce the possibility of waste generation during the design phase. Moreover, Ekanayake and Ofori (2006) indicated that wastes usually occur during design, operational, procurement and material handling. The majority of these consume time and effort without adding value for the client thus resulting in losses of material, delay times and execution of unnecessary work. Waste has a direct impact on the productivity, material loss and completion time of projects, resulting in a significant loss of revenue. The physical waste from construction contributes a significant part of landfill, and studies show that 13-26% of landfill is construction waste, which

emphasises on the need for a systematic and more efficient waste minimisation method to control the volume of generated wastes at different levels (Bossink and Brouwers, 1996).

This paper seeks to identify the factors that contribute towards the generation of waste. For this purpose, waste statistics were collected from 3 semi-commercial construction sites to analyse and highlight the factors that cause waste generation. This information will help researchers to identify some of the main causes of waste generation.

2 Background Research

Waste can be anything which is no longer needed or useful. In construction, waste is generated throughout project phases, irrespective of the size of the project, the value of the contract and its duration, and the variety of building type (Adnan, 1996). Wastes are generated right from foundation up to the finishing works, and emanate from sources such as wooden materials, concrete, gravels, aggregate, masonry, metals, plastic, plumbing and electrical fixtures, glass, and material handling (Napier, 2012). Approximately 5 to 10% of the construction materials will eventually end up as waste. Cheung et. al., (1993) through their study found that waste generated typically represents 10–20% of the total weight of building materials delivered to a building site. Meanwhile, Bossink and Brouwers (1996) found that the level of waste at construction sites, for instance in the Brazilian construction industry, is 20–30% of the total weight of materials on site.

Table 1. Typical building materials and reason for their wastage (Source: Hung and Kamaludin, 2017)

Material	Factors contributing to waste	Reason of waste generation
Plasterboard / gypsum	Cutting	Use of products whose size does not fit.
	Ordering more than the required quantity.	Required quantity of products unknown due to imperfect planning.
	Unexpected damp due to moisture in the atmosphere.	material stored in the wrong place or not protected properly.
Timber	Cutting	Use of products whose size does not fit.
Concrete	Ordering more than the required quantity.	Required quantity of products unknown due to imperfect planning.
	Loss during transportation.	Settlement of concrete on long transportation time.
	Scraping off	Method to lay the foundations of a building.
Insulation	Ordering more than the required quantity.	Required quantity of products unknown due to imperfect planning; Or required quantity not properly calculated during the planning phase.
	Left over pieces after installation.	
Brick/block	Cutting	Use of products whose size does not fit.
	Damaged during transportation.	Unpacked supply.
Tiles	Sawing consequently on the design of the surface.	Attention not paid to sizes of the used products in design; types and sizes of the different products do not fit.
	Damaged during transportation.	Negligent handling by the supplier.
Reinforcement	Cutting	Use of steel bars that does not fit.

In the Netherlands, the amount of waste for each building material lies between 1% and 10% of the amount purchased, depending on the type of material. In the UK, a research indicated

that at least 10% of all raw materials delivered to most sites are wasted through damage, loss and over-ordering (Guthrie et. al., 1998). Meanwhile, a study conducted in Palestine revealed that 5–11% of the purchased materials were not used well and ended up as waste (Enshassi, 1996).

3 Data Collection

The data collected from the 3 semi-commercial construction sites consisted of various types of material waste. The collected material waste data has been listed in the Table 2 which also highlights the possibility of putting these wasted materials to alternative uses.

Table 2: Waste data collection and measures for reuse, recycle and reduce (*Source: VivianTam, 2011*)

Collected waste data		**Waste %**	**Possibility of utilising the collected waste**		
Material	**Sub-Type**		**Reuse**	**Recycle**	**Reduction**
Plasterboard / Gypsum	Fire proof board	21%	Reusing gypsum for other purposes such as filling.	Gypsum waste can be recycled continuously to make the same product.	NIL
	Acoustic board				
	Moisture board				
	Normal/non fire proof board				
Insulation	Thermal insulation	9%	Insulation can be reused for filling gaps between the cavity walls or for ceiling voids.	NIL	NIL
	Acoustic insulation				
	Celotex floor insulation board				
Bricks	Miscellaneous	8%	Can be reused for landfill on the existing site, if required.	Damaged bricks can be recycled to make aggregate for use as general fill or highway sub-base.	Use of cladding, if possible
Timbers	OSB boards	15%	Timber products, such as formwork, joists and deck boards, can be reused for several times.	Timber can be recycled to local and export recyclers.	Using other materials to substitute such as pre-fabricated building components, drywall partition and standard wooden panels
	Joists				
	Cls studs				
	Deck boards				

Cardboards	Packaging	7%	Reuse cardboard material, such as packaging.	Encourage manufacturers to recycle their original packaging materials.	Use of environmen t friendly paper, in which the composition processes will have less emission of pollutant or products and materials with reduced packaging.
	Floor covers				
	Delivery boxes				
Electrical wires	Miscellaneous	4%	NIL	Copper and rubber coating on the wire can be recycled for many other purposes.	NIL
Plastic	Plastic wrapping	4%	Reusing plastic for other purposes, such as material protection.	Used plastic can be recycle to local and export recyclers.	Using other materials to substitute plastic.
PVC conduits and waste pipes	Electrical and plumbing pipes	5%	Can be reused for small works.	PVC is recyclable.	NIL
Concrete	Type C40, C30 etc.	4%	Reuse concrete waste as temporary work.	Concrete can be recycled as aggregate for concrete production.	Accurately calculate and order quantity of concrete; Use of prefabricate d building components ; Or alternative construction methods.
	Solid, precast and reinforced etc.				
	Screed				
Glass	Miscellaneous	4%	Glass can be reused for several purposes.	Glass waste can be recycled as aggregate for concrete production.	Using other materials, in substitute glass; Or alternative construction methods.

Iron pieces / Reinforcements	Beams Columns Bolts Connection plates Reinforced bars	3%	Can be reused and cut into size for smaller structural works.	There are various steel / iron recycling yards where these can be sent	NIL
Paint boxes	Miscellaneous	8%	Can be reused for filling and pouring liquid material, if undamaged.	These are recyclable, as mentioned at the bottom surface	NIL
Ducts	HVAC works	8%	Can be reused if not too old and has a remaining design life as specified by manufacturer.	Ducting mostly consists of galvanised, stainless steel or aluminium, that can be recycled.	NIL

The Table lists the percentage of materials wasted, approximately calculated from the waste data gathered from 3 construction sites. According to the site waste management and logistics team, there were 88 skips (14 cubic-yard skip on average) delivered and collected from these 3 sites. Out of these 88 skips, 34 were collected from one site, 31 from the second and 23 from the third. Considering the fact that a single 14 cubic-yard skip takes up to 14 tonnes of waste, the total maximum load of these wastes sums up at 1,232 tonnes. This in itself indicates the magnitude of wasted material that could have been reused through proper planning and use of better strategy prior to the commencement of the construction phase.

3.1 Mapping of the waste causing factors

Upon reviewing the material waste data collected in Table 2, certain aspects of the project cycle were found where improvement was possible. In order to highlight the causes of waste generation, a mapping of the waste causing factors has been generated where these areas are classified into phases and categories (see Table 3). Details of the causes of waste are indicated in the Table. Some of these causes were past published papers on waste causes that have been gathered and thoroughly investigated in order to get to the primary cause of waste.

In order to simplify the data, each cause of waste is listed to its respective group, as this will give a preliminary idea of what past researchers had discovered in this sector. This mapping evaluation can identify the severity of each factor based on the frequency of the factors identified by past researchers around the world. There are 10 scholarly research papers selected for this study and 54 factors behind construction waste generation were found in the study. These factors are grouped into 8 sub categories of the 3 primary construction project phases. Table 3 shows the mapping of the waste contributing factors taken from some past published papers.

Table 3. Mapping of waste causing factors (Source: Nagapan et al., 2011)

Design Phase											
Group	**Cause of Waste**	**References**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Design	Design errors	1		1		1	1		1		1
	Lack of co-ordination					1		1			
	Lack of information				1	1	1	1	1	1	
	Frequent design changes	1		1	1	1	1	1	1	1	1
	Poor design quality								1	1	
	Inexperience designer				1						1
	Lacking of waste efficient design								1	1	1
	Complex drawings	1			1	1					
Pre-Construction Phase											
Group	**Cause of Waste**	**References**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Planning	Un-realistic project schedule			1	1			1		1	1
	Discrepancies in the Bill of Quantities		1	1	1						1
	Discrepancies in material procurement schedule			1	1						1
Construction Phase											
Group	**Cause of Waste**	**References**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Management	Poor site management			1	1			1			
	Poor planning	1	1		1	1			1	1	1
	Poor resource management			1	1			1	1	1	
	Poor supervision								1	1	
	Inappropriate construction methods						1			1	1
	Lack of co-ordination					1		1	1	1	
	Scarcity of equipment					1			1	1	
	Lack of resources	1						1	1		
	Waiting periods						1	1			
	Rework error					1		1			
	Communication problems			1							
	Lack of environmental awareness										1
	Lack of effective waste management plans					1		1			1
	Non availability of equipment									1	
	Outdated equipment							1	1	1	
Handling	Poor material handling	1		1	1	1		1	1	1	
	Wrong material storage	1		1	1			1	1	1	1
	Material damage during transportation				1			1			1
	Poor quality of material								1	1	1
	Equipment failure			1	1						1
	Delay during delivery					1			1	1	
Worker	Workers' mistakes			1	1	1		1			1
	Incompetent worker					1			1	1	
	Un-ethical work attitude of				1			1			

	workers										
	Damage caused by workers				1	1					1
	Insufficient training for workers							1			
	Lack of experience								1	1	
	Shortage of skilled workers					1			1		
	Inappropriate use of materials								1	1	1
	Poor workmanship	1									
Site Condition	Leftover materials on site	1		1							1
	Poor site condition								1	1	
	Waste resulting from packaging	1									1
Procurement	Ordering errors	1		1	1	1			1		1
	Error in shipping			1							
	Mistakes in quantity surveys				1	1					
	Ignorance of specifications							1			
	Waiting for replacement					1					
Un-expected Factors	Effect of weather	1	1	1	1	1	1		1	1	1
	Accidents	1		1	1	1					1
	damages caused by third parties								1	1	
	Festivities										1
	Unpredictable local conditions					1					

4 Discussion and Analysis

Considering the amount of waste data collected and the findings from Nagapan et al.'s (2011), study suggests that numerous improvements are required throughout the project lifecyle, from the design to the completion phases, in order to reduce the maximum possiblity of waste. There is a need for maximum co-ordination among all relevant stakeholders involved in the design, planning and construction processes, and meetings should be held at regular intervals to address the issues concerning waste. At least waste minimisation can be achieved through the normal practices of building work, such as reducing concrete by using prefabricated components; reusing steel formwork; and recycling steel for generating income (Shen and Tam, 2002). Although the reuse, recycling and waste reduction of construction materials have been promoted for several years, environmental awareness is still not satisfactory, likewise the support of different layers of management. The primary problem of inefficient and ineffective practices of reuse, recycle and reduction of construction waste is lack of understanding of how to treat construction wastes. Based on the discussions with construction practitioners, several measures of reusing, recycling and reducing construction materials are suggested in Table 2.

Further, it has been observed that a huge amount of waste can be predicted during the design phase of the project. Hence, the designers can play an important role by coming up with efficient designs where minimum waste is entailed. This is especially possible if the designers and engineers collaborate with each other during the design phase. They can use their expertise effectively to minimise waste during the evolutuion of the design by giving their opinions on the relevant areas of the design.

5 Conclusions

Through the present study, which is based on a literature review, the wastage level for different materials commonly used in construction have been identified, as well as the common causes of waste. It is expected that these findings can contribute to improved estimation of waste generation in a construction project from design to completion phase, thereby enhancing the knowledge-based decision-making in developing appropriate strategy for construction waste management to reduce the waste generation to a minimum.

The reported study, which takes the form of a review of the findings of research on three construction projects, relies on professionals' perception during the construction operation, which represents a subjective assessment. Nevertheless, the presented level of construction

material wastage can provide interested parties or stakeholders, such as local authorities, policy makers, government, as well as the contractors and practitioners with a basis to consider in order to make more informed and sustainable decisions for reducing waste in construction.

Moreover, construction waste is one of the major contributors to environmental pollution; and this pollution generation from construction activities seems to be uncontrollable. Therefore, the most commonly used and encouraged practice of reusing, recycling and reducing construction materials need further revisions with a decision-making strategy or a guideline.

References

Adnan, E. (1996). Materials control and waste on building sites, *Building Research & Information*, 24(1), 31 – 34.

Alwi, S., Hampson, K. and Mohamed, S. (2002) "Non Value-Adding Activities in Australian Construction Projects". In *Proceedings of the International Conference on Advancement in Design, Construction, Construction Management and Maintenance of Building Structure*, Bali, Indonesia, 2002.

Alwi, S., Hampson, K. and Mohamed, S. (2002) "Waste in the Indonesian construction projects", *Proceedings of the 1st International Conference of CIB W107 - Creating a sustainable Construction Industry in Developing Countries*, South Africa, ISBN: 0-7988-5544-4, pp. 305-315, 2002.

Bossink, A.G. and Brouwers, H.J.H. (1996) "Construction waste: quantification and source evaluation", *Journal of Construction Engineering and Management*, ASCE, Vol. 122(1), pp.55–60. , 1996.

Bossink, B.A.G. and Brouwers, H.J.H. (1996). Construction waste: Quantification and source evaluation. *Journal of Construction Engineering and Management*, pp. 55-60.

Cheung, C.M., Wong, K.W., Fan, C.N. and Poon, C.S. (1993). *Reduction of Construction Waste*: Final Report, Hong Kong Polytechnic University and Hong Kong Construction Association, Hong Kong.

Ekanayake, L.L. and Ofori, G. (2006) "Construction Material Waste Source Evaluation", In *Proceedings: Strategies for a Sustainable Built Environment, Pretoria*, 2000.

Enshassi, A. (1996). "Materials control and waste on building sites", *Building Research and Information*, 24(1), 31 – 34.

Faniran, O.O. and Caban, G. (1998) "Minimizing waste on construction project sites", *Engineering Construction and Architectural Management Journal*, Vol. 5(2), pp. 182–8, 1998.

Garas, L.G., Anis, R.A. and Gammal, E.A. (2001) "Material Waste in the Egyptian Construction Industry", In Ballard, G. & Chua, D. (Eds) *Proceedings of the 9th Annual Conference of the International Group for Lean Construction*, National University of Singapore, Singapore, 2001.

Gavilan R.M. and Bernold, L.E. (1994) "Source evaluation of solid waste in building construction". *Journal of Construction Engineering and Management*, ASCE, Vol. 120(3), pp. 536-552, 1994.

Guthrie, P., Woolveridge, C. and Coventry, S. (1998). "*Managing Materials and Components on Site"*, Construction Industry Research and Information Association, London.

Hung, C.F and Kamaludin S.N. (2017). "Professionals' views on Material Wastage and Causes of Construction Waste Generation in Malaysia", Malaysian Construction Research Journal. Vol. 21(1), pp. 34-35, 2017.

Nagapan, S., Rahman, A.I and Asmi, A. (2011). "A Review of Construction Wastes Cause Factors". Proceedings of the Asian Conference of Real Estate: Sustainable Growth Managing Challenges (ACRE), Johor, Malaysia.

Napier, T. (2012). Construction waste management, National Institute of Building Science, Available online http://www.wbdg.org/resources/cwmgmt.php (Accessed 02/11/2018).

Nazech E. M, Zaldi D and Trigunarsyah B, (2008). “Identification of construction waste in road and highway construction projects”, In Yang, Yeong-Bin and Leu, Liang-Jenq and Chen, Chuin-Shan and Su, Po-Chieh, (Eds)*: The Eleventh East Asia-Pacific Conference on Engineering and Construction*, Taiwan, 19 November 2008.

Polat, G. and Ballard, G. (2004) “Waste in Turkish Construction: Need for Lean Construction Techniques”, In Bertelsen, S. & Formoso, C.T. (Eds) *12th Annual Conference of the International Group for Lean Construction (IGLC-12), Elsinore, Denmark*, 2004.

Poon, C.S., Yu, A.T.W., Wong, S.W. and Cheung, E. (2004). “Management of construction waste in public housing projects in Hong Kong”. *Construction Management and Economics*, 22(7), pp. 673-688.

Senaratne S. and Wijesiri, D. (2008). “Lean ,Construction as a Strategic Option: Testing its Suitability and Acceptability in Sri Lanka”, *Lean Construction Journal*, Vol. 4(1), pp. 34-48, 2008.

Shen L.Y. and Tam, W.Y.V. (2002). "Implementing of environmental management in the Hong Kong construction industry", International Journal of Project Management, 20(7-9), pp. 535-543, 2002.

Vivian W.Y. Tam, (2011). “Rate of Reusable and Recyclable Waste in Construction”, The Open Waste Management Journal, Vol. 4, pp. 28-32, 2011.