Factors affecting the Construction Waste Management in terms of Refurbishing, Reusing or Recycling

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Abstract

There is an increasing need to reduce construction waste and to promote more greener and sustainable construction. Refurbishing existing buildings and re-using existing construction materials may provide the right answer to reduce such waste and minimise its impact on the environment.

The construction industry globally consumes around 40% of global raw stone, gravel, and sand; 20% of virgin wood; and uses about 40% of total energy. According to Defra statistics, 108.8 million tonnes of Construction Demolition and Excavation waste was generated in the UK in 2012, which increased to 120 million tonnes in 2014. In England, the share of 'Construction' was higher at 64% of the total waste generated from other sectors.

When a building starts showing serious structural defects or reaches its original design life, a well-informed decision is required on whether to refurbish, reuse or demolish such building. Unfortunately, most developers go for a complete demolishing simply because it is an easy option.

There is a great potential for refurbishment across the world. In the UK, the current composition of the building stock and the preferred public attitude towards keeping older stock and composite buildings may support the refurbishment criteria.

This research project, which uses data from selected existing construction-demolition sites in the UK and relevant Building Information Modelling (BIM) tools, aims to develop a framework to define suitable criteria for the developer to decide whether to refurbish, re-use or demolish existing buildings. The developed criteria would also be helpful for the sustainable design of new buildings to achieve less demolition and waste generation at the end of their life. The initial findings of this PhD study will be reported in the full paper.

Keywords: *BIM, Construction Waste Management, Sustainability.*

Introduction

This research aims to investigate and analyse different aspects and causes of the construction waste and based on these findings, a framework will be developed that would help in decision making in order to determine whether it would be economically, environmentally, and socially feasible to demolish a building or refurbish or partially demolish and refurbish it. This framework would ideally be working in parallel with Building Information Modelling (BIM) in order to let all the stakeholders (including principal designers, designers, principle contractors, contractors, engineers and management, procurement and clients) of the project to work collaboratively and specifically on each area of the waste management/reduction criteria that contribute towards the decision making strategy. The primary purpose of this framework is to achieve the minimum waste generation with less minimum cost.

Ideally, there would be two frameworks, one for existing buildings and one for new development projects. The BIM strategy will more be implementable in the framework for new development projects.

Considerably, Waste has a negative impact on the environment, cost, productivity, time, social and economy. Production of construction waste in huge amount is due to increasing demand of infrastructure; commercial buildings and housing development projects, which has generated large amount of construction waste (Saez P, del Rio Merino M). Design, operational, procurement and material handling activities lead to site waste generation. This waste generation activities consume time and effort without adding values to the client thus resulting losses in material, delay in meeting the stipulated time and effort without adding values to client thus resulting losses in material, delay in meeting the stipulated time and execution of unnecessary work.

Background Research

Over the last 20 years, waste management in the UK has changed dramatically due to changes being done to further improve the waste management system over these years and so on. Some positive outcomes have been recorded from these changes such as, there has been a major decrease in the quantity of waste being disposed off to landfill and on the other side, an increase in recycling. Recycling the waste means less environmental impact and zero carbon.

Through multiple resources and waste data collection from various construction sites, it has been identified that the volume/quantity of construction and demolition waste (CDW) generated in the today's world is significantly high and causing series of severe issues. Eurostat estimates the total for Europe to be 970 million tonnes/year, representing an average value of almost 2.0 tonnes/per capita (Sonigo et al., 2010).

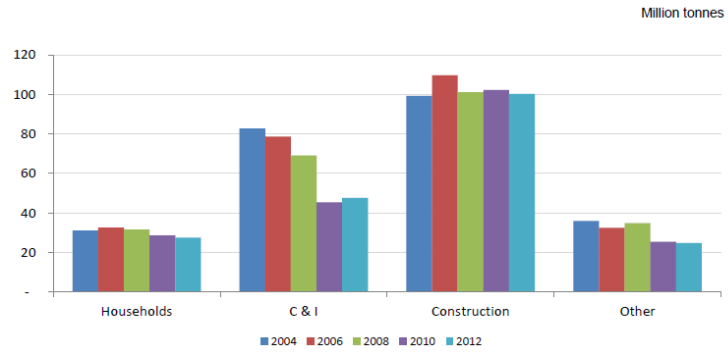


Figure 1: Waste arising by UK sectors (Source: Defra statistics 2014)

Figure 1 indicates that significantly higher amount of waste arises from the construction sector in the UK with an average of 105 million tonnes of construction waste generated every year.

Table 1: Hazardous waste arising from construction sector (million tonnes)

2004	**2006**	**2008**	**2010**	**2012**
225	586	1,258	1,018	1,057

Source: Defra Statistics 2014

According to Defra statistics in table 1, there has been an enormous increment in the generation of hazardous waste from the year 2006 to 2008, as the difference has exceeded from 596 million tonnes per year to 1,258 million tonnes per year.

Table 2: Waste generation split by responsible economic activity, UK and England, 2012-2014 - proportion of tonnages (million tonnes and % change)

		C&I	CD&E	Total
UK	**2012**	32.8	108.8	193.8
UK	**2014**	27.7	120.4	202.8
UK	**Change**	**-15.6%**	**10.6%**	**4.6%**
England	**2012**	24.2	93.8	157.1
England	**2014**	19.8	107.6	167.6
England	**Change**	**-18.1%**	**14.6%**	**6.7%**

Source: Defra Statistics 2014

Table 2 shows that the UK generated 202.8 million tonnes of total waste in 2014. This represents an increase of 4.6% from 2012. England generated 167.6 million tonnes of total waste in 2014.

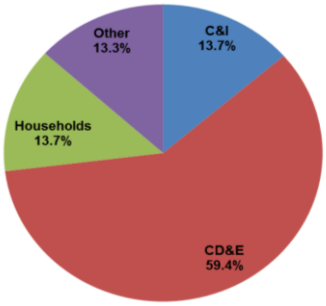


Figure 2: Waste generation split by source, UK 2014

From different construction project surveys, it has been found that most of the contracting companies do not have a proper site waste management plan in place and also, they lack in the planning of waste management before the commencement of works on site. This is also a cause of sudden increment in the construction waste.

Table 3: Waste generation split by responsible economic activity, UK and England, 2012 – 14 – Proportion of tonnages (% of total waste tonnage and % point change between years)

		C&I	CD&E	Households	Other	Total
UK	**2012**	16.9%	56.2%	14.1%	12.8%	100.0%
UK	**2014**	13.7%	59.4%	13.7%	13.3%	100.0%
UK	**Change**	**-3.3%**	**3.2%**	**-0.5%**	**0.5%**	
England	**2012**	15.4%	59.7%	14.5%	10.4%	100.0%
England	**2014**	11.8%	64.2%	13.8%	10.2%	100.0%
England	**Change**	**-3.6%**	**4.4%**	**-0.7%**	**-0.2%**	

Table 3 and Figure 2 shows that CD&E produced over half (60%) of total UK waste in 2014. The remaining waste generation was evenly split between 'Commercial & Industrial', 'Household' and 'Other' activities. In England, the share of 'Construction' was higher at 64% of the total (March 2016).

After considering all the above and various other statistics on construction waste, the author came up with the idea to propose a framework that if followed by the designers and engineers, there will be minimum waste generated from any proposed construction project and that will also determine for existing developments whether it is feasible to rebuilt the whole structure or partially demolish and refurbish.

Methodology

The methodology followed in this research is based on the facts and findings from the previous construction projects and the area that generates the maximum amount of waste in a construction project.

As BIM is the latest addition to manage waste in the industry, the idea is to integrate the proposed framework into BIM as described in the introduction.

However, the methodology of this research is still due to be finalised, some of the key elements have already been added to the list of procedure that shall be further refined during the second phase development of this framework. Following are the initial key elements:

Design Phase

There seem to be a fairly large co-ordination gap between the designers and the contractors at the initial stage of the project. Most of the designers and principal contractors does not aim to reduce the generation of waste or have a proper waste management plan in place until the project reaches to the construction phase. This is the very first step that in most cases, lay the foundation of a poor waste management.

There is a good example of waste management during the construction of New South Glasgow Hospital (NSGH), where the principal contractor, Brookfield Multiplex, used tools developed by the Waste and Resources Action Programme (WRAP) to identify potential waste reduction opportunities throughout the design stage of the project (Case Study). Following were the waste management criteria used throughout this project:

- design for re-use and recovery;
- design for off-site construction;
- design for materials optimisation;
- design for waste-efficient procurement; and
- design for deconstruction and flexibility.

Remaining Design life of a building

In this section, there are two cases:

First, when there is an existing building and it needs some demolition and refurbishment. Then, in order to maximise the efficiency in the usage of building material, there will be a need to figure out the remaining design life of the existing material. This can be done by taking account of the year when the building came into operational, then subtract those years from the maximum design life of a material:

Remaining design life = maximum design life – used design life

After calculating the remaining design life and considering the new proposed development of the existing building, actions can be taken that should be in favour of the minimum cost and waste generation.

In the second case, if there is a new proposed development on an empty land, then design life of each of the main material should be noted throughout the construction project as this will minimise the waste and save cost of future planned or unplanned refurbishment works on the building.

Material Waste Estimation and Transportation

Material is the primary source of waste. Maximum accuracy in material estimation and management ensures minimum waste generation. Once the design life of the building is identified, material can then be estimated depending on the type and design of project. Again, the design phase already includes minimum material wastage plan as it requires designer and the engineer to work collaboratively on the plans and make sure the minimum material wastage plan is in place.

Minimum material wastage highlights the economical aspect, as this will keep the material cost at minimum.

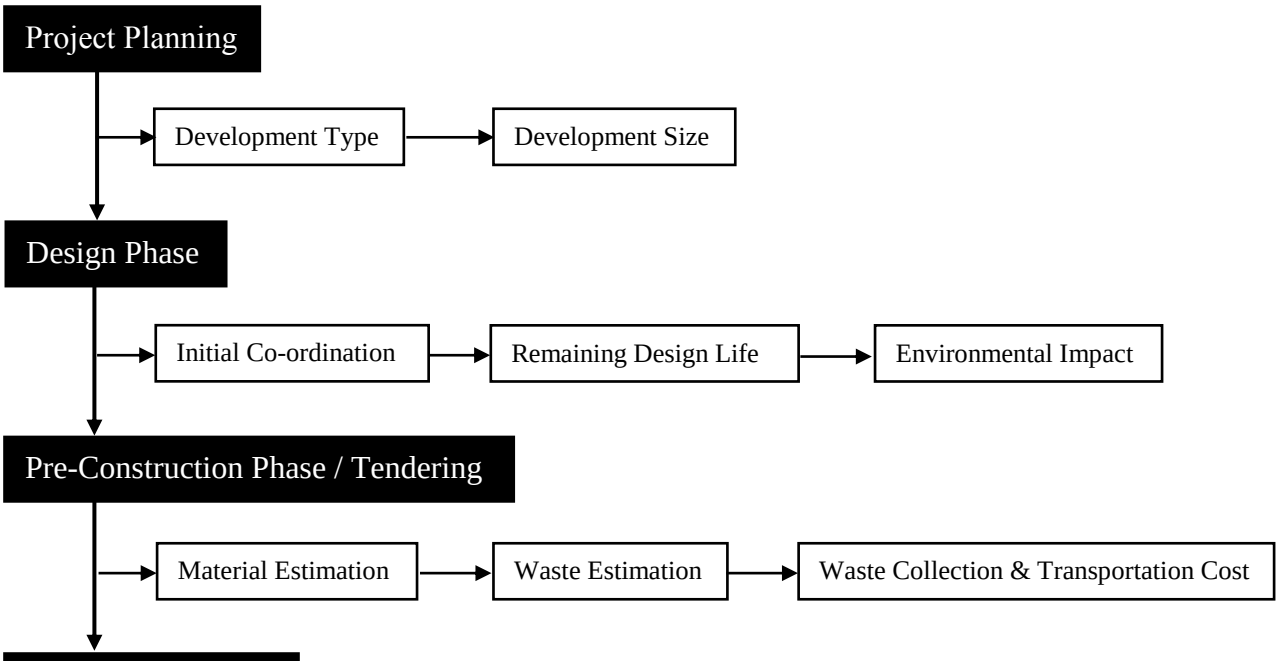
Integration into BIM

Once all the above factors are addressed, the collected data can then be integrated into BIM tool in order to have a collective set of information in one platform.

Development of the Initial Framework

Based on the initial findings, the framework to achieve the minimum waste generation and decision making contribution to existing and new development is as follow:

Flowchart 1: Framework



The decision making strategy from the above framework will be based on the factors highlighted. Once all the data is integrated onto BIM platform, all the stakeholders of the project will then be able to work collaboratively and come up with a decision for an existing building of whether to demolish the whole structure or partially demolish or refurbish. The decision will mainly be based on the minimum waste generation strategy as highlighted in the above framework.

In terms of new development, the data from the above framework will maximise the chances of achieving minimum waste during the construction phase.

Analyses and Discussion

The proposed framework aims to achieve the minimum waste from any development project. All the considered factors in the framework works in co-relation to each other. Steps should be followed in sequence. The first step will determine the type and size of the development. This indicates whether it is a new development or refurbishment of existing building is required. The size of the development will give the first idea of the quantity of material to be used.

The design phase comes into place when the project is set to be designed according to client's needs. However, there has been a slight change into the design phase of this framework, where an engineer/estimator needs to co-ordinate with the designer during different stages of the design, and here, the role of engineer/estimator is to be able to identify the maximum areas of material wastage from the plans and the designer can then make amendments accordingly.

If a new design is required for refurbishment of an existing building, then the remaining design life formula need to be used in order to identify the remaining life of the existing material on site to figure out whether it can be recycled, re-used or dispose off (this will be the least priority).

Pre-construction strategy indicates the need for the final material estimation and a rough amount of material wastage followed by the strategy for the transportation of material and waste.

All the above data can then be integrated into BIM tool and each area will be designated to the relevant person. Each person will generate a report based on the data collected from each section of the framework. After all the results are combined into one report, the decision making for rebuilt or demolish shall then be based on the minimum waste hierarchy.

Conclusions

Construction waste minimisation strategy is an important contribution to the goal of achieving sustainability in the construction industry. In order to regulate C&D waste management practices, a specific set of framework is required that should include the better practice for managing waste and achieve minimum waste strategy.

This paper discussed the C&D waste management and some facts on the waste arising every year in the UK, which is continuously increasing every year. Apart from EU's target for UK to achieve the 70% waste recycling by 2020 (F. Pacheco – Torgal), this is still looking difficult to achieve by looking at the last few years statistics. So, further necessary steps need to be taken and new better policies on waste management should be introduced by the Government in order to tackle these issues.

The proposed conceptual framework in this paper needs further amendments and revisions in order to achieve the best decision making outcome. For this purpose, this research will be continued and more relevant waste management aspects will be taken into account along with some real site waste data and opinions from the construction experts on this framework.

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