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Reducing Waste Generation on the UAE Construction Sites

Al-Hajj, A. and Iskandarani, T.

Abstract

Sustainability is becoming the focus of many industries and countries around the world, particularly in the Middle East construction industry. Despite the economic downturn since 2009, the UAE is determined to continue face the great challenges to achieve sustainable developments and communities. Reducing construction waste is considered a unique challenge to the UAE government to resolve. Most of the construction companies prefer to dump their waste straight to landfills rather than considering more environmentally friendly methods. This paper reports on a study aiming to identify good construction practices to reduce construction waste generation in the UAE construction sites. A mixed research strategy was implemented, a literature review of existing research and analysis of data collected from two case studies of construction projects. The research concluded that awareness and self-discipline of people are lacking on sites. The research results showed that the main focus of contractors is the progress of work, considering waste management as additional cost without added value to the project. The research also concluded that a stringent disciplinary act by the government is critical to motivate contractors to implement effective practices to reduce construction waste. The research revealed that most of contractors are aware of the causes of waste generated but only few measures such as; proper storage, ordering materials on time and segregation of specific materials for reused or resell, are practiced to reduce or eliminate waste. Awareness and construction related education plus incentives are needed under a stringent law in order to motivate contractors in the UAE construction industry to start implementing efficient waste reduction plans.

Key words: construction, sustainability, waste reduction, waste management plan

Introduction

General waste is any material by-product of human and industrial activities that has no residual value (Alarcon & Serpell, 1998). Construction waste materials can be defined as the unwanted residue generated from construction, modifications, demolition of any structure. Construction waste and demolition debris usually makes up about 10-30% of the waste received at many landfill sites around the world (Begum and et. al. 2006). The typical wastage rate in the construction industry in the UK may reach as high as 10-15% (Lu and Yuan 2010). According to Environmental Protection Agency (EPA) in the USA, construction and demolition waste represent approximately 1/3 of the volume of material in landfills. In Canada, construction waste and debris represent about 35% of the volume space of landfills Begum, et. al (2009). The GCC countries generate approximately 120 million tonnes of general waste annually. Saudi Arabia and the UAE are considered the top two generators of waste per capita in the world (Construction week, 2009). During the 2009 Middle East Waste Summit, statistics indicated that the GCC countries generate 55% of waste from construction and demolition, 2% is municipal, 18% is industrial and 7% is hazardous (Construction week, 2009). A total of 30,000 tonnes per day of construction and demolition waste was generated in Dubai according to Dubai Municipality (gulf news, 2008). Therefore, construction waste reduction has become a critical issue forcing the entire stakeholders to improve the construction industry by managing construction waste more efficiently. Construction waste occurs within the project lifecycle starting with the client, design team, construction, and modification and demolition phases. Had clients' requirements been clearly defined during the procurement process, forced changes can be avoided during construction, thus reducing the overall quantity of construction waste. A study by Ekanayake & Ofori (2000) revealed that design changes during construction are the most significant cause of building waste generation at site. Apart

from changes by the client, errors in design documents, lack of coordination between disciplines. Other reasons would include improper material procurement, unskilled workforce, and poor quality control which considerably increase construction waste. This paper reports on an investigation conducted in order to identify sources of construction waste on construction sites, assess people and practices that could reduce construction waste on sites and promote awareness among contractors toward the reduction of construction waste.

SOURCES OF CONSTRUCTION WASTE

The construction industry and the fundamental problem of construction waste

Ekanayake & Ofori, (2000) defined waste as: “Any material, apart from earth material, which needs to be transported elsewhere from the construction site or used within the construction site itself for the purpose of land filling, incineration, recycling, reusing or composting, other than the intended specific purpose of the project due to material damage, excess, non-use, or non-compliance with the specifications or being a by-product of the construction process”.

Sources and Causes of Construction waste Generation

Figure 1 provides an overview of the sources of construction waste throughout the project life cycle and per stakeholders.

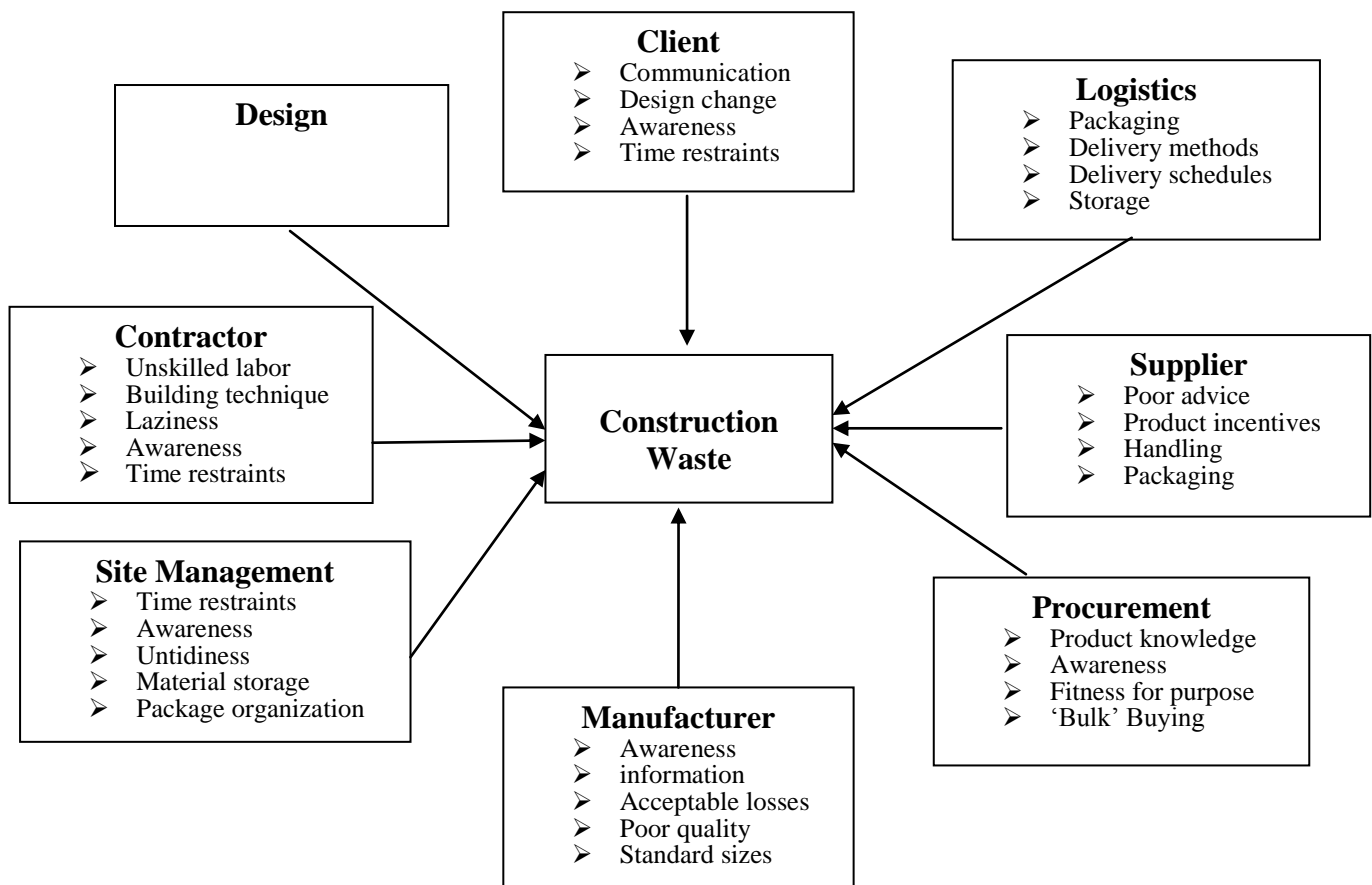


Figure 1: Origins of Construction waste.

Adapted from: Andy Keys, A. Baldwin, A. and Austin, S. (2000)

The design stage is extremely critical in impacting construction waste generation. If good attention paid to dimensional coordination and standardization of products and sizes, this will help in reducing construction waste. Recent studies by Osmani, M., Glass, J. and Price, A. (2006) demonstrated that the last minute changes by the client or designer are major causes for generating waste. A study revealed

that construction waste reduction up to 84.7% was achieved with the use of prefabrication when compared to traditional construction material (Tam, V. W. Y. Tam, C. M. and Ng, C. Y., 2007). During the operational stage, Ekanayake & Ofori, (2000) suggested that construction waste generation will be affected by the following issues: errors caused by workers or tradespersons, accidents due to negligence, damage done to finished work by subsequent subcontractors and the use of incorrect material which requires replacement of such material or delays in giving information to contractors. Ekanayake & Ofori, (2000), found that the procurement of materials and proper handling both affect construction waste generation. If materials are ordered wrongly, quantities are significantly less or more and if the ordered materials do not comply with the project specifications will increase the potential of construction waste generation.

Construction waste problem

The construction industry is a major producer of construction waste. Recon (1996) reported that in Australia, about 14 million tons of waste was disposed into landfills each year, 44% of that waste is construction waste. In the US, construction waste is 29% of the total waste, (Rogoff, M.J., and Williams, J.F., 1994), 26% in the Netherland, (Faniran, O.O. and Caban, G., 1998) and 19% in Germany (Brooks, K.A., Adams, C. & Demsetz, L.A., 1994), and finally in the UK construction waste makes more than 50% of the total waste disposed in landfills (Ferguson et al, 1995). For decades, landfills have provided a convenient and cost effective solution to its wasteful practices, (Hao *et. al*, 2008). This has given a bad platform to contractors to fully depend on landfills and tend to ignore waste management procedures. As a consequence, the generation of construction waste are on the rise and therefore the commercial benefits including time and cost are been compromised. Begum *et. al* (2009) stated that clients carry more burden from construction and demolition waste, thus more cost.

Sources of construction waste include materials from earth work like soil and sand, concrete and aggregate, masonry block and brick, wood, metal products, interlock paving, plastic materials, roofing materials and different packaging of materials. If proper waste reduction plan is implemented on sites, most of the materials produced are likely to be reused and recycled and the estimated percentage of reusable and recyclable can reach up to 73% of the total waste (Begum R.A. *et al.*, 2006). Reusing and recycling of construction materials will help to reduce the demand upon new resources, reduce costs of transportation and production energy, and the full utilisation of use rather than having it wasted in landfills (Edwards, 1999).

Construction waste generation is a resultant of poor waste management plan throughout the project lifecycle starting from the early stage of the project brief given by the client followed by the design and finally the construction phase

Construction waste in the UAE

The UAE economy is one of the fastest growing in the Middle East and became the largest construction market (20.3%) in the GCC, (Oryx ME, 2010). Despite of the downturn in the economy, the UAE is still a major player in the world. As a result, the UAE has faced a multifaceted problem of uncontrolled construction waste generation which put the UAE under tremendous pressure with the rest of the world to deal with the environmental issues.

Figure 2 shows the hierarchy of construction and demolition waste indicating that reduction at the highest level and has the lowest impact on the environment. It is based on the principles of prevention and reduction, to eliminate or reduce waste at source. Landfill has the highest impact on environment.

Eliminating waste is the ideal practice, however it is difficult to achieve in the construction industry due to the complexity of each project.

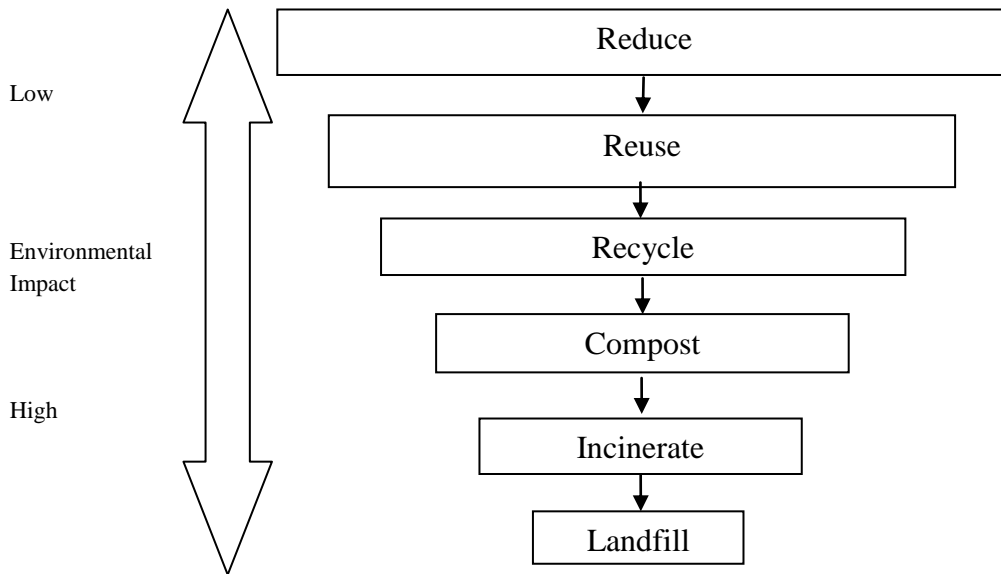


Figure 2: Hierarchy of Construction and Demolition Waste

Source: Tam, V. W. Y. and Tam, C. M. (2006)

In the UAE, the majority of the workforces are uneducated and have none or little knowledge about environmental awareness and construction waste generation. This is one of the main fundamental problems that the construction industry is facing in the UAE. Teo et al. (2000) stated that “the labour intensive nature of construction activity suggest that behavioural impediments are likely to influence waste levels significantly”.

In the UAE, there are almost no data or studies available on construction practices and how to reduce construction waste. The process of construction waste reduction in the UAE is still in its infancy stage. Construction practices are almost the same around the world, and the differences are dependent on the type of materials and the cultural background and awareness of workforce. The construction industry in the UAE is doing very little toward waste reduction and it is still at the bottom of the priority list for contractors. In a recent study, Al-Hajj and Hamani (2011) examined the main causes of construction waste and minimisation practices implemented in the UAE construction sites. The main direct causes of material waste were found to be the workers' lack of awareness; poor design; and the rework and variations. Indirect causes of construction waste were found to be the lack of legal and contractual incentives. To minimise material waste contractors used adequate storage, staff training and awareness, and ‘just- in time’ delivery. Construction sites in the UAE rarely practised waste recycling, measurement and segregation. Al-Hajj and Hamani (2011) stated that the environmental benefits are usually neglected, overlooked and considered as less important by contractors in the UAE construction sites.

Common practices to reduce construction waste

The UK Environmental Protection Agency (EPA) (1991) that waste can be reduced at source, by comprehending processes and make changes to minimize and eliminate waste. Resource or process efficiency is another description for waste reduction. During the production process, substituting the harmful materials with less environmentally harmful materials is part of the waste reduction. Crittenden & Kolaczowski, (1995) stated that any activity, technique or process that can prevent, eliminate or

minimize waste from its origin, usually within the limits of the produced units, or utilizing the recycling and reuse of waste for the purpose of good products (Poonprasit, et. al 2005).

Nebraska Department of Environmental Quality (DEQ), highlighted the following steps to be considered to prevent and minimize waste;

Step 1; Optimize building dimensions in order to correspond to standard material dimensions, modifying framing details to optimize the use of standard materials size, utilize the available technology like Auto- CAD to review drawings and details in lieu of making unnecessary blueprints and reproduction, salvaging of materials while remodelling.

Step 2; Prepare a plan on how to prevent construction waste from developing by making an estimate and programme of the types and quantities of construction waste the project will produce and when, maintain a balance between suppliers and procurement strategy, by requesting the suppliers to buy back unused materials or salvage the materials with good conditions, to ensure that the materials supplied are delivered on a sturdy returnable pallets and containers and to make sure that the suppliers must pick up the containers and pallets on the same time they deliver new materials.

Step 3; contractor to set up a proper storage area, to have a good practice in handling the material at site to prevent damages from weather and other means.

Step 4; To store materials on level blocking undercover, protected and elevated area to prevent warping, twisting and loses, set up a designated area to store cut –offs from wood, steel, gypsum, metal and other materials that can be used in the same site or elsewhere, to clean concrete chunks, broken blocks and other masonry rubble which can be used as backfilling along foundation walls, to avoid excessively packaged materials and supplies, where packaging should be adequate enough to prevent damage and waste, ordering the needed quantity in project with specific dimensions, accurately evaluate the estimated procedures to avoid delivery of excess materials to site, ordering the amount of materials the project needs as accurately as possible and arranging for ‘just in time’ deliveries to reduce storage and material loss. Another good practice and part of the site activities, keeping the site clean to minimize loss of material and waste generation, (Clackmannanshire Council, 2011).

From a case study about construction waste minimisation in housing which was conducted by the Centre for Research in the Built Environment, Welsh School of Architecture, at Cardiff University-Wales, found that construction waste vary greatly between construction stages from the contract agreement between client, contractor and architect, design and construction stage dependant on construction methods implemented. Practices that can reduce construction waste were identified: Segregation of construction waste, Proper material handling, Improve storage methods, Encourage the market flow for recycled materials and to be reflected on contractors, improved relations between company policies to reduce waste on construction sites, proper handling of materials and proper storage. Other factors influencing construction waste reduction a include: Activeness of the contractor project manager, Poor partnership among supply chain, Poor behaviors by some sub-contractors, Poor communications between project parties, Low interest in the construction market for recycling and reused materials.

Good waste management practices & benefits

Clackmannanshire Council, (2011), stated that good waste management practice can help reduce cost of disposal and fees of landfills; minimize cost of construction waste transportation ; provide more recycling and reuse of site materials to reduce procurement of raw materials; reduction wastage of material; saving of construction time; and an overall increase of project profitability.

The causes of construction waste generation and the practices are almost the same around the world. However, the seriousness of implementation differs between contractors dependent on factors like: the type of materials used, cultural background and awareness, recognizing the benefits and the self-discipline of the individual. Few good practices to reduce construction are as follows: good site management, good terms of relation with supply chain, efficient and timely procurement, good handling and proper storage of materials, standardization of sizes and the use of more of pre-fabricated systems.

Awareness of Construction Waste within the Project Team

Loosemore et al. (2002) and Skoyles and Skoyles (1987) highlighted the significance of human affects in waste minimization. Both argued that changing attitudes can prevent waste. Lingard et al. (2001), stated “the extent to which reduction, reuse and recycling of waste can be achieved depends, to a large extent, on motivational influences on the behaviour of construction workers”. Teo et al. (2000) stated that “the labour intensive nature of construction activity suggests that behavioural impediments are likely to influence waste levels significantly”. Tam and Tam (2008) demonstrated that offering incentives and rewards contribute to the staff knowledge and inspiration towards reduction of waste, an estimated waste reduction of 23%.

Company policies should focus on increasing staff knowledge, promoting awareness and encouraging contractors towards waste management and environment practices. The implications of such policies are beneficial to the construction industry to improve its performance towards waste management (Begum, et. al 2009).

Attitudes and waste reduction

Education and training are critical for the site operatives to improve their attitudes towards waste reduction; According to McDonald and Smithers (1998) operatives that were trained were found to be highly motivated towards reducing levels of waste. The perceptions among all employees with various categories including site operatives and head office management that: waste management is not financially beneficial; and the company are lacking of incentives towards effective waste management (Sanders and Wynn 2004). A survey conducted in Australia by Teo and Loosemore, (2001); Teo et al., (2000) found that; Operatives are only able to contribute towards waste minimization according to the given support by the higher management. Also the contribution can be more effective if high priority were given to waste management similar to the priority level given to other project’s objectives like cost, time, and quality.

Case study about attitude and behavioural factors in waste management

An interesting research was carried out by Begum et al. (2009) describing the impact of contractor’s behaviours towards waste management to include the 3 R’s practices.

it was found that attitudes toward waste reduction are generally positive which support the findings of Lingard et al. (2000), McDonald and Smithers (1998) and Teo et al, (2000). The attitudes was more positive regarding waste management practices for the large and experienced contractors that have a considerable level of education related to construction and attended training program as compared to small and medium contractors. This finding supported by Tam et al. (2005) that attitudes can be changed by offering proper training and education for the entire industry. It was also found more positive attitudes regarding waste management for contractors that implement recycling and reuse strategies. The results showed more positive attitudes for contractors that did not realize the harm of construction waste to human health. Many contractors prefer not to sort construction waste. Factors

affecting contractor behaviours regarding waste are size and culture of contractor which include construction related education and experience, unawareness of the consequences of waste, the lower charges of disposal discourage contractors to segregate, reduce, reuse and recycle.

Attitudes and behaviours toward waste in the UAE

The UAE government has set standards and regulations to stipulate waste management. They have taken positive steps in regional waste management. According to Al Rostamani Group's Emirates Recycling LLC commences operations (2007) Emirates Recycling plant built at a cost of over AED 65 millions to convert more than 80 million tons of construction waste material which is generated annually in Dubai alone into usable construction material. Al Rostamani Group's Emirates Recycling LLC commences operations (2007) the managing director of Emirate Recycling Robert Biasizzo stated "There are no down sides to using recycled aggregate: it is as robust, safe and high-quality as current market alternatives, if not more so", and further said "Emirates Recycling will provide developers and contractors with a readily available, high quality, low-cost and eco-friendly product."

LEED Leadership in Energy and Environmental Design is a Green Building Rating System that motivates and accelerates the adoption of sustainable construction buildings and practices during the project life cycle. The entire project approach by LEED to achieve sustainability is being recognized by adopting the following main items: Sustainable construction buildings; Efficiency of energy and water; Selection of materials; and quality of indoor environment. Lack of responsibility and self-discipline of people with regard to waste management are major shortfalls in the UAE construction industry. All in all, despite of what the UAE government is doing, the question is whether or not laws and legislations are tough enough to be effective.

Government laws and regulations:

The UAE is now reacting positively towards the growing requirements of construction waste management. A report by the UAE Interact (2008) showed that considerable budget was allocated for management of waste and recycling facilities. The allocated spending for the waste management and operation for Abu Dhabi is approximately Dh500 million over 10 years. Similar act in the city of Dubai, a US\$150m spent to establish Waste Recycling Park and other Recycling plants in different areas of the Emirates. Although there is a strong movement towards improving management of general waste, but the problem with the construction waste is still at large because many contractors are still reluctant to deal effectively with construction waste management.

Many countries around the world have established stringent rules and regulations. According to the Environmental Protection Law and Regulations in Hong Kong (2010) the ordinance and its subsidiary regulations, including but not limited to the Waste Disposal (Charges for Disposal of Construction Waste) must be observed and complied with by contractors (Chapter 354N of Laws of Hong Kong). Also, for contractors that work on construction projects with a value of HK\$1 million or above are required to establish a billing account with the Environmental Department in respect of that specific project.

According Environment Agency (2011), In the UK, projects which started after July 2008 and its value exceed £300,000 not including VAT; site waste management plan (SWMP) must be available prior to starting the project. Contractors who fail to produce (SWMP) could result in a fixed penalty notice as this negligence is considered an offence (Business Link, 2010). In the USA, the city representative of Connecticut is debating a law that require businesses to recycle 50 percent of construction and demolition waste (Tam, V. W. Y 2009). The law would allow the city to fine violators 50 cents per

pounds for any material that should have been diverted under its requirements (Magdalene Perez, 2010). Moreover, other countries have applied landfill tax to positively push contractors to improve their attitudes toward construction waste management.



In this regard, a strong law to include rewarding and disciplinary programme can encourage contractors to improve their waste management plan on sites. Therefore, the UAE are in more need for a stringent law and legislation to give incentives to contractors toward construction waste reduction as suppose to only recycling or reusing of waste taking in consideration the

Case Studies Analysis

Table 1 provides a comparison between two projects both located in Dubai but have a different approach or attitude towards construction waste minimisation.

Table1: Comparison between the two case studies

	CASE STUDY 1	CASE STUDY 2
Description of project	320 residential villas, located in Dubai. Project is at different stages of construction.	Two warehouses with a total area of 65,000 m ² , and two detached offices, located in Jabal Ali free zone, Dubai. This development is green building with LEED, silver rating. Project is at different stages of construction. For warehouse1, earthwork and foundation works were complete and the wall cladding and roof panels were on progress. On warehouse 2, the earth work and foundation works were on progress and no activity on the wall cladding or roof panels.
Procurement strategy	Traditional; no special requirements for waste management plan in contract or by management	Design and Build
Data collection methodology	Questionnaire, site visit and direct observations, and interviews	Questionnaire, site visit and direct observations, and interviews
Contractor	Medium size organisation	Joint Venture with a European company. Senior management is from the European company and the site operations including construction manager, site engineers, foremen and labour force are from the local company
Workforce	Mostly Indians	Mostly Indians
Project profit margin	Tight	Comfortable
Authority	Dubai Municipality	Jabal Ali Free Zone Authority (JAFZA)
Interviewees	Senior Project Manager, Construction Manager, Site Engineer, H&S Manager	Project Director, Deputy Project Manager, Project Coordinator, H&S Manager
Waste quantities	Never measured, some records on the number of trips are available but not accurate	Some records were kept for waste removed out of site. Approximately 8,000 m ³ . It is part of LEED's requirements to show proof of disposal into landfills or recycling facilities. Also, it was mandatory by the Authority to use specific company (Imdad) for waste removal. Records are not well documented nor are they accurate.
WMP	Casual	In place
Type of waste	At foundation stage: Earth, concrete, steel and wood	Earth, concrete, steel, wood, damaged pieces of aluminium sandwich panels, plastic and considerable amount of timber from transporting sandwich panels

Generated wasted materials and causes	<p>1. <u>Dry plastering materials:</u></p> <ul style="list-style-type: none"> • Poor practice of plastering work causing considerable amounts of excess plaster material as workers are reluctant to reuse • Materials falling on the floor while applying rush coat or plastering. • Repetitive marking and chasing for services by MEP subcontractors in the absence of coordinated drawings for all services. 	
	<p>2. <u>Cut Masonry blocks</u></p> <ul style="list-style-type: none"> • Poor initial setting out of block works resulting in large amounts of unusable cut blocks. • Workers not taking extra care while cutting the blocks • No segregation of cut pieces for reuse as infill • Absence of coordinated drawings by MEP contractor for all services 	
	<p>3. <u>Packaging material, plastics and card boards</u></p> <ul style="list-style-type: none"> • Plastic and card boards used for protecting delivered materials. 	
	<p>4. <u>Cut pieces of insulation boards for roofing works</u></p> <ul style="list-style-type: none"> • Inaccurate orders of materials and workers reluctant to use small cut pieces for infill. • Workers used card boards to rest on during break time. 	
	<p>5. <u>Damaged & Cut pieces of ceiling tiles</u></p> <ul style="list-style-type: none"> • Poor workmanship, inaccurate quantities and wrong timing of orders. 	
	<p>6. <u>Damaged & Cut pieces of floor tiles</u></p> <ul style="list-style-type: none"> • Poor workmanship. 	
	<p>7. <u>Dry lumps of mixed cement</u></p> <ul style="list-style-type: none"> • Negligence by workers and poor supervision. 	
Waste Minimisation Practices	<ul style="list-style-type: none"> • No segregation of construction waste was observed • Anti-segregation practices observed • Use of standard metal form work for the repetitive activities • Providing a well protected storage area, • Selling excess of materials like steel or wood and reuse the same on site or other sites within the company. • Allocating space on site for the stock piles of soil produced to be reused on the same site. • Just-in-time applications • Unlabelled skips were available on site 	<ul style="list-style-type: none"> • Operatives and workers were repeatedly made aware of the importance of managing materials properly to reduce construction waste. • Materials segregation is applied.
Management of Construction Waste		

Case Study 1

- In theory, contractor staff's are positive and recognizing the construction waste as a serious problem but the implementation on site is random and not properly organized.
- There is a communication gap between senior management the construction team on site on the concept of waste reduction plan. The site engineer, H&S seems more logical and it is in agreement with the green building consultant to include waste reduction plan in all projects as part of their strategy.
- Contractor staff's are generally aware of the benefits and harms of waste generation, but the actual situation on site is clear evident of the lack of self-discipline.
- The staff emphasized that lack of knowledge and awareness is one of the major causes for poor waste management on site, and therefore the solution should come from higher management. There is also lack motivation among staff and workers to reduce construction waste.
- There is agreement that the law is too soft. Strict implementation is required. Waste generation is a team responsibility and not the contractor only. This includes: the client, designers, contractors, subcontractors, suppliers and the regulatory authorities.
- Contractor staff's are convinced that the law is too soft to motivate contractors to improve the system. In the absence of strong laws and lack of construction related education, the current situation will not improve.

Case Study 2

- The team is generally aware of the sources and practices that mostly generate construction waste. Also types of waste are well identified.
- Serious actions to reduce construction waste are not implemented on site by the operatives. The difference of attitude is obvious between both sides of the JV staff. The European side of the team are well aware of SWRP and its implementation on site as part of the projects requirements but staff on the other side is not familiar with such plan.
- The team appreciates the harms and benefits of construction waste generation and agree that segregation will reduce cost and facilitate recycling and re-use of materials and is the preferred practice, but its implementation is not mandatory in the UAE. In addition, it is difficult to find facilities to accept materials for recycling.
- Offering educational sessions is part of company procedure for the European staff, but not for the non- European. This is a major factor for falling behind with regard to awareness. The team generally aware of the benefits and harms out of construction waste reduction are not seriously undertaken by operatives.
- The law is too lenient. Until companies enforce the waste management plan as part of the company procedures and integrated with the Government regulations, the problem will remain unchanged.
- Record for quantifying waste generated and to be disposed was available but not properly recorded.

Discussion

From the conducted case studies, it was clear that there is a general knowledge and awareness among the majority of interviewees regarding construction waste generation. However, this knowledge is not utilized as part of the normal construction practices which contractors are used to in the UAE. The majority of interviewees emphasized on cost as benefits from waste reduction. One critical finding from both studies, that contractors are motivated to achieve sustainable construction by means of waste reduction only if the project cost gets reduced and the profits increased. This is a clear indication that attitudes of contractors toward waste reduction need a serious change of the fundamental problem.

Neither project has a formal SWMP, but only partial implementation due to LEED requirements in second study. Segregation and quantification of materials particularly steel and wood was performed in both projects mainly for reselling or reusing.

It is evident from the case studies that the performance in case study 2 was generally better and this may be due to the following reasons:

- 1) The procurement route of the first project is traditional and the second project is design and build contract which allow the contractor to participate in the design which in return helps the adaption of better materials and construction practices that can contribute to waste reduction.
- 2) The contract in the first project has no requirements for SWMP, in the second project; it was specified as part of the contract with LEED Certification. This scenario made the waste management and reduction mandatory.
- 3) The second project was managed by European staff where their backgrounds are familiar with the issue of construction waste generation and its management. The first project was managed by non- European staff where waste reduction is not a priority. Although, the background of staff is important, but in the absence of enforced law, regulations and incentives the problem will persist.
- 4) Both projects were in Dubai but under different Zoning and Authority. The second project was monitored more strictly by the Authority than the first project which may be a reason for having better results. This refers to the need for a strict law by the Government for the entire UAE.
- 5) The budget in the second project was very relaxed that motivated the contractor to improve on waste management plan. The budget in first project is too tight which making the contractor reluctant to spare efforts on issues that are not considered as priority compared to progress. This refers to the basic problem starting from the client, designer, contractor and the rest of the supply chain. They need not to cut corners in the project by focusing only on time, cost and quality. Sustainability must be given similar priority.
- 6) Although, lack of awareness and self-discipline were not found among site operatives in both studies, however, in the second project, the management successfully manipulated the staff and the workforce to improve their attitudes. Therefore, culture and attitude play a major role in controlling construction waste generation on site. The industry should therefore focus more on change of attitudes and behaviors toward waste minimisation.

Conclusions

- Causes and sources of construction waste generated on site include: Procurement, handling of materials, construction practices, attitudes and behaviour of the team.
- Poor practices have a major impact on waste generation. This includes poor waste management plan, errors in ordering materials, low quality of ordered materials, improper storage, traditional construction methods, poor segregation, poor coordinated documents and rework due to errors. In addition, lack of incentive for contractors to improve their practices.
- Lack of awareness within the construction team is a major cause for generating waste. Attitudes of site operatives were focused mainly on progress not waste management, as this is considered an additional cost without tangible benefits. Many contractors do not see the financial benefits in reducing construction waste.
- Law and regulations in the UAE is a major cause for the construction waste problem. Although the government have started taking steps particularly in sustainability, there are no serious fines against violators. The law is seen to be so lenient.

- There is need to offer incentives that can aggressively motivate contractors and stakeholders to act more responsibly and be committed to waste reduction as part of the integral supply chain.

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