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CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT IN THE UAE: APPLICATION AND OBSTACLES

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ABSTRACT: The purpose of this paper is to identify and evaluate the advantages and the obstacles of C&D (Construction and Demolition) waste management in UAE (United Arab Emirates). A mixed research methodology was used to identify and evaluate the advantages and barriers facing C&D waste management in the UAE. The qualitative method reflects collecting a review of published literature from peer-reviewed journals on C&D waste as well as from the conducted unstructured interview. The quantitative portion of the study was a questionnaire using a multiple-choice questionnaire and a five scale Likert-style ratings for quantifying the results. The adoption of sustainable methods for waste minimisation on construction sites in the UAE looks positive. The profile of the UAE construction sector has radically changed during the last two decades. The sharing of knowledge and a culture of cooperation on construction sites are highly needed currently. The research could be presented in much stronger base analysis if it was based on a case study with the UAE local market. However, organizations are very much reluctant to offer such data due to the sensitivity of the matter.

Keywords *Construction and Demolition- Sustainability- Waste Management- Construction Industry*

1. INTRODUCTION

The high rate of urban growth in the UAE is causing so much building construction that hundreds and thousands of tons of construction and debris C&D is resulting [13]. The need to produce and use strategies for sustainable solutions in urban areas is immediate [2]. The UAE government is leading the drive for the adaptation of sustainable policies and construction activities, and it is a major priority of UAE city planning and development. In the construction sector sustainability goals can be met by integrating appropriate and efficient waste management and waste disposal [24]. The construction industry in the UAE considered being the biggest shareholder for generating solid waste, though solid waste stream is extended to other different sources like households and manufacturing industries. 75% of the solid waste that is generated in the UAE is from the construction industry [36]. 2011 records show that the construction industry in UAE contributed 10.3% of the gross domestic products and expected to increase to 11.5% in 2021 [1]. All types of buildings constructed regardless of their financing are expected to meet sustainable goals for safety, healthy surroundings and durability [17]. The focus on C&D is the area where GHG (greenhouse gas) reductions, natural resource use and energy can eventually lead to transforming the building industry into a sustainable industry in the UAE [37].

2. UAE AND SUSTAINABLE C&D WASTE MANAGEMENT

Kofoworola and Gheewala, (2009) define construction wastes as wastes that originate to construction, demolition and renovation activities, and it is simply described some time as construction wastes.

2.1 Cause of C&D Waste Problem

The UAE, like some other countries around the world, is experiencing high growth in urban areas, due to expansion in population resulted from the migration and country well fair [38]. UAE is asserted to be one of the highest waste generations per capital in the world [13].It is vital to understand that any new construction, renovation or refurbishment project will produce waste at any point of it [20]. The following point's shortlist the cause of wastes in construction;

a- Frequent changes into design and design errors**;** Faninan and Caban, (1998) these changes into design counted to be the highest and the most important factor that affects the waste generation in construction that can be related to poor communication between project stakeholders and client's change orders.

b- Supply Chain & Material Handling; [10] Applying for adequate methods and strategies to ensure that materials are delivered on time, stored correctly and handled carefully will have a great impact to reduce the construction waste for items that are yet to be worked on.

c- Poor planning; LO et al., (2006) shows that ineffective planning of utilized resources and activities can lead to overuse of machinery, materials, tools, labours, etc. and most often reworks for carrying out works prior to others that should be conducted first.

d- Bad weather; Climate is something that is beyond human control, hence wastes can be voided through effective decision making, proper planning and high administration skills [4].

e- Inefficient implementation of quality control and procedures; Efficient project manager and supervisor can grab control on workers and reduce waste [25].

f- Bad Operation; Workers should be accountable for the final executed product, and adequate tools and machinery should be supplied to reduce the waste generated [16].

g- Communications; the gap between the construction operation team and the design team is the predominate factor in communication quality [25].

h- Technology; Building information modelling (BIM) is a tool that enhances efficiency, speedy changes in design plans and day-to-day movement on constructions sites as well as incorporating any change in building plans in a matter of seconds, thus leading to efficiency in waste management [1].

2.2 Types of C&D Wastes

The major challenge of construction projects in urban areas is a large amount of waste generated, these wastes can be divided into two, the first is the demolition waste if a building already existed on a site while the second type of waste is the construction waste from the building project [3].

2.2.1 C& D waste materials

(C&D) waste is defined from EPA, (2017) as not containing toxic or hazardous waste that calls for special handling; those are often from non-renewable sources.

2.2.2 C& D labour and machinery waste

Labour waste is the result of human inefficiency, Taylor, (1913) argues that the generation of wastes due to work ineffectiveness by human has larger economic impact than those related to material waste. While Machinery waste is a result of inadequate usage of heavy equipment's and in most kept idle or wrongly utilized [29].

2.3 The Need to Minimise Waste

Dainty and Brooke, (2004) describe the essential requirements for waste minimisation strategies included reduction of materials use and improved waste management processes which are identified as

- Attitude.
- Legislative policies.
- Design changes.
- Acceptance of sustainability practices.
- Culture of waste minimization.

The culture of the construction site is identified as problematic in terms of efficiency and waste minimisation. The meaning of sustainability and its importance even to workers on the individual levels needs to be known throughout the site and the other stakeholders. Training on how C&D wastes are handled is something that needs to be offered if workers are not knowledgeable about the topic [22]. Improved integration of the supply chain is a suggested method for enhancing the minimization of C&D wastes to ensure that all parties are working towards a common goal [5].

3. SUSTAINABLE ASSESSMENTS OF C&D WASTE MANAGEMENT DRIVERS & BARRIERS

Hammoud et al. (2017) said that the construction waste is generated from the first stage of inception to the final stage of completion. Based on this, the concept of sustainability must be involved in the construction industry early at the design stage

3.1 Global Requirements For Sustainable Development

The UNEP Copenhagen 15 meeting listed priority activities all relating to building and the lifetime of a building that must be initiated; all also relate to construction and C&D waste. The activities can be discussed as below:

- National (GHG) emissions reduction targets need to prioritize reductions in the construction sector;
- Nationally Appropriate Mitigation Actions (NAMAs) must identify and create the necessary programs for the building sector in the country, which will ensure efficient energy use and reduction in GHG emissions;
- Construction Design and Management (CDM) in developing countries must be redesigned to enhance investment directly to energy-efficient building; and use of internationally accepted performance frameworks to develop baselines for GHG emissions from the building sector [37].

3.2 UAE Guideline for Sustainable Construction

Asif (2016) indicated that the overuse of fossil fuels had brought the crucial problem of climate change that must be addressed. The GCC (Gulf Cooperation Council) is taking into account the negative environmental impacts of the construction sector and making changes under the umbrella of sustainable strategies. Building assessment systems have been developed in different parts of the world in order to assign credits based on the waste management successes. The purpose of sustainability rating systems is to regulate the handling of resources and materials by offering guidelines which will reduce environmental threats. The rating systems for (C&D) that first made an international presence were LEED developed in the United States of America (USA), the BREEAM developed in the United Kingdom (UK). The Pearls Rating System for *Estidama* is a UAE system designed with similarities to the other systems, but that better fits the culture and environment of the region [33].

Small and Mazrooei (2016) identifies The Dubai Green Building Regulations (DGBR) and the Abu Dhabi Estidama Pearl rating systems as the two highly advanced systems developed to meet the UAE goal of sustainability in the UAE building sector. Ferreira et al. (2014) discuss that the assessments of construction projects must be critical and objective. The overall purpose of every rating system is to make sure the negative impact of the environment is reduced regardless of the chosen strategy [17]. The UAE rating systems were developed and continue to be improved as new knowledge is gathered over time [33].

3.3 Sustainable Initiatives to Minimize Construction Waste

Sustainability is an approach of reducing construction waste**,** this approach should be increased as green buildings are not only cost savers but also reduce the waste and use renewable sources that can be reused and recycled [26].

The following initiatives were implemented in the UAE to address the above-stated waste issue and to minimize its effect in response to the UAE vision for sustainable development.

Abu Dhabi 2030; The Masdar Institute and Masdar City are located in the Abu Dhabi emirates composed an internationally recognized research institution responsible for producing the Estidama Pearl Rating System. The Estidama Pearl Rating System draws basic elements from LEED and BREEAM and is based on the same sustainability concepts. A big difference is that the Pearl rating for Estidama is UAE-centric, and the ratings reflect Abu Dhabi's climate (very hot) and arid environment (lack of water) [32].

Dubai Green Building Sustainable Regulation; The Sustainability Green Building Department EHS Trakhees was organized in late 2007. The department has nine years of regulatory experience and has already certified several Green Buildings under the EHS jurisdiction.

Bee'ah Sustainable initiative; Bee'ah (C&D) recycling facility process's daily more than six thousand tons of construction waste which is reused at infrastructure projects, it is among the busiest similar facility in UAE [17].

3.4 Waste Minimization in Construction, The Four Rs Concept

The strategies of reduction, recovery, reuse and recycling shown in figure 1 all have the same goal; to ensure that nothing from the construction process is left that may cause a negative environmental impact including avoiding depletion of natural resources [31].

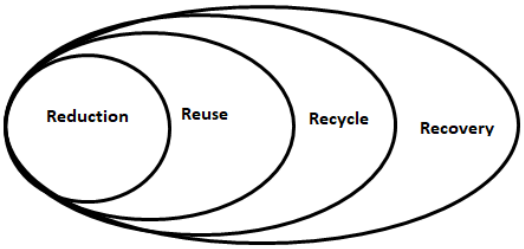

Fig. 1 Four Rs of waste management [31]

3.4.1 High quality recycled products

Reduction of waste materials is addressed in all the rating schemes by requiring that recycled materials are used for the temporary buildings and false-work associated with the construction operations [33]. Bravo et al. (2015) notes that aggregates account for one of the most promising recycled materials in the construction industry. Concrete made with coarse and fine recycled aggregates (RA) from (C&D) wastes from Portugal building sites were tested for durability. Performance in the category of durability showed a negative performance when fine RA was integral to the concrete.

An earlier study by Kwan et al., (2012) also concluded that recycling coarse aggregate (RCA) had a strong potential for sustainable construction, but adoption was slow, proving that more testing and education on the results of the tests were needed. Medina et al., (2014) notes that partial replacement of raw material, natural coarse aggregate, with (C&D) waste aggregate showed better results. The waste aggregate from (C&D) debris is considered low quality on its own but used

as a manufacturing component for 30 MPa strength grade aggregate that was acceptable for housing construction.

3.4.2 The drive for waste minimization

The drive to minimise waste according to Rogers, (2011) can be classified into four main categories that include; legislative, economic and environment.

Legislative; This includes governmental influential decrees & laws, organizations policies and contractual terms & conditions.

Economic; The centre of waste management in Abu Dhabi estimates that the UAE economy loses AED 1.5 billion a year due to landfilling waste, which can be otherwise recycled into useful products [31].

Environment; The purpose of sustainability rating systems is to regulate the handling of resources and materials by offering guidelines which will reduce environmental threats [34].

3.4.3 Barriers for waste minimization

Now at this turning point, it is important to understand the barriers which prevent the construction industry professions from the implementation of the waste reduction.

Financial incentives; The main barrier behind waste minimization is the high availability of low-cost virgin raw material of higher quality than the salvaged or recycled materials [29].

Human Nature to resist change; This character somehow is imbedded in the human nature, and that there is part of them who are not by any means aware of the importance of waste reduction, most of them hesitate to change being familiarized with the old traditional methods.

Limitation of Time; Rogers, (2011) pointed out that the high demand from investors on construction projects deliverables (cost & time) is not beneficiary to preserve materials and reduce waste.

Costly investments; Cost is a crucial obstacle for contractors to adapt waste minimization. [30].

Difficulties to Adopt New Technology; The difficulties faced by contractors to embark in new systems and technics is one of the main causes that makes the contractor be reluctant and show resistance to implement, [11].

4. RESEARCH METHODOLOGIES

A mixed-method was used in order to take into account descriptive and quantitative data. The descriptive data includes a literature review, interviews and comments from the stakeholders. The quantitative component is accomplished by using a Likert-type rating to evaluate the data from the questionnaire. To illustrate, a population sample was composed of facility Management professionals, contractors, project managers, and Consultants with a stake in the efficient conclusion of C&D projects. Due to the time constraint, 90 questionnaires were emailed across, and a total of 47 survey forms were returned, a response rate of 52% achieved.

A postal email format questionnaire was also designed, and the targeted potential respondents were professionals from the construction industry field that covers all activities from a construction site, renovation and maintenance works. The questionnaire encompasses twenty questions, which were divided into three sections (General Information of Survey Participants- Current Situation for C&D Waste- Waste Minimisation, Drivers & Barriers) with an intent to cover the subject of this research as much near possible, though limitations were there as prolonging the questions can discourage the participant from answering. Semi-structured interviews with open-ended question type shall be the bases for the qualitative research analysis, where an in-depth resourceful information can be gathered that shall enrich the understanding of the researched subject and supports the findings. Apart from responding to the asked questions, the interviewees have the free will to express their ideas and opinions and provide suggestions or recommendations.

5. DATA COLLECTION AND ANALYSIS

These data collection has been acquired via the questionnaire response and the undertaken semi-structured interviews. A blend of nominal & ordinal scales is used in assessing the questions.

5.1 The Research Questionnaire

The questionnaire layout has a significant role to motivate respondents in communicating the questions aims. The research questionnaire was divided into three sections as following:

5.1.1 Section one – general information of survey participants

This section covers the respondent high-level details, which include the working experience and the nature of work. These questions attempt to analyse the level of respondent knowledge on the research subject.

Four groups of professionals were targeted for the current research. The original population sample amounted to 90 potential participants. A total of 47 participants took part in the questionnaire component of this research, which means the population sample returned a rate of about 51%. All professionals had a good construction experience in UAE, 35%, have a construction work experience of more than 11 years,

and four of them have worked in the UAE construction for about 50 years. Based on the small number of respondents and the nature of the questions, it is considered satisfactory. The main reason is due to the large range of years of experience the respondents have worked in the construction business.

5.1.2 Section two – current situation for C&D waste

This part of the questionnaire attains to research the condition of construction and demolition waste management practices in UAE and what are the causes and types of wastes. The questions have been structured in a mix of multi-choice and five-point Likert scale rating.

- *Implementation of waste segregation on site:* 72% of the respondents replied positively to the answer. The results confirm that the majority of professionals in the UAE are considering waste management in their workplaces.

- *UAE C&D projects current disposal practices:* Responses from table 1 illustrate that the least of 4% of companies are burying the waste within their working site area. Evidently, recycling is not yet common practice in the construction industry, although the strategy is highly supported theoretically.

Table 1 Response percentage for disposal practices

Answer Options	Respondent Percentage	Respondent Count
Landfill	77%	36
burry at site	4%	2
recycle	19%	9

- *Effects of different items of construction wastes on the total waste generated at a construction site:* The high percentage of wastes materials as illustrated in figure 2 presents an opportunity to reuse them in the temporary works (road access and others) if a sustainable construction waste management approach is to be implemented.

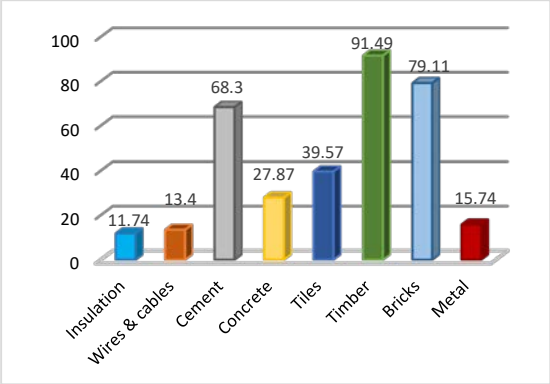

Fig. 2 Percentage distribution of respondents towards the ranking of material wastes

- *Vendors adaptability to supply materials in smaller quantities:* When asked whether suppliers are adaptable and provide materials in small quantities on request, 40% of the respondents agreed, while 34% disagreed. Thus, it is figured out that cooperating suppliers can play a major role to assist site personnel to minimize waste

- *Recycling practices for construction wastes in UAE C&D projects:* The received results table 2 reflects the companies' reactions towards the implementation of waste recycling. Transporting the construction wastes to recycling centre ranked as highest practised among professionals with a sensible difference in comparison to other recycling methods, followed by reusing of waste material in the temporary site works and lowest-ranked registered for the use of waste material in the permanent works.

Table 2 The performed recycling methods

	Answer Options	RII	Ranking
1	Temporary Site Activities	24.44	2
2	Permanent Works	12.22	3
3	Transport to Recycle Centres	48.89	1

- *Weather effect on C&D wastes increase:* When respondents were asked whether disturbed/bad/uncomfortable Weather can influence the increase in waste generated on-site. 41% of respondents agreed with the statement that bad weather could increase the generated waste. Nevertheless, 38% of respondents disagreed. This is perhaps due to the well-managed sites and the less disturbance of bad weather due to the climate stability in UAE, though the high humidity has a significant effect on materials.

- *Last minute design change effect on C&D wastes increase:* 2% of respondents only disagreed when asked if they think that last-minute design change can increase the waste generated on-site. On the other hand, 85% of respondents acknowledged that last-minute design changes increase construction wastes.

- *Works bad supervision effect on C&D wastes generated on C&D project:* When asked about improper supervision that leads to bad workmanship and increase reworks on-site respondents, the majority agreed with a rate of 70%. It is important to make sure that workers that are hired or employed have the needed experience that match to their assigned duties and that they are well trained for new duties prior to have them assigned on them. 21% of respondents showed their neutral stand and 9% disagreed, perhaps errors and mistakes that cause reworks due to happen; this is because of the implied pressure on operations to meet deadlines.

5.1.3 SECTION THREE – C&D Waste Minimization, Drivers & Barriers

This section will address the barriers and drivers which influence the construction and demolition waste control for meeting performance goals in UAE. The questions were developed in a semi-structured to section 2, where a mix of multi-choice and a five-point Likert scale rating.

- Factors affecting the performance of C&D projects: From append figure 3, we extract that the construction industry professions pay less attention to the environmental issues and all their efforts and concentration are towards early completion of work. Time factor ranked first and followed by cost then quality. It is evident that the respondents considered the environment to be the least important factor.

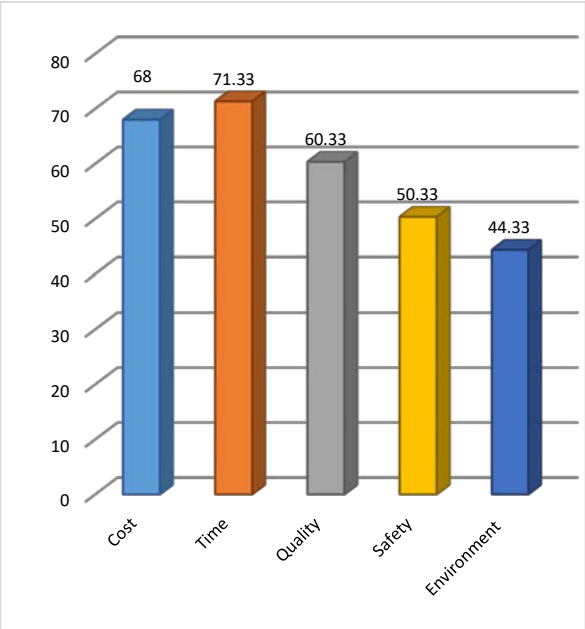

Fig. 3 Respondent answers on the importance of factors, which effects C&D project

From the above results in figure 3, we extract that the construction industry professions pay less attention to the environmental issues and all their efforts and concentration are towards early completion of work. Time factor ranked first and followed by cost then quality. It is evident that the respondents considered the environment to be the least important factor figure 3.

- *Implementation of sustainability assessment tools like LEEDS, BREEAM or PEARL on C&D projects:* Almost 28% of respondents agreed when asked whether they think assessment methods like LEEDS, BREEAM or PEARL are applied on the construction site, while 55% disagreed.

This indicates the urgent need for the government to take immediate steps to enforce the implementation of waste minimization on to the construction industry, which will incorporate improvements recommendations towards a sustainable waste management system.

- *Impact of C&D wastes on the environment:* Majority with 91% of respondent agreed when asked whether they think that construction and demolition wastes have an impact on the environment. On the other hand, 9% were preserved with their answer; however, they did not show resistant and seems that they hold some very minimum information towards the subject.
- *Impact of C&D wastes reduction on C&D project profitability:* Majority of 77% supported the statement that reducing construction & demolition wastes can improve the project profitability, while only 4% showed their disagreement and 19% were neutral. This is due to the fact the worth of final developed products in construction and to a great extent is dependent on the work that has been extended on the raw materials.
- *Effect of enforcing of contractual clauses over wastes minimization:* When asked whether provisions are made in contracts to initiate penalties for poor waste management, 70% of participants confirm that contracts do include provisions for penalties imposed on the contractor for poor waste management. 30% of respondents disagree with the statement, perhaps that the C&D projects managed by them do not have enough budget to run such essential activities.
- *Investment in new technologies:* 55% of participants expressed their disagreement when asked whether they would invest in new systems or construction technologies that can enhance your C&D project savings using less material consumed other than the old traditional system. This, as a result, can be a major obstacle for the organization to take an interest to minimize wastes. However, 28% expressed their willingness in investing which is a good sign for those well-established contractors towards the achievement of waste minimization.
- *Comments and suggestions to improve the C&D waste management system in the UAE:* Eight respondents only replied when asked whether they have comments/suggestions or ways to improve related to the construction and demolition waste management system in the UAE.

The general extracted idea is related to the poor practices of construction waste management, and suggestions are given to emphasize on recycling of wastes and the implementation of proper waste management strategies and all highlighted on the authorities role in promoting for the implementation of waste management.

5.2 Qualitative Comments from Interviews

Three project managers and one consultant designer agreed to answer the interview questions. Project managers and consultants are accessible as project managers work on the construction site with very much organized time schedule and with free hand authority. Consultants are even much more organized than the project operation team and have more control over their job. The facilities' managers usually operate from a temporary office built somewhere within premises being managed by them though due to their unforeseen nature of works, they were much difficult to approach to schedule a meeting time. Contractors are more difficult to approach for an interview because they are being supervised or at least controlled by the project managers.

5.2.1 Research Questions

The interview commenced by asking indirect questions to develop the link with the interviewee and build a rapport in order to encourage them to reveal as much possible detailed answers. The interview questions were conducted in this order:

- *Waste minimization controls: Do you practice waste minimization techniques at your site projects? Do your organization have a waste minimization plan? Do you discuss the waste minimization in your agenda meetings? Do your organization have a separate waste management department? And is there any waste audit that was conducted at your construction site?*

All professionals confirmed that waste minimization practices are part of their work agenda and daily practices due to the low-profit margins, taking into consideration the current market situation and high competition, though there are no documented actions or a plan. It is all related to awareness actions for the importance to reduce the wastages and save on cost. The facility manager disagreed with one point due to the nature of works and surrounding parameters since fit-out works in most are executed at premises where buildings are occupied and daily disposal of the generated waste is a must to perform due to space limitation. A similar comment received from one of the project managers for his previous experience with one of the construction projects located in a very high traffic population and with very limited workspace that's in the gold market, Deira.

Interviewee confirmed that waste minimization and waste management get discussed during the internal site progress meetings only, as to their opinion that consultants and clients' representatives were paying attention to the progress and quality of works and in most to site cleanliness as part of site safety actions.

When asked if waste audits are conducted, all confirmed that there are no separate waste management department within the structure of their organization nor a team assigned for such activity.

The interviewed managers saw the ability to reduce waste as a very important priority. One explained that the huge amounts of waste become problematic on a construction site where room for workers and vehicles were needed.

All interviewees have shown their interest in waste minimization with consideration to financial benefits gained from reducing the overall wastage, which affects the construction project profitability. The interviewees have expressed through their answers the factor that drives them towards the implementation of waste management at construction projects that is the contractual obligations, employer/client values and interests which contractors appreciate and value to ensure a long term relation.

- *Allowance of wastages within construction projects: As understood that it is recognized by all C&D project stockholders to consider a percentage allowance for material wastages during the preconstruction stage. Do you think that individuals tend to less care while execution keeping in mind that these losses are costed in the project? What is the acceptable waste level in normal practice?*

All interviewees confirmed that wastages are considered within the project costing at tendering stage being an unavoidable element with the construction project life cycle. However, theses wastes can be controlled if well addressed during the design stage and managed carefully by the operation team. Examples provided like in the design of floor and ceiling cut pieces can be voided and reused depends if well-presented and concrete wastes can be reduced if well managed by operation team and so on.

All confirmed that although losses are costed within the C&D project; however, individuals will not intentionally profligate in material consumed. And all emphasized on the supervision and project management role to control these type of sates.

All interviewees confirmed that up to five present is the acceptable level of material wastages which most contractors do consider as a buffer margin during tendering. However, all are targeting to reduce to less than 2% and in most achieving between 2% to 4% range depending on the operating activity and how well the in charge engineer is having control on his site.

- *C&D waste effects on the environment:* Every single project manager of the three interviewed in addition to the facility manger acknowledged that construction wastes affects the environment as more waste means more exhausted natural resources and more pollution, though they

all shared the thought that construction wastes are of less effect on environment than other industries which reflects the lack of awareness towards the contributed amounts of construction wastes volume in the overall waste generated basket. Two of project managers emphasized on the old construction ways when the prevailed culture was towards salvaging of most possible of demolished items to reuse them back in new construction though they highlighted that this an impossible mission to achieve nowadays with the new development conceptual philosophy that emphasizes on mass production, shorter construction project duration and modern designs. They all agreed that the site workforce is aware of the waste and its effects on the environment. However, the difficulty relies on the implementation side and controls.

- *Adequacy of C&D waste management legislations:* The interviewees agreed that the UAE government needed to offer more education, training and workshops on the topics of sustainability and waste minimization. The project managers left the impression that they did not resent government involvement. Instead, they felt the government had to produce smart policies and make sure they were implemented, or nothing would change in the construction sector.

Two of the project managers brought up the difficulty of dealing with supply chains towards the implementation of sustainable waste management when no one along the chain was interested in either sustainability or waste minimization neither effected by the governmental legislations or laws.

- *Main causes of C&D waste:* Interviewees provided the following collective responses with regards to their opinion on the main cause of waste as following:

1. Reworks due to change orders, errors and wrong/low-quality workmanship is one of the main reasons that generate wastes. This is mostly related to last-minute change order instructions and unqualified workers. However, it can be related as well to inadequate supervision, planning and management since the C&D project consists of interrelated activities that need to be executed in a certain sequence to avoid activities clashing and unnecessary damages.
2. Poor material quality, there is no doubt that poor material quality generates more waste due to disposal of inadequate finish products and an increase in damages due to improper quality.
3. Improper store management and wrong material handling.
4. Conventional construction system that involves fabrication and erection of building members on-site within an uncontrolled environment and a lot of restricted conditions that deem to produce waste, this can be mitigated by means of use of reconstructed member elements and by use of new building technology and technics that substitute the old traditional methods and materials.
5. One of the project managers brought to the attention the advantage of using BIM in construction projects and expected benefits that can be extended to finding possible design errors and expected unforeseen issues prior to execution that shall benefit not only the construction waste reduction but the whole life building cycle waste minimization.

- *Way forward if money and time are not of a concern:* The interviewees provided the following statements when asked about their thoughts for the top prioritized activities they would consider if money and time are not of a concern:

1. Investing in new technology and systems was the most significant concern among all due to budget limitations and low-profit margins considering nowadays market competition and anticipated difficulties in learning and implementing that can highly affect the construction progress.
2. Support for carrying waste to recycling sites if the waste that cannot be used on the site rather than disposing it at landfills.
3. The costs and hassle of dealing with construction wastes slow down the construction progress. No time is available while constructing a building to sort waste. Performance efficiency is really difficult to keep high, simply because of the amount and variety of waste. The ideas were for a team to sort the waste, and preferred to have a one supervisor responsible, and in order to do it properly huge bins are required. The waste contractor needed to come regularly to empty the bins.
4. The problem of dust from the waste of aggregates and sand needs to be addressed; mist sprinkler system could be a solution to the pollution problem; however, the expected high operation and maintenance cost due to anticipated damages are a big hurdle.
5. Educate workers about sustainability and how to reduce waste. Though a couple of the project managers suggested that a national education program is needed. The problem is that educating takes time, but eventually, it needed to be part of the culture.

- *Barriers affecting the implementation of C&D waste minimization:* The following points were highlighted by interviewees when asked to express their thoughts for the top barriers that effects the implementation of waste minimization:

1. Cost and time were the top most effective barriers in which all interviewees shared their concerns upon, especially with the consideration to current market situation and high competition.

Project managers are facing tough time to manage their C&D projects with the provided projects limited budget and short durations. Waste concerns are always the last to look at and consider.

2. Resistant to change is always an issue even if organisations managed to overcome the investment problem, professionals whom been in practice for such a long period felt to be the hardest people to change or accept new ideas unless tested practically and proven adequate to use by themselves, though this presents the interviewees themselves as well. Changes and new ideas are not accepted easily since such a relaxation in time to learn, test and prove its adequacy and functionality is not available within the construction project short lifetime and the pressure to finish early.

3. Each interviewee has expressed his concerns and experience on the implementation of existing authorities' legislation with regards to construction waste management since these decrees and laws do vary from one emirate to another. All interviewees emphasised on the need for the country to unify those set regulation across all emirates and on the importance to set strict controls and as well on the cooperation of all government bodies on the implementation part. RTA and traffic police can have a great influence on the control of vehicle movement and destinations by setting stricter controls that can bring a change.

6. CONCLUSION

The rapid expansion in UAE urban construction created a problem of millions of tons of C& D waste for disposal. The UAE construction industry must find a solution to the problem. For that reason, the UAE construction sector led by municipal and national government departments is focused upon waste elimination and inefficiency problems. A survey for stakeholders was conducted to rank the actions for construction site waste minimization in terms of meeting performance goals in the UAE. Forty-seven respondents took part in responding to the questionnaire, and three project managers and a facility manager took part in informal interviews. The literature review and questionnaires showed somehow many workers on the construction site understood the 4Rs and sustainability. In fact, during the interviews the need for education, training and workshops were needed to make sure that the concepts become integrated into UAE's culture. An in-depth illustration was also conducted on the causes of C&D wastes that was supported by the analysis of the results of questionnaires and interviews. It clearly showed that organizations priorities are towards on-time completion and cost savings and last to think about was the waste management and reduction.

6.1 Recommendations

The UAE is one of the 22 Arab League countries targeted by activists in INDY act and GAIA organizations to eventually meet zero waste goals. Material recovery from (C&D) wastes is not applied often in the construction sector, but the potential for useful materials from the waste stream is great. A developing strategy is to offer Resource Recovery Centres for carrying out the processes necessary to make materials available for sale to the public, the industrial or the recycling sector. The construction sector and other industrial and retail businesses drop off waste materials, and the centres collect, process, dismantle and sell the recycled items.

The research demonstrates that sustainability, as addressed for the UAE by Pearl, needs to be made a higher priority because the problem of large amounts of (C&D) waste needs to be solved. Public services such as the garbage service and recycling station need to be geared to take care of the waste. Therefore, all stakeholders, including the supply chain members, need to be consciously involved in reducing waste. At this point, more rewards need to be offered for taking part in sustainability activities, either from government organizations, owners who are paying for construction or both. Cooperation and collaboration between all parties need to be nurtured because the two assets will lead to success.

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