Impact of Using Recycled Materials in the Construction Industry of the United Arab Emirates

تأثير استخدام المواد المعاد تدويرها في عمليات البناء في دولة الإمارات العربية المتحدة

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Abstract

The construction industry in the UAE has undergone massive transformation in the recent years. However, the country faces significant challenges in ensuring the sustainability of the industry. The main barrier to the achievement of sustainability relates to the increasing levels of wastes generated in the industry. The increased concerns about the amount of construction and demolition (C&D) waste generated in the country has led to different groups calling for increased recycling of the waste rather than disposal in landfills. The study investigates the benefits associated with recycling C&D waste. The study began with an examination of previous studies concerning the sources of waste, sustainable C&D management practices, and the barriers to recycling. Three construction sites and four demolition sites were visited, and interviews conducted with various project members. A qualitative interview was used to collect in-depth information regarding recycling practices at the sites. The most recycled materials at the construction sites include metals and timber. Cost and technology requirements hinder on-site recycling in the projects. However, recycling has significant social, economic, and environmental benefits that the industry should embrace. However, the government should increase its participation in ensuring recycling of materials in the industry. Additionally, project participants such as project managers and contractors should increase their awareness on the environmental impacts of C&D waste and incorporate effective waste minimization, recovery, and recycling strategies.

Keywords: C&D, construction, sustainability, waste, waste management and minimization, recycling

الملخص التنفيذي

عمليات البناء والتشييد في دولة الإمارات العربية المتحدة شهدت تحولا هائلا في السنوات الماضية. ومع ذلك، تواجه الدولة تحديات كبيرة في ضمان استدامة هذه الصناعة. العائق الرئيسي لتحقيق الاستدامة المنشودة تتعلق بالمستويات المتزايدة من النفايات التى تولدها عمليات البناء والهدم. وقد أدى تزايد المخاوف بشأن كثرة النفايات المتولدة من عمليات البناء والهدم الى وجود مطالبات من جهات مختلفة دعت الى التوسع في إعادة تدوير النفايات الناتجة عن عمليات البناء والهدم بدلاً من التخلص منها في مدافن النفايات. هذه الدراسة تناقش الفوائد المرتبطة في إعادة تدوير النفايات الناتجة عن عمليات البناء والهدم. تبدأ الدراسة بمناقشة الدراسات السابقة المتعلقة بمصادر النفايات، وممارسات إدارة عمليات البناء والهدم المستدامة والحواجز التي تحول دون إعادة التدوير. تم خلال الدراسة زيارة ثلاثة مواقع بناء وأربعة مواقع للهدم، و تم إجراء مقابلات مع أعضاء المشاريع المختلفة. وتم استخدام المقابلات النوعية لجمع معلومات متعمقة بشأن ممارسات إعادة التدوير في المواقع التى تمت زيارتها. أكثر المواد المعاد تدويرها في مواقع البناء شملت المعادن والأخشاب. علماً بأن التكلفة والتكنولوجيا يعيقان عمليات إعادة التدوير في مواقع الإنشاء. ومع ذلك، فإن لإعادة التدوير فوائد اجتماعية واقتصادية وبيئية ضخمة والتى يلزم للصناعة أن تتبناها. لابد على الحكومات الاتحادية والمحلية أن تزيد من مشاركتها في ضمان إعادة تدوير المواد في هذه الصناعة. بالإضافة إلى ذلك، يجب على المشاركين في المشاريع - مديري المشاريع والمقاولين - زيادة وعيهم حول التأثيرات البيئية للنفايات المتولدة من عمليات البناء والهدم و تفعيل أنظمة لتقليل النفايات المتولدة، وتفعيل استراتيجيات إعادة التدوير.

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CHAPTER 2: LITERATURE REVIEW

2.0 Overview

The United Arab Emirates has faced constant challenges in achieving sustainability in the construction industry and management of waste. Based on this, the chapter aims at evaluating and appraising the existent literature. The review will focus on the condition of the UAE construction industry, the dynamics of waste production in the GCC and UAE as compared to other countries around the globe. Further, the section will examine the benefits of recycling C&D waste and the alternatives available.

Across the globe, societies have consistently tried to adopt various aspects and rationalize the ways of satisfying their needs under the increasing scarcity of resources. Apparently, business-as-usual has turned into an incompatible element in the contemporary economic and demographic conditions. The reality of the situation calls for significant paradigm shifts to limit the impact of humanity on the environment and ensure the security of the future generations. The straightforward characterization of the issue relates to the increasing amount of waste produced in the construction and demolition of structures in the United Arab Emirates. As it will be observed, C&D waste accounts for approximately 70-75% of the total waste produced in the country. The increasing amounts of C&D waste reflect the fast pace of industrial growth and a rapid increase in construction activities, as well as increasing urbanization and population in the UAE. The alarming rate of growth in the load of waste in the country calls for stringent measures in the construction industry to control C&D waste.

2.1 Definition of Terms and Quantification of Waste

In understanding the effects of using recycled materials in the construction industry, it is crucial to define several terms used in the industry. *Recycling* refers to the processes and procedures used to transform waste into useful materials. The process of recycling involves the collection, separation, and processing of the materials, which involves physical or chemical techniques or a blend of the two depending on the stage of recycling. However, Kennedy (2013) notes that recycling consumes significant amounts of energy. Consequently, industries should determine the cost and benefits associated with the recycling of waste materials. However, Al-Hajj and Hamani (2011) asserts that the recycling of materials in the UAE aims at environmental benefits based on the large quantities of waste produced per capita. The assertion coincides with Kennedy (2013) observation that recycling often considers the environmental benefits rather than the economic benefits of the processes.

Down cycling refers to a one-time process of recycling waste into a material of lesser value. Conventionally, construction companies down cycle by-products and waste products to have additional functional uses in the construction. For instance, fly ash, a coal by-product, is often down-cycled and utilized as aggregate in the production of concrete. According to Kennedy (2013), down cycling involves little additional resources and energy. *Embodies energy value* (EEV) refers to an equation that quantifies the amount of energy needed in obtaining, extracting, or harvesting raw materials, fabricating or manufacturing the raw material into a usable form, and transporting the material into the location of utilization (Kennedy 2013). Recycled materials have lower embodies energy values than the nonrecycled materials. *Construction and Demolition (C&D) waste* is any material considered excess in the process of construction and any materials deemed obsolete in the construction process. Demolition waste encompasses the waste materials produced during the demolition of buildings. *Fine materials* refer to the materials that originate from the earth and cannot be reused. The materials are conveniently referred to as non-renewable materials and include mined materials such as coal, crude oil, and various ores. The materials cannot be returned into any usable form after processing or utilization.

Al-Hajj and Hamani (2011, p.2) identify several categorisation models for waste. The commonest models include categorization according to state (solid, liquid, and gaseous), characteristics (combustible, inert, biodegradable, nuclear, or hazardous), or origin (household, processing, emission treatment, energy conversion, or Construction and Demolition – C&D). However, construction and demolition waste has found its place as a distinct category according to different other studies. Early studies tried to define C&D in different ways. The Building Research Establishment (1978 cited by Al-Hajj and Hamani, p. 2) referred to waste as the "variance between the materials ordered and those utilized in the construction project. Later, the Environmental Act defined C&D as the scrap, effluent, or surplus materials and substances arising after application of raw materials in any process (Al-Hajj and Hamani 2011, p. 2). The Hong Kong Polytechnic made a clearer definition of C&D. According to the Polytechnic, C&D engrosses the by-products produced and removed from renovation, construction, and demolition sites, including civil engineering structures (Al-Hajj and Hamani 2011, p. 2).

Additionally, other studies included other forms of waste other than solid waste in the definition of C&D waste. According to Alrcon (1993 cited by Al-Hajj and Hamani 2011, p. 2), time and processes waste in the construction industry falls under C&D waste. According to the study, time and process waste emanates from the activities that utilize time, space, and resources but do not add value to the overall construction process. Formaso et al. (1999 cited by Al-Hajj and Hamani 2011, p. 2) extended the earlier definition of time and process waste to include the losses produced through activities that generate costs without adding value to the product from the client's viewpoint. Consequently, the lean philosophy emerged as a strategy for minimizing activities that do not add value. However, Al-Hajj and Hamani (2011, p. 2) acknowledge that the material waste has more importance than the time and process waste in C&D based on the environmental ramifications of the former.

Waste quantification has become a crucial aspect in the construction industry with different ways for implementation coming into existence. As suggested earlier, quantification of measurement of waste can be done in terms of EEV (Embodied Energy Value) of the materials. Several other studies have identified a multiplicity of ways in which companies or environmental practitioners could quantify the amount of waste from an industry. Al-Hall and Hamani (2011, p. 2) highlight three different ways identified through previous research: as a percentage of the total waste in the construction, as a percentage of the total purchased materials, or a percentage of the overall cost of the waste. The methods illustrate the levels of waste that a construction project generates. However, the strategies require the measurement or identification of the waste streams, as well as the weight or volume of the generated waste. Al-hajj and Hamani (2011) suggest that waste quantification acts as a prerequisite to waste management and a tool for benchmarking against other projects, good practices, or companies.

2.2 UAE Construction Industry

The Gulf region has been among the areas with the fastest-growing construction industries. After a short slump, the UAE construction industry has returned to near full capacity with many megaprojects under construction. The Emirates of Dubai and Abu Dhabi dominate the construction industry since the two act as the economic drivers of the country. The real estate market in the two emirates has maintained stability throughout 2014 and the first quarter of 2015. The growing pipeline of megaprojects in the two Emirates has increased the construction spend in 2014 and the first quarter of 2015. The Emirate of Sharjah has continued experiencing significant growth in the industry as individuals affected by the Arab Spring flock the emirate. Consequently, the social infrastructure in the UAE has continuously grown with activities focused on hospitality and other business establishments.

The UAE has portrayed its commitment to the diversification of the economy and increasing the attractiveness of the UAE as a destination for investors. The strong construction industry is crucial to maintaining the progress of the city. The industry provides auspices for increased urbanization. The UAE faces completion from other Gulf States including Qatar and KSA (Kingdom of Saudi Arabia). Essentially, the competition for resources in the industry provides a strong backing for the need to recycle materials in the industry.

In the backdrop of the growth of the industry has been the incessant increase in the levels of C&D waste produced. The increasing growth and competition in the industry has provided auspices for different calls to demand increased efforts in waste management. The industry has continuously focused on increased recycling of the waste derived from construction and demolition activities. Recycling and reusing C&D waste materials will help in minimizing the reliance on virgin materials.

2.3 The Types, Sources, and Quantities of Waste

According to Al-Hajj & Hamani (2011), the major barrier towards the minimization of waste in the UAE lies in the increasing generation of waste in the construction industry. The study found that minimization of waste or recycling of waste was viewed as a cost-cutting strategy rather than a strategy aimed to benefit the environment. Additionally, the study found that many construction industries neglect the environmental aspects of waste management in the construction industry. Kennedy (2013) identified the percentages of waste in the construction industry in the UAE. According to the study, fine aggregate, coarse aggregate, cement, and steel accounted for 6.85%, 4.79%, 4.53% and 6.19% of all the waste in the construction industry. However, the study suggests that the actual waste could be much higher than a single study could account.

A parallel study by Yuan (2012) tried to address the problem deeply and analytically. According to the study, many researchers have focused on the economic performance of waste management in the construction industry. Conversely, a few researchers have focused on the social and environmental impacts of construction and demolition (C&D) waste management. Yuan (2012) developed a model (Systematic Dynamic Model) for waste management that utilizes waste management approaches that include causal loop diagrams, as well as stock-flow diagrams. The study indicates the increasing consciousness in waste management in the construction industry.

Kennedy (2013) observes that construction and demolition account for approximately 45% of the world's solid waste. However, many countries have continuously encouraged recycling of C&D waste for both economic and environmental benefits. However, the study observes that most studies offer an analysis of waste management based on traditional economic models, which fail to create harmony between economic benefits of waste management and the environmental effects. Consequently, the study proposes that researchers should engage in the search for dynamic approaches to waste management in C&D for the achievement of integration between the social, environmental, economic, and sustainable effects.

The quantification of the waste produced in C&D has emerged as many countries aim at sustainable development. The notion of sustainable buildings has become a crucial issue among the members of the Gulf Cooperation Council. The United Arab Emirates has been the leader in encouraging sustainable development in the construction industry. Studies from the region suggest that the GCC member countries produce approximately 120 million tons of waste per year. Roughly, 18.5% of the waste is associated with solid waste from the construction industry. A study by Abdelfatah and Tabsh (2011) quantifies the amount of solid waste in some of the GCC member countries. Focusing on the UAE, the study highlights that construction and demolition solid waste accounts for up to 75% (seventy-five percent) of the 100,000 tons of waste generated in the Dubai Municipality. The city produces approximately 76,000 tons of waste daily making it the highest waste producer in the world. The increasing level of solid waste from the construction industry emanates from rapid urbanization, high population growth rate, and a high growth rate of the construction industry.

Several studies have investigated the factors that contribute to the high levels of waste generation in the United Arab Emirates. Other comparative studies have tried to establish the relationship between the factors causing a build-up of C&D waste in the UAE and other countries, including the GCC member countries. Al-Hajj and Hamani (2011, p. 3) categorized the factors into design, procurement, handling of the materials, and construction operations. The study suggests that design issues contribute the highest towards the build-up of waste materials in the construction industry. According to a study by Keys et al. (2000), waste management and minimisation starts from the early stages of a construction project. Consequently, improper designs will lead to a build-up of waste materials.

In the United Arab Emirates, the construction industry has acquired an unprecedented growth as the process of industrialization and urbanization continues (Al-Hajj and Hamani 2011, p. 3). The Emirates have constructed multiple mega structures with many others under construction. Consequently, Al-Hajj and Hamani (20011) investigated the attitudes of the stakeholders to determine their contribution to the increasing waste in the industry. According to Osmani et al. (2008), waste generation is both a technical and behaviouristic issue. Therefore, other than sustainable strategies such as waste recycling, the attitude of the stakeholders towards the generation and reuse of waste affects the waste issue significantly. According to Al-Hajj and Hamani (2011), the sources of waste relate to procurement, operations, handling, and culture as illustrated in figure 1.

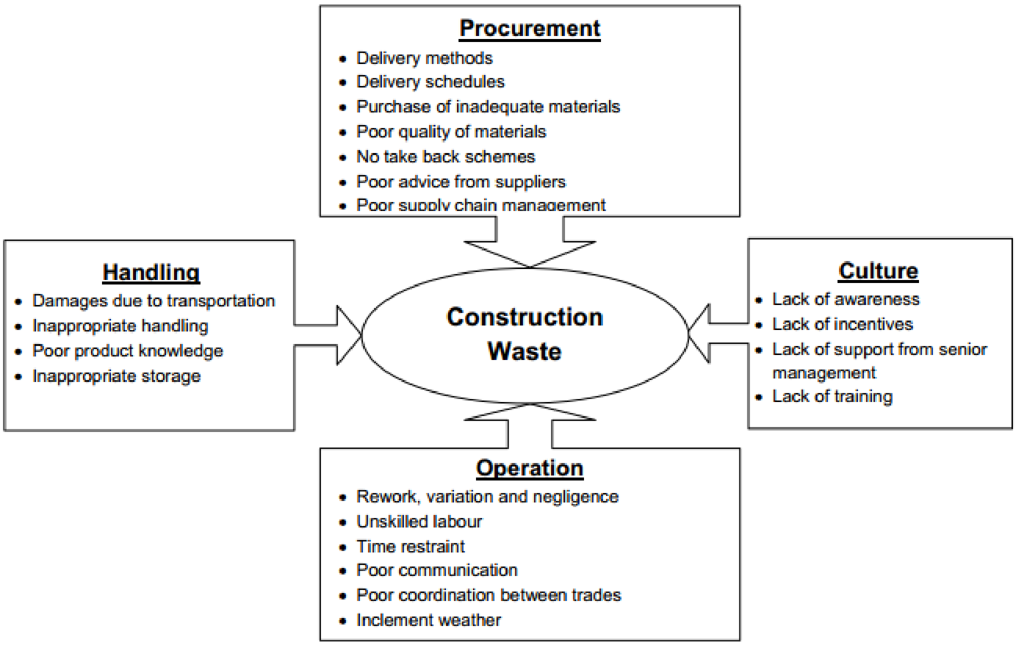

Figure 1 Factors associated with the generation of C&D waste

Kennedy (2013) also identified almost similar factors associated with the generation of C&D waste. According to Kennedy (2013), several factors provide an advantage on the waste management practices in the construction industry. According to the study, several low-cost waste segregation and sorting technologies exist in the construction industry. Specifically, the segregation and sorting of C&D waste does not require complex chemical process. As depicted by Elchalakani and Egaali (2012), the recycling of waste in the construction industry requires physical processes such as crushing of the materials obtained from landfills.

Additionally, Kennedy (2013) finds that the current trends in innovation have led to the development of innovative designs for the reuse of excavated materials as backfills for balancing cut and fill. Additionally, other modulated technologies have led to the development of reuse technologies in the form of tiles and bricks.

Consequently, some studies have suggested the need to use low-waste technologies in the construction projects. The studies also emphasize the need to encourage a proactive behaviour and approach in waste management in the industry in the country. According to Kennedy (2013), the United Arab Emirates suffers from the high levels of C&D waste because of the lack of systematic solutions in waste management, as well as reluctance among contractors to use recycled materials**.** According to the author, many contractors consider the recycled materials as low quality. Additionally, the contractors consider the recycling process is a waste of time. Therefore, Al-Hajj and Hamani (2011) and Kennedy emphasize on behavioural change in the management of waste in the United Arab Emirates.

The construction industry can benefit from manufacturing, household, and C&D waste according to Kennedy (2013). Relating the study to the UAE, it is evident that the construction industry in the country can benefit significantly from the different categories of waste suggested**.** Household waste include papers and cardboards, aluminium, plastics, glass, and steel. According to Kennedy (2013), recycling aluminium saves costs over the production of virgin aluminium even after taking the costs associated with the collection, segregation and recycling into account. According to the International Aluminium Institute (2001 cited by Kennedy 2013), recycling aluminium involves slicing and melting the metal, which exerts only 5% of the energy required for the formation of the metal from bauxite. Steel is a 100% recyclable ferrous metal, and the process of recycling resembles that used for aluminium. The industry can profit significantly from the recycle of the two metals because they are used widely in different operations.

Several manufacturing wastes can be used in the construction industry. Most notably, polyurethane foam, a residue from the textile industry, poses significant environmental problems in many countries, including the UAE. However, the materials can be used in the manufacture of sound absorbing materials. A study conducted by Rey, Alba, Arenas, and Sanchis (2011 cited by Kennedy 2013) concluded that polyurethane had better sound absorbing capabilities than most conventional materials used in the industry.

The construction industry itself offers a multiplicity of recyclable materials. For example, construction projects can use foundry sands and concrete aggregates in the construction projects. The use of concrete aggregates has found a mainstream application in the UAE construction industry as the country aims at achieving its goal of reusing and recycling 80% of the total waste by 2018 (NADAFA, n.d).

2.4 Sustainable C&D Waste Management

As noted earlier, C&D waste includes many subcategories of materials that arise from construction, demolition, or renovation activities. The idea behind sustainable C&D waste management systems is that they allow for the recovery of materials that could be disposed. Discarding materials that the industry could recycle causes an increment in the prices of the raw materials. Different researchers have evaluated different elements of an appropriate C&D waste management system.

2.4.1 Waste Collection and Transportation

The industry requires sound systems and infrastructure for the collection and transportation of the waste materials. According to Alnaser (2008), organized systems include incentives that allow contractors to transport the waste to recycling plants. Additionally**,** the contractors may be encouraged to conduct on-site recycling to cut on the costs associated with the collection and transportation of the waste. Therefore, effective management of C&D waste in the UAE requires a consideration of the collection and transportation infrastructure established to encourage recycling and re-use of the materials.

2.4.2 Sorting and Segregation of C&D Waste

The C&D waste contains materials considered as pollutants. Consequently, sorting and segregation should take a centre stage in the recycle and reuse of C&D waste. Essentially, much of the recycled materials in the UAE originates from the landfills. Unfortunately, the landfills contain all sorts of waste since the collection process does not emphasize on sorting. Therefore, the construction industry should make a clear distinction between inert and non-inert substances. For example, inert substances include concrete, sand, and bricks while non-inert substances include glass, plastics, and wood among other organic materials. Essentially, properly sorted materials cane be processed, reused, or recycled directly or appropriately. Therefore, effective recycling of C&D waste requires an adaptive system that allows effectiveness in the material flows to cope with the increasing growth of waste.

2.4.3 Reprocessing C&D Waste

Several technologies have emerged for the reprocessing of C&D waste. Essentially, many countries with profiles that resemble the UAE in terms waste accumulation have made significant progressing in implementing technologies for the reprocessing of C&D waste. Various researchers have analysed the benefits of reprocessing C&D waste based on the case of Kuwait. Kuwait institutionalized mechanisms that enabled it to recycle almost 90% of the accumulated C&D waste (Saravanan 2011). The United Arab Emirates can benefit significantly from the Middle East Waste Summits, which deliver the leading experts, officials, managers, and environmentalists in the industry to present their views and strategies for recycling management.

2.5 C&D Waste in the GCC & UAE versus Other Countries

The United Arab Emirates is among the six members of the Gulf Cooperation Council. As highlighted by Echakalani (2012, p.110), the GCC has among the highest rates of waste generation alongside the EU and USA. The GCC members have in the recent past engaged in a number of strategic decision for sustainability development aimed at the minimization of waste. The GCC has among the highest rates in the development of commercial and residential building, as well as other infrastructural projects including roads. Therefore, the generation of C&D waste in the region has continuously increased over the years. The governments of the respective countries including UAE consider sustainability issue as an important element in the continual growth of the region (Abdelfatah and Tabsh, 2011). Sustainability involves providing today's needs without compromising the capability to satisfy future needs (Srour, Chehab and Gharib 2012). Therefore, sustainability construction practices in the GCC revolve around cutting on energy consumption, using few natural materials, and most importantly, reducing waste or recycling waste while attaining the benefits of the traditional construction materials and methods.

Sustainability in the UAE construction industry has taken a significant turn after the launch of the Estidama Initiative in 2008, as well as the establishment of NADAFA. NADAFA has consistently encouraged the recycling of waste materials in the construction projects in the country for both economic and environmental benefits (Abdelfatah 2011 and Tabsh, p. 2). Essentially, the focus of the initiatives entails the conservation of natural resources, as well as the reduction of the accumulated waste and costs incurred in clearing the wastes. According to Al-Hajj and Iskandarani (n.d), the construction industry in the UAE should focus on increased recycling because concrete can be recycled continuously for different applications.

A study conducted in Bahrain suggested that lack of awareness constrains the implementation of sustainable construction in the country (Alnaser 2008). According to the study, issues such as lack of sustainable technology, concerns among clients regarding the payback period and profitability, as well as lack of markets dealing with sustainable technologies affect the recycling of C&D in Bahrain. The authors conducted a follow-up cross-sectional study in Kuwait, UAE, and Bahrain to identify the trends in sustainable practices in the countries' construction industry. According to the researchers, sustainable projects in the three countries require government policies, rating systems, economic incentives, and coordination among the stakeholders to facilitate such practices.

According to Kayali et al., the inclusion of C&D waste in the manufacture of sustainable concrete is an opportunity for the UAE industry. However, Al-Hamadani et al. (2014) maintain that the recycling of waste materials should be judged against the relevant environment. However, the authors assert that sustainability in the construction industry can benefit significantly from the inclusion of recycled materials in the production of high-performance concrete.

The use of recycled concrete in the construction industry has received significant attention from diverse researchers. The GCC has been on the forefront of using recycled concrete to reduce the build-up of C&D waste in the countries. The UAE government encourages sustainability in the industry by encouraging recycling of concrete from demolished sites for different purposes. Focusing on the GCC as a whole, several studies have identified the trends in the recycling of rubble from demolished sites. Additionally, various researchers have concluded their studies to determine the strength of the recycled concrete. One early study by Khan and Rasheeduzzafar (cited by Abdelfatah and tabsh 2011)used laboratory tests to determine the failure mechanisms, durability, and strength of recycled concrete. However, the study showed that recycled aggregate concrete had low durability characteristics, modulus of elasticity, as well as strength.

However, an almost similar test in Kuwait demonstrated that recycled concrete could attain a design strength of up to 35 MPa when the right conditions for preparation and curing are used. Rahal (mentioned by Abdelfatah and Tabsh 2011) conducted a test to identify the mechanical characteristics of recycled concrete used in the UAE. According to the study, the strength of the recycled concrete was within 10% of the natural concrete with a compressive strength of between 20 and 50 MPa. Further, Al-Mutairi and Al-Khaleefi (mentioned by Abdelfatah and Tabsh, 2011) tested the flexural behaviour of concrete containing different levels of crushed concrete. The study concluded that the modulus of rapture was within the acceptable levels. Additionally, the study observed that the use of recycled materials in the production of concrete did not affect permeability to any notable extent.

Elchalakani and Elgaali (2012) investigated the durability and strength of recycled concrete produced from wastewater and recycled aggregate from demolished buildings. The study found that the use of recycled concrete did not affect bending and axial strength but affected the durability of the structures. Therefore, the author suggested the use of fly ash and blast furnace slag to enhance the durability of the recycled concrete. According to the author, the combination offers an opportunity for the reduction of the increasing C&D waste in the UAE and the Gulf region as a whole.

Abdelfatah and Tabsh (2011) also highlights the activities of sustainable construction in the Emirate of Sharjah. The study highlighted the benefits accruing from the newly opened recycling plant in the Emirate's industrial area. The plant sources concrete and other waste materials from construction sites in the Emirates. Ultimately, the plant processes the materials for reuse for other construction purposes.

Several other studies have investigated the use of recycled concrete in other construction application other than the production of new concrete. Al-Maaded et al. 2012) evaluated the sustainability of utilizing recycled concrete aggregate as a sub-base in the construction of pavements. The experimental study considered different material gradations, composition, pavement loads, and layer thicknesses. According to the study, pavements constructed suing recycled concrete as the sub-base portrayed less deflection under load when compared to pavements constructed from virgin concrete. Therefore, the study suggested that recycled concrete could be an opportunity for the construction of roadway pavements.

A different study in Kuwait identified the use of recycled concrete in the manufacture of sand lime bricks (Abdelfatah and Tabsh 2011). The study investigated aspects such as compressive strength, specific gravity, and absorption characteristics of the produced bricks. The investigators found that the properties of the bricks were within the specified requirements for bricks in the country.

The multiplicity of studies in the GCC shows the increased focus on recycling of waste materials in the construction industry. As observed from the findings of different studies, the recycling of concrete offers several benefits ranging from cost-reduction to environmental benefits. Therefore, the duty of the construction companies entails identifying the innovative strategies that can help in the use of recycled materials from the demolished sites. However, the companies should also follow the strict stipulations to avoid the inclusion of hazardous waste in the recycling process. For example, asbestos from the construction sites is considered a hazardous waste that should not be included in the recycling processes. Additionally, the construction industry should consider the characteristics of the recycled materials prior to utilizing them in the projects. As observed, the recycled concrete aggregate falls within the range of the requirements. However, several mechanical characteristics such as strength and durability may disqualify recycled concrete from use in some projects.

Therefore, the companies that aim at recycling C&D waste should first consider the ultimate utilization to avoid further jeopardy on the environment or human life.

As highlighted earlier, there lacks a universal definition of C&D waste. During construction, several materials of high economic value may be separated for recycling purposes. Demolition occurs in two phases: the first involves the elimination of the interior finishing for reuse, resale, or recycling while the second phase involves the demolition of the concrete structures. In most cases, steel is isolated from the debris for sale to scrap metal dealers. Asphalt removed in the refurbishment of roads is often mixed with new asphalt for other uses. Factor such as the type of structure (residential, non-residential, industrial, commercial, road, bridge), size of the structure (low or high-rise) and work performed (renovation, demolition, repair, construction) determine the amount and characteristics of C&D waste.

The levels of C&D waste varies from one country to another. A study conducted by Taher (2013) quantified the amount of C&D waste in several countries. As of 2006, the United States produced the highest amount of C&D waste at 136 million tons per year. The country recycled approximately 20-30% of the C&D waste generated. In the same year, the United Kingdom generated approximately 70 million tons of C&D waste. In Australia, construction and demolition activities contributed approximately 16-40% of the total solid waste while, in Hong Kong, approximately 2900 tons of construction and demolition waste ended in landfills per day. China contributed approximately 29% of the total municipal solid waste in the world of which C&D accounted for up to 40% of the waste. The European Union generates approximately 450 million tons of C&D waste per year. Spain produced approximately 47 million tons of C&D waste and recycled only 13.6% of the waste. However, countries such as Denmark, Estonia, and Netherlands show recycling index of more than 90%.

Despite the high rates of C&D waste generation in the Emirates, the waste management conceptions are still in the nascent stages. A report compiled in 2011 tried to quantify the amount of C&D waste in Abu Dhabi, Al Ain, and the Western regions as determined by weighbridge tickets. According to the report, Abu Dhabi produced more than 33,000 tons of waste daily. Almost 50% of the waste comprised of C&D waste from the construction activities in the country. A different study indicated that the generation rates of C&D waste in Al Ain were between 750 and 1,000,000 tons of waste per year (Taher 2013).

2.6 Reasons for Reusing and Recycling Materials in Construction

The protection of the environment is within the tenets of the Koran. Consequently, the build-up of waste in the United Arab Emirates compromises the dedication to the principles of the Holy Book. Therefore, the country has significantly changed its views regarding the management of waste. The management of solid household waste involves collection by local municipalities. However, municipalities face inadequacies in the collection of the solid waste that accumulates from the construction sites. However, individual contractors have the duty to ensure that the waste ends up in the designated landfills. Kennedy (2013) identified three major reasons that instigate reusing and recycling of waste in the construction industry. The reasons include sustainable waste management, the search for alternatives with low EEVs, and the need to decrease the reliance on finite materials. According to the study, recycling waste materials reduces the amount of accumulated waste in the landfills. Consequently, this reduces the challenges in the waste management initiatives employed in a country. Further, Kennedy (2013) observes that different materials used in the construction industry do not necessarily undergo changes in their EEV after recycling. However, the researcher observes that the use of low EEV alternatives such as recycled aluminium offers significant benefits related to cost-reduction. Lastly, Kennedy (2013) observes that recycled materials decrease the reliance on finite materials. Essentially, finite materials place a significant strain on the natural resources available in a country.

The three factors have a significant relation to the UAE in terms of waste management. As observed earlier, the UAE produces approximately 76,000 tons of solid waste daily. Much of the solid waste may not end up in the landfills. Consequently, the waste is left at its production sites or dumped irresponsibly leading to environmental degradation. However, the use of waste, for example, from demolition sites, can reduce the amount of accumulated waste, which, in turn, eases the management of the landfills. Further, the use of recycled materials in the construction industry can help in saving the costs associated with the acquisition of expensive virgin materials in the country (Al-Hamadani et al. 2014). Essentially, this would help in reducing the increasing strain on the natural resources within the UAE.

The Centre for Waste Management – Abu Dhabi identified two main benefits associated with the recycling of C&D waste in the United Arab Emirates. According to their report, recycling of materials in the industry has cost reduction and environmental benefits. The report observes that many contractors have institutionalized changes in their practices and operation to take advantage of the reduced costs of waste disposal, as well and revenues achievable from reuse, recycle, and salvage materials. The report indicates that the utilization of salvage and reuse methods on the construction sites reduces the need to acquire new materials. Additionally, the methods reduce the amount of waste materials that end up in the landfills. The reuse and salvage methods improve community relations, create safe project sites, and maintain clean environs on the construction site.

The Centre for Waste Management suggests that the reusing and recycling C&D waste accrues environmental benefits. According to the report, recycling waste reduces the reliance on natural resources such as minerals, oil, and trees, which have a central position in the construction industry. Additionally, recycling materials on-site reduces pollution related transportation and manufacturing emissions. Further, the process reduces the water and energy requirements in the production of construction supplies from virgin materials. Other practices also reduce the emission of greenhouse gases.

2.6.1 Environmental Considerations in C&D Recycling

The management of C&D waste requires proper and stringent considerations to reduce the negative effects on the environment. The accumulation of C&D waste has attracted widespread concerns from different countries and environmental groups with a focus on the environmental stance. The harmful effects of accumulated C&D waste in the environment exist. Consequently, utilization of large amounts of land reserve for C&D waste landfill is a key importance. The restrictions placed on the disposal of C&D and in some countries, the development of new landfills complicates the disposal of C&D waste. Essentially, the common practice in most countries including the UAE has been dumping C&D in landfills. The dumping of the wastes in landfills has evoked significant environmental concerns, especially in the UAE where the production of C&D waste has continuously increased over the years. However, in all cases, the disposal of construction and demolition in landfills cannot be seen as the most effective disposal technique (Alnasser 2008).

According to Taher (2013), dumping C&D waste in landfills and other uncontrolled sites causes significant environmental strains**.** Uncontrolled dumping of C&D in UAE has been reported on several occasions where companies dump their waste in open dumpsites. The uncontrolled open site dumping causes a severe burden on the environment leading to water and soil contamination, as well as air pollution. Additionally, the waste leads to the destruction of the open spaces and reduction of land value. Additionally, C&D waste includes wastes such as asbestos and other hazardous wastes, which pose significant health risks.

Overall, dumping the wastes in open, uncontrolled sites causes hazardous pollution and poses risks to the health of the population of the people living around.

Therefore, environmental considerations are essential in mitigating the negative effects of C&D waste on the environment. According to Tehar (2013), the industry can consider selective demolition in which they dismantle selected parts of a building before the destruction of the other parts. Additionally, the industry can consider on-site preparations for the segregation of the unwanted materials and removal of the unwanted materials to ensure that the waste is reused within the site.

2.6.2 Reusing and Recycling C&D Waste

The use of recycled materials from construction sites requires a number of considerations. Natural aggregates of crushed stone, sand, gravel, and quarried rock are utilized in preparing foundation material used in construction. The existent standards for coarse and fine aggregates provide the specifications of the standard size of aggregates in compliance with the requirements for grading. According to Taher (2013), recycled materials are used based on their specifications in different areas. The uses include use as a foundation material in the construction of roads, use as hardcore for applications in building foundations, use as fill or base for drainage-related functions, and use as aggregates in the preparation of concrete.

According to different studies, recycled concrete aggregates have different properties from the natural aggregates. The differences emanate from the impurities such as cement stones attached to the natural concrete’s surface even after recycling. Essentially, the particles reduce the density and porosity of the recycled aggregate. The impurities contribute to the lowering of the particle density, as well as causing higher porosity, which contribute to the qualitative differences in the water absorption properties. Consequently, the qualitative differences lead to marketing differences between the recycled and virgin products.

2.7 Barriers to Increased Use of Recycled Materials in the Industry

Despite the increased call to use recycled materials in the construction industry, several barriers may impede effective implementation of the calls. Kennedy (2013) analysed the main barriers to the utilization of recycled materials in the construction industry. According to the study, the main barriers to utilization of recycled materials include limited research, waste disposal costs and procedures, and inflexible building codes. In some cases, the costs associated with recycling outweigh the achievable benefits. Specifically, metals are considered an ineffective candidate for recycling. A study by Srour et al. (2012) found that many discarded materials had low efficiencies that limit the recycling processes making the end-of-life rate of recycling low. Currently, only eighteen metals have an end-of-life rate of recycling above 50%. However, most of these metals are rarely used in the construction industry.

Further, countries have established their systems of waste management to handle the increasing volumes of waste. The systems and practices are deeply entrenched, inflexible, and rigid. Consequently, attempts to introduce new strategies for using waste materials may prove difficult since the established mechanisms are considered cost-effective. Additionally, some organizations involved in waste management resist any new ways of using waste materials in case the new ways do not lead to financial gains.

Further, Kennedy (2013) blames limited research for the ineffective use of recycled materials in the construction industry. As observed, much of the existent literature revolves around concrete and the possible aggregates. The industry lacks innovative thinking concerning other ways in which waste materials could be utilized. According to Kennedy, a larger body of research in the area would increase the strategies applicable to the utilization of waste materials. Consequently, this would reduce landfilling and ease the pressure on the current systems of waste management.

Lastly, the inflexible building codes affect the utilization of waste materials in the construction industry significantly. Kennedy (2013) observes that the building standards and legislation portray significant rigidity, which limits the extent to which contractors can use recycled materials. Currently, there lacks a guide or specifications for the implementation of waste materials in the industry. Essentially, the UAE government can permit the use of recycled materials in construction only after verifying the viability and safety of the materials. Many contractors may consider the time consumed in the process as disadvantageous for the completion of the project. Consequently, the contractors may shun the use of recycled materials in their projects.

The Centre for Waste Management – Abu Dhabi identified several other barriers related directly to the UAE. First, the organisation acknowledges the problems associated with the variations in the composition of C&D waste. According to the report, the C&D waste reaching the landfills has a varying composition of useful materials. Additionally, the waste comprises of other non-recyclable materials or materials that cannot benefit the construction industry. Consequently, the process of recycling may require expensive methods to ensure effective segregation and complete removal of the incompatible, unwanted, and hazardous materials. On the same note, the report notes the need to ensure that hazardous materials from the demolition sites do not end up in the materials destined for recycling. The process of segregating hazardous materials from non-hazardous materials may require expensive input, which may reduce the cost-efficiency of the process.

Several other researchers have analysed the challenges the Emirates face in its drive to recycle the accumulated C&D waste. According to Abdelfatah and Tabsh (2011), the Arab Gulf faces similar challenges in maintaining effectiveness in the implementation of sustainable waste management. The current rate of recycling of C&D remains low in the United Arab Emirates. Viana, Formoso and Kalsaas (2012) blame this on the lack of effective infrastructure for the recycle of the waste. Despite the establishment of the recycling plant in Sharjah, the current rate of production outweighs the capacity of the plant. The plant processes less than thirty percent (30%) of the total C&D waste produced in the United Arab Emirates. Additionally, the plant does not serve all the emirates effectively. One recycling plant cannot offer adequate capacity for reprocessing all the waste produced in the Emirates considering the current rate of growth in the construction industry throughout the Emirates. Additionally, the industry faces challenges in the collection and transportation of the waste to the plant. As noted earlier, the collection of household waste relies on the local municipalities. However, the collection of C&D waste lacks a central organization. Therefore, the Emirates perform poorly in the collection and transportation of materials to the recycling site.

However, several tools for the implementation of the changes towards increased reuse and recycling of C&D waste. Government policies can help in changing the viewpoint of many contractors. The lack of knowledge about the quality of recycled concrete among other recycled materials should not act as a scapegoat for evading recycling. According to Kayali et al. (2008), the low levels of recycling emanate from the lack of incentives to use recycled materials in the industry and lack of minimum requirements in the same. **Therefore,** several strategies could be applied to increase recycling and reuse of C&D waste. Some of the examples include:

1. Charging disposal of waste through polluter-pays-principle in the traditional landfills
2. Increasing taxes on raw materials over recycled materials to reflect the social costs of recycling
3. Establishing minimum requirements for recycled materials in construction projects. Essentially, this would provide businesses with an opportunity to assess their performance in sustainability

4. The government can also provide fiscal incentives to companies that engage in the effective use of recycled materials in their projects.
5. The government should increase its commitment to waste management through creating awareness among the stakeholders in the industry.
6. Industry players should increase the quality standards for recycled materials to tackle the challenge of reluctance to use recycled materials.

2.8 Impacts of Recycling on Sustainability

As mentioned earlier, recycling and reusing C&D waste is aimed at sustainability in the construction industry. Consequently, recycling waste materials has significant environmental, social and economic impacts.

2.8.1 Environmental Impacts

Sustainability in any sector has a significant relationship with the issues of global warming and changes in climate. Changes in the climate change are recognized as a major threat in the twenty-first century. Essentially, climate change and global warming emanate from human activities that cause an increase in the emission of greenhouse gases. The atmosphere contains 32% more carbon dioxide than there was in the industrial area. The construction industry contributes a significant percentage of the production of greenhouse gasses. The C&D waste dumped illegally may contain waste that emit gasses to the atmosphere increasing the carbon load. Additionally, the designing of the building in the current age emphasizes on sustainability, especially in the usage of energy and control of emissions. In essence, controlling the emissions through recycling materials acts as a significant sustainability step towards environmental protection (Saravana 2011).

2.8.2 Social Effects

According to Taher (2013), waste causes threatens the basic existence of the human life I terms of food production, water, health, and land use, besides degrading the environment. As noted earlier, the United Arab Emirates produces significant amounts of C&D waste, much of which ends up in landfills. Until recently, the Emirates did not own a plant for recycling C&D waste. Consequently, the waste increased the strain on the landfills as the municipalities tried to extend the capacity of the landfills to accommodate the increasing levels waste. However, increasing the capacity of the waste meant that more land meant for human use was being used for the disposal of waste. The creation of the C&D recycling waste in Sharjah was a crucial step in controlling the levels of waste in the country.

The dumping of C&D waste materials in landfills, as well as illegal dumping has significant social effects. According to a study by Miller (2004 cited by Taher 2013), C&D waste has adverse effects on agriculture, water resources, human population, and biodiversity among others. Illegal dumping of C&D waste **c**auses a shift in the food growing areas as waste takes up the land useful for agriculture. The scenario is true for the agricultural oriented Emirates such as Ras Al Khaimah. Additionally, illegal dumping near water resources decreases the quality of water, propensity to flooding and changes in water supply. Further, some wastes expose human health to several risks. Therefore, reusing and recycling the waste can help in mitigating some of the social effects. For example, reusing the C&D waste eases the congestion of the landfills and clears the environmental from waste that could make the environment inhabitable.

2.8.3 Economic Effects

A multiplicity of studies has concluded and indicated the extensive economic benefits associated with the recycling of waste. According to Taher (2013), unsustainability in the construction industry causes an imbalance in a country's economy, which, in turn, causes instability in the economic growth. A significant correlation exists between sustainability and economic growth, although studies have only shown only indirect relationships. According to Taher, dumping of waste may contribute to 20% shrinkage in the global economy in the future. Therefore, other than cost reduction, recycling C&D waste contributed to the reduction in the levels of global warming, which has a significant effect on the economic condition of a country.

Further, recycling relates to sustainability in that it minimizes the energy demand for the transportation of the waste to the landfills, as well as the production of new building materials. Further, recycling helps in the fabrication of products that can have an extended lifetime. Further, the technologies used in reducing and reusing waste help in the effective usage of space, nature, and materials, which save the costs associated with construction of buildings. Therefore, Taher (2013) asserts that the use of appropriate techniques and methods for recycling C&D waste can improve the quality of construction, but most importantly, increase the profitability of the undertakings. According to the author, numerous studies have already indicated the relationship between sustainability and cost-effectiveness. Therefore, the UAE construction industry can benefit from the strategies proposed through different studies to increase its survival and credibility in the region.

Undoubtedly, construction causes significant environmental problems to the environment across the United Arab Emirates. Megaprojects in the United Arab Emirates continue posing a significant problem to the environment, so do the demolition sites that generate a high amount of waste. According to Bolden et al. (2013, p. 14), prefabrication in the construction industry aids in reducing waste. However, the demand for dumping waste has led to significant burdens on the UAE's landfills, which are almost reaching their capacity. Therefore, the increasing waste production in the industry has become a pressing issue for the authorities.

The industry has a responsibility of ensuring that the construction activities and products observe the environmental policies and good practices through waste minimisation. According to Tam and Tam (2006a, p. 2), reduction, reuse, and recycle are the main minimisation strategies. Notably, different studies concede that the best strategy to dealing with waste would minimising its production in the construction sites. However, the difficulties in establishing a working methodology for the minimisation of C&D waste has become a major hindrance in the minimisation of C&D waste. Although recycling waste for sustainable development has been constantly promoted, there exists limited implementation of the efforts established to motivate the recycling of materials such as metal, soil, and concrete (Tam and Tam 2006b). Therefore, the construction industry should come at the forefront in the implementation of the efforts to realise the benefits of recycling materials.

Different studies have documented the environmental and economic benefits associated with waste minimisation and recycling. Essentially, the benefits are an advantage to both the environment and construction companies since they offer cost reduction strategies. Some of the economic benefits associated with recycling and minimisation of waste include the possibility of selling the waste and removal of waste from the construction or demolition sites without incurring costs. Consequently, such a strategy can increase the competitiveness of the contractors since it helps in maintaining low production costs. However, a limited number of contractors consider the environment in their construction activities. Many contractors consider timing as the priority for the projects they undertake. Consequently, their efforts focus on the completion of the projects within the shortest possible time. Therefore, their books of account cannot reveal any potential savings acquired from the reduction or recycling of waste at the sites. According to Tam and Tam (2006b), the management of building materials can help in the increasing productivity, as well as save the time and costs required in acquiring new materials.

While construction activities generate significant amounts of waste, the demolition activities in the country are associated with the largest bulk of C&D waste. The disadvantage with the waste produced in the demolition site is that some of the materials from old buildings do not fit the sustainability requirements of modern buildings. For example, many traditional buildings relied on asbestos as the main insulating material. However, the material is highly toxic and other materials discussed earlier have replaced its use. Demolition activities remove whole structures, which leads to the production of 20-30 times the waste generated from construction activities. The waste from demolition sites is usually contaminated with fasteners, paints, wall coverings, adhesives, dirt, and insulation, which reduce the reusability of the waste. However, materials such as metals from demolished structures are rarely wasted.

The demolition of construction produce significant waste as observed above. Traditionally, the low tipping fees and affordability of raw materials have suppressed the interests in recycling and reusing of building materials from demolition sites. However, as the interest in the benefits associated with recycling increases, the construction industry has shown significant reorientation, especially in the separation of waste. Consequently, the industry has adopted methodologies such as selective demolition to help in segregating valuable materials from other non-recyclable materials. While contractors use selective demolition to increase the quantity of materials available for reuse and recycling, the ability of the methodologies to reduce environmental strains on landfills has begun to be appreciated. The economic competitiveness of selectivity in demolition in comparison to traditional demolition depends on the local costs of labour, waste disposal costs, and the labour force productivity. The high costs of disposal and increased labour force productivity are associated with increased profitability and cost effectiveness in the demolition activities. Additionally, the local value of the materials from the demolition sites also play a crucial role in determining the cost effectiveness of the demolition activities. Additionally, the type of construction demolished affects the economic value of the waste and the viability of its reuse. For example, the deconstruction or demolition of brick structures can take long in case the contractor aims at reusing the bricks. Consequently, this could increase the costs of demolition and reduce the economic value of reusing the bricks (Jeffrey 2011, p. 10).

Demolition of old buildings has a significant correlation with sustainability. Particularly, traditional practices of demolition and deconstruction generated a stream of waste that was costly and difficult to manage or recycle. Essentially, local landfills have a significant effect on the economic viability of the alternative deconstruction and demolition practices. Therefore, in the absence of regulations from the government, landfill fees act as the only factor influencing the demolition practices while market price for the reused materials and labour costs play secondary roles. While the process of recycling varies from one site to another, it is widely accepted that the separation of materials at the demolition site through demolishing selectively ensures the production of clean, uncontaminated, and reusable materials. Essentially, the use of demolition materials can be mixed to offer materials for use in other activities in their mixed form rather than being dumped in landfills. For example, ceramics, concrete, and bricks are often mixed and used as fill in road construction. Such activities are associated with sustainability in the construction industry (Jeffrey 2011, p. 11).

2.9 Chapter Summary

The chapter has reviewed several studies conducted regarding construction and demolition waste, as well as the reuse and recycling of the waste. The focus of the literature was the UAE. However, the literature compared the UAE with other Gulf States, as well as other countries across the globe. As observed, the UAE produces significant amounts of C&D waste because of the enormous growth of the construction industry. Much of the waste is directed towards the landfills constructed in respective municipalities. However, the literature has highlighted some of the challenges associated with dumping C&D waste in landfills, as well as illegal dumping. The establishment of a C&D waste recycling plant in Sharjah aimed at easing the burden placed on the landfills. However, the study states that the current capacity of the plant cannot cater for the demand to recycle C&D waste in the country. Therefore, the chapter observed a need to increase the capacity of recycling in the country. Nonetheless, the review of the literature has observed the different impacts of recycling C&D waste in the country. Most notably, the study has observed the economic, environmental, and social benefits associated with recycling.

CHAPTER 3: METHODOLOGY

3.0 Overview

The methodology chapter outlines the theoretical and practical techniques and methods used in the collection and analysis of data. The chapter is based on the description given by Lewis, Thornhill and Saunders (2007) regarding a study methodology. According to the authors, a study methodology entails a set of procedures, techniques, and beliefs that guide the collection and analysis of data. The chapter outlines the philosophy, strategy, design, and approach used in the collection of data. Additionally, offers a description of the instruments used in the collection of data and its suitability in the study.

3.1 Research Philosophy

According to Saunders et al. (2009, p. 108), a research philosophy entails a worldview based on the researcher's perspective. Therefore, a study philosophy entails the beliefs a researcher holds in relation to the context of the study. According to Saunders et al. (2009), researchers can apply four different philosophies in their work: interpretivism, realism, positivism, and pragmatism. The four philosophies relate largely to the context of the study in which a researcher engages. The current study investigates the effect of using recycled materials in the construction industry in the United Arab Emirates. At the face value, the topic has significant subjectivism and realism that involves social actors. However, the study will adopt an interpretivist philosophy in the acquisition of data. The choice of the philosophy relies on the notion that the context of the study is a complex social and business concept with complexity that cannot allow theorisation through definite laws. Therefore, the study draws from Saunders et al. (2009) advocacy of understanding the difference between humanity and its roles as a social actor. Essentially, the interpretivist philosophy assumes that humans interpret social phenomena in a particular before influencing it. An interpretivist philosophy suits the study because it allows subjectivism in the acquisition and interpretation of data. Ontologically, the interpretivism allows a researcher to construct the data subjectively allowing for changes that may occur in the phenomena (Saunders 2009, p. 119). Epistemologically, the philosophy will allow the research to focus on the details of the phenomena and construct the meaning of the details of the phenomena, as well as understand the factors motivating the occurrence of the phenomena (119). Further, the philosophy allows an in-depth analysis reliant on a small sample. Essentially, the construction industry in the UAE is extensive and covering it as a whole would be far from attainable. Therefore, the study must rely on a convenient sample size that can allow the generalisation of the findings to the entire construction industry in the country. Therefore, the philosophy suits the study because it provides a platform through which the researcher could identify the changes in the perceptions towards the phenomena among the respondents.

3.2 Research Strategy

Yin (2003) suggested five different strategies. Saunders et al. (2009) expanded the categories to seven different research strategies. According to Yin (2003, p. 5), researchers can use case studies, archival analysis, experiments, surveys, and historical analysis. Conversely, Sunders et al. (2009, p. 141) categorises the strategies into experiments, surveys, ethnography, case studies, archival analysis, action research, and grounded theory. According to Saunders et al. (2009, p. 141), the research strategies suit different approaches but none has superiority over the other. According to Yin (2003), a researcher should choose a strategy based on three general characteristics of a study. First, the researcher should consider the questions chosen in the study. Different strategies answer different questions. For example, an experiments, case studies, and historical research answers the *"how"* and *"why"*. Conversely, surveys and archival analyses will answer *"who", "where", "what", "how many" and "how many"*. Secondly, a researcher should consider the requirement to control the behaviour or outcomes of the phenomenon or event. Consequently, only an experimental study would require the control of the behaviour of the variables. Lastly, the researcher should consider the study in relation to its focus on contemporary or current events. Case studies, surveys, and experiments focus on contemporary events while an archival analysis may rotate between a contemporary and historical archive. However, historical researches do not focus on contemporary phenomena. Therefore, the selection of the strategy for the current study relied on the three characteristics. The study relies on a case study strategy. Essentially, the main study question aims at answering the question *"how"* in relation to a contemporary phenomenon of the expected outcomes from the use of recycled materials in the construction industry in the UAE. Further, the question and its context shows that the researcher cannot manipulate or control the event and its outcomes.

According to Yin (2003), a case study entails an experiential investigation focused on a contemporary phenomenon in its novel context. Additionally, a case study suits studies whose boundary between the phenomenon and its context lack clarity (Yin 2003). Yin (2003) Saunders et al. (2009) clarify on the different forms of case studies. According to their suggestions, case studies can be single case versus multiple case or embedded versus holistic depending on the number of cases and units of analysis. A single case study involves the investigation of only one case. For example, a single case study could focus on one organisation. Conversely, a multiple case study draws data from several cases. For example, an investigation could analyse a phenomenon in different organisation. A holistic case study relies on a single unit of analysis. For example, a study on an organisation can focus on one department. Conversely, an embedded case study uses several units of analysis. For example, it could analyse different departments within one organisation. The current study utilises a holistic multiple case strategy. Essentially, the study uses several cases related to the use of recycled materials in the construction industry. However, the outcomes of the use of recycled materials are the sole unit of analysis in the study. According to Saunders et al. (2009, p. 146), the need to establish whether the outcomes of one case through other cases prompts the use of multiple case strategy. Essentially, multiple case studies help in the generalization of findings to a broad population. Following Yin (2003), the study chose the multiple case strategy to avoid string justification for the outcomes the study could have drawn from a single case.

3.3 Research Purpose

The classification of research purpose in the contemporary literature focuses on three categories: exploratory, descriptive and explanatory (Saunders et al. 2009, p. 139). Exploratory studies form a valuable platform for researchers seeking new insights and assessing a phenomenon in a new perspective (Saunders et al. 2009, p. 139). According to diverse studies, exploratory studies follow three principles: search of related literature, conduction of interviews on experts, and conduction of focus group interviews. Saunders et al. (2009, p. 140) observe that exploratory studies have a broad focus at the start and emphasize on flexibility. Essentially, the current study would not fit in the purpose and principles of the exploratory studies because it requires a narrow focus on a single issue within one country.

A descriptive study aims at portraying an accurate profile of an event, person, or situation (Saunders et al. 2009, p. 140). Descriptive studies act as forerunners of exploratory and explanatory studies. Descriptive studies focus on the evaluation of data and synthesis of ideas form the data. However, the application of descriptions would not fit the study because the study aims at gaining an in-depth understanding of the phenomena under investigation.

Following Saunders et al. (2009, p. 140) idea, the study considers the description of the case as a precursor to its explanation. Lastly, explanatory studies involve the establishment of relationships between variables (Saunders et al., 2009, p. 140). Essentially, explanatory studies focus on a phenomenon or problem to explain the relationship between the variables involved. An explanatory stance suits the study because it allows for the collection of qualitative data essential for the explanation of the phenomenon.

3.4 Research Methods and Approach

Saunders et al. (2009, p. 151) identify different research methods. However, the authors identify quantitative and qualitative methods as the predominant ones in research work. According to the authors, a qualitative research entails the collection of data based on the perceptions, beliefs, and opinions of the participants. Additionally, qualitative studies involve the use of data collection techniques such as interviews and analysis through categorisation of the ideas. Conversely, Saunders et al. (2009, 151) equate quantitative methods to data collection techniques such as questionnaires and presentation of the data through statistics or graphs. Other methods identified by Saunders et al. (2009) include mixed method and mixed model.

The study relies on a qualitative method based on several aspects. First, the study seeks to offer an in-depth account of the phenomenon. First, the method relates to the interpretivist philosophy identified in section 3.1. The current study relates to business and management (social sciences). Essentially, the method promotes the notion of subjectivism in the collection of data. According to Greener (2008, p. 19), a qualitative method based on an interpretivist paradigm helps in the understanding of a phenomenon and arrival at causal explanation of the course and effects of the phenomenon. The qualitative method applied in the study helps the researcher to collect the data through the view of the participants rather than on fixated objective notions. Additionally, the utilisation of the philosophy and method supports the participation of the researcher in the collection of data to gather subjective ideas.

On the same note, researchers can use inductive or deductive approaches depending on whether they apply quantitative or qualitative techniques in data collection (Saunders et al. 2009, p. 489). According to Yin (2003), a deductive approach helps a researcher to move from theory to data collection. Saunders et al. (2009, p. 489) assert that a deductive approach relies on existing theories for the formulation of research questions and objectives. Therefore, the approach starts with theoretical propositions that guide the formulation of hypothesis to guide in data collection (Saunders et al. 2009, 490). Essentially, the deductive approach suits quantitative studies and allows researchers to adapt the research as it progresses. Further, Yin (2003) suggests that a deductive approach relies on prior experience in a phenomenon, which guides the identification of variables, themes, components and issues related to the phenomenon under investigation. The researcher builds expectations for the outcomes of the study through the formulation of hypotheses.

Conversely, an inductive begins with a focus on the research for the generation of theory related to the problem Greener 2008, p. 16). Essentially, inductive studies do not have to start with a clearly defined theoretical framework. An inductive approach helps in the collection of subjective qualitative data for the generation of theory. Based on the descriptions, the study applies an inductive approach. Fundamentally, an inductive approach suits the study because of its orientation towards subjectivity of data. Additionally, the current study does not have defined outcomes based on the complexity of the investigation. Fundamentally, theories emerge in the process of data collection and analysis. Greener (2008, p. 17) supports the choice by indicating that a n inductive approach would suit a qualitative study since it helps in the generation of theory using an interpretivist strategy through subjective perspectives.

3.5 Data Collection and Analysis

3.5.1 Data Collection Method and Materials

Data collection is one of the most essential part of research. Researcher rely on primary and secondary data. Additionally, a researcher can combine both categories of data sources depending on the needs of the investigation. Usually, secondary data is derived from peer reviewed journals, archived materials, books, and other academic materials. Conversely, primary data relates to the novel data a researcher collects from the field. The study relies on both primary and secondary data for a comprehensive understanding of the effects of recycling C&D waste in UAE.

The study considers an appropriate understanding of the concept of triangulation as essential towards acknowledging the reliance on multiple sources of data. According to Yin (2003, p. 97), the use of a single source of data does not suit case studies. The use of multiple sources of data allows a researcher to address a multiplicity of behavioural, attitudinal, and historical issues embedded in a study. Most importantly, triangulation of data helps in the creation of converging lines of inquiry (Yin 2003, p. 97). Fundamentally, data triangulation helps in the mitigation of problems associated with quality of studies (construct validity).

The rationale for the use of both sources relates to the study strategy chosen. According to Yin (2003, p. 86), a case study relies on six different sources of evidence: documentation, archival records, interviews, direct observations, participant observations, and physical artefacts. Secondary data in the study came from documentation. According to Yin (2003, p. 85-86), researchers can use formal and informal documents from the organisation under investigation or from the academic world. The study relied largely on formal studies on the case under investigation. Consequently, the study used peer-reviewed journals and expert articles concerning the issue of C&D waste recycling in the UAE.

The study acquired primary data through interviews and direct observations. According to Yin (2003, p. 89), interviews are the most essential sources of information for case studies. Case studies use guided conversations as the basis for interviews rather than using structured queries often used in surveys. Consequently, most interviews maintain open-endedness and allow respondents to give their insights regarding a phenomenon. Yin (2003) characterised interviews into open-ended interviews, focused interviews, and structured interviews. The study relied on focused interview based in the time constraints in the collection of data. According to Yin (2003, p. 89), a focused interview utilises a short period but maintains open-endedness. The collection of interview material involved audio recording, as well as note taking. According to Yin (2003, p. 92), audiotaping offers an accurate rendition of the interview than any other method of recording. Additionally, Saunders et al. (2009, 479), audio recording allows easy analysis since the researcher can constantly refer back to the original interview to ensure that he or she captures all the information an interviewee offers. Individual interviews were conducted with project managers. Quantity surveyors, onsite-workers, and site foremen in three construction sites (identified as Case Study 1, Case Study 2, and Case Study 3) and four demolition sites (DS 1, DS 2, DS and DS 4)

The second source of primary data involved direct observations. According to Yin (2003, p. 92), direct observations involves a field visit to the study site. Direct observations can involve formal or casual data collection procedures. The direct observation used in the study involves both formal and casual collection of data. The researcher made visits to several construction sites to collect data on the level and techniques of recycling used on-site. A formal observational protocol guided the process of data collection. Broadly, the formal visit aimed at collecting data on the type of waste generated and the strategies used to recycle or minimise the production of waste. The researcher visited three different construction sites, as well as the Sharjah recycling plant. The casual data collection involved the visit to the participants during the collection of data. The visit to Sharjah recycling plant (Case Study 4) aimed at identifying the entry of recyclable C&D waste into the plant.

The materials required for the interview included a survey guide, as well as the audio recording equipment. The following is the survey guide for the interview.

Survey Guide for Interview

Introduction

- Brief introductions
- State the purpose of the interview
- Prompt for consent to record the interview
- Check whether the audio recording equipment is working

Guide

1) Briefly explain your role in the organisation
    a) What activities define your role in the organisation
2) Briefly explain what challenges the problem faces in relation to waste
    a) What types of waste are generated in the site?
    b) What strategies does the project use to minimise waste
3) Briefly explain the reusability and recyclability of the wastes
    a) What benefits do you draw from recycling the wastes?
    b) Explain whether financial benefits outweigh economic benefits
4) Explain your opinion on the effect of recycling on the project cost
    a) How does wastage affect the costing and estimation of materials?
5) Briefly explain your opinion on the issues the project should address to gain benefits from waste materials

Conclusion

- Ask whether the interviewee has have any more remarks

- Thank the interviewee for participation

3.5.2 Data Analysis

Qualitative data entails non-numerical data that has not been quantified (**Saunders et al. 2009, p. 480). Most** researchers conduct qualitative data analysis manually (480). According to Greener (2008, p. 83), almost all case studies using interviews as the data collection instrument require the preparation of the data through transcription. Therefore, the initial step taken in the analysis of the data for the study involved the transcription of the recording. Greener (2008, p. 84) suggests that researchers should maintain a context sheet for the documentation of non-vernal interventions and interruptions that could affect understanding of the transcribed data.

The study applies a manual technique in the analysis of the data despite acknowledging the benefits associated with computer-based analysis software discussed by Saunders et al. (2009) and Greener (2008). Saunders et al. (2009, p. 490) identifies three processes of analysing qualitative data.

1. Summarising of meanings (condensation)
2. Categorising meanings (grouping)
3. Structuring meaning (ordering)

The three strategies have their advantages and disadvantages when applied in research. Additionally, Saunders et al. (2009, p. 491) notes that some processes may be structured and formal while others are unstructured and informal. The study relied on the condensation of data in the process of analysis. The condensation of data involves the documentation of key points that emerged from the transcribed interviews. Saunders et al. (2009, p. 491) observes that summarising meaning helps in the compression of long statements to concise statements that can easily be understood. The rationale helped in the triangulation of the data obtained from documentation, interviews and direct observations. However, the presentation of the results relied on some verbatim transcripts to maintain the integrity of some crucial observations as Saunders et al. (2009, p. 497) suggests.

3.6 Credibility of Data

A researcher has to focus on reliability, validity and generalizability of data to reduce the possibility of offering flawed conclusions.

3.6.1 Reliability

According to Greener (2008, p. 37), reliability of data is synonymous to repeatability or consistency. Saunders et al. (2009, 157) define reliability as the extent to which the data collection techniques applied in a study yields consistent findings. Several factors may affect the reliability of data. Some of the factors include participant error, participant bias, observer error, and observer bias. The reduction of participant error relates to the time of data collection. The study minimised participant error by choosing the most appropriate time according to the participant's schedule. Participant bias relates to a participant offering information that his or her employee would wish them to offer for the fear of exposure. The study reduced this bias through articulating the observance of ethical issues of anonymity and confidentiality. Observer error and bias were reduced using an interview protocol and guide in the conduction of interviews. Additionally, the triangulation of data helped in increasing the reliability of the findings.

3.6.2 Validity

Saunders et al. (2009, p. 156) define validity as the extent to which the findings show what the study intended to measure. Greener (2008, p. 37) characterises validity into construct, face, and internal validity. Construct validity relates to the strength of the instruments used in the collection of data. The use of open-ended interviews helped in maintaining construct validity since the respondent could seek clarification on any question he or she did not understood. Additionally, the interviewer acted as a guide in the conduction of the interview, which ensured the acquisition of the most relevant information from the interviewee. Following Yin (2003, p. 99) suggestions, the use of multiple sources of data increased construct validity because they helped in measuring the same phenomenon using multiple measures. Internal validity relates to the causality of the variables. Essentially, the issue of internal validity did not reflect much in the conduction of the study since the aspect relates to quantitative studies more than to qualitative studies.

3.6.3 Generalizability

Saunders et al. (2009, p. 158) external validity. Generalizability of seeks to identify whether the data can be applied in other study settings. Essentially, generalizability relates to the selection of the study population and sample, data collection procedures, interpretation of data, and the development of conclusions. The study ensures generalizability of data through selecting a broad population from which to draw the sample and articulating clearly the methods used in the collection and analysis of data. Further, triangulation of data helps in easing the process of interpretation to offer generalizable conclusions.

3.7 Ethical Concerns

Several ethical concerns are associated with qualitative methods of data collection. Specifically, researchers using qualitative methods should adequately address confidentiality, anonymity, informed consent, and privacy. The study will ensure confidentiality of the information through effective storage. All the raw data gathered will be stored in safe cabinets and password-protected computer folders to avoid unauthorized access. Further, the study will ensure the anonymity of the respondents and cases using pseudonyms. Therefore, each cases under investigation will be assigned the title CASE STUDY or DS (Demolition Site) while the respondents will be identified by their positions only (Project Manager, Foreman, and Quantity Surveyor). The researcher will seek informed consent from the respondents prior to the conduction of the interview. The respondents will sign a form indicating their consent to offering information to the researcher to avoid conflicts. Lastly, the researcher will reaffirm that the respondents have a right to ask for a copy of the interview and the results to avoid misquoting or misrepresentation.

3.7 Chapter Summary

The chapter outlined the methods, techniques, and beliefs adopted in the process of data collection and analysis. Specifically, the study uses an interpretivist philosophy based on a case study strategy. Further, the study uses an explanatory view in analysing the study question. Inductive qualitative approach is applied for the maintenance of subjectivity in the collection of data. Based on the case study strategy, the chapter shows that the research relies on data triangulation with interviews, direct observations, and documentation forming the main sources of data. Further, the chapter has shown the rationale for applying a manual process of analysis relying on condensing the interviews into short understandable themes and statements. Lastly, the chapter has reviewed some of the issues related to the credibility of qualitative studies. Notably, the chapter shows that triangulation of data helped in the acquisition of credible information. The next section (Chapter 4) presents the analysed qualitative data.

CHAPTER 4: DATA PRESENTATION AND ANALYSIS

4.0 Overview

The chapter offers the data acquired from the different sources of information. As noted earlier, the analysis and presentation of data relies on the condensation of the interviews to triangulate them with the information acquired through the other techniques.

4.1 Results from the Case Studies

The initial aim of the interview entailed identifying the reusable and recyclable materials found in the construction and demolition sites. Direct observations led to the identification of six different types of recyclable and reusable C&D materials: plastic, paper, timber, metal, glass, and concrete. Additionally, direct observations from the construction and demolition sites showed that many sites did not recycle or reuse plastics to any notable level. An interview with the Project manager on Case Study 2 explains the reasons why the sites did not recycle plastics at the sites. According to the interviewee, the current on-site technology did not allow for recycling of plastics.

> "The major problem in recycling plastics relates to technological capabilities. Currently, we cannot afford the facilities and equipment for recycling the small quantities of waste plastics produced at the site"

Additionally, the Foreman in the site stated that reused and recycled plastics were of low quality and could compromise the quality of the construction. Most notably, the Project manager in Case Study 2 indicated the economic side of recycling plastics. According to the interviewee, the site considered budgetary controls as a crucial factor in deciding whether to recycle plastics. The manager stated,

> "The transportation of materials to the recycling plants adds to the operational costs. The current budget does not allow us to rely on the Sharjah recycling plant, which is the nearest."

The manager noted that the recycling facility was far away from the site and the technology capacity at the site could not allow recycling. Consequently, the interviewee observed that transporting the materials to the recycling plant would add to the costs incurred in the construction since the project owner would cater for the transportation. Therefore, the site has often relied on landfills located nearby for the disposal of the plastic waste. The Foreman in Case Study 3 indicated that the quantity of plastic waste generated on-site could not offer economic benefits to the owner and reduced the motivation for reusing and recycling. Additionally, the observer noted that the lack of government transportation for the plastic waste from the sites to the recycling plants reduced the economic value for recycling the plastics.

However, the interview noted that the sites engaged in significant recycling of paper waste. According to the interview conducted on the Project manager in Case Study 1, the project participants have high environmental awareness and understand the benefits of recycling and reusing waste paper. According to the Manager, the site has consistently used recycled cardboard generated through collaboration with private recycling companies in the vicinity. Additionally, the Foreman in Case Study 2 indicated that the site relied on recycled cardboard sourced from local suppliers. The Foreman noted that the site consistently collect the recyclable cardboard and allow the local recyclers to buy for recycling and sell and a reduced price. Consequently, the Quantity Surveyor in the site supported the Foreman by noting that the reliance on recycled cardboard reduced the overall costs associated with the acquisition of new materials.

The Case Study interviewees also unanimously agreed that timber was one of the most recyclable wastes in the sites. The Project Managers in Case Study 1 and 3 and the Foreman in Case Study 2 reported the relative ease of reusing and recycling timber.

> "Although timber is relatively environmentally unfriendly, we understand the benefits it can offer through recycling. We intend to chop the waste timber and use it as mulch for landscaping."

According to the interviewees, the site management intended to chop the waste timber materials and use some of it in landscaping. Additionally, the Quantity Surveyor in Case Study 2 noted that the project aimed at reusing some of the waste timber in the construction of the building's inner fittings and roofing felt. However, the respondents also agree that the recycling of waste timber materials had insignificant economic effects on the project's budget. However, the respondents, including the on-site workers, agree that recycling timber reduced the environmental burden of waste disposal.

The interviews indicate that the sites rarely reuse or recycle glass at the sites. The Foreman in Case Study 1 stated,

> "We rarely recycle glass because the process of recycling involves sophisticated technology. The waste has little reusability at the site because we require glass in specified dimensions."

According to interviewees with the on-site workers in all the Case Studies, glass waste emanated from cutting glass to size and breakages during transportation. The Project Manager in Case Study 3 noted that reusing glass on-site did not have any economic benefit despite acknowledging the environmental burden glass waste caused. The Foreman and Quantity Surveyor in Case Study 3 reported that the project did not cut glass on-site. Instead, the company relied on the supplier who cut the glass to the required measurements provided.

Therefore, the Foreman notes that the use of glass in the site did not pose significant environmental concerns, although it increased the costs.

Direct observations and interviewee results from the case studies also reveal a high propensity towards the recycling of metal waste. The recycling and reusing of metal waste related to the economic benefits. According to the Quantity Surveyor in Project 1 and 3, the site did not consider metal as a waste in the site. The Quantity Surveyor in Case Study 3 stated,

> "Metal is not a waste in the site. We prefabricate it for reuse in other areas."

The respondent indicated that the site reused even the small pieces of metal through welding them together for the construction of fittings. According to the Project Manager in Case Study 2, the reuse of metal had a significant economic benefit, besides the environmental benefits. The interviewee observed that the site saved approximately 10% of the costs required in the acquisition of metals. The project Manager stated,

> "Metal waste on the site is the most reusable product. We associate recycling of metal with economic benefits because it helps in cutting the costs of acquiring new materials. We have a prefabrication section where the small pieces are reassembled and welded together for reuse."

The on-site workers in Case Study 1 also noted that they were required to assemble the metal waste and deliver it to a special location within the site from where welders would mould them together again. The Project Manager in Case Study 1 indicated that he required the Foremen to recycle the metal waste to reduce the overall costs of purchasing metal because suppliers maintain high prices. Therefore, the results indicate a unanimous consensus that reusing and recycling metal has a significant effect on the overall cost of construction.

Most notably, the interviewees showed the trends in the recycling of concrete and the difficulties encountered. From direct observations, concrete was one of the least recycled materials on the construction sites. According to the Quantity Surveyor, in Case Study 3, the calculations for concrete required in a construction often adds 5-10% extra concrete to cater for the wastage. The Project Manager in Case Study 3 reported that the on-site technology and capabilities could not afford the recycling of concrete. The Manager stated,

> "We acknowledge the benefits achievable from recycling concrete. However, the current technology at the site does not allow effective recycling of concrete. Much of the concrete waste is taken to the local landfill. Some contractors have also asked permission to collect the waste to recycle it for their use. We consider it a financial advantage because no costs will be incurred in the collection and transportation of the waste."

According to the interviewee, the project transported all the waste to the nearby landfill. However, The Quantity Surveyor in Case Study 3 reported the benefits of recycling concrete the contractor had considered prior to starting the construction work.

> "Initially, it was though that recycling would not be feasible at the site. However, the contractor brought in machinery and equipment that have facilitated in reusing waste concrete. The move has helped in saving costs of acquiring new materials, as well as reducing the burden on the environment from construction waste."

The interviewee noted that the contractor in the project had an on-site crusher to recycle any waste concrete. Therefore, the project was acquiring financial benefits from the recycling and offered environmental benefits since it did not take the waste to the landfills.

Further, the interview prompted the rationale behind recycling among the interviewees. The prompting aimed at identifying the benefits the respondents associated with the recycling of C&D waste at the sites. The interviewees maintained consensus on the economic and environmental benefits associated with recycling. According to the Quantity Surveyors in Case Study 1 and 3, the environmental benefits associated with recycling outweighed the economic benefits. The Quantity Surveyor in Case Study 2 noted that most waste materials had little reusability and recyclability. Consequently, the project engaged in minimal on-site recycling to avoid escalating the costs associated with the project.

The Project Manager in Case Study 3 stated,

> "We understand the economic and environmental benefits of recycling waste. However, on-site recycling is close to impossible because it increases the costs of production, which contradicts the aims of the contractor."

However, the interviewee indicated responsiveness towards environmental issues and benefits associated with recycling. He reported that the company collaborated with external companies who would collect and deliver the waste materials to recycling plants and others materials to the landfills.

Further, direct observations from the three Case Studies helped to reveal the waste materials considered most for recycling. Across the five sites, the observations showed that on-site recycling was limited to timber, paper, and metal. However, most of the concrete waste was directed to the recycling plant for further recycling. The interview identified a lack of environmental plan in the projects, which limited the sensibility to recycling and reusing materials at the sites.

The last results on the case study involved the observations of the trends in the entry of waste in the Sharjah recycling plant. The observation noted the different materials entering the recycling plant. Notably, plastic and concrete formed the bulk of waste entering the plant. A short interview with one of the workers in the company revealed the benefits of recycling the waste. According to the interviewee, demolition sites contribute heavily to the degradation of the environment. Additionally, diverting C&D waste from the landfills offered an avenue through which construction sites would 1acquire recycled concrete at lower prices. According to the respondent, the recycling plant aimed at reducing the effect of C&D waste on the environment and offering financial benefits to contractors who would acquire recycled concrete aggregate at reduced prices. The respondent stated,

> "The main aim of the recycling plant is to reduce the burden on the landfills across the country. Recycling reduces the amount of waste destined for landfills and increases the availability of lowly priced materials for different construction activities. The low-priced recycled materials such as concrete aggregate and other materials can benefit the construction of roads."

Another respondent in the firm indicated the benefits contractors were drawing from the plant. The respondent stated,

> "We have seen an increased number of contractors acquiring materials from us. The contractors obtain the materials at low cost, which has a financial benefit to their activities. Recycling has significant economic and financial benefits that the industry should not overlook."

Therefore, the interviews show an increased consensus on the environmental and economic benefits drawn from recycling. However, most responses show that the industry players consider the financial benefits they would draw from the activities despite environmental benefits outweighing financial benefits.

4.2 Results from the Demolition Sites

The visit to the demolition sites included direct observations and short interviewees with some on-site workers at the sites. The data collected included the type of construction demolished, waste separation processes, the approximate recycling rates, salvage costs of reinforcing bars, the opinions of the project staff. Additionally, the visit also investigated the challenges encountered with dealing with the waste. Table 1 provides an overview of the condensed results from the interview and direct observations from the four sites visited.

Table 1 Summary of Results from the Interviews and Observations at the Demolition Sites

	Demolition Site 1	**Demolition Site 2**	**Demolition Site 3**	**Demolition Site 4**
Site Details	Three residential blocks of six-storey high	Four residential blocks of seven-storey high	Two residential blocks and a school playground	Four residential blocks of nine-storey high
Waste separation	- Inert waste (concrete blocks) - Heavy metals (reinforcement) - Non-inert wastes (timber and furniture)	- Inert waste - Non-inert waste	- Inert waste - Non-inert waste The demolition company invited recyclers to collect electricity cables, furniture, metals (aluminium, steel, and copper). The contractor sent fluorescent bulbs for treatment prior to disposal in landfills	The contractor separated individual wastes into separate categories. The wastes included concrete, plastering, paperboard, metals, and cement packaging bags. However, the contractor considered concrete the most beneficial waste from the demolition.
Recycling rate	- Almost 10% of the concrete blocks sent to the recycling plant - 100% reinforcement waste recycled	- Nearly half of concrete waste recycled locally - All reinforcement waste recycled by local companies and contractors	- Approximately 10% of the concrete recycled for high-quality recycled aggregate - All reinforcement sold to local contractors	- All concrete recycled by the demolition company in the production of low-priced concrete blocks
Salvage costs	- AED 4/Kg of	- AED 4/Kg of steel	No information offered	No information offered

of reinforcement bars	steel reinforcement - AED 2/Kg of mixed steel	reinforcement - AED 2/Kg of mixed steel		
Opinion of project staff	- Uneconomic because of the high costs of labour in sorting - Space constraints for the recycling tools and equipment - Additional environmental pollution from diesel-run equipment	- Uneconomic because of high costs of labour	- Uneconomic because of high costs of labour	- Timber the most environmentally unfriendly material - Prefabrication of steel economically beneficial to contractors - Direct labour in sorting reducing economic constraints - Economically viable through production of other beneficial products such as concrete blocks
Challenges to recycling	- Costs of labour - Ineffective sorting - Highly damaged and unrecyclable waste	- High labour costs - Inappropriate technology - Lack of incentives	No information offered	No information offered

The results show the acknowledgement of the financial benefits associated with recycling. However, the results also indicate the perceptions on the costs associated with recycling. The high costs of recycling materials deter many contractors from engaging in consistent recycling to avoid the escalation of costs.

4.3 Learning Points from the Results

The themes emerging from the results help in the identification of some trends related to recycling of waste in the United Arab Emirates. Essentially, most of the learning points relate to the hindrances from the realisation of benefits of recycling.

1. Limited space at the sites constrains effective sorting and separation of waste
2. Demolition of buildings in the urban and residential areas is limited by time since the clients want the debris to be removed as fast as possible to avoid creating a public nuisance
3. Cost is the most essential factor in determining whether to recycle materials. Knocking down constructions is the quickest and cheapest way of demolition. Additionally, the waste is delivered to the landfills or recycling plants fully mixed to avoid incurring costs of sorting.
4. Inadequate technology ate the sites reduce the capability of recycling materials on-site
5. Lack of adequate recycling facilities instigate the reliance on landfills
6. Quality requirements hinder recycling of some products such as concrete at the site
7. Lack of standards governing the use of recycled materials hinder their use
8. Contractors avoid recycling some materials to avoid further burdens on their budgets

4.4 Chapter Summary

The chapter has presented the results for the data collected from the case studies. The data entailed results acquired from direct observations, interviews, and documentation. Essentially, the data shows a consensus on the benefits that construction companies could draw from recycling waste. However, the data also shows the hindrances to the realisation of the goal. The next section will discuss the results in relation to the literature review to help in understanding whether the benefits are perceived throughout the UAE.

CHAPTER 5: DISCUSSION

5.0 Overview

The chapter discusses the results in relation to the literature review. Essentially, the chapter discusses the results based on the objectives set in Chapter 1. The chapter includes an overview of the practices and trends in the UAR construction industry, the challenges associated with the recycling of C&D waste, and the benefits of recycling C&D waste. The discussion aims at identifying the congruence of the current trends with the trends established in the literature.

5.1 Practices in the Construction Industry

The studies portray a common trend in the construction industry. Essentially, the trend observed is similar in most countries in relation to the generation of C&D waste. The construction projects produce the same types of waste. Most significantly, the interviews and direct observations show that concrete, timber, metal, glass, and paper are the commonest construction and demolition wastes. As reported in the interviews, the current on-site technologies do not allow the recycling of most waste. Technological capabilities are only found in the recycling plants such as the one in Sharjah. Consequently, the waste accumulates at the construction sites before being delivered to the landfills.

As suggested by Al-Hajj and Hamani (2011), the UAE construction industry has experienced significant growth over the last couple of years. The rapid growth has resulted in increased waste generation at the construction and demolition sites. The generation of C&D waste relates to both behaviouristic and technical issues. Technical issues identifiable in the study include the inefficient processes in the construction projects. The behaviouristic issues include the attitudes towards the recycling of waste. As the interviews suggest, some of the respondents do not consider environmental gains from recycling as a motivation for recycling waste. The observation portrays consensus with the current body of research, which has largely concentrated on the economic benefits achievable from the recycling of R&D waste. The broad categorization suggested by Osmani et al. (2008) relates to the factors that Al-Hajj and Hamani (2011) identified. The authors identified processes such as procurement, handling, operations, and culture as the main factors contributing towards the generation of waste in the industry. The behaviouristic issues identified include the culture and attitudes towards recycling and the dedication of the government to recycling waste materials. The technical issues include the operations, procurement, and handling procedures established at the sites. The study confirmed the existence of both behaviouristic and technical issues in relation to recycling of construction and demolition waste in the UAE.

The generation of C&D waste is attributed to different stages of the construction as the interviews report. According to Al-Hajj and Hamani (2011), C&D waste emanates from the processes of procurement, operations, handling and the culture established among the contractors. The interviews confirmed several of the processes. The initial trend observed is the lack of take-back schemes in the procurement stage. Take-back schemes involves the suppliers taking back the excess materials that they supply. However, in many construction projects, the schemes do not exist. As observed, contractors usually require 5% more concrete to cater for the wastages. However, this does not necessarily mean that they will consume the extra 5%. The excessive concrete means that the workers are susceptible to the feeling that they have adequate materials to cater for even the waste. Consequently, they rarely observe best practices associated with construction leading to the wastage of the excess materials.

Additionally, the construction industry can be said to be suffering from poor supply chain management. As observed from the interviews, the contractors face challenges in the collection and delivery of the waste to the landfills and recycling plants. Essentially, the assertions from the interviews show that the supply chain is loosely integrated where every unit conducts its activities individually. Consequently, the collection and delivery of waste materials faces challenges because the contractors have to cater for the transportation of the materials.

Further, the responses showed a significant problem in the handling of materials in many construction industries. As noted in the review of the literature, handling is among the chief contributors towards the generation of C&D waste. The generation of waste from handling relates to glass waste. As identified, much of the glass waste originates from breakages during transportation and cutting. Cutting glass requires careful handling and appropriate technology to minimize the amount that goes to waste. However, many construction sites lack appropriate technologies for handling glass. Further, the process of demolition of structures leads to significant problems related to glass waste. From the observations, few demolishers engage in the process of deconstruction identified in the literature review. The inappropriate methods of demolition that involve the destruction of the whole structure at once has led to significant problems in relation to waste accumulation. The accumulation of glass waste may also be attributed to inappropriate or skilled labour.

Further, the handling of the deconstruction materials create problems in the construction industry. As noted from the demolition site observations, many demolishers do not sort the waste completely before sending it to the landfills or recycling plants. Essentially, the demolishers associate the process of sorting with increased operational costs. Consequently, the contractors may conduct the sorting partially to avoid some of the associated costs. However, the ineffective sorting means that the waste reaches the recycling plants in mixed form, which complicates the process of recycling. Consequently, the trend may justify the low rates of recycling observed from the demolition sites with many demolition sites having only 10% of the waste recycled. Additionally, the handling of waste at the construction sites leads to complexities in the recycling of the materials

The industry also suffers from a culture of the lack of incentives for the recycling of wastes. As observed earlier, the contractors manage the collection of the waste. According to the responses, the government does not offer incentives for the collection of the waste. Consequently, the contractors do not treat the collection and efficient disposal of waste as an obligation. Additionally, operations also limit the industry's capability of recycling R&D waste. As identified in the responses, the project managers require the contractors to complete the projects within the stipulated budget and time. Consequently, the budgetary and time constraints mean that the contractors may not engage in the recycling of waste to ensure that the projects are completed within time. Additionally, the budgetary constraint mean that the projects cannot include an on-site recycling section because of the high costs of technologies required for effective recycling. Therefore, the contractors have to rely on local subcontractors who collect and deliver the materials to the landfills. However, the interviews observed that the delivery could face delays, which could be attributed to ineffective communication between the project participants.

5.2 Challenges Associated with Recycling of R&D Waste

The interviews led to the identification of several challenges associated with recycling of R&D waste in the construction and demolition sites. The challenges vary in terms of their complexity. First, the projects analysed face challenges related to time and space limitations. As observed, the projects have limited space from where to set up recycling sections. Recycling of materials such as concrete requires heavy machinery, which demands sufficient space for effectiveness. However, most of the projects are within the urban centres in which space constraints limit the capability of the projects to recycle concrete. Additionally, time constraints make the recycling of materials from demolition sited hard. As observed from the responses, many project owners require quick removal of the waste to necessitate the utilization of the space for other projects. Consequently, the contractors find it hard to establish on-site recycling plants.

Second, the industry faces challenges related to technological capabilities in the recycling of the waste. As indicated in the interviews, many local contractors do not have the requisite technologies for recycling R&D waste. Essentially, the technologies associated with recycling of concrete and other materials are highly expensive. Unlike metals, concrete requires crushing for its reuse in other processes. However, the interviews suggested that the small pieces of metal require only fabrication through welding for their use in other light-duty uses. The cost of the technology discourages the contractors from engaging in on-site recycling of wastes such as concrete despite concrete being the largest contributor towards C&D waste.

Further, the study identified challenges associated with the quality of the recycled materials. First, recycled materials such as metals cannot be reused for heavy-duty purposes. Consequently, their economic value reduces once they are recycled. Second, the stringent requirements for the strength of the high-rise structures investigated may render recycled concrete ineffective. As observed in the literature review, recycled concrete aggregate has lower quality in terms of porosity, which contribute to differences in the water absorption capabilities of the materials. Third, the rigidity and inflexibility of the waste management practices in the country also act as a challenge in the recycling of materials. The country maintains strict requirements for the quality of the materials used in construction. As Kennedy (2013) observes, the industry has inflexible building codes that render the utilization of recycled materials in the construction of high-rise buildings irrelevant. Additionally, the United Arab Emirates lack effective legislation and guidelines for the use of recycled materials. Consequently, the rigid requirements mean that the contractors are restricted to using recycled materials for a number of processes, which means they have to acquire virgin materials. Consequently, this discourages them from engaging in effective recycling because the materials may be rendered useless for their projects.

Additionally, many contractors compare the costs and benefits of recycling to determine the course of action. Essentially, the costs associated with recycling and the limited perceived benefits act as a challenge in the recycling of the construction and demolition waste in the United Arab Emirates. The problem of the costs affects demolition more than it affects the construction sites. As observed earlier, many demolitions involve the knocking down of the whole structure rather than selective and systematic demolition. As the interviews reported, destruction of the structures as a whole acts as the easiest and cheapest way of demolition. Therefore, cost and benefits considerations affect the recycling of C&D waste significantly. Many contractors avoid the recycling of several forms of wastes to avoid constraining their budgets.

Fundamentally, the issue of recycling construction and demolition waste relates to labour costs. According to the results acquired from the demolition sites, the respondents identified labour costs as one of the challenges they face in their quest for extensive recycling of waste. In many cases, manual sorting of materials is required for their ultimate recycling. However, the manual sorting is labour intensive, which means increases the overall cost requirement for the recycling process. Additionally, some waste materials may require expensive chemical treatment, which increases the overall cost of the project cost. Therefore, the contractors evade the recycling of such materials for profit maximization.

Other than the labour costs and costs of technologies, the industry suffers from the risk of increased costs from the transportation of the waste to the recycling plants. As identified by some interviewees, much of the recycling in the country relies on the recycling plant in Sharjah. However, the distance from the projects to the plants increases the costs of transportation. Additionally, some of the interviewees considered that the environmental damage caused by the transportation exceeded the benefits they could acquire from the recycling of the materials. The combination of the transportation costs and the lack of incentives for recycling leads to the reliance on landfills located nearby.

The results also show a challenge associated with the extent of damage and quantity of the waste. As identified in the interviews, the amount of waste generated at the sites may lack economic benefits when compared to the resources used in recycling. For example, some contractors, project managers, and workers claimed that the projects produced small quantities of metals, which could not justify the costs of recycling. Additionally, the damage caused to some materials pose challenges in their recycling. For example, the respondents observed that the recycling of glass on-site was challenging because the damage caused rendered the waste inappropriate for recycling. Consequently, this accounts for the trend identified in the literature review concerning the limited recycling of glass in the construction industry.

5.3 Trends in the Recycling of Waste in the UAE

The trends established from the interviews portray significant consensus with the trends established in earlier studies. The types of C&D wastes identified are similar to the ones previous researchers observed. Kennedy (2013) identified fine aggregate, coarse aggregate, cement, and steel as the main waste materials in the construction industry. Further, Kennedy (2013) asserts that construction and demolition waste account for the largest bulk of waste around the globe. The results identified concrete as the major waste product from the construction projects in the UAE. Essentially, concrete encompasses fine aggregate, coarse aggregate, and cement. Further, the study identified other wastes from the industry including plastic, paper, timber and metal. However, the results acknowledge the insufficiency of the materials such as plastics from the industry and their benefits from recycling. Further, the direct observations helped in the identification of the materials that qualify for recycling at the sites, as well as the materials that end up in the recycling plants and landfills. From direct observations, the study identified papers, timber, and metal as the commonly recycled materials in the UAE. Essentially, the inadequacies in the recycling of materials such as concrete at the sites relate to the lack of environmental plans in many of the sites as observed.

The recycling of waste materials in the UAE faces the challenges identified earlier. However, some of the contractors and project managers acknowledged the benefits associated with the recycling of materials. Based on the technological incapability, the recycling of all materials at the site becomes hard. However, the interviews show that environmental awareness among some project owners, managers, and contractors has led to the recycling of materials such as metals and paper. Indeed, the interviewees confirm an earlier observation that paper was most commonly recycled R&D waste at the construction or demolition sites. Observations from some of the projects led to the confirmation of the study by Kennedy (2013) concerning the high rate of recycling of metals and papers. As identified in the direct observations and interviewees with the stakeholders in the demolition sites, much of the reinforcement metal was reused and recycled. Further, interviews confirmed that paper from cement wrappings was highly recyclable. Some of the project managers identified the use of cardboard from recycled paper as a major motivation towards recycling because of its cost-effectiveness.

However, the study refutes other studies that suggest that timber is an effective and unsuitable material for recycling. According to the interviews, many participants observed that timber was the most suitable candidate for recycling. Essentially, timber can be converted to many other usable products despite their low economic value. For example, one interview suggested that they intended to chop the timber for use as mulch in landscaping. Additionally, large chunks of timber can be used in the production of some of the inner fittings that require timber. Therefore, the study shows that despite timber being environmentally unfriendly, it can be reused for environmental benefits since the recycling does not lead to significant economic benefits.

The most pressing issue in the construction industry in the UAE relates to the recycling of concrete. As observed earlier, the poor quality of recycled concrete aggregate coupled with the rigid building code complicate its use in the construction of new high-rise structures. According to the study by Elchalakani and Egaali (2012), reusing and recycling concrete waste from construction and demolition sites requires processes such as crushing, which have cost implications on the contractors. Additionally, previous studies have identified the lower physical characteristics of recycled concrete aggregate. Although Elchalakani and Egaali (2012) identify the introduction of modulated technologies that allow recycling of concrete into bricks and tiles, the study did not identify such a trend in the UAE construction industry.

Specifically, only one of the investigated cases incorporated concrete recycling within its plans. As mentioned earlier, the recycling of concrete has high financial implications that discourage contractors from engaging in its recycling. The high costs of recycling concrete coupled with inadequate space and technological requirements has led to limited recycling of concrete at the sites. Additionally, the excessive concrete procured at the start of the projects create laxity in the minimization and recycling of waste. Additionally, the presence of landfills in nearby locations within the municipalities provided an escape route from the rigorous process of recycling. In essence, all the respondents observe cost implications as the most significant factor that discourages the recycling of concrete.

The same trend was observed from the demolition sites. Although some of the sites involved selective demolition, the results observed low rates of recycling and reusing concrete. Essentially, most of the sites separated the waste prior to transporting the bulk of it to the landfills. Some of the sites cited additional environmental concerns related to the recycling of concrete through diesel-run equipment. However, the demolition sites identified had some use of the recovered concrete. Although the overall economic benefits of the recycled aggregate concrete are low, some of the sites send the materials to local recyclers who produce low-priced bricks.

The other trend identifiable from the project relates to the choice of the materials for recycling. Fundamentally, the comparison between the construction and demolition sites portrays significant differences in the trends of recycling. Therefore, the several observations were made regarding the trends of recycling based on the type of project, cost-effectiveness, project timeline, and availability of space at the site, market for the recycled materials, and contractor experience or capability. According to direct observations, demolition projects produce larger amounts of waste as compared to construction projects. As observed, most demolition sites were residential. According to Al-Madeed et al. (2012), the demolition of residential building produces concrete and steel as the main waste. However, construction projects produce lesser amounts of concrete, but larger quantities of glass and metal cuttings. Therefore, the recycling processes in the two types of projects differ as observed in the interviews and direct observations.

Further, the interviews observed differences related to the availability of space at the construction sites. According to previous studies, material recovery is easy in sites that have adequate space. For example, some respondents observed that they had set a fabrication section for the recovery of metal waste. Additionally, the availability of space eases the process of sorting and storage of the waste in preparation for transportation to the recycling plants. Therefore, the unavailability of space at most construction sites may act as a barrier towards recycling.

Differences related to the market for the materials were also observed. The differences have a significant impact on the motivation to engage in recycling. As observed, many projects consider the recycled materials as low quality. The low quality of the recycled materials in combination with the stringent building code in the country make the recycling of many of the materials close to impossible. For example, the market for timber is low considering the attitudes towards timber as an economically unfriendly building material. Therefore, projects involving high-rise buildings may shun the materials that have a low market.

The cost-effectiveness of the processes also acts as a determinant in the processes of recycling. As discussed earlier, contractors consider the cost-effectiveness of materials as compared to the costs of hauling and disposing of the materials. Essentially, the costs of accessing the landfills are lower compared to the costs associated with recycling. Therefore, the study observed differences among the interviewees in relation to the fate of the waste. Specifically, projects located far from recycling plants consider transporting the materials to the nearby landfills as a cost-effective method of dealing with waste. However, if the costs of disposal are higher than the costs of recycling, the contractors recycle the materials. For example, the collection, sorting, and recycling of plastic is highly cost-intensive considering the low amounts produced per project. Consequently, contractors consider the nonselective methods of material collection and disposal in the nearby landfills.

Differences in project timelines were also identified as a factor affecting the recycling of materials. Comparably, the demolition of a site is expected to take a short duration to facilitate the construction of new sites. Conversely, the project managers in construction projects may relate quality to the time taken to complete their projects. Summarily, the recycling of materials at demolition site is rare because of the timeline between the start and the termination of the project. The time constraint means that much of the waste is taken to landfills as observed in section 4.2. On the same note, the experience and capability of the contractor may also determine whether he or she engages in recycling. Essentially, the construction industry in the UAE is in the nascent stages, which means that many local contractors do not have adequate experience in the recycling of C&D waste. Consequently, the inexperienced contractors choose landfilling rather than recycling.

5.4 Benefits of Recycling

The ultimate objective of the study was to assess the impact of recycling construction and demolition waste in the UAE. Previous studies identified the main benefits three categories of benefits associated with recycling C&D waste: social, economic or financial, and environmental benefits. Therefore, the interviews were also structured in a way that could identify the benefits in terms of those variables.

5.4.1 Social Benefits

Earlier studies have established the social benefits or social costs in the construction industry. As Taher (2013) suggested, waste has significant social costs because it threatens the existence of human life in terms of food production, land use, and health among others. The construction industry has a significant effect on the social dimensions of the UAE population. According to the study results, much of the construction and demolition waste ends up in the landfills established by the municipalities, although some companies engage in limited recycling. The increased number of projects in the UAE has led to an explosion of the C&D waste and increased strain on the existent landfills. Consequently, some municipalities have expanded the landfills to cater for the increasing waste from the industry. Subsequently, the increasing encroachment of landfills poses significant health concerns in the UAE. Essentially, the C&D waste that ends up in the landfills has a significant amount of dust and several other hazardous materials. The materials may lead to health costs, especially when the dust is blown from the open-air landfills. Additionally, the encroachment of landfills limits the amount of land available for the social purposes, for example, construction of social amenities.

Although the respondents did not indicate their involvement in illegal dumping, direct observations near the sites identified significant amounts of illegally dumped materials. As Taher (2013) observes, illegal dumping of C&D waste has a significant impact on biodiversity, water resources and agriculture. Essentially, the lack of government transportation for C&D waste has led to irresponsible behaviours in dumping non-biodegradable wastes such as plastics. According to the interview results, the construction sites engaged in minimal recycling of plastic waste because they lacked technological capabilities. Additionally, the small quantities of plastics from the construction sites had insignificant economic benefits. Consequently, the waste was rarely collected meaning that the waste littered the environment. Unfortunately, some of the litter ends up in water bodies, especially for the projects near the sea. Consequently, the plastics, which may contain significant amounts of hazardous materials, may affect the biodiversity in the sea.

Therefore, the recycling of C&D waste has significant social benefits. Fundamentally, the recycling of C&D waste means that little of it will be taken to the landfills. Additionally, transportation of the non-biodegradable wastes to the recycling plants can mitigate the concerns regarding the effect of waste on biodiversity and health of the population. The observation echoes the findings by Al-Hajj and Hamani (2011) relating to health and improvement of health. Additionally, the maintenance of clean environs at the site through effective recycling strategies has a significant impact on the social well-being and health of the workers. Further, the recycling of construction and demolition waste improves the public image of the involved companies since the community considers them as considerate towards the society. The observation from the interviews portray consensus with the findings from Al-

Hajj and Hamani (2011) who observed that recycling enhanced the corporate image of the involved companies.

5.4.2 Environmental Benefits

The interviews identified the environmental consciousness among many respondents. C&D waste has significant effects on the environment. Consequently, the issue of sustainable construction has emerged as a priority for several contractors. As observed in the literature review, construction and demolition waste may contain hazardous waste that contribute to the greenhouse effect on the environment. Additionally, the choice of materials used or recycled has a significant impact on energy efficiency of the buildings, which relates significantly to the environment. According to Saravana (2011), recycling and sustainable building aims at the protection of the environment. The environment issues associated with C&D waste can be classified as “operational”, “incorporated”, and “transport-related.” The incorporated concerns emerging from the responses include emissions arising from the waste dumped irresponsibly. Operational environmental concerns relate to the operations at the construction sites that cause increased pressure on the landfills. The transport-related environmental concerns include the issues of increasing environmental pollution through the transport of the materials to the landfills and recycling plants.

According to the interviews, the environmental benefits associated with recycling outweigh the economic benefits obtained. Therefore, the observation shows that many projects engage in recycling because of the benefits it has on the environment. Earlier studies indicated that recycling reduces environmental effects related to transportation, extraction, and processing of the raw materials. According to some interviewees, the transportation of the materials to the landfills and recycling plants exacerbates the environmental effects because of the pollution emanating from motor vehicles. Additionally, the extraction and processing, as well as transportation of some raw materials has a significant effect on the environment. For example, concrete or aggregate is obtained from quarries, which lead to the destruction of land resources. Essentially, the dereliction of land is considered as a form of pollution. Therefore, the utilization of recycled concrete can help in reducing the reliance on virgin concrete, which, in turn protects the environment from dereliction. Further, recycling of C&D waste, especially from demolition sites, can mitigate the pollution of water bodies that comes from leachates. The demolition waste contains products such as paints, which may contain lead and other heavy metals. The metals could leach into underground water sources causing pollution and negative consequences of the communities relying on the water sources. However, the recycling of such the materials derived from painted walls may help in mitigating this problem. Essentially, the study confirms the observation from diverse studies that environmental benefits associated with recycling of C&D outweigh the costs of recycling.

5.4.3 Economic Benefits

Despite the costs associated with recycling C&D, the study confirms the existence of economic benefits of recycling. Earlier studies suggest that recycling reduces the costs associated with disposal and acquisition of new materials. Additionally, recycling may be essential to cost recovery especially for the projects that resell the recycled materials to contractors involved in other construction projects. According to the interviews, some of the contractors reuse waste concrete to cut the costs of acquiring new concrete. Additionally, one interview suggested that they sell the waste materials to local recyclers to recover some of the project costs. Al-Hajj and Hamani (2011) identified cost saving as one of the main motivations for recycling in the UAE construction industry. The same observation was made in the current study. For example, the results show that the recycling of timber through chopping and landscaping using it would reduce the costs associated with acquiring materials for landscaping. Additionally, one interview observed cost savings of approximately 10%

emanating from the recycling of metal waste. The study confirms earlier observations that on-site recycling leads to the avoidance of costs associated with the collection and transportation of materials. Further, recycling of C&D wastes reduce external costs such as disamenity costs, which include the impacts of noise, odour, and dust from the landfills used for the disposal of C&D waste.

However, the study observed the traditional reservation towards recycling based on the economic benefits. As suggested in many interviews, the environmental benefits outweigh the economic benefits. A combination of factors makes recycling of materials economically ineffective. As reported in the results, the process of recycling requires expensive technology and equipment, which, ultimately, increase the costs of the projects. Consequently, the increased costs may dissuade contractors from recycling some of the materials. However, environmental consciousness has led to a change in attitude towards recycling by contractors. The trends in recycling identified in the results show that the contractors engage in recycling to reap long-term economic benefits. For example, the building of a good reputation would ensure the longevity of the company in the market. Therefore, recycling of waste in the industry may not relate to the short-term benefits, but to the long-term benefits.

5.5 Chapter Summary

The chapter aimed at discussing the results from the interviews and direct observations in relation to the literature review. The chapter has identified the trends in the UAE construction industry in relation the type and "quantity" of waste produced. The results portray consensus with previous studies that concrete is the main waste product in the industry. Further, the discussion has shown that the challenges identified in previous studies continue affecting the industry. Minimal changes have occurred in the trends of recycling in the country with contractors considering the cost-effectiveness of the materials as the most significant determinant of recycling. However, the study also acknowledges the existence of benefits of recycling as identified from the interviews. The benefits identified fall into social, economic, and environmental benefits. Essentially, the environmental benefits outweigh the economic benefits. The next section concludes the study by highlighting the main points learnt. Additionally, the study will offer recommendations for practice that could change the current trend in the UAE construction industry. Further, the section will highlight the main limitations of the study and offer suggestions for future studies.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.0 Overview

The chapter entails an overview of the main ideas garnered from the qualitative case study conducted. Other than the conclusion, the chapter also offers recommendations for practice, as well recommendations for future research based on the limitations identified.

6.1 Conclusion

The paper examined the impact of recycling waste in the UAE construction industry. Alongside, the study investigated the sources of waste and trends in the recycling of waste in the country. The study relied on interviews with several stakeholders in different construction and demolition projects, as well as direct observations into the sites. The study draws several conclusions based on the results acquired. First, the main types of construction and demolition waste in the UAE include concrete, timber, metals, plastics, and paper waste. Concrete contributes the largest bulk of the waste. However, the type of project determines the amount of concrete waste produced. On this note, demolition projects produce more concrete waste than construction projects do. The main causes of waste in the industry relate to material handling, operations, culture or attitudes, and procurement. Many contractors acquire an excess amount of materials to cater for the waste. Consequently, this creates complacency in the use of the materials since many workers lack awareness of the implications of the waste created. Additionally, some onsite operations increase the amount of waste generated from the projects. Other indirect causes of waste identified in the study include lack of legal regulations on dumping of waste, as well as lack of incentives that would motivate the recycling of materials.

Further, the study identified a number of challenges that make recycling of C&D waste in the UAE difficult. First, projects face time and space limitations since the storage of waste and recycling equipment require additional space. Project timelines in which the project managers aim at completing their projects within the stipulated budgets and timeframe also restrain recycling in the country. Secondly, technological capability at the sites limit the recycling of the waste materials. Technological capabilities relate to the perceived costs associated with the recycling of waste. Third, the study identified the quality of recycled materials as a factor that dissuade contractors from recycling some of the materials. As identified, recycled materials show significant quality dissimilarities with virgin materials. Consequently, contractors may evade recycling materials such as concrete to maintain the quality standards established. Fourth, the rigidity of the building code in the country in conjunction with the low quality of recycled materials make the use of recycled materials in some types of construction projects impossible. Fifth, the study identified costs associated with recycling as a challenge. Essentially, all project managers and contractors aim at completing their projects within the stipulated budget. Therefore, adding recycling requirements would increase the overall costs of the project. Additionally, recycling is labour intensive and discourages many contractors because it increases the overall costs of the project. Further, the transportation of the waste materials to the recycling plants is associated with an increase in the costs of the projects because there lacks government transportation for such waste.

However, the results indicated a notable trend in the recycling of waste. The study observes that the materials that require complicated technology dissuade contractors from recycling. However, materials such as metal require straightforward techniques such as welding for complete recycling. Further, materials such as timber can be converted into other usable forms without much complication. However, five factors were found to affect the choice to recycle the materials: availability of space at the site, market for the materials, project timeline, type of project, and the experience of the contractors.

However, the study identifies a number of benefits associated with recycling. The benefits fall under social, environmental, and economic categories. The social benefits relate to the impact recycling has on the improvement of the standards of living of the people in relation to health and other social matters. Further, the social benefits include building a reputation for the involved companies in the society. The environmental benefits relate to the reduction of pollution and land dereliction. Further, the benefits include cutting emissions associated with the excavation and processing of raw materials for the construction industry. Lastly, the economic benefits identified include cutting costs of acquiring virgin materials, costs of dumping, and costs of transporting the waste to the landfills.

Summarily, the study draws the following conclusions.

1. There exists an adequate body of literature concerning the sources of C&D waste and the benefits of recycling the waste.
2. Project processes such as procurement, handling, operations, and attitudes lead to the production of waste in the UAE construction industry.
3. Indirect causes of increasing amounts of waste from the industry include the lack of government incentives to contractors who choose recycling waste and, as well as the absence of effective legislation controlling dumping of C&D waste.
4. The UAE has limited regulations on dumping, which has led to a dumping culture justified by the high costs associated with recycling of C&D waste.
5. The main C&D waste produced in the UAE construction industry include concrete, metal, paper and timber.
6. The recycling of concrete is rarely done at the construction sites.
7. Factors such as costs of recycling, quality of the recycled materials, technological requirements, and time constraints affect recycling at the construction sites.

8. Recycling has long-term economic benefits including the creation of a positive reputation for the company.
9. The environmental benefits of recycling outweigh the economic benefits, but they are often overlooked in the industry.
10. The low rates of recycling of C&D waste relate to the inadequate awareness among the contractors regarding the environmental effects of the waste.
11. Appropriate use of recycled materials in the UAE construction industry is at its nascent stages and requires further investigations.

6.2 Recommendation for Practice

Based on the findings of the study, several recommendations would benefit the industry. The recommendations relate to the role of the government in recycling, as well as the role of other stakeholders involved in the industry. The recommendations would increase the rate of recycling of the waste. The government has a central role in ensuring the embracement of recycling in the country. First, the government should increase regulations on dumping of waste in landfills. For example, this could include increasing the amount of fees for dumping recyclable waste such as concrete and paper. Further, the government could offer incentives to contractors who incorporate the recycling of materials from their projects. The incentives would instigate an additional number of contractors to recycle waste at their projects. Further, the ministry responsible should seek to create flexible regulations regarding the use of recycled materials in the construction projects in the country. The government could also establish temporary recycling plants in the areas considered to have a high growth of construction projects. The recycling plants could offer subsidized prices for recycling of the materials, which would motivate higher rates of recycling. On the strict side, the government could create laws requiring all contractors to conduct on-site recycling to reduce the amount of waste transported to the landfills. Further, the government could provide subsidized prices for the transportation of C&D waste to the recycling plants to motivate a culture of recycling in the rapidly growing construction industry. The local municipalities could also consider incorporating requirements for C&D recycling in offering permits to contractors.

The government could fund research on the technologies that relate to the recycling of waste materials in the industry. Further, this could be followed by offering subsidies that offset the costs of the new materials introduced in the industry. The subsidies would quicken the embracement of the materials for mainstream use. Lastly, the government could create testing sites in which experimental buildings using recycled materials would be tested. The government could also liaise with private organizations including banks to offer loans to contractors to purchase the equipment and machinery required for the recycling of materials at the construction sites.

The project managers also have a significant role to play in increasing the rate of recycling in the industry. First, the contractors should include C&D recovery within their project plans. The option relates to the demolition sites in which some of the recovery options may be lost if not considered during the planning of the project. For example, the plans could stipulate the method of demolition to maintain the integrity of the reusable materials such as doors, wall panels, ceiling panels, and other fittings. Further, the project managers could include recovery requirements in the project specifications given to the contractors. The inclusion of recovery requirements in the project's objectives would ensure the commitment of the contractors to the practices. The project managers could make the contractors and sub-contractors to stipulate their strategies for material recovery at the pre-qualification stage. The plans would help the contractors and subcontractors understand their responsibilities in ensuring the recycling of the recyclable waste. Additionally, this would help in holding the contractors and subcontractors accountable for their activities.

Contractors should also seek educational and training opportunities to understand the most effective recycling or recovery methods. Essentially, this would help the contractors in planning their work and evade the excessive costs associated with sorting of the waste at the construction sites. The effectiveness in sorting would make the recycling process easy for the contractors. The rapid changes in the global view of the environment mean that the contractors will be forced to conduct intensive recycling of materials ultimately. Consequently, the contractors should seek early opportunities in the acquisition of the technologies requisite for recycling of C&D waste. Additionally, the contractors require a paradigm shift in their attitudes towards the quality of recycled materials. The change in the attitude would help in the embracement of different categories of waste materials in the construction projects if the building codes were made more accommodating. Additionally, the contractors could store the timber used in one project for use in subsequent projects. For example, timber waste can be used as pegs for survey work in construction sites.

Other general recommendations to the stakeholders in any construction project include.

1. Ensure the design team and the client share the same goals for environmental protection.
2. Selecting contractors and subcontractors who portray capability of reducing waste and engaging in effective waste recovery
3. Involving the main contractor early in the design and planning phases of the project
4. Require the contractors to estimate the quantity of waste the projects would generate to anticipate the amount of recyclable materials and budget for their recycling.
5. Hold pre-construction meetings early to educate the workers about the benefits of material recovery

6.3 Limitations and Recommendations for Future Studies

The study faced a number of limitations associated with the methodology used. First, the qualitative methods used in the study expose data to subjective generalization since the data collected entails the opinions and perceptions of the respondents. Additionally, small samples used in qualitative case studies exposes studies to lack of generalizability. Consequently, the study may have low reliability and credibility. However, the study concedes that the triangulation of interviews with direct observations helped in mitigating the issues related to generalizability, validity, and credibility of the data. However, the construction industry in the UAE is highly dynamic because it is in the phase of rapid growth. Therefore, the industry has undergone a massive transformation compared to the available studies cited. Additionally, the study concentrated on projects in the areas with a high growth rate of construction projects and limited recycling facilities. Consequently, the data provided could be different for other locations. Consequently, future studies could consider some of the following recommendations.

1. Future studies could increase the sample size and include projects located in areas with a low growth rate. In essence, this would help in comparing the recycling practices in the areas with a high demand and those with a low demand for housing. Further, the sample could include residents in areas with a high housing demand to identify the impact of recycling and landfilling on the society.
2. Future studies should also investigate material selection in the industry and its impacts on the recycling processes.
3. Additionally, an additional number of case studies could be incorporated to increase the volume of information, which would increase the reliability of the data.

6.4 Chapter Summary

The chapter has concluded the study through highlighting the main points garnered from the study. Additionally, the chapter has offered a number of recommendations that relate to the roles of the different stakeholders in the industry. The section also highlighted the limitations associated with the methods used in the study and offered several recommendations for future investigations.

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