Utilization of Industrial Waste in Construction Industry

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Acknowledgements

Abstract

Background: Waste material from industrial processes are harming the environment and ecology of the planet. Therefore, construction industry is looking for different ways to incorporate waste materials in buildings so as to decline the amount of landfills.

Aim: the aim of this research study was to assess the significance and extent of utilising industrial waste in construction industry.

Method: in order to answer the research question, the work has utilized quantitative methodology wherein surveys were conducted among the professional from construction industry. A total of 75 participants from different construction organizations in the UAE has been selected to take part in the survey. Using descriptive analysis, the results and discussion has been carried out.

Results: the results of the study inferred that construction industry is currently no sustainable completely. The major benefit of utilising waste in construction industry is linked with its cost effectiveness and compliance with the governmental policies regarding green building and sustainable environment.

Keywords: *Waste utilization, construction industry, industrial waste, waste management, green buildings, and sustainable construction*.

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Chapter No. 1 – Introduction

1.1. Outline

There are considerable quantities of waste that are produced on earth as a result of human activities approximating over 2,500 million tonnes in a year that involve agricultural and industrial wastes from urban and rural societies. According to one of the articles published on the World Bank Data (2022), it is demonstrated that only municipal solid waste of the globe is more than 2 billion tonnes yearly with at least 35 per cent of this waste is not managed in manner that is safe for the environment. At the global level, the average waste generated by an individual is 0.74 kilograms in a day, however the range may not be illustrating significantly high figures in comparison to the population of the world, and countries that have high- income tend to generate over 600 million tonnes of the total waste. As a result, the planet is experiencing serious problems with respect to its environment, landfills, flora and fauna.

In previous decades, the progress in technology and industry, because of the modern lifestyle, had led to a crucial rise in the type and amount of waste being produced. Moreover a number of researches have agreed that the waste problem is accumulating yearly across the globe. By-products such as slag, bagasse, brick dust, rice husk ash, cement dust, tires, glass, sludge etc. are the wastes of agriculture and industries. The problem of waste indicates a major problem for the earth's atmosphere for the reason that it is creating pollution in the air, water and land which emit toxic chemicals along with dumping in the landfills, rivers, quarries and oceans. It is difficult to capitalise on waste due to its variety along with its unknown properties (Barbuta et al., 2015). Taking a glance at the environmental news and research studies, it is noticed that the topic of

environmental sustainability has become a significant problem for the earth with respect to natural resources and waste.

One of the main causes of depletion of nature is linked with improper practices of managing and disposing of wastes. In accordance with the studies of Khan et al. (2018) and Onat and kucukvar (2020), a major role in global warming and environmental pollution is played by the construction industry leading to a number of natural disasters as well including forest fires, tsunamis and floods. Therefore construction industry has been blamed for environmental and social challenges. The industry of building material is the domain of interest for utilising wastes and studies have attempted to produce newer means of construction where wastes can be incorporated. The latest version of the construction is developing theories that are aligned with the goals of bringing sustainability to the environment (kylili and Fokaides, 2017). Thus, the focus is given on utilising industrial waste in the construction field.

Under the consideration of the fact that cement is responsible for almost 7 per cent of the emission of carbon dioxide (CO2) globally i.e. more than 1.5 billion tonnes of CO2 into the environment, in preparing concrete, the dosage of the cement can be reduced by utilizing additions of mineral (Naik, 2008; Lehne and Preton, 2018). This strategy is potential of contributing to the protection of the environment with the help of preserving the energy and consuming the extensive quantities of wastes. In this regard, some of the building materials are obtained totally from wastes, for instance green materials. As Howe (2011) mentioned that the novel concept of green buildings industry is likely to achieve. However use of technologies of obtaining green materials is limited despite its availability.

The construction industry can become the principal users of wastes in the process of obtaining products or materials for building highways, bridges in hydraulic construction, in stabilisation etc. considering environment and nature depletion, extensive waste utilisation in construction industry has been recommended greatly (Luhar and Luhar, 2019), though some of the specific wastes materials can be too risky for utilisation.

According to Belpoliti et al., (2018) it is noticed that one of the biggest challenges in the industries in the UAE is waste management. Construction industry produces large pile of wastes particularly in countries like UAE where construction takes place in large scale. Need for technologies are persistent in the construction industry for utilising waste in proper and efficient manners (Tam et al., 2020).

1.2. Rationale

Economic growth of the country is based on how well its industries are flourishing and generating more business. When it comes to business Huang et al (2018) have indicated that certain sectors are fundamentally important for boosting the economy; construction industry is one such sector. It is this industry that plays a great role in developing and making infrastructure of the country. As world is becoming global village, it is very important for a country to hold an infrastructure that supports both import and export freely. With the advanced processes, waste is also producing in increased quantity. This era has also changed the living pattern of most of the people which is also contributing directly or indirectly towards increasing the waste on this planet. In accordance with one of the news recently published which inferred that more and more people are moving towards cities for changing their life style and achieving better quality of life while seeking new opportunities to succeed (El-Kholei and Al-Jayyousi,2018; Ehteshami,2020). This leads to more construction in turn leading to cause waste which is why there is an urgent need for introducing

newer ways that can utilise waste. Process of recycling, thus, in general is also pacing in every industry. Whether it is fashion industry or consumer goods industry, every sector is attempting to bring recycling and up cycling in their processes in order to reduce their carbon footprints on earth. Since buildings are already on earth and its construction process is capable to decontaminate the environment.

This research is looking at UAE's construction industry for the reason that it is noticed in the studies: high air pollution is recorded among GCC countries due to the reason that more and more people are moving towards urban areas (such as Zmami and Ben-Salha, 2020). It is significant that sustainable practices of construction in UAE must be introduced since it is increasing the amount of carbon dioxide is emitted yearly. As per the approximation, the volume of total solid waste generated in the Abu Dhabi Emirate was more than 11 million tonnes in 2019 (Waste Statistics Annual Yearly, 2018.) while in 2018 the volume of solid waste produced by Abu Dhabi was more than nine million tonnes (Statista.com. 2022) – showing a constant increase in the waste production with the increase in urbanisation.

While initiatives and policies are introduced in the region for dealing with the problem of waste management, the literature has lack of evidence specifically targeted on UAE. With the help of this research, the importance of utilising waste in construction industry will be enlightened. Moreover, this research is also significant and justified as it helps emirate in fulfilling the goals that the country and state are publicising with respect to sustainability and waste management. For instance, municipality of Dubai has declared establishing the largest plant in the region to convert solid industrial waste into energy with the aim of reducing landfill by 75% by 2021.

1.3. Aim and Objectives

The significance of utilising waste from industries into the construction industry of the UAE. In order to achieve this aim, the following objectives of the research need to be achieved:

- To comprehend the properties and attributes of waste materials from industry to be used in the construction of UAE.
- To study about the different categories of waste and the change they encounter when combined with material of construction.
- To designate the level of awareness of regarding economic and environmental advantages of recycling waste materials.
- To make recommendations to utilise industrial waste in to achieve sustainability in construction in UAE.

1.4. Research Question

The research question of this study is as follow:

- What are the significances of using industrial waste in construction industries?
- What are the challenges of using industrial waste in construction industries?

1.5. Overview of Research Methods

The main goal of this topic is linked with performing a thorough study on utilisation of waste materials in construction industry that industrial sector produce. The methods of research involved

in the study include primary and secondary collection of data via review of literature and survey questionnaire as per the need of the individual objectives.

For understanding the industrial waste materials along with their utilisation in construction industry, literature review has been used. Moreover literature review is also used as the research method for the objective related to comprehend various types of waste products and its changes when combined with materials of construction. However to achieve the objective of gaining the level of awareness of waste recycling with respect to advantage of economy and environment, primary data collection has been utilised where survey questionnaire has been performed.

1.6. Structure of Study

The structure of the study is similar to standard and generic dissertation consisting of 5 interconnected chapters for completing the study effectively.

Chapter 1 – Introduction

In the first chapter, as its name depicts its sheds light on the overall outline and all the fundamental aspects of the research by going through the aim, objective, rationale and the challenges stated.

Chapter 2 – Literature Review

After setting the clear direction of the study, this study portrays the empirical evidences from authors and researches. This information assists in building arguments to support or contradict the findings.

Chapter 3- Methodology

This methodology chapter can be considered as the blueprint of the study where numerous research and data gathering methods are used to attain the data that is useful for the thesis. The objectives of thesis are mainly addressed by the methodologies.

Chapter 4 – Result and Findings

Once the collection of data and methodology are drawn, all the data gathered in chapter 3 is summarized. Examining the studies and analysing the literature review helps with the findings of the study and to attain the result.

Chapter 5- Conclusion and Recommendation

The last chapter of the research aims in summarizing the study and suggesting recommendations on utilization of industrial waste in construction industry of UAE. This chapter also shows the constraints encountered during the research and the need for further research.

1.7. Significance of Study

Waste material is one of the major environmental issue in the present era which is a threat to human and wild life (Otakulov, Abdullayev, and Sultonov, 2021). It is significant to reuse these waste material rather than disposing them off. Waste could be utilized in the construction industry in two essential ways: through reusing the components and recycling the components which includes processing the waste in the raw material which is utilized in producing the materials for building (Kishore and Gupta, 2020). The most significant advantage which is associated with the industrial recycling is that it puts lesser strain on the resources of earth by getting the ways that can help in reusing or recycling the industrial waste. When the by-products or the waste of the industry is used

in important and productive things like construction, it not just reduced pollution but also the need for producing newer raw materials.

There are always huge costs that are associated with disposing off the material which goes unused along with the commercial by-products (Dvorkin, Dvorkin, and Ribakov, 2015). Through looking for the ways to recycle or recuse the waste, the expenses of the industries could be reduced along with the costs for construction industry as cheaper raw material can now be used in construction of big structures (Otakulov, Abdullayev, and Sultonov, 2021).

The business that follow environmental friendly process are always recognized by the people and build good reputation for themselves. When an industry or a construction business strives for becoming sustainable, the social benefits of the industrial recycling can also be anticipated. It represents a commitment for the future of the entire community which can easily turn into a competitive advantage over the rest of the market place (Kongar-Syuryun et al., 2020). The manufacturing industries in the present era and the construction industry have long carried the stigma of being environmentally-unfriendly but now it is high time to test and implement new ways of using waste in construction and become sustainable.

When waste does not get dumped appropriately, it can run issues in the future which will need money and time to get resolved. (Dvorkin, Dvorkin, and Ribakov, 2015) When the waste management practices are introduced, the business could be run in more efficient ways and the resources can be allocated to the new initiatives for growth rather than a disaster response. The federal, state and local government need numerous waste practices for the safety of the community and the concerns for the environment. Such requirements can vary between the industries on the basis waste different operations can be created (Kishore and Gupta, 2020). The accountable waste

management can facilitate the operations to comply with the regulations and the prevention of the penalties for the future (Otakulov, Abdullayev, and Sultonov, 2021).

The building material industry has recently remained as an interesting domain for utilizing the waste and the researchers have given their best for the production of new construction materials that consist of wastes. The creation of new building materials is under development on the theories that align with the environmental sustainability. Lately, environmental sustainability has turned into a significant problems from the natural resources and that of wastes (Kongar-Syuryun et al., 2020). The building materials and construction sector are engaged in both the process the building industry is considered as one of the biggest user of waste material along with the amount of wastes that comes from the demolition of constructions.

The concrete is becoming a further interesting material in building for the reason that it possesses improved characteristics in construction alongside being able to combine with different types of wastes. The presence of fibres or/and additions is also critical to be researched since it can improve the concrete's' performances while allowing smaller quantities of cement to be used (Dvorkin, Dvorkin, and Ribakov, 2015). Green materials are also developing due to research in the field of using different waste materials in the concrete to obtain new types of mixture suitable for green construction processes. The category of green construction mainly involve inorganic polymer concrete obtained principally from the waste materials of industries. Therefore, research into introducing waste in construction material such as powder or filler is very important for achieving sustainable procedure in construction industry (Kishore and Gupta, 2020). In this regard, concrete is one type of material in building that may be incorporate with many types of industrial waste such as fly ash, silica fume, glass, tires, cinder, husk, etc., which are evaluated and explored in this research papers (Otakulov, Abdullayev, and Sultonov, 2021).

Chapter No. 2 – Literature Review

2.1. Introduction

A literature review is considered as a survey of research evidences the offers comprehensive overview of information regarding a specific topic. A collection of most reliable and important publications is included in the literature review so that readers will get appropriate proves about a topic based on the past researches (Okoli and Schabram, 2010). In literature review, the main arguments and ideas are summarised and synthesised of the existing knowledge without amalgamating any new information. Being established on present knowledge, literature review

provides wheels to the researchers to run their own research in an effective manner (Jesson et al., 2011).

This literature review begins with providing generic information regarding some the evidences of industrial waste used in the construction industry. Later on, in this chapter, more detail information is present that helps the reader to develop an understanding regarding what type of industrial waste are largely produced that can be reusable in the construction industry. In last, literature review offers a brief implementation of the researches and design recommendations for construction industry on how to successfully integrate these practices to develop a sustainable environment.

In order to effectively carry out literature review, a total of three databases are selected to bring the relevant research articles, including PubMed, Google Scholar and Scopus. There are 7 research articles selected to include in this literature review following a thorough analysis of the existing research evidences. Following are the themes that are observed from the selected research articles.

2.2. Review of Literature

2.2.1. Commonly Available Industrial Waste

2.2.1.1. Quarry Dust

Quarry or rock dust are actually granite fines which are generated as by-products during concrete aggregates development by rock crushing. Quarry dust is not able to be mixed in the normal concrete mixes due to its high fineness. Moreover, it increases the water content demand and subsequently the demand of cement in order to improve the strength and workability (Bahoria et al., 2013). However, one of the potential reasons of utilizing the quarry dust is its low cost and easy availability. There are many studies which have compared mortar paste and concrete mixes with the powder of limestone (Chen et al., 2014). These studies have provided positive results that

when granite fines are incorporated in high quantalities that improves the rheological properties of mixes.

2.2.1.2. Rice Husk Ash

RHA is recognized as a prominent pozzolanic substances which has the ability to be mixed successfully with Portland cement for the development of durable kind of concrete. In this manner, this material is found to be value added technology (Aprianti, 2017). In rich yielding countries, rice husk is widely available as waste product. It has been found that almost 1000 kg of rice can generate 200 kg of RHA. Following the process of combustion, this amount of RHA produces 40 kg of ash (Zerbino et al., 2011). Rice husk is used in industries for generation of power or in the form of fuels for boilers. RHA is found to have high ash content, ranging from 18 to 20%. This high content of ash makes it a valuable ingredient in the supplementary cementing material, especially for developing countries. Higher generation of carbon will be yielded when darker ash will be generated. RHA has the higher composition of pozzolanic characteristics when extended temperatures and increased duration of controlled burning environment is provided to it (Siddika et al., 2021).

In the present days, the main requirement of the construction industries is to produce strong as well as durable building materials that accomplish the needs, suffer devasting forces and control polluted environment. Mixing reactive RHA in cement material has now evolved as a successful recommendation for all the international building codes. Rice husk ash has the properties of high surface area, average size and it is porous in nature as well. Due to the quality of RHA as a pozzolana, it has the required ability to integrate compressive strength to concrete material in initial as well as later phases, specifically in cases, when water reducing substances are added to mixes (Rößler et al., 2014).

When RHA is added to portland cement, it blends much faster as compared to fly ash with the lime during hydration process in cement. This helps in the generation of initial stage strong concrete material and generates calcium hydrate silicate (CSH) gel in the surrounding of cement particles that are found to be porous as well as dense. As a result of this, cement pores are redefined or densified, reducing permeability of concrete material and enhancing its resistance abilities towards the regression of chloride. Much information has already been published regarding the integration of RHA in cementing material, however, chemical and physical materials may differentiate on the basis of climatic condition and geographical location of different countries (Paris et al., 2014).

2.2.2. Motor Development Utilizing Other Materials

In the research conducted by Gowda et al. (2011), self-compacting mortar was developed by utilising local material such as quarry dust and rice husk ash and its strength was studied. This process indicated the partial replacement of sand and cement. Material used were properly characterised and several tests were done in order to assess refinedness, specific gravity, consistency and compressive time for approximately 28 days. Th findings of this research present very potential results in the form of satisfied rheological properties which are according to the expectations. However, the compressive strengths of mixes were less as compared to the initial mixes which became reduced with passing time. But the research is involved in providing an effective approach which possess opportunities for betterment in addition of adequate characteristics flow and strength.

Rashid et al. (2010) in his research established a mortar by using rice husk ash. In the mixes of mortar, ordinary Portland cement (OPC) was mixed with four other types of rice husk ash (RHA) in which varying concentrations of OPC was utilised. Following the development of mortar, compressive strength tests were analysed on the developed specimens. Average results were

accumulated of three samples. In order to determine the porosity, two specimens were casted, involving, 100 mm diameter and 200 mm diameter. These samples were assessed at 7, 28 and 90 days. The findings showed that strength of specimens was slightly reduced at 28 days. Filler effect was produced in mortar due to the integration of RHA as it has fine particle sizes.

In the research conducted by Fontes et al., 2004, potentiality of sewage sludge ash (SSA) was assessed as a mineral additive in cement mortar as well as in high performance concrete. The findings of this research evaluated that SSA had the property to act like a prospective material which could be used as a replacement in the cement related material. The mixtures of mortar that contained 10 to 30% of sewage sludge ash as a replacement material showed potential compressive strength. The high-performance concrete established also had the higher compressive strength. The integration of SSA in OPC enhanced the total porosity and minimised the values of absorption in the mortar mixtures.

Corinaldesi et al. (2010) demonstrated the experimental findings of paper mill sludge ash in their research material by providing their role as cementitious material. The mortar that contained approximately 5% paper mill sludge ash promoted its compressive strength that was considered quite higher as compared to conventional mortar at the day 28. The findings of this research is found to be very beneficial for researchers to carry out further investigation in the use of paper mill sludge ash in concrete as well which can result in the reduction of cornet cost as well as present a successful procedure for the disposal of paper mill sludge.

2.2.3. Production of Building Material Using Industrial Waste

There are many researchers occurred that have explored the utilisation of quarry and ornamental stone wastes for the purpose of cement related building material production such as solid bricks, light weight concrete elements and artificial stones which increases the beauty of buildings. In the

study conducted by Align and Turgut (2008), cotton waste and lime powder were utilized in the formation of bricks. The increasing percentage of cotton waste is inversely proportional to compressive strength and unit weight. Moreover, water absorption also increases to approximately 40% when cotton water replacement is used. On the other hand, the amalgamation of glass powder waste has higher levels of flexural strength as well as compressive strength. This has indicated that this water material has the potentiality to be used in the establishment of new brick material that would be lighter and economical as well.

From the above-mentioned studies, it has been revealed that industrial waste can be used in a variety of ways for the construction industry that leads to the development of sustainable environment and reduces the environmental pollution as well.

Chapter No. 3 – Methodology

3.1. Introduction

Waste material is referred to the one which is rejected, unused and worthless, but in the recent times, it has been discovered that this material can be actively utilized in the construction industry so that the environment is saved. Similar to the previous researches, this research has also emphasized upon the pozzolanic matter that is found in the industrial waste including "Silica fumes, Rice husk ash, Ground granulated blast furnace slag (GGBFS), Metakaolin, Copper Slag, Air Bubble film Rolls/ Bags, Red Mud as mortar, Red Mud as bricks, Red Mud in cement production, Dry Sludge in concrete, fly ash, rock dust and Coal ash in concrete". There is seen an increasing awareness in UAE related to the extensive amount of damage that is caused to the environment because of the accumulation of the waste materials from the plants of industry, colliery pits, power houses, demolition sites and has turned into a major economic, environmental and social issue. Hence this chapter is focused on the manner in which these materials could be utilized in the construction industry along with the road pavements that can majorly help the environment of UAE and the society. This will be followed by making recommendations for the construction that is sustainable for UAE market along with highlighting the main challenges that can be faced and the manner for utilizing pozzolans in UAE construction industry through two main data resources i.e. primary and secondary data sources.

3.2. Research purpose

The reason behind carrying this research s to expand the knowledge base regarding the utilization of industrial waste in UAE construction industry. The waste materials which are very well-known are: "blast furnace slag, fly ash, silica fume (from Power Plants) recycled aggregates (from Demolition sites), solid waste, plastic waste (Domestic waste) and rubber waste (commercial

waste)" and the replacement of cement with these waste material along with pozzolans and some other solid waste can bring significant reduction to the UAE's environmental pollution.

3.3. Research philosophy

As Saunders et al., (2015) defined, research philosophy is linked with the belief of research regarding the collection, analysis, and use of data on a particular topic. At the very beginning stage of the research, it is essential to create a process to be followed before the primary data is collected and analysed. The researcher must select such a research philosophy that complements the study's aim and objectives to achieve those objectives as per the plan. For this reason, the philosophy considered in this study is combined paradigms of inductive and deductive research philosophy which allows investigation from both perspectives, and so allowing researcher to combine hypothesis testing and theory generation within a single study (Jogulu and Pansiri, 2011). Combined paradigms of philosophy is adopted in the study as it is aim to explore the topic qualitatively and quantitatively.

3.4. Research study by objectives

As mentioned in the earlier section this research is collecting and using qualitative data as well as quantitative data, the research type can also be linked with objectives of the study as chapter no. 1 has also discussed briefly. According to types, there can be four research studies in nature i.e. diagnostic research, experimental research, formulative research, and descriptive research study. As this study is linked with exploring why and how waste can be used in the construction industry, best results according to the objectives can be achieved by using descriptive method.

3.5. Basic vs. Applied research

Basic research or pure research is the one which is focused on the advancement of the scientific knowledge for the completion of understanding related to a topic or a specific natural phenomenon,

specifically in the natural sciences or study of waste. In conclusion, when the knowledge is attained for the purpose of gaining knowledge, it is known as basic research (Panday and Panday, 2021). The basic research is wholly theoretical which is focused on the fundamental principles and testing the theories. It is focused on understanding the basic law.

The basic research method deals typically with the formulation and the generalization of the fundamental theories that are related to the behaviour of humans (Flick, 2015). This is aligned with gathering the information which is adaptable universally. Hence the basic research facilitates in adding new knowledge to the one already existing.

The applied research is referred to the research which consists of the application in the real life scearios related to the natural science. It is pointed towards the provision of the solutions for the particular problems and the development of the innovative technology. In simpler terms, it is the method of research which can be applied for the scenarios of real life. It goes through the set of circumstance so as for relating the results to the circumstances which are corresponding.

For the respected dissertation, the adoption of basic research methodology is appropriate as it is gives good explanation regarding the materials – which is an industrial waste material – and the positive impacts it can make in the society and construction.

3.6 Qualitative and Quantitative research

It has been said by Thomas (2006) that a research contains two wide design frames i.e. quantitative and qualitative method. The quantitative research is method is all related to the numbers. The quantitative research is dependent upon the gathering and interpretation of the data which is numeric. It is focused on measuring the numbers and then processing the results (Flick, 2015). The qualitative data on the other hand is descriptive, is showed in the area of language rather than the numeric values. The data analysis that is qualitative explains the information and could not be

counted or measured (Panday and Panday, 2021). It is referred to the labels or the words which are utilized for describing specific traits or characteristics.

The quantitative research method is the most appropriate for this research so that the trend of utilizing the industrial waste in the UAE construction industry can be measured. Under this method, a Likert Scale questionnaire is developed that can quantify the utilization of waste material by the architects of construction industry. So, a survey questionnaire had been created for bringing the quantitative data for expressing the architects opinions and the roles they play towards the utilization of industrial waste matter in the materials for constructions.

3.7 The research design

The research design is referred to the general strategy which is adapted which can be chosen to integrate the various components in a study in a logical and coherent way hence ensuring that the researcher can effectively address the problem of the research, it consists of the blueprint for gathering, measuring and analysing data through specifying population sampling, collection, sampling technique and the final procedure for research.

3.7.1 Data collection

Data collection is referred to the process of collecting and measuring the information in the variables which interest the researchers, in a systematically established fashions which helps an individual to answer the stated “research questions, test hypotheses, and evaluate outcomes”. It is a significant step of research because it helps in specifying the sources for data collection and the how the findings could be linked to the results. The data can then be collected through secondary or primary data sources.

Primary data collection is the best suitable method for data collection in the respected dissertation as it has been discussed in the section of research method that the primary data will eb collected

in this research. It will help in exploring trend for utilizing the waste material in the construction industry by the architects and how the recycling of the material contributes towards a sustainable environment. The data collection through experimentation, surveys and questionnaires is known as primary data collection. The primary collection of data is an essential component of arithmetic study or calculation. This provides authentic, new and adds extra to the information which is currently present. These methods for data collection mandate a good involvement of the researcher for interacting directly with the source audience with the help of telephone or email connection. Primary data collection is the best suitable method for data collection in the respected dissertation as it has been discussed in the section of research method that the primary data will be collected in this research. It will help in exploring trend for utilizing the waste material in the construction industry by the architects and how the recycling of the material contributes towards a sustainable environment.

3.7.2 Population sampling

The population sampling is referred to the process of getting a subset of subjects which are representing the complete population. The sample is required to have enough size that it provides the needed amount of information and data for the completion of primary research. Through this, the individuals who have different meaning and perspectives related to a topic come to a commonplace to share their ideas through the survey. In sampling, a small group of people from the society is selected that represents that have common traits and represent the whole society for the specific purpose i.e. the users of the same product. A sample of structural engineers is selected for this dissertation along with a sample of architects who will form the populations of the study. Architects not just decide the design of the project but also the material which is needed in the construction hence they are selected in the population of this research.

3.7.3 Sampling technique

The research sampling technique is the selection of the individual societal members or a population subset in order to make the inferences that are statistical from this population and estimation of the characteristics that come from this sample population (Taherdoost, 2016). The sampling techniques could be utilized in the survey software of the research in order to get optimum derivation. The sampling for the population is of two types. Probability sampling: 1. Simple random sampling 2. Systematic sampling 3. Stratified sampling 4. Clustered Sampling. Non-probability sampling: 1. Convenience sampling 2. Quota Sampling 3. Purposive Sampling 4. Snowball Sampling. For the respected research, the technique of random sampling could be used for the dissertation for the selection of 20 respondents that includes structural engineers and architects for having their answers.

Using social media platforms, researched communicated with the participants of the study and distribute questionnaire via their email addresses. Prior to take part in the survey, the researcher has acquired their consent and fully informed them with respect to the aim and purpose of the study. Under ethical considerations, the anonymity of the researchers have been maintained throughout the study (Taherdoost, 2016). The survey has been conducted from 75 respondents working in the construction industry with different experiences. Employees of different construction companies were considered to be included in the survey to acquire overall and generalised responses.

3.7.4 Research process

The survey questionnaire for the dissertation clearly depict the utilization of the industrial waste material as another material for input for construction. By analysing the literature thoroughly, researcher gained the knowledge regarding variables in the study thus formulated a questionnaire

using those variables (Flick, 2015). The questionnaire design was close ended questions wherein some of the responses can be given using 5-point Likert Scale while some of the responses can be given using multiple answers' set. To acquire responses from questionnaire, the researcher has designed questionnaire in two major parts; one part acquired the demographic information of the participants while the second part of the questionnaire acquired information related to waste utilisation in the construction industry. The second part of the questionnaire is further divided into three sub-parts wherein first-sub part of the questionnaire inquire about the common types of wastes being produced utilised in the construction industry. Second sub-part inquire regarding the need or benefit of using waste product in construction. Lastly, the third sub-section of the report is aimed at acquiring responses for fulfilling the objectives of the study and assess the trends of construction industry from the lens of sustainability and waste utilisation.

3.8 Data analysis method

The application of the logical and statistical techniques for describing the scope of data, the data structure modularization, data representation condensation, illustration through "images, tables, and graphs, and evaluate statistical inclinations, probability data" and provision of meaningful conclusion is referred as Data Analysis (Nayak and Singh, 2021). The quantitative data, as explained by Downe-Wamboldt can analysed with the help of SPSS software. For analysis of data, descriptive statistics have been considered and frequency of responses are generated and analysed.

3.9. Summary

The chapter has showed the method through which the whole research can be analyse and concluded and consisted of the discussion regarding "research purpose, research philosophy, and research design and research process". The focus of the study remained upon industrial waste and techniques that could be utilised in construction instead of cement so that the waste as well as the

cost is reduced for the construction industry in UAE. So the respondents who have the structural or architectural engineering background had been selected for helping in the collection of data through the methods of primary research that consist of questionnaire for the creation of nominal and ordinal data for meeting the requirements of the research.

Chapter No. 4 – Results and Discussion

Sustainability is one of the goals of the organizations lately so that earth and its environment can be viable for upcoming generations to live. In this regard, waste from different industrial operation is greatly hurling and contributing in increasing carbon footprints. This chapter has analyzed and interpreted the data acquired from participants and related its results from the objectives and research question of the study. The first section of this chapter presented the demographic information about the participants showing their number of experience in construction field, their qualification, and their gender. Afterwards, the responses to questions were analyzed.

4.1. Demographic distribution of participants in the survey

The first demographic question inquire about the gender of the participants in order to analyse the gender distribution of the participants in the survey with respect to its validity and generalizability. The question asked participants: “What gender do you identify as?” to which three options were provided namely; male, female, and prefer not to answer. The gender of participants of the study are given in the figure no. 1 below:

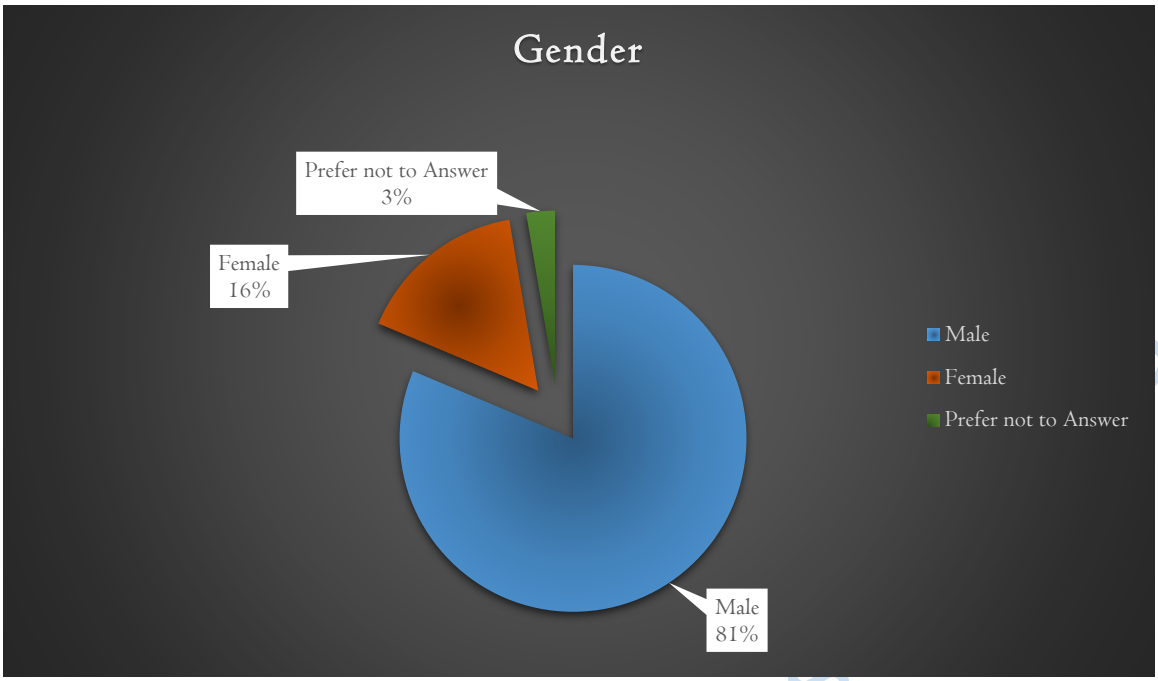

Figure 1: Gender Distribution of the Participants

The above pie-chart is illustrating that majority of the participants in the survey were male while some of participants were female. This can be relate with the fact that dominance of male is present in the construction industry (Dvorkin, Dvorkin, and Ribakov, 2015). Nonetheless, 81 per cent of the participants were male i.e. 61 participants out of 75 participants. 16 per cent of the participants were male i.e. 12 participants out of 75 participants. Only 3 per cent of the participants chose not to reveal their gender i.e. 2 participants out of 75 participants. This shows that most of the answers can be generalize from the perspective of male gender in the construction industry.

The second demographic question inquire about the age of the participants in order to analyse the age distribution of the participants in the survey. The question asked participants: "What is your age?" to which four options were provided namely; 20 to 30 years old, 31 - 40 years old, 40 to 50 years old, and 50+. The age of participants of the study are given in the figure no. 2 below:

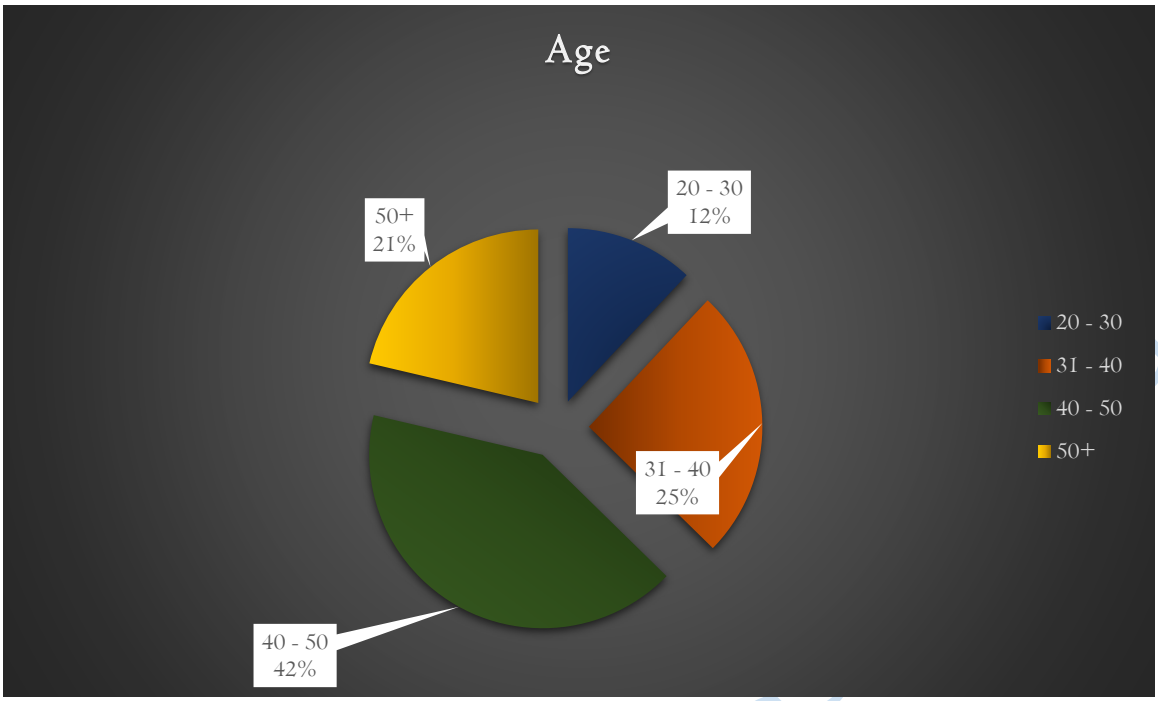

Figure 2: Age Distribution of the Participants

In accordance with the above pie-chart in figure no. 2, it is evident that majority of the participants were either aged between 30 to 40 or 40 to 50. Taking a closer look at the statistics of this question's responses, it is known that 42 per cent of the respondents were aged between 40 to 50 years followed by 25 per cent of the respondents were aged between 31 to 40 years. There were only 12 per cent of the participants who aged between 20 to 30 years while 21 per cent of the participants aged more than 50 years. The distribution of age among respondents of the survey showed that majority of the participants were those who were in the mid of their career of surpassed the middle of their career i.e. have extensive experience while only few of them were in the early stages of their career.

The third demographic question inquire about the qualification of the participants in order to analyse the qualification distribution of the participants in the survey. The question asked participants: "What is the highest degree or level of education you have completed?" to which four

options were provided namely; High School, Bachelor's Degree, Master's Degree, and Ph.D. or higher. The qualification of participants of the study are given in the figure no. 3 below:

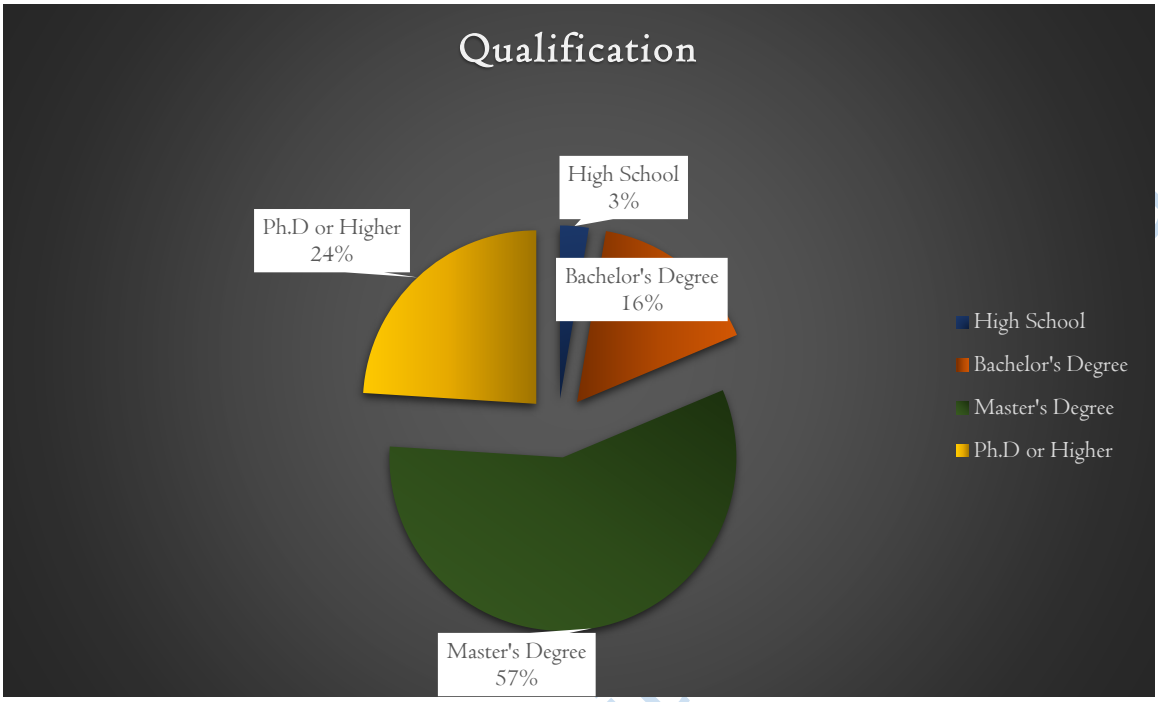

Figure 3: Qualification Distribution of the Participants

From the above pie-chart presented in figure 3, majority of the respondents have Master's degree while second majority of the participants were Ph.D. holders or have higher degrees that master's. Looking at the chart, it can be said that only minor number of participants have just past high school. This chart represents that 57 per cent of the participants i.e. 43 out of 75 participants have Master's Degree which enforces that the responses are credible and acquired from the educated and knowledgeable audiences. Onwards, the chart has represented that 24 per cent of the participants i.e. 18 out of 75 participants have Ph.D. or higher Degree which further enforces that the responses are credible and acquired from the educated, knowledgeable, and scholarly audiences. Only 2 participants has high school degree which is negligible amount while 12 out of 75 participants have Bachelor's Degree. The more educated participants are involved in the survey, the more credible information it possesses.

The fourth demographic question inquire about the years of experience of the participants in order to analyse the experience distribution of the participants in the survey. The question asked participants: “many years of experience you have in construction industry?” to which five options were provided namely; less than a year, 1 to 3 years, 4 to 6 years, 7 to 10 years, and more than 10 years. The number of years of participants’ experience in the study are given in the figure no. 4 below:

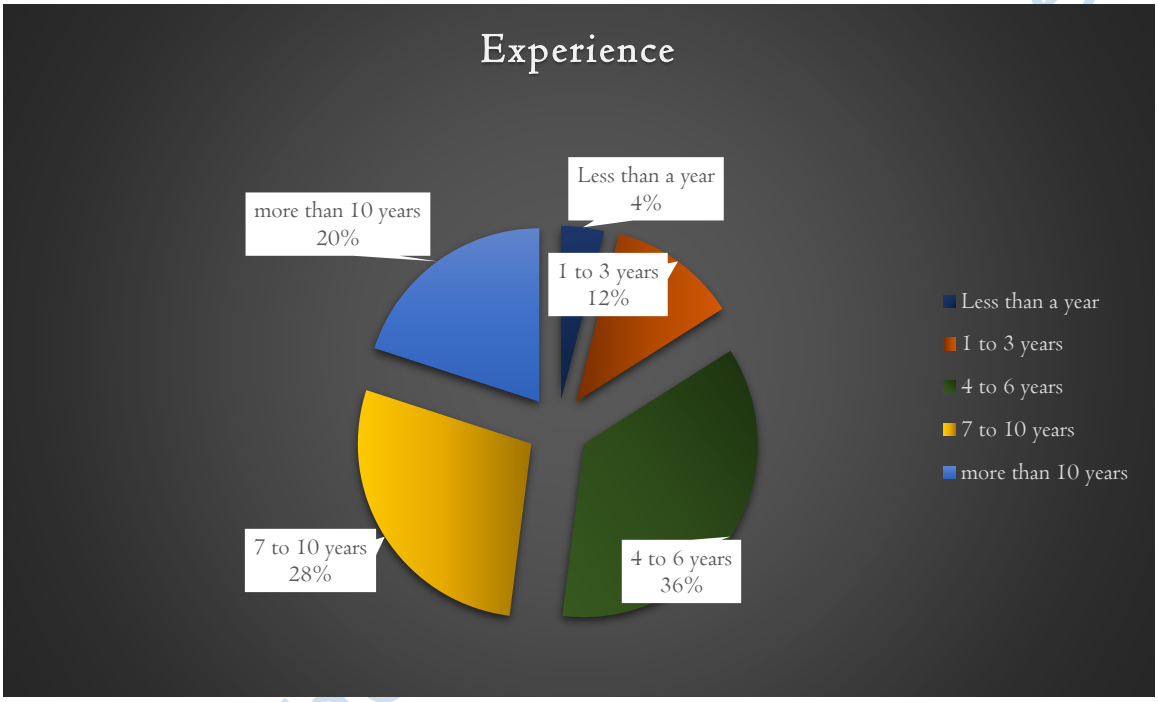

Figure 4: Experience Distribution of the Participants

From the above figure no. 4, it is shown that participants having experience between 4 to 10 years are in majority while participants having experience of less than a year were in minor ratio. Considering the pie chart, 36 per cent of the participants i.e. 27 out of 75 participants have experience ranges from 4 years to 6 years while 28 per cent of the participants i.e. 21 out of 75 participants have experience ranges from 7 years to 10 years. At cumulative level, there are 64 per cent of the participants i.e. 48 out of 75 participants who have experience between 4 to 10 years. 20 per cent of the participants i.e. 15 out of 75 participants have experience of more than 10 years

in the construction industry. Only four per cent of the participants, i.e.3 out of 75 participants have less than a year of experience in the field of construction. Therefore, it can be said that majority of the participant have major field experience which why their responses can be deemed trustworthy and reliable for utilization of waste in the construction industry.

The fifth demographic question inquire about the profession of the participants in order to analyse the profession distribution of the participants in the survey. The question asked participants: "what is your profession?" to which five options were provided namely; structural engineer, project manager, civil surveyor, architect, and charted surveyor. The professions of participants who took part in the study are given in the figure no. 5 below:

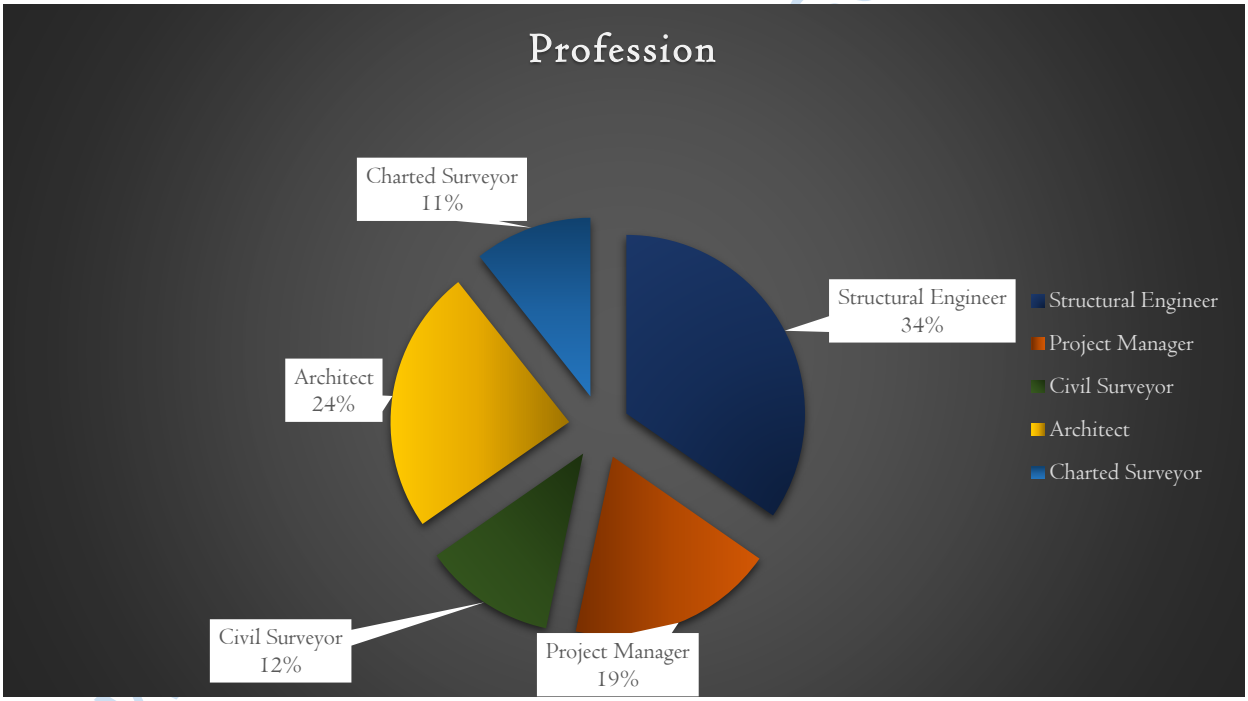

Figure 5: Profession Distribution of the Participants

The above pie-chart in figure no. 5 is illustrating that majority of the participants in the survey are structural engineer while other participants in majority are either architect, project manager, civil surveyor, or charted surveyor. The involvement of all these profession is important in utilizing waste in construction processes. Therefore, involving them in the survey enforces the credibility

of primary findings. As depicted, there are 34 per cent of the participants were structural engineer i.e. 26 out of 75 participants; 24 per cent of the participants were Architect i.e. 18 out of 75 participants; 19 per cent of the participants were project managers i.e. 14 out of 75 participants; 12 per cent of the participants were civil surveyor i.e. 9 out of 75 participants; and 11 per cent of the participants were civil surveyor i.e. 8 out of 75 participants. The distribution of participants with respect to their professions is generalize to some extent.

The sixth demographic question inquire participation of the respondents in waste utilization projects in order to analyse the experience of sustainable projects. The question asked participants: "Have you participated in any projects involving waste utilization in the past two to three years?" to which two options were provided namely; yes or no. The involvement of participants of the study in waste utilization project is given in the figure no. 6 below:

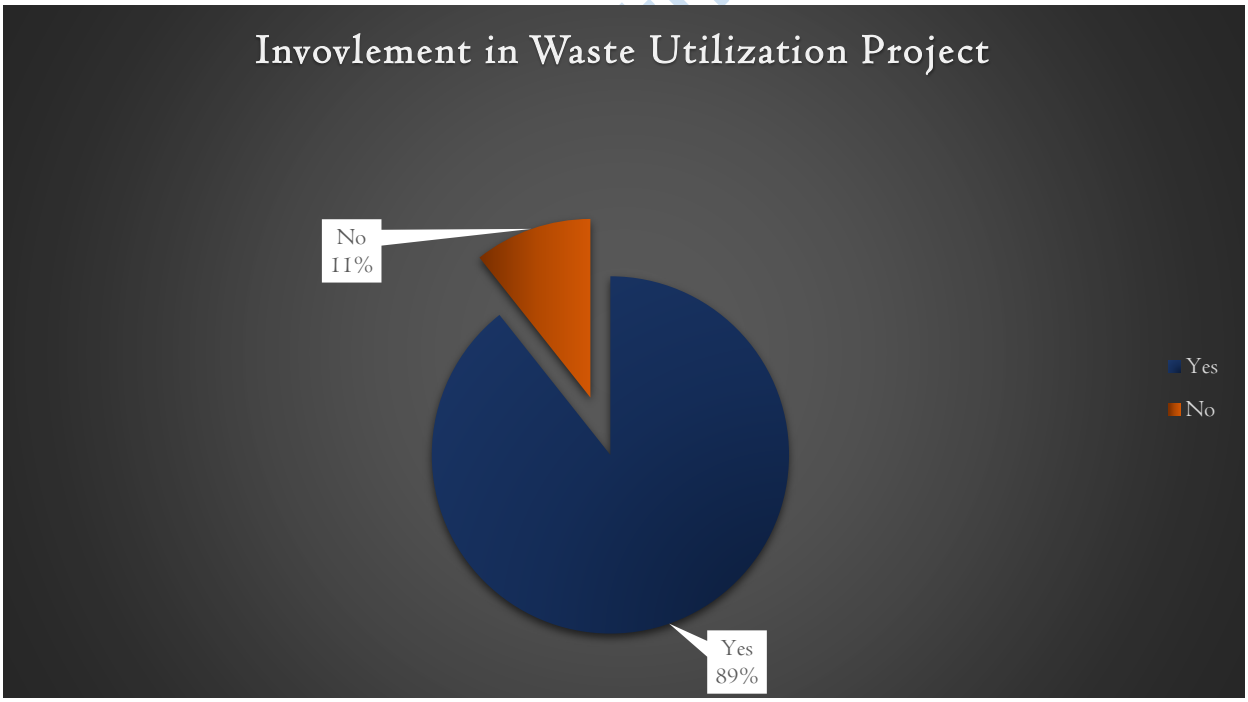

Figure 6: Involvement in Waste Utilization Projects

From the above pie chart, it is quite evident that majority of the participants in the survey has taken part in such construction projects that have utilised waste in building. While only few of the

participants did not taken part in the any such projects. To be precise, the above figure no. 6 illustrates that 89 per cent of the participants i.e. 67 of the participants out of 75 participants have participated in any projects involving waste utilization in the past two to three years while only 8 of the participants out of 75 participants have not participated in any projects involving waste utilization in the past two to three years. This reflects on the credibility of the results' analysis that most of the participants have the experience of working in projects that have utilized waste materials therefore, overall results of the research become credible.

4.2. Questionnaire Responses & Interpretation

This section of the questionnaire asked participants to mark their level of agreement or disagreement to set of statements regarding utilization of waste in the construction industry:

The first statement asked participants to state their level of agreement or disagreement on the statement that construction industry is currently sustainable. The results of responses for this statement is given below in the figure no. 07.

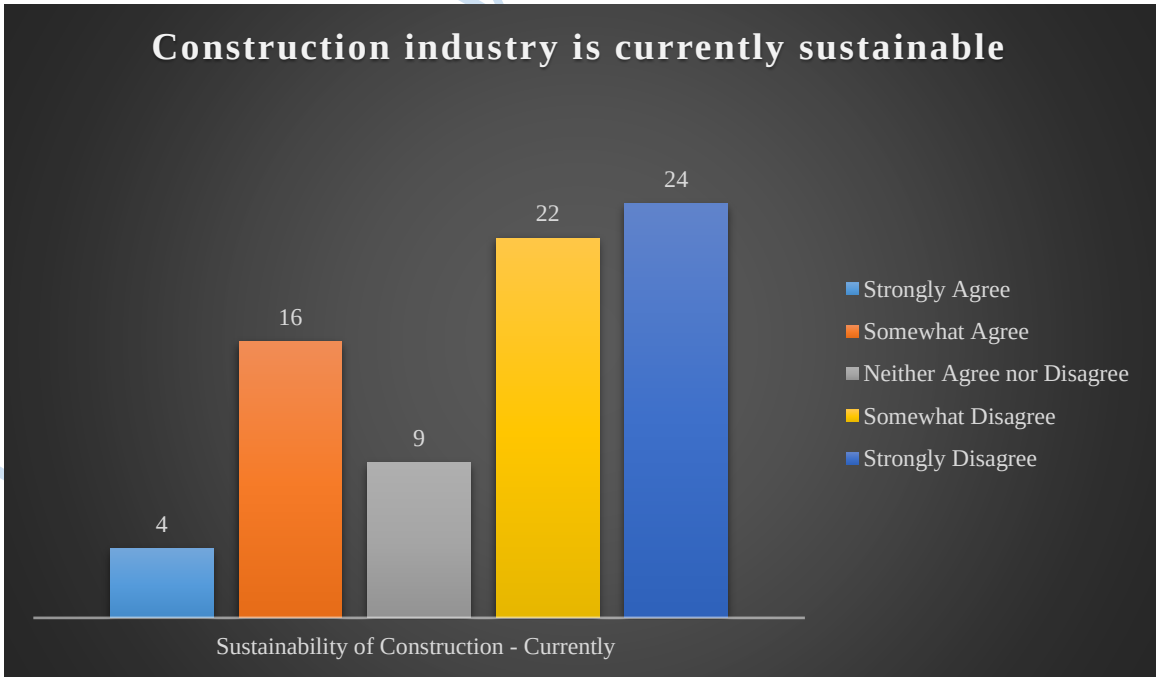

Figure 7: Sustainability of construction Industry – Currently

From the above histogram of the data, it is revealed that majority of the participants in the study were strongly disagreed with the statement that construction industry is currently sustainable while very less number of participants are shown to be agree with the statement that construction industry is currently sustainable. Looking at the statistics, 24 participants out of 75 participants were strongly disagreed that construction industry is currently sustainable; moreover, 22 further participants out of 75 participants were also somewhat disagreed that construction industry is currently sustainable. On the other hand, 16 out of 75 participants were also somewhat agreed with the statement that construction industry is currently sustainable while only four out of 75 participants were also strongly agreed with the statement that construction industry is currently sustainable. Only 9 out of 75 participants were neutral towards this statement i.e. they were neither agreed nor disagreed that construction industry is currently sustainable. The response of this statement implies that currently, construction industry of UAE is not sustainable.

The second statement asked participants to state their level of agreement or disagreement on the statement that Construction industry will become highly sustainable in next 10 years. The results of responses for this statement is given below in the figure no. 08.

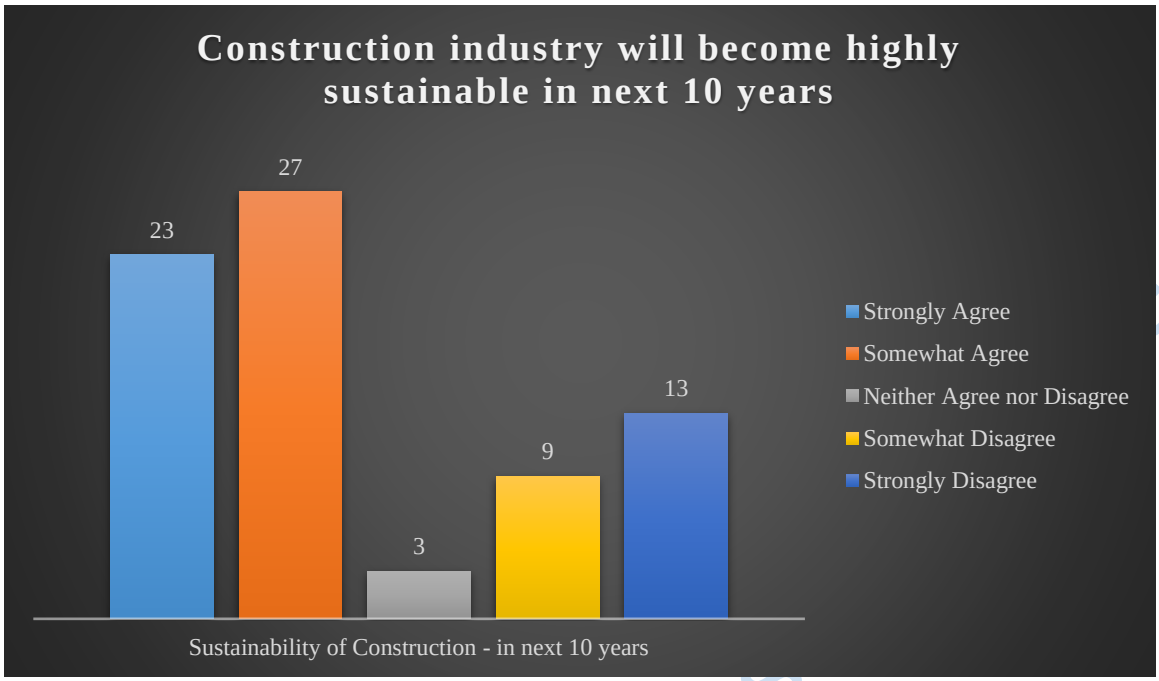

Figure 8: Sustainability of construction Industry – in next 10 years

From the above histogram of the data, it is revealed that majority of the participants in the study were strongly agreed with the statement that construction industry will become highly sustainable in next 10 years while very less number of participants are shown to be disagreed with the statement that construction industry will become highly sustainable in next 10 years. Looking at the statistics, 23 participants out of 75 participants were strongly agree that construction industry will become highly sustainable in next 10 years; moreover, 27 further participants out of 75 participants were also somewhat agreed that construction industry will become highly sustainable in next 10 years. On the other hand, nine out of 75 participants were somewhat disagreed with the statement that construction industry will become highly sustainable in next 10 years while only 13 out of 75 participants were also strongly disagreed with the statement that construction industry will become highly sustainable in next 10 years. Only three out of 75 participants were neutral towards this statement i.e. they were neither agreed nor disagreed that construction industry will

become highly sustainable in next 10 years. The response of this statement implies that construction industry of UAE, in next 10 years, is very likely to become sustainable.

The third statement asked participants to state their level of agreement or disagreement on the statement that achieving sustainability in construction industry can be done by utilizing waste material from different industries in its operations. The results of responses for this statement is given below in the figure no. 09.

Figure 9: sustainability in construction industry by utilizing waste material

In accordance with the above bar chart, it can be assessed that majority of the participants in the study were strongly agreed with the statement that achieving sustainability in construction industry can be done by utilizing waste material from different industries in its operations while very less number of participants are shown to be disagreed with the statement that achieving sustainability in construction industry can be done by utilizing waste material from different industries in its operations. Looking at the statistics, 28 participants out of 75 participants were strongly agree that achieving sustainability in construction industry can be done by utilizing waste material from

different industries in its operations; moreover, 31 further participants out of 75 participants were also somewhat agreed that achieving sustainability in construction industry can be done by utilizing waste material from different industries in its operations. On the other hand, six out of 75 participants were somewhat disagreed with the statement that achieving sustainability in construction industry can be done by utilizing waste material from different industries in its operations while only eight out of 75 participants were also strongly disagreed with the statement that achieving sustainability in construction industry can be done by utilizing waste material from different industries in its operations. Only two out of 75 participants were neutral towards this statement i.e. they were neither agreed nor disagreed that achieving sustainability in construction industry can be done by utilizing waste material from different industries in its operations. The response of this statement implies that utilizing waste materials in the construction industry of UAE is helpful in achieving sustainability and making its operation sustainable.

The fourth statement asked participants to state their level of agreement or disagreement on the statement that one of the major goals of the organisation is achieving and maintaining sustainability in its operations and functions. The results of responses for this statement is given below in the figure no. 10.

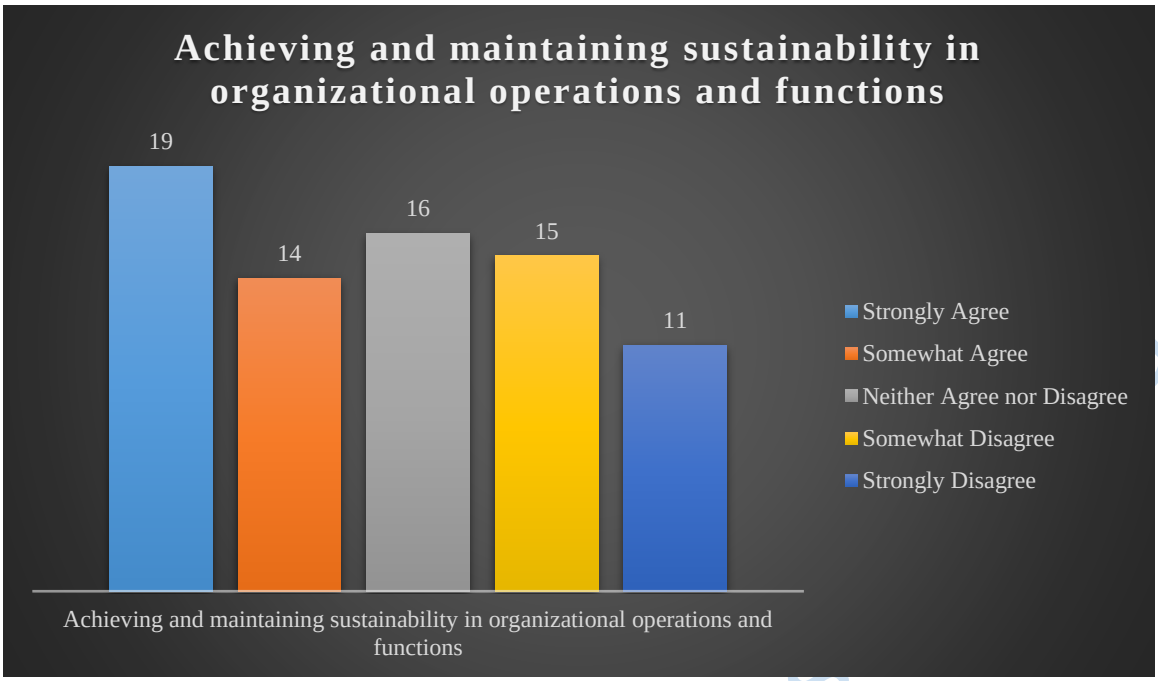

Figure 10: Achieving and maintaining sustainability in organizational operations and functions

In accordance with the above bar chart, it can be assessed that participants in the study, who were strongly agreed of somewhat disagreed with the statement that one of the major goals of the organisation is achieving and maintaining sustainability in its operations and functions, were similar to some extent. Looking at the statistics, 19 participants out of 75 participants were strongly agree that one of the major goals of their organisation is achieving and maintaining sustainability in its operations and functions; moreover, 14 further participants out of 75 participants were also somewhat agreed that one of the major goals of their organisation is achieving and maintaining sustainability in its operations and functions. In similar fashion, 15 out of 75 participants were somewhat disagreed with the statement that one of the major goals of the organisation is achieving and maintaining sustainability in its operations and functions and 11out of 75 participants were also strongly disagreed with the statement that one of the major goals of their organisation is achieving and maintaining sustainability in its operations and functions. The number of participants who were neutral towards this statement i.e. they were neither agreed nor disagreed

that one of the major goals of their organisation is achieving and maintaining sustainability in its operations and functions, was 16. The response of this statement implies that some of the organizations of the construction industry of UAE have goals for ensuring sustainability while some of the organizations are not considering sustainability as the goal.

The fifth statement asked participants to state their level of agreement or disagreement on the statement that due to achieving and maintaining sustainability, companies are looking to utilize industrial waste in construction process. The results of responses for this statement is given below in the figure no. 11.

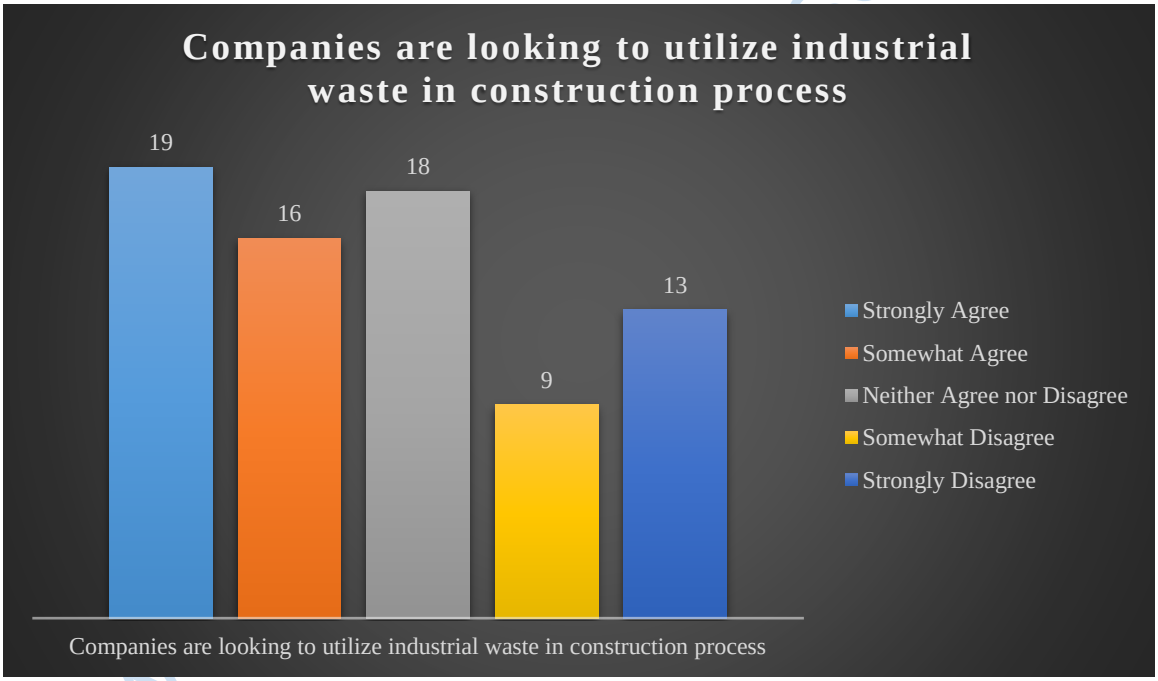

Figure 11: companies are looking to utilize industrial waste in construction process

From the above histogram of the data, it is revealed that majority of the participants in the study were strongly agreed with the statement that companies are looking to utilize industrial waste due to achieving and maintaining sustainability in construction process while relatively less number of participants are shown to be disagree with the statement that companies are looking to utilize

industrial waste due to achieving and maintaining sustainability in construction process. Looking at the statistics, 19 participants out of 75 participants were strongly agreed that companies are looking to utilize industrial waste due to achieving and maintaining sustainability in construction process; moreover, 16 further participants out of 75 participants were also somewhat agreed that companies are looking to utilize industrial waste due to achieving and maintaining sustainability in construction process. On the other hand, nine out of 75 participants were also somewhat disagreed with the statement that companies are looking to utilize industrial waste due to achieving and maintaining sustainability in construction process while 13 out of 75 participants were also strongly disagreed with the statement that companies are looking to utilize industrial waste due to achieving and maintaining sustainability in construction process. Meanwhile, 18 out of 75 participants were neutral towards this statement i.e. they were neither agreed nor disagreed that companies are looking to utilize industrial waste due to achieving and maintaining sustainability in construction process. The response of this statement implies that most of the companies in UAE are looking to utilize industrial waste with aim to achieve and maintain sustainability in construction process.

The sixth statement asked participants to state their level of agreement or disagreement on the statement that when company work towards achieving sustainable environment, the reputation of the company tend to increase and flourish. The results of responses for this statement is given below in the figure no. 12.

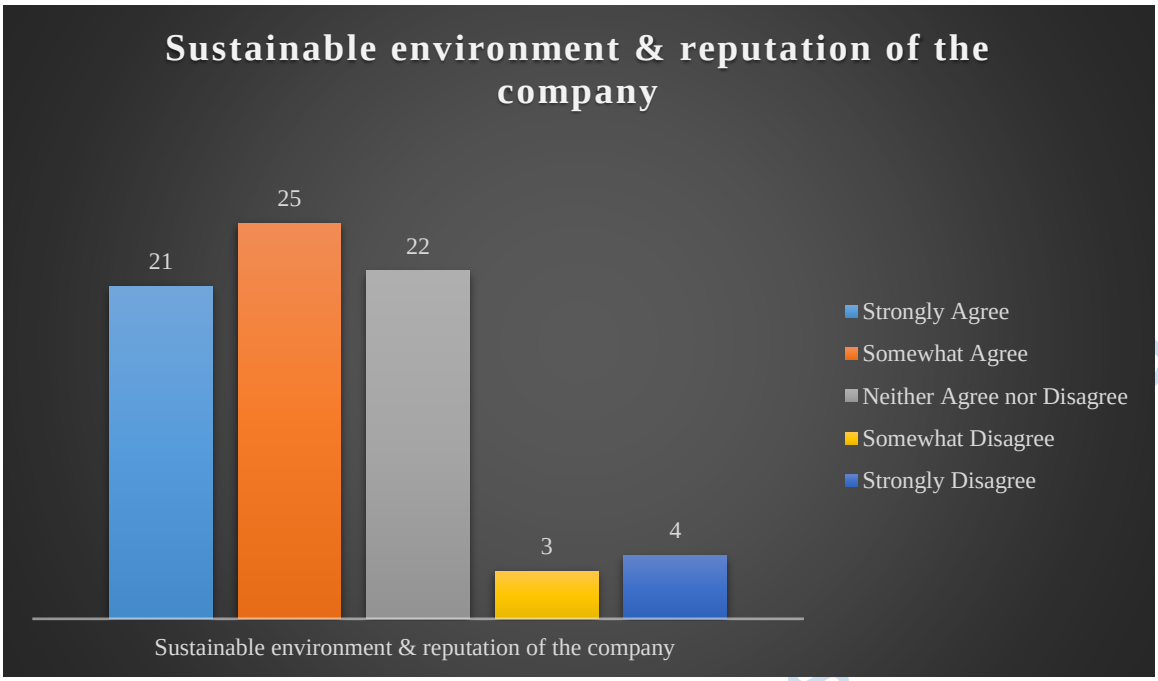

Figure 12: Sustainable environment & reputation of the company

In regards to afore given data chart, it is revealed that majority of the participants in the study were strongly agreed with the statement that the reputation of the company tend to increase and flourish when company work towards achieving sustainable environment while very less number of participants are shown to be disagree with the statement that the reputation of the company tend to increase and flourish when company work towards achieving sustainable environment. Looking at the statistics, 21 participants out of 75 participants were strongly agreed that the reputation of the company tend to increase and flourish when company work towards achieving sustainable environment; moreover, 25 further participants out of 75 participants were also somewhat agreed that the reputation of the company tend to increase and flourish when company work towards achieving sustainable environment. On the other hand, three out of 75 participants were also somewhat disagreed with the statement that the reputation of the company tend to increase and flourish when company work towards achieving sustainable environment while only four out of 75 participants were also strongly disagreed with the statement that the reputation of the company

tend to increase and flourish when company work towards achieving sustainable environment. Meanwhile, 22 out of 75 participants were neutral towards this statement i.e. they were neither agreed nor disagreed that the reputation of the company tend to increase and flourish when company work towards achieving sustainable environment. The response of this statement implies that most of the companies in UAE considers that its reputation will increase and flourish if it works towards achieving sustainable environment.

The seventh statement asked participants to state their level of agreement or disagreement on the statement that client are interested and looking for such solutions of construction that incorporate waste materials. The results of responses for this statement is given below in the figure no. 13.

Figure 13: Client are looking for solutions that incorporate waste materials

From the figure no. 13, it is revealed that majority of the participants in the study were somewhat agreed with the statement that client are interested and looking for such solutions of construction that incorporate waste materials while the number of participants, who are shown to be disagree, neutral, and agreed, with the statement that client are interested and looking for such solutions of

construction that incorporate waste materials are more or less equal. Looking at the statistics, 31 participants out of 75 participants were somewhat agreed that client are interested and looking for such solutions of construction that incorporate waste materials. On the other hand, 13 out of 75 participants were strongly agreed with the statement that client are interested and looking for such solutions of construction that incorporate waste materials while 12 out of 75 participants were somewhat disagreed and neutral with the statement that client are interested and looking for such solutions of construction that incorporate waste materials. Only 7 out of 75 participants were strongly disagreed towards this statement that client are interested and looking for such solutions of construction that incorporate waste materials. The response of this statement implies that most of the clients in UAE also want to see projects that are utilizing waste.

The eight statement asked participants to state their level of agreement or disagreement on the statement that all of the companies across the globe utilize waste in its operations. The results of responses for this statement is given below in the figure no. 14.

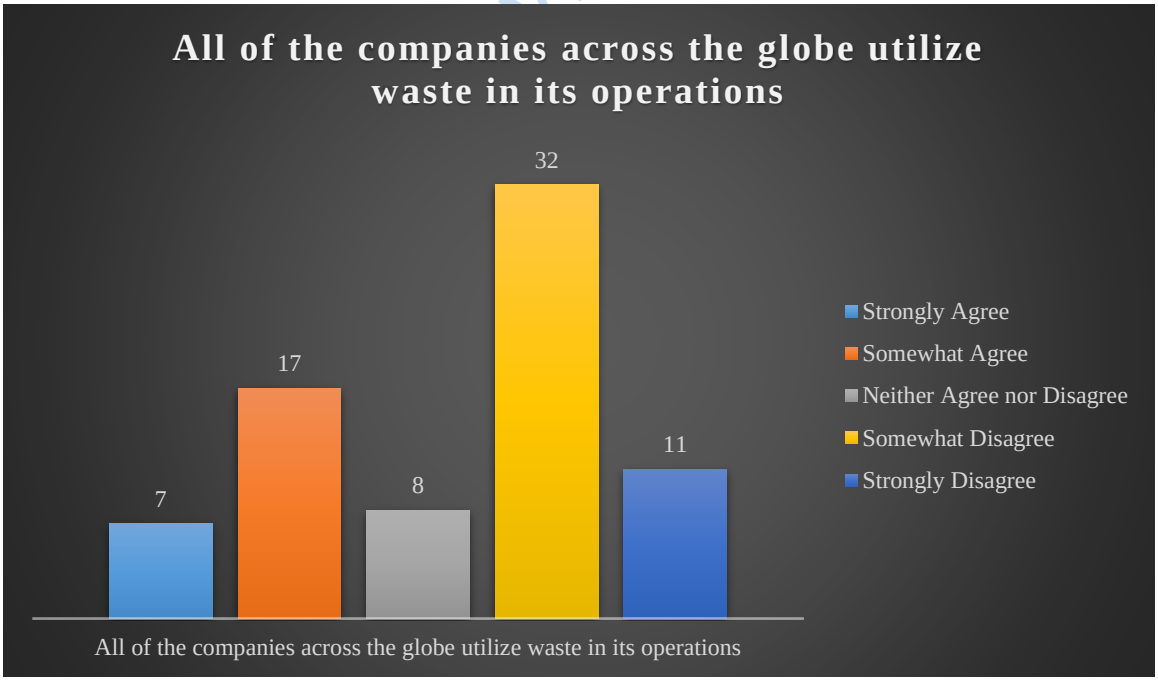

Figure 14: All of the companies across the globe utilize waste in its operations

In regards to afore given data chart, it is revealed that majority of the participants in the study were somewhat disagreed with the statement that t all of the companies across the globe utilize waste in its operations while less number of participants are shown to be agreed with this statement. Looking at the statistics, 32 participants out of 75 participants were somewhat disagreed that all of the companies across the globe utilize waste in its operations; moreover, 11 further participants out of 75 participants were strongly disagreed with this statement. On the other hand, seven out of 75 participants were also strongly agreed that all of the companies across the globe utilize waste in its operations while 17 out of 75 participants were also somewhat agreed with this statement. Meanwhile, only eight out of 75 participants were neutral towards this statement i.e. they were neither agreed nor disagreed all of the companies across the globe utilize waste in its operations. The response of this statement implies that most of the companies globally are not utilizing waste in its operations currently.

The ninth statement asked participants to state their level of agreement or disagreement on the statement that installing and maintaining recycling & reuse machine is difficult. The results of responses for this statement is given below in the figure no. 15.

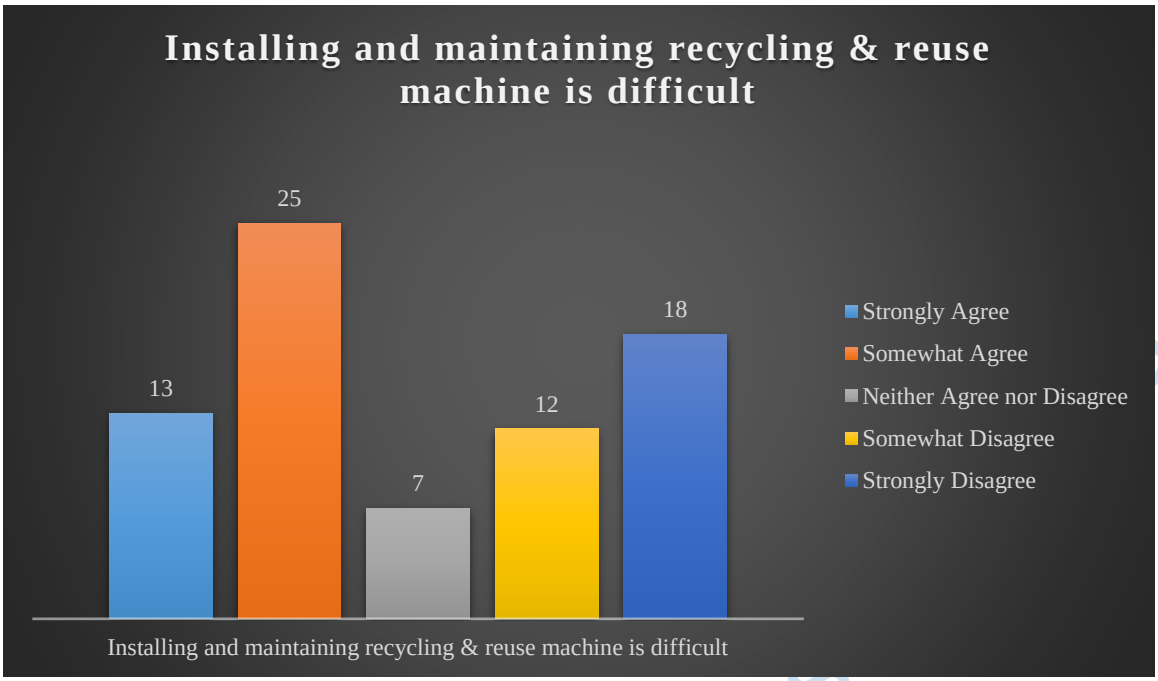

Figure 15: Installing and maintaining recycling & reuse machine is difficult

In regards to afore given data chart, it is revealed that majority of the participants in the study were somewhat agreed with the statement that installing and maintaining recycling & reuse machine is difficult while less number of participants are shown to be disagreed with this statement. Looking at the statistics, 25 participants out of 75 participants were somewhat agreed that installing and maintaining recycling & reuse machine is difficult; moreover, 13 further participants out of 75 participants were strongly disagreed with this statement. On the other hand, 18 out of 75 participants were also strongly disagreed that installing and maintaining recycling & reuse machine is difficult while 12 out of 75 participants were also somewhat disagreed with this statement. Meanwhile, only seven out of 75 participants were neutral towards this statement i.e. they were neither agreed nor disagreed installing and maintaining recycling & reuse machine is difficult. The response of this statement implies that installing and maintaining recycling & reuse machine is neither too difficult not too trivial.

The tenth statement asked participants to state their level of agreement or disagreement on the statement that there is need for enhanced technologies in waste recycle for construction processes. The results of responses for this statement is given below in the figure no. 16.

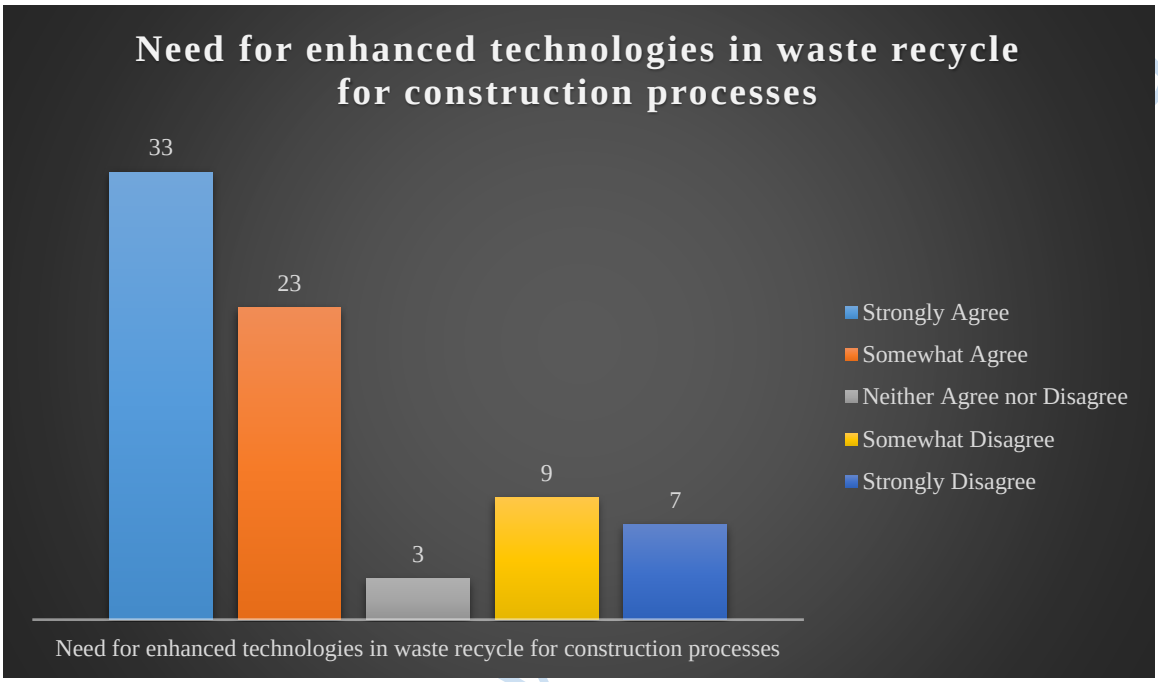

Figure 16: need for enhanced technologies in waste recycle for construction processes

In regards to afore given data chart, it is revealed that majority of the participants in the study were strongly agreed with the statement that there is need for enhanced technologies in waste recycle for construction processes while relatively lesser number of participants are shown to be disagreed with this statement. Looking at the statistics, 33 participants out of 75 participants were strongly agreed that there is need for enhanced technologies in waste recycle for construction processes; moreover, 23 further participants out of 75 participants were somewhat disagreed with this statement. On the other hand, only seven out of 75 participants were also strongly disagreed that there is need for enhanced technologies in waste recycle for construction processes while nine more out of 75 participants were somewhat disagreed with this statement. Meanwhile, only three

out of 75 participants were neutral towards this statement i.e. they were neither agreed nor disagreed that there is need for enhanced technologies in waste recycle for construction processes. The response of this statement implies that there is need for enhanced technologies in the construction companies of UAE for recycling waste effectively in the processes of construction.

The eleventh statement asked participants to state their level of agreement or disagreement on the statement that effective training is needed for proper utilization of industrial waste in construction process. The results of responses for this statement is given below in the figure no. 17.

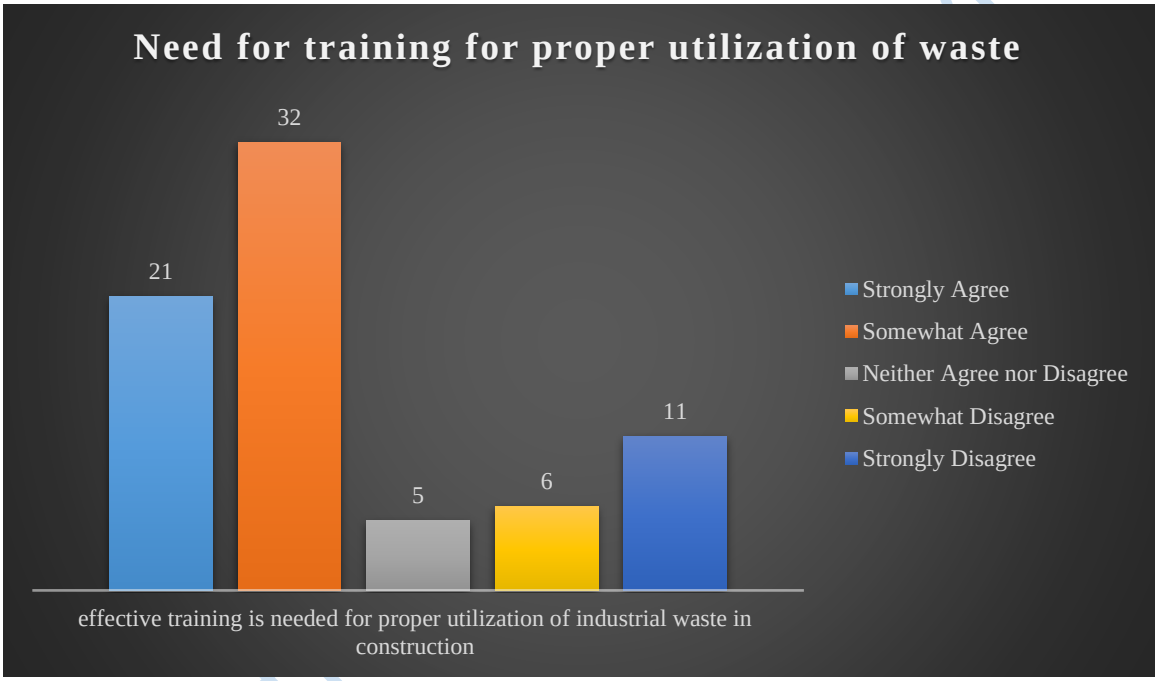

Figure 17: Need of training

In regards to afore given data chart, it is revealed that majority of the participants in the study were somewhat agreed with the statement that effective training is needed for proper utilization of industrial waste in construction process while relatively lesser number of participants are shown to be disagreed with this statement. Looking at the statistics, 32 participants out of 75 participants were somewhat agreed that effective training is needed for proper utilization of industrial waste in construction process; moreover, 21 further participants out of 75 participants were somewhat

disagreed with this statement. On the other hand, only s11 out of 75 participants were also strongly disagreed that effective training is needed for proper utilization of industrial waste in construction process while six more out of 75 participants were somewhat disagreed with this statement. Meanwhile, only five out of 75 participants were neutral towards this statement i.e. they were neither agreed nor disagreed that effective training is needed for proper utilization of industrial waste in construction process. The response of this statement implies that there is need for effective training in the construction companies of UAE for proper utilization of industrial waste in construction process.

The twelfth statement asked participants to mark which of the given list of benefits of waste utilization they have observed to be delivering in construction industry so that it becomes sustainable. The options for this question given to the respondents include: save natural materials, save space from landfills, comply with the policies of government towards environmental protection and green building, lower the budget of the project by utilizing recycled materials implying cost reduction, or / and enhance the competitiveness of the company while increasing opportunities of business. The results of responses for this statement is given below in the figure no. 18.

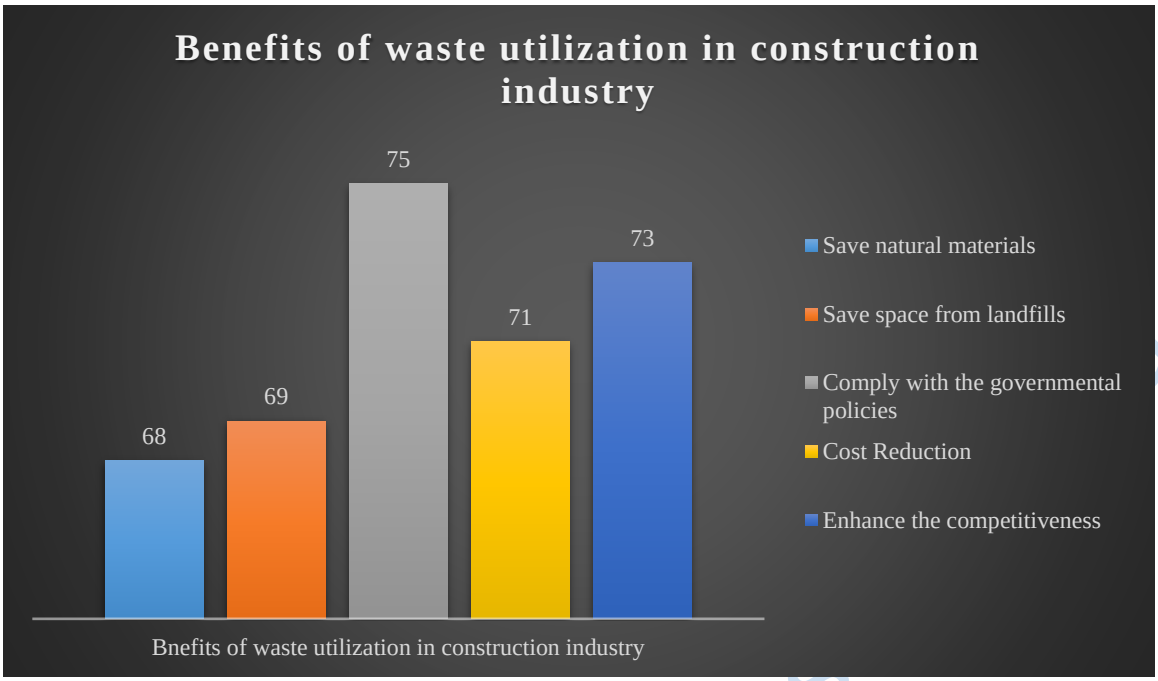

Figure 18: benefits of waste utilization in construction industry

From the above data shown in the bar chart, the majority of the votes has been received to the benefit of complying with the policies of government when companies utilize waste and work for sustainable construction. However, saving natural materials, cost reduction, and saving space form the landfills are also the benefit of waste utilization in the construction industry. The least vote i.e. 68, were given to enhancing competitiveness of the company while complying with the policies of government has received most the votes i.e. 75. It suggests that all of the participants considered that waste utilization is one way of showing that company is following the governmental policies of green building and sustainable future.

The thirteenth statement asked participants to mark which of the given waste materials are commonly utilized in construction projects of your organization. The options for this question given to the respondents include: fly ash, pozzolans, silica fumes, Ground granulated blast furnace slag (GGBFS), Metakaolin, Copper Slag, Air Bubble film Rolls/ Bags, Red Mud as mortar, Red

Mud as bricks, Red Mud in cement production, Dry Sludge in concrete, and Coal ash in concrete. The results of responses for this statement is given below in the figure no. 19.

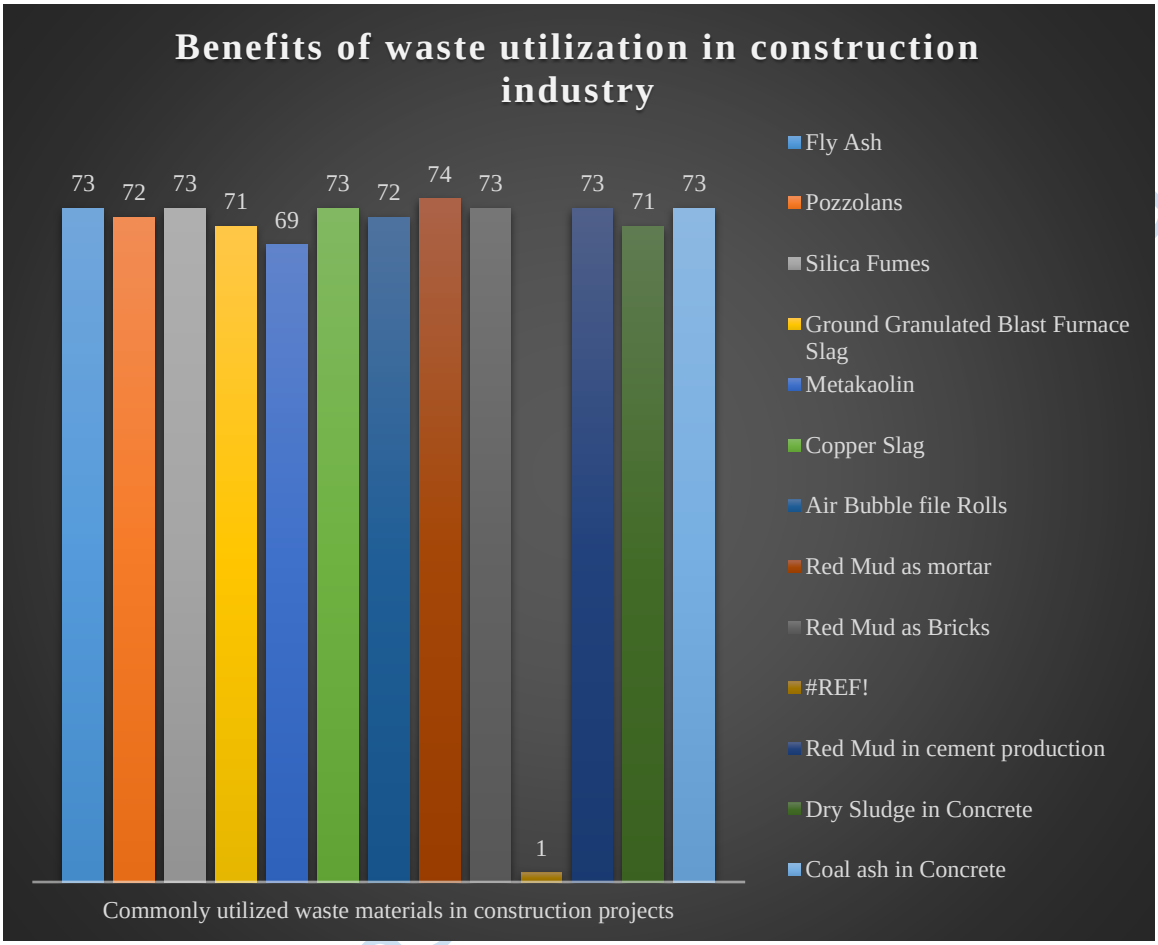

Figure 19: commonly utilized waste materials in construction projects

From the above data shown in the bar chart, the majority of the votes has been received to the waste material: red mud as mortar, fly ash, silica fumes, and pozzolans. However, copper slag, air bubble file rolls, coal ash in concrete, and red mud as brick are also the commonly utilized waste materials in the construction industry. The least vote i.e. 69, were given to metakaolin while red mud as mortar has received most the votes i.e. 74. It suggests that most of the utilized materials in UAE's construction industry are red mud as mortar, fly ash, silica fumes, and pozzolans followed by copper slag, air bubble file rolls, coal ash in concrete, and red mud as brick.

Chapter No. 5 – Conclusion & Recommendations

Particular combination of factors related to environment determine useful life of a material in place thus service life or durability of the material always relate to the certain conditions involved. In past couple of years, environment degradation is more prominent and highlighted for the reason that there were no proper measures in place to protect the surrounding natural process. As a result of increasing population with increasing needs, huge energy requirement stimulated the development of industrial processes resulting in greater extent of natural resource consumption, higher pollution, and more wastes. To overcome this problem for the entire planet, new material for building are being developed with the aim of obtaining materials that are eco-friendly and protect natural resources. For quite a few years, cement industry is incorporating several quantities of wastes including fly ash, metakaolin, blast furnace slag, silica fume, ceramic waste, etc., because of the reasons of protecting economy and environment. In addition to that, developing composite materials for construction with low thermal conductivity involving the usage of waste is said to be a thought-provoking substitute to solve the concerns related of environment and energy at the same time. Thus, concrete of any material can be obtained with the help of adding wastes, with statistical optimization and experimental studies, helping characterisation of new materials.

It is recommended in the research studies explored in the review of literature that building materials must be sustainable while ensuring the ratio between energy and cost for satisfying the requirements of modern day life. It is also shown in the research that adding waste to concrete is capable of improving some properties of materials. Therefore, combining industrial waste is most of the time utilised along with introducing other materials to composite for compensating any disadvantage. Other materials can be fibre of different lengths, types, or some nanomaterial including glass, carbon, textile, Nano- argillaceous material, steel, polyester, bore, or nanotubes of

carbon. It is also approximated in the research studies that new materials for building, based on usability of nano-materials will influence and develop the sector or industry of construction.

Industrial waste is utilised for producing nano-powder and other nano-products which allow obtaining cements of new generation based on the materials that are more durable using new nanotechnologies. Today, it can be said that technologies for handling nano-products are in their pre-exploration stage thus its applicability is limited in construction industry and there must be experimental research to its application. Composite materials in construction industry are developing based on new research studies in the domain of recycling as an innovative opinion with economic, environmental, and performance benefits.

This research study was aimed at analysing the significance of utilising waste from industries into the construction industry of the UAE. For this reason, the research has conducted a survey along with carrying out secondary research to not only assess the importance but to further unfolded the related aspects of utilising waste from industries into the construction industry of the UAE. The results of the study inferred that utilising waste in construction industry is the way to achieve sustainable future and environment. While many of the companies do not currently aim to become sustainable, with the right and advanced technologies in the industry; UAE's construction industry can become sustainable. At this moment, the construction industry at global level is not sustainably completely but with the right policies, approach, and attitude, it is potential that construction industry will become sustainable in next 10 years.

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Appendix

Questionnaire

Demographic Questions

1. What gender do you identify as?
   - ☐ Male
   - ☐ Female
   - ☐ Prefer not to answer
2. What is your age?
   - ☐ 20 to 30 years old
   - ☐ 31 - 40 years old
   - ☐ 40 to 50 years old
   - ☐ 50+
3. What is the highest degree or level of education you have completed?
   - ☐ High School
   - ☐ Bachelor's Degree
   - ☐ Master's Degree
   - ☐ Ph.D. or higher
4. How many years of experience you have in construction industry?
   - ☐ Less than a year
   - ☐ 1 to 3 years
   - ☐ 4 to 6 years
   - ☐ 7 to 10 years

- ☐ More than 10 years

5. What is your profession?
   - ☐ Structural Engineer
   - ☐ Project Manager
   - ☐ Civil Surveyor
   - ☐ Architect
   - ☐ Charted Surveyor
6. Have you participated in any projects involving waste utilization in the past two to three years?
   - ☐ Yes
   - ☐ No

Please mark your level of agreement or disagreement to the following statements regarding utilization of waste in the construction industry.

1. Construction industry is currently sustainable
   - ☐ Strongly Agree
   - ☐ Somewhat Agree
   - ☐ Neither Agree nor disagree
   - ☐ Somewhat Disagree
   - ☐ Strongly Disagree

2. Construction industry will become highly sustainable in next 10 years
   - ☐ Strongly Agree

- ☐ Somewhat Agree
- ☐ Neither Agree nor disagree
- ☐ Somewhat Disagree
- ☐ Strongly Disagree

3. Achieving sustainability in construction industry can be done by utilizing waste material from different industries in its operations.
   - ☐ Strongly Agree
   - ☐ Somewhat Agree
   - ☐ Neither Agree nor disagree
   - ☐ Somewhat Disagree
   - ☐ Strongly Disagree

4. One of the major goals of the organisation is achieving and maintaining sustainability in its operations and functions
   - ☐ Strongly Agree
   - ☐ Somewhat Agree
   - ☐ Neither Agree nor disagree
   - ☐ Somewhat Disagree
   - ☐ Strongly Disagree

5. Due to achieving and maintaining sustainability, companies are looking to utilize industrial waste in construction process

- ☐ Strongly Agree
- ☐ Somewhat Agree
- ☐ Neither Agree nor disagree
- ☐ Somewhat Disagree
- ☐ Strongly Disagree

6. When company work towards achieving sustainable environment, the reputation of the company tend to increase and flourish
   - ☐ Strongly Agree
   - ☐ Somewhat Agree
   - ☐ Neither Agree nor disagree
   - ☐ Somewhat Disagree
   - ☐ Strongly Disagree

7. Client are interested and looking for such solutions of construction that incorporate waste materials
   - ☐ Strongly Agree
   - ☐ Somewhat Agree
   - ☐ Neither Agree nor disagree
   - ☐ Somewhat Disagree
   - ☐ Strongly Disagree

8. All of the companies across the globe utilize waste in its operations

- ☐ Strongly Agree
- ☐ Somewhat Agree
- ☐ Neither Agree nor disagree
- ☐ Somewhat Disagree
- ☐ Strongly Disagree

9. Installing and maintaining recycling & reuse machine is difficult

- ☐ Strongly Agree
- ☐ Somewhat Agree
- ☐ Neither Agree nor disagree
- ☐ Somewhat Disagree
- ☐ Strongly Disagree

10. There is need for enhanced technologies in waste recycle for construction processes

- ☐ Strongly Agree
- ☐ Somewhat Agree
- ☐ Neither Agree nor disagree
- ☐ Somewhat Disagree
- ☐ Strongly Disagree

11. Effective training is needed for proper utilization of industrial waste in construction process

- ☐ Strongly Agree
- ☐ Somewhat Agree

- ☐ Neither Agree nor disagree
- ☐ Somewhat Disagree
- ☐ Strongly Disagree

Please mark which of the following benefit waste utilization deliver in construction industry so that it becomes sustainable:

- ☐ Save natural materials
- ☐ Save space from landfills
- ☐ Comply with the governmental policies of green building and environmental protection
- ☐ Lower project budget by using recycled materials – Cost Reduction
- ☐ Enhance the competitiveness and increasing business opportunities

Which of the following waste material is commonly utilized in construction projects of your organization?

- ☐ Pozzolans
- ☐ Fly ash
- ☐ Silica fumes
- ☐ Rice husk ash
- ☐ Ground granulated blast furnace slag (GGBFS)-
- ☐ Metakaolin-
- ☐ Copper Slag-
- ☐ Air Bubble film Rolls/ Bags

- ☐ Red Mud as mortar
- ☐ Red Mud as bricks
- ☐ Red Mud in cement production
- ☐ Dry Sludge in concrete
- ☐ Coal ash in concrete