ST. MARY'S UNIVERSITY
SCHOOL OF GRADUATE STUDIES

PLASTIC WASTE MATERIALS MANAGEMENT AND REUSE IN THE CONSTRUCTION INDUSTRY: THE CASE OF SELECTED FIRST GRADE CONTRACTORS IN ADDIS ABABA

BY
BETHELHEM SOLOMON

July 2021
ADDIS ABABA, ETHIOPIA

PLASTIC WASTE MATERIALS MANAGEMENT AND REUSE IN THE CONSTRUCTION INDUSTRY: THE CASE OF SELECTED FIRST GRADE CONTRACTORS IN ADDIS ABABA

BY

BETHELHEM SOLOMON

ID NO. SGS/0644/2012A

PLASTIC WASTE MATERIALS MANAGEMENT AND REUSE IN THE CONSTRUCTION INDUSTRY: THE CASE OF SELECTED FIRST GRADE CONTRACTORS IN ADDIS ABABA

July 2021

ADDIS ABABA, ETHIOPIA

ST. MARY'S UNIVERSITY

SCHOOL OF GRADUATE STUDIES

PLASTIC WASTE MATERIALS MANAGEMENT AND REUSE IN THE CONSTRUCTION INDUSTRY: THE CASE OF SELECTED FIRST GRADE CONTRACTORS IN ADDIS ABABA

BY

BETHELHEM SOLOMON

ID NO. SGS/0644/2012A

APPROVED BY BOARD OF EXAMINERS

-----------------------------------	------------------------
Dean, Graduate Studies	**Signature**
------------------------------------	------------------------
Advisor	**Signature**
------------------------------------	------------------------
External Examiner	**Signature**
<u>Muluadam alemu (Ph.D)</u>	------------------------
Internal Examiner	**Signature**

DECLARATION

I, the undersigned, declare that this thesis is my original work; prepared under the guidance of Chalachew Getahun(Ph.D.). All sources of materials used for the thesis have been duly acknowledged. I further confirm that the thesis has not been submitted either in part or in full to any other higher learning institution for the purpose of earning any degree.

Bethelhem Solomon ------------------------------

Name Signature

St. Mary's University, Addis Ababa **June, 2021**

ENDORSEMENT

This thesis has been submitted to St. Mary's University, School of Graduate Studies for examination with my approval as a university advisor.

CHALACHEW GETAHUN (Ph.D.) ------------------------------------

Advisor Signature

St. Mary's University, Addis Ababa July, 2021

ACKNOWLEDGEMENTS

First, I would like to thank Almighty GOD for being with me all the way from the beginning to the end of this thesis, then, I would like to thank the various people involved in making this thesis a success.

I take this opportunity to express my profound gratitude and deep regards to Chalachew Getahun (Ph.D.)., my advisor for his exemplary guidance, monitoring and constant encouragement throughout the duration of the research.

I would like to further extend my deepest gratitude to my beloved family for their support by providing everything I needed. And my special thanks goes to Selam HaileMariam and her husband Aman Adinew for everything.

Lastly, I offer my regards and blessings to all of those who supported me in any aspect during the completion of this thesis report.

Table of Contents

LIST OF ACCRONYMS

ASTM- American Society of Testing and Materials

CD- Compact Disk

CM- Centimeter

Cumm.- Cumulative

DC- Developing Countries

DVD- Digital Versatile Disk

EBCS- Ethiopian Building Code of Standard

FM- Fineness Modulus

HDPE- High Density Polyethylene

HRS- Hours

IS- International Standards

KG- Kilogram

Kg/m^3- Kilogram Per Meter Cube

KN- Kilo Newton

LDPE- Low Density Polyethylene

Mil- Million

MM- Millimeter

MP- Mega Pascal

MPA- Mega Pascal

MS- Mild Steel

PC- Pieces

PETE/PET- Polyethylene Terephthalate

PP- Poly Propylene

PS- Polystyrene

PVC- Polyvinyl Chloride

Ret. - Retained

RII- Relative Importance Index

RRR- Reused, Recycled or Recovered

SPI- Society Of Plastics Industry

w.t. - Weight

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Plastic is widely used in our day to day life. Plastic waste reuse in construction according to this study is very important both to the environment and the construction sector. The study helps to fill the knowledge and practical gaps in the reuse of waste plastics practice in construction, the insufficient study and the gaps in the trend of using plastic wastes as suitable construction matterials. The objective of this study was to assess waste plastic materials management practice in Addis Ababa selected construction sectors. As a research methodology qualitative and quantitative approaches were used to assess the responses given to questionnaires. From several contractors in Addis Ababa level one/grade one contractors were selected as target population. For meeting the objective of the study data collection was made using questionnaire as data collection tool. And among the 100 questionnaires, only 72 were collected. Samples were drawn using convenient sampling approach. Based on the data analysis, the result of the study revealed that 'Reduced Consumption of financial resources to purchase products', "Less plastic waste in the environment", "Easy to use and maintain", "Increased work opportunity", "Lesser labor energy consumption" and "Minimum cost of labor" were the major impacts of reuse of plastic materials in construction and concluded that reusing plastic wastes in production of construction materials is important in major concerns of construction management areas like time , cost, quality, human resource management and also environmental protection. To support the findings according to the responses of the respondents, laboratory tests on produced plastic waste floor tile materials were made. Finally the study recommended for the study to be made in wide range including other areas, extended population size including consultants, clients, and other construction stakeholders. In addition, experimental researches should be made in order to recycle plastic wastes to use different purposes and decrease the exposure of the environment to plastic waste.

Key words: Plastic waste, plastic waste reuse, impact, environmental protection, construction material

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Construction industry is one of sectors that contribute for the socio economic growth of one country. The industry plays an important role that is required for the development and economic growth of a country (Brouwers, *et al.,* 1996). Despite the roles it plays , construction faces various problems like cost overrun, time overrun, low quality, pollutes the environment, and the like. Speaking of the environmental pollution, plastic wastes are to this day biggest problems which cause environmental degradation. Plastics are widely used synthetic materials in variety of sectors (Ilyas, et al., 2018).

As per the study of Ilyas, et al. 2018, plastic has been widely used as main package material in the community's day to day activity. In many developing countries low-density polyethylene (LDPE) sheets, bags and water sachets are major waste problems because local collection and recycling systems do not exist. Hence, recycling and re-use of these waste plastics has been in trial for long period and now it came to a point in which plastic-sand floor finishing tiles as a new trend in some countries like America, India, Cameroon, Senegal, Nigeria, Uganda and now (to some extent at study level), in Ethiopia. A relatively simple technology has been developed in Cameroon that produces LDPE-bonded sand tiles and blocks. The management and reuse of plastic wastes has been vital in production of for the environment and the construction industry. In Ethiopia, until recent times, plastic wastes were simply collected and disposed off for landfilling or incinerated.

In Ethiopia, most industrial and domestic activities are associated with significant amounts of non-biodegradable solid waste, which include a wide range of plastic and glass waste. The research studies to be undertaken intended to determine the efficiency of reusing waste plastic in production of floor tile, roof tiles and hollow block plastic. Utilization of these waste materials is a partial solution to environmental and ecological Problems. Use of plastic and glass not only helps in getting them utilized in such types of material, it helps in reducing the cost of concrete making, numerous indirect benefits such as reduction landfill cost, saving energy, and protecting the environment from possible pollution effects.

At a time when landfill space is becoming almost impossible due to increasing land value, then recycling and reuse of wastes as beneficial products should be strongly encouraged and examined. One potentially strong and viable market is to develop recyclable wastes into construction material, a common material used throughout the construction industry. The reuse of waste materials in building construction is a great idea, and the high demand for construction materials makes them a favorable medium in which to reuse recyclable materials.

Aggregates are used in a variety of building applications, and can be said to be the largest quantity of material used in any industry. Almost all aggregates are produced from natural resources such as gravel pits, river beds and rock quarries. In addition to depleting these natural resources, mining for aggregates also poses serious environmental risks like disturbance of natural habitats and creating open areas with no vegetation.

In Ethiopia, there is a great strain placed on the environment at the moment, specifically by waste plastic. A very small percentage of it is recycled, probably due to lack of investment or a low demand for recycled plastic waste. As a result, most of it usually ends up dumped in landfills, or just burned. The effect of such actions on the environment is degrading, at a time when the world is focusing its efforts on tackling pollution and environmental issues such as global warming.

1.2 Statement of the problem

Plastic waste is becoming extremely threatening to the environment due to its high quantities generated which pose serious harm to both the environment and its inhabitants. Wastes disposed in landfills or any other places generally find their way to the marine. These plastics in the marine environment, which are ingested by fish, are also deleterious to human health moreover to the ecosystem when such fish are consumed. In order to find an effective way to manage these wastes and improve the sustainability of our environment, this study, therefore, assesses the management practices of the plastic wastes into using in the construction industry in Addis Ababa.

Polymer wastes take years to degrade in the natural environment. The slow degradation properties of waste polymer materials cause environmental and ecological problems such as: The burning of waste plastic release toxic gas into the atmosphere, breeding sites for mosquitoes and causes floods. Therefore, there is the need for an efficient and reliable method for solid waste management in Ethiopian. A developing country like Ethiopian is currently experiencing rapid urbanization and industrialization and as a result a lot of infrastructure developments are going on. These developments come with problems such as shortage of construction materials, high cost of building due to shortage of cement and other construction materials. Several studies have been carried out in countries like Egypt, India, Australia, and U.S.A where waste plastics have been converted to other products. Ethiopia is yet to document a work done on the reuse of plastics into gasoil in the place of “koshe” Addis Ababa . This study defines the potentials and benefits in using of plastic waste like binding agent (replacement of cement) to produce a more flexible and durable HPB, floor tile and roof tile and at the same time being an alternative way to recycle the plastic waste (Behera, 2018).

Now a days, Construction materials have high cost, so people who have low income especially in developing countries like Ethiopia are not quite able to afford those materials for better housing (Delz, 2011). Not only cost is the problem, but also the long durations of material production, construction, transportation, availability, and environment degradation. This problem needs solution to full fill the demand of low cost material. Plastic wastes have high environmental impact especially in Africa. Management and reuse of plastic wastes could be one of the solutions in many aspects.

In a thesis research conducted by Kestride Estil, it assesses the plastic waste management and housing problems in Haiti. It explores the possibility of using plastic wastes to help in the construction of housing. It has shown that plastic wastes have been applied in production of walls, roof tiles and walkway pavements in Colombia and India (Estil, 2019). The study tries to implement the practices of waste management of Colombia and India in Haiti to introduce affordable housing system for the low income parts of the population.

In Netherlands about 40% of waste arises from construction firms. A study made by Lisane Moulders, showed the importance of recycle and reuse of construction and demolition wastes and the future assessment of waste recycling system of building materials (Moulders, 2013).

Another study made in Nepal, examines the solid and plastic waste management and the steps used in the process. Some of the methods showed the proper collection process and disposal methods in the country (Banskota, 2015).

There is a theoretical, knowledge and practical gaps. To this day there have not been sufficient studies especially for cases in Ethiopia and waste management practice has not been applied in good range. Local studies so far have not covered the mandatory research area that is plastic wastes management, which are found in and out of construction areas.

This problem led the researcher to study management and reuse of these plastic wastes, which are non-decomposable wastes and which are now becoming biggest problem of our environmental health and hygiene, in the construction firm. Not much studies have been made in Ethiopia or practical applications been made on plastic wastes reuse in constructions. So the study is developed with the intention to fill the theoretical and practical gap and the findings provide insightful reference for further studies and practical applications.

1.3. Research questions

- How do plastic waste management practices in Addis Ababa constructions look like?
- What are the prospects of using plastic wastes in construction companies if they are reused and managed?
- What are the possible application areas of plastic wastes in the construction industry?
- What are the importance of reusing plastic wastes in the construction management practices?

1.4. Objectives of the study

1.4.1 General objective

To assess waste plastic materials management practice in Addis Ababa selected construction sectors

1.4.2 Specific objectives

- To identify the current status of plastic waste management practices in construction sectors in Addis Ababa
- To assess the impacts of plastic wastes reuse management in construction sectors
- To assess the possible application areas of plastic wastes in the construction sector
- To assess the efficiency of reusing plastic wastes in terms of cost, time, quality and Human resources

1.5. Significance of the study

This study helps to add both theoretical and practical knowledge to create awareness on the reuse of plastic materials in the construction sector for further studies and create understanding among construction stakeholders on the efficiency of recycling plastic waste. Theoretically the study may contribute to fill the research gap in existing study in Ethiopia and trend of reusing plastic wastes in construction. The findings of this study may serve as a reference for further research in the area of plastic reuse in construction.

1.6. Scope and limitations

In terms of location, this study covered a single city Addis Ababa, Ethiopia. Among the sectors this study focus only on level 1 contractor. The perspectives of the other construction stakeholders need to be seen. The other limitation is that, since plastic is a problem of all sectors, separate studies should be made for the other sectors.

Considering laboratory tests and results, the study is only limited to assessing the compressive strength, water absorption, cost, time and human resource consumption of the waste plastic sand tile material.

1.7. Organization of the study

The first chapter delivered a background of the study. In addition it explained the problem of the statement, objective of the study, significance and limitation of the study. The second chapter provides literature review of related subjects from works of different literatures. It mainly focuses on the definition, uses, types, recycling practice, management and reuse practice of plastic waste materials in the construction industry. The third chapter explains about the methodology used in order to come up with findings of the study. Includes research approach and design, population and samples, data collection methods used to consume data and at last the procedures used to produce plastic waste based floor tile material. The fourth chapter discussed the research findings using the mythologies stated above and analyzed the findings. The last chapter concludes the findings and analysis, gives recommendations and gives insights for future studies based on the findings.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter delivers a detailed review of literatures related to the objectives of the study. It starts by defining the term plastic, plastic wastes, plastic types, its advantage and disadvantages, and continues to investigate its use in the construction industry according to review of different researchers.

2.2. Theoretical literature

2.2.1. Definition

Plastic, according to oxford Dictionary, is a light, strong material that is produced by chemical process and can be formed in to shapes when heated. It is synthetic or semi synthetic material but use polymers as a main ingredient (Wikipedia, 2011).

Plastic waste is the accumulation of plastic objects and particles in the environment which affects wildlife, its habitat and humans.

Plastic is a very useful substance in our daily life, but after the use of plastic it is very difficult for us to dispose it because it is a non-biodegradable substance. After its usage it is a hazardous material.

Plastic is a new engineering material in which researchers take more interest to invest their time and money because it has a wide scope to enhance the usage of plastic in different work. The properties of plastic are very unique and it can mix with every kind of material. Plastic is a composition of synthetic and semi synthetic organic compounds. They are malleable and ductile and remold into any solid substance.

Plastic is used in various objects which we use in our daily life like plastic cups, furniture, bags, packaging of food and other accessories, drinking containers, bottles, frames, basins etc.

According to study by Condor Ferries, (Condor, 2020-2021), 300 Million tons of plastic gets created yearly, and this weighs the same as the entire population of America, and 50%of it is single-use only.

There are 5.25 trillion bits of plastic waste in our oceans. These objects are floating in the sea with a total of 269,000 tons of plastic waste and 4 billion microfibers per km² dwelling below the surface.

According to Condor, 70% of our debris ends up in the ecosystem of the ocean while 15% of it gets remains on beaches. And 15% floats on the ocean. In terms of plastic waste, 8.3 million tons are dumped into the sea each year. Of these, 236,000 are micro plastics that are ingestible by marine creatures being mistaken for food. About 100 million aquatic animals die each year from plastic waste alone. This is either the animals are entangled, or they have ingested the debris. These animals starve to death, clogging their stomachs with plastic so they can't eat real food. Not only marine animals but also birds are infected by this. They ingest plastic debris mistaking it for fish eggs also feeding them to their chicks. With this record, over 500 marine places are globally considered dead zones.

Ferries further described, that the average lifespan of plastic waste is 500-1000 years. Of this plastic wastes 79% is sent directly to landfills or oceans, 9% recycled and the rest incinerated. 90% of the worldwide ocean debris comes from 10 rivers alone. (Ferries, 2020-2021)

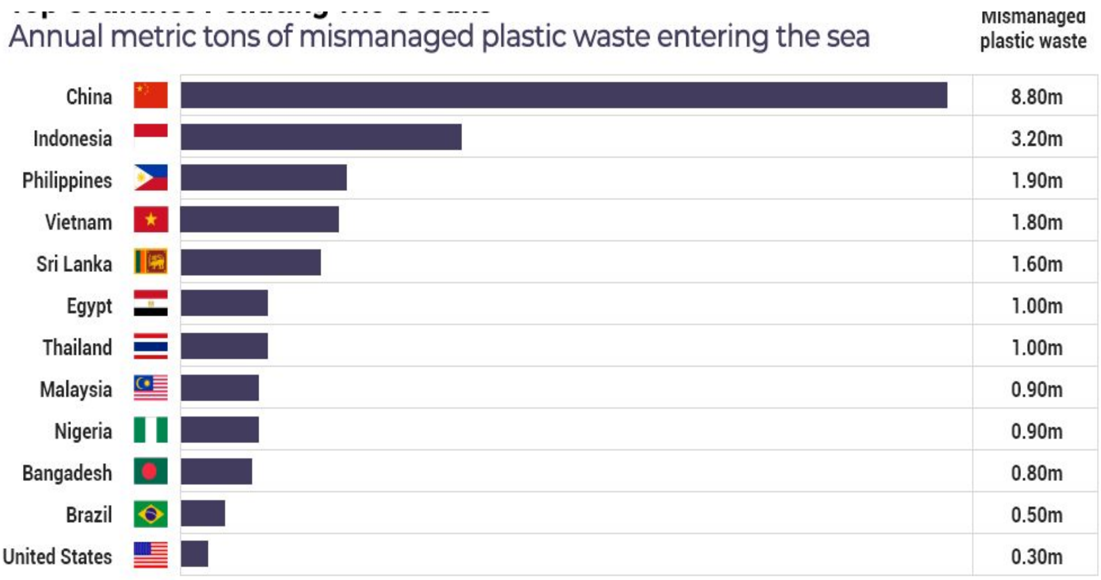

Figure 1 Top countries polluting the oceans, (Ferries, 2020-2021)

The majority of fish we consume as humans would have ingested plastic and microfibers.

In Ethiopia, there is no proper disposal of plastic wastes in which they are one of the big wastage. Those plastic waste affect the environment, visually, chemically on soil. Due to this, a large number of people get affected and suffer from many harmful diseases. Not only health is the issue of waste disposal but also aesthetically the city is engulfed with waste which are blocking the drainage systems which in turn blocks the passage of fluid waste and leave it on the roads. The following is one example of drain blockage by waste here in Addis Ababa Jemo area:

Figure 2 Waste plastics blocking urban sewerage system, Addis Ababa, Jemo Area

Some researchers suggest that if plastic isn't disposed off soon, it can sustain for centuries to millenniums years without degradation according to their chemical formation and natural environment of existence (Chamas, et al., 2020). Now, these days the rate of plastic use keeps increasing. So the collection of plastic waste also increases at a rapid speed.

2.2.2. Types of plastics

There are various types of plastics. As per the "society of plastics Industry's" classification of plastics, the following table was provided to allow customers and recyclers to identify different types of plastics. These identification (SPI) codes are molded into the bottom of most plastic products ever since 1988 (Mertes , What are different types of plastics?, 2020).

\

Table 1 Types, properties and uses of plastics

Types	**SPI Symbols and abbreviations**	**General properties**	**Common household uses**
Polyethylene Terepthalate	 **OR PET**	•Good gas & moisture barrier properties •High heat resistance •Clear •Hard •Tough •Microwave transparency •Solvent resistant	Polyethylene Terephthalate sometimes absorbs odors and flavors from foods and drinks that are stored in them. PET(E) plastic is used to make many common household items like beverage bottles, medicine jars, rope, clothing and carpet fibre.
High Density Polyethylene		•Excellent moisture barrier properties •Excellent chemical resistance •Hard to semi-flexible and strong •Soft waxy surface •Permeable to gas •HDPE films crinkle to the touch	Milk jugs, Juice containers, Grocery bags, Trash bags, Motor oil container, Shampoo and conditioner bottles, Soap bottles, Detergent containers, Bleach containers, Toys
Polyvinyl Chloride		•Excellent transparency •Hard, rigid •Good chemical resistance •Long term stability •Good weathering ability •Stable electrical properties •Low gas permeability	Some tote bags, Plumbing pipes, Grocery bags, Tile, Cling films, Shoes, Gutters, Window frames, Ducts, Sewage pipes
Low Density Polyethylene		•Tough and flexible •Waxy surface •Soft – scratches easily •Low melting point Stable electrical properties	Cling wrap, Sandwich bags, Squeezable bottles for condiments such as honey and mustard, Grocery bags, Frozen food bags, Flexible container lids

		•Good moisture barrier properties	
Polypropylene		•Excellent chemical resistance •High melting point •Hard, but flexible •Waxy surface •Translucent •strong	Plastic diapers, Tupperware, Kitchenware, Margarine tubs, Yogurt containers, Prescription bottles, Stadium cups, Bottle caps, Take-out containers, Disposable cups and plates
Polystyrene		•Clear to opaque •Glassy surface •Rigid or foamed •Hard •Brittle •High clarity •Affected by fats and solvents	Disposable coffee cups, Plastic food boxes, Plastic cutlery, Packing foam, Packing peanuts
Other		•There are other polymers that have a wide range of uses, particularly in engineering sectors. They are identified with the number 7 and OTHER (or a triangle with numbers from 7 to 19).	Plastic CDs and DVDs, Baby bottles, Large water bottles with multiple-gallon capacity, Medical storage containers, Eyeglasses, Exterior lighting fixtures

Source: Types of plastics and their Recycle codes (Mertes, 2019)

2.2.3. Waste plastics and their impacts

Developing countries (DCs) typically have inadequate solid waste management, with low waste collection rates, disposal primarily by dumping and limited outlets for reusing potentially recyclable materials (Wilson D. c., 2015). However, waste materials in DCs can provide livelihoods to a highly entrepreneurial informal sector (Wilson, 2007). The management of wastes, and particularly waste plastics, has become a high profile, environmental and public health issue. Recycling infrastructure for these materials often does not exist in DCs, and as a result, waste plastics have little or no value, resulting in uncontrolled disposal. Dumping into waterways has severe adverse effects on local communities.

Waste plastics are not only unsightly, but they block urban drainage systems and sewers, causing flash floods, as well as providing a fertile breeding ground for mosquitos and other waterborne diseases. Plastic waste has become so ubiquitous that it is now a serious threat to marine ecosystems and biota. It has been estimated that between 4.8 and 12.7 million metric tones of plastics waste was added to the oceans in 2010 (Jambeck *et al.,* 2015). Oceans are downstream from waterways, 60–80% of marine litter is plastic and poor waste management in DCs is a major cause and contributor to plastics in the oceans (Sebille *et al.,* 2016). Despite the low biodegradability of plastics and the associated potential for long-term adverse environmental impacts, single use polyethylene drinking water sachets are very widely used throughout much of Africa. These are used in enormous numbers because water sold in sachets has higher quality than the local tap water. As a result, water sachet use has increased to such an extent that they are now a major environmental issue in many parts of Africa, as reported for the AccraTema Metropolitan Area in Ghana (Stoler *et al.,* 2012).

Uncontrolled and indiscriminate dumping of plastics into water bodies is very common in DCs because there is often no local recycling infrastructure. It is estimated that 15–40% of waste plastic is dumped into water bodies and this contributes to the estimated 5.25 trillion pieces of plastic debris currently in the oceans ((Crawford *et al.,* 2017); (Sebille *et al.,* 2016)).

2.2.4. Advantages and disadvantages of plastics

Plastics are integral parts of human life. It is preferable for the many uses it provides.

Among many of the advantages, the following are some of them (Miller, 2020):

- Gives safety and hygiene for food and drink packaging
- Resistant to chemicals and water effects
- Lesser production cost
- They are Low density
- Have high Strength
- Are user friendly
- Have long life, which means it gives long durations of purpose
- Have low cost
- Easily molded in to desired shape
- Better aesthetics
- Gives high thermal and electrical insulation

Among the disadvantages of plastics the following are some of them:

- Are toxic in nature
- Health problems to human and animals

- Pollute the environment
- Are non-renewable
- Are non-biodegradable substances
- Contributes to economic loss
- Cannot be infinitely recycled
- Takes up much energy to clean
- Takes long time to decompose
- Harm the eco system

2.2.5. Waste plastics reuse in construction

The usage of plastic can't be banned, but can be reused in many ways. Plastic can be reused in various sectors like marketing, manufacturing, transportation etc. In construction sector, we can use the plastic waste on a very large scale after recycling it, which means the problem of plastic waste can be removed for a long period of time. In some countries, plastic wastes are being used to different forms of construction materials either partially or full replacement (Madan, 2018).

A. Flooring tiles from waste plastics

In construction field, many types of bricks and tiles are used like - clay bricks/tiles, concrete bricks, fly ash bricks, foam bricks. Plastic sand mix tiles are cheaper than normal tiles. People can easily afford these types of tile products.

Previous research has reported on the re-use of waste plastics as construction materials in developing countries. Polyethylene terephthalate (PETE) bottles filled with sand or earth have mechanical properties suitable for use in walls and in slab construction (Mansour and Ali, 2015). Plastic bottles can also be filled with plastic food wrappers to form eco-bricks (Webster, 2017). Lightweight concrete has been produced by using waste plastics as aggregate (Gu *et al.,* 2016); (Ismail *et al.,* 2008). Plastic coated aggregates have been used to form asphalt and this allows a 10% reduction in bitumen usage (Vasudevan, *et al.,* 2012). Plastic fibers have been used in concrete to provide a cost-effective, corrosion resistant reinforcement option (Gu, *et al.,* 2016). PET fibers have also been used to improve the compressive strength and energy absorption capacity of soils (Consoli, *et al.,* 2002).

Plastic-bonded sand paver blocks were produced using waste plastics in the Cameroon by Pierre Kamsouloum et al. (Kamsouloum, *et al.,* 2018). This has now become a leading example of a community-driven waste management initiative that has had an impact on local communities and local waste management (Webster, 2017). By turning wastes into potentially valuable resources it also has the potential to contribute to solving the global waste crisis. However, the manufacturing process and the mechanical properties of the materials formed have not previously been reported in the scientific literature to date and these technologies will benefit from the type of laboratory-based systematic research reported in this paper.

The aim of this research is also therefore to optimize the production process at laboratory scale and determine the properties of these materials in order to provide guidance to those working in the field on the key production parameters that determine performance. In this work the effect of the sand particle size and the sand to plastic ratio in PETE-bonded sand is reported. The optimum samples have been further characterized for stress-strain behavior during loading to failure in bending.

B. Plastic road construction

As per study by Bhoot, *et al.*, 2012, titled "*Potential reuse of plastic waste in road construction*" plastic wastes were used as highway road construction. The use of these plastic wastes as partial replacement of natural minerals extracted, helped for environmental protection and decreased cost of material extraction. The melting and blending of plastics as binding materials for the roads showed good result, decrease of wear and tear of roads and doesnot need any new machinery for the production.

In another study made in India, plastic waste in road construction showed good result in the the properties of the roads. As per the field tests, resuts showed it to withstand stress and solve environmental problems and increase source of income (Trimbakwala, 2017).

C. Plastic waste usage in building construction

In building the other way of usage of plastics other than melting and mixing under controlled environment is filling plastic pet bottles with sand and using it as building blocks and bricks. Through the use of PET bottles in construction materials, low cost housing can be achieved for the poor. A study by (Shilpi, 2013), shows that using plastic bottles in construction materials can provide better thermal comfort to the occupants than buying air conditioning and heating systems.

The plastic bottle walls are less costly compared to bricks. They also have good compressive strength and are lightweight bearing high weight. The structures made by this plastic bottles are proven to be durable, earth quake resistant and have low water absorption and percolation properties and less construction period (Andreas, 2001).

2.3. Review of empirical literature

A study in Malaysia with a title of *Utilization of Plastic bottle Waste in sand bricks* (Wahid *et al.*, 2015), properties of different proportions of plastic in sand bricks were tested for their compressive strength, efflorescence, and water absorption. It has been found that introducing plastic waste into the sand bricks can improve their performance. The experiment in the study showed a great result in water absorption p and efflorescence and enhanced compressive strength with addition of super plasticizer in the mix.

Some other studies show plastic addition in concrete mix as partial substitution for sand. Like the experimental study titled *Eco-Friendly Concrete containing recycled plastic as partial replacement for sand* (Almeshal *et al.*, 2020) concrete was cast with the addition of plastic (PETE) to determine the behaviour of fresh and hardened concrete in terms of workablity, unit weight, compressive strength, flexural strength, tensile strength, pulse velocity and fire resistance. By which the result showed in reduction of weight, affected the mechanical properties of the concrete at different rates and deduced that plastics can be effectively applied in industrial usage.

The other research with the same process as Almeshal is the research made in Islamic University of Gaza Engineering faculty (Ishaiba, 2015), adding plastics (PETE) in concrete to investigate the compressive, tensile and flexural strengths, weight reduction and workablity with four different ratios of adding plastic in the concrete mix. The research's study revealed that there was a 12% reduction in weight, and with increase in plastics to the concrete there occurred a significant decrease in the compressive strength.

In other journal made by Seybold Report, with title of *Reuse Of Plastic Waste For For The Production Of Floor Tiles*, the floor tiles were made by mixing plastic wastes and fly ash, and compared it to normal cement tiles to evaluate the different physical and mechanical properties. These testes are water absorption test, , transverse resistance, resistance of impact and abrasion resistance test. The tests shown better result compared to the normal concrete floor tile. 3.8% average water absorption, 10.8N/mm^2 average transverse strength, 0.6cm sverage abrasion resistance and 27cm average impact resistance was found from the result. Finally the aughtors concluded that the plastic floor tile can replace cement as binding agent in pavement construction. (Parangi, *et al.*, 2020)

A research in Ethiopia, Debrebrhan university, with title of *Experimental Investigation on recycling of plastic wastes and broken glass in to Construction material*, shows a comarable difference in the construction materials ordinarily used with different proportions of plastic and broken glass. The reseaarch generally shows ka significant weight reduction when the percentage of plastics added is increased (Behera, 2018).

The greatest challenge to the recycling of plastics is the difficulty of automating the sorting of plastic wastes, making it labour-intensive. Typically, workers sort the plastic by looking at the resin identification code, although common containers like soda bottles can be sorted from memory. Typically, the caps for PETE bottles are made from a different kind of plastic which is not recyclable, which presents additional problems for the sorting process. Other recyclable materials such as metals are easier to process mechanically. (Reusing potentially recyclable materials (Wilson et al., 2015), However, new processes of mechanical sorting are being developed to increase the capacity and efficiency of plastic recycling.

While containers are usually made from a single type and colour of plastic, making them relatively easy to sort, a consumer product like a cellular phone may have many small parts consisting of over a dozen different types and colours of plastics. In such cases, the resources it would take to separate the plastics far exceed their value and the item is discarded. However, developments are taking place in the field of active disassembly, which may result in more product components being reused or recycled. Recycling certain types of plastics can be unprofitable as well. For example, polystyrene is rarely recycled because the process is usually not cost effective. These unrecycled wastes are typically disposed of in landfills, incinerated or used to produce electricity at waste-to-energy plants. (Wilson et al., 2006).

2.4. Conceptual framework of the study

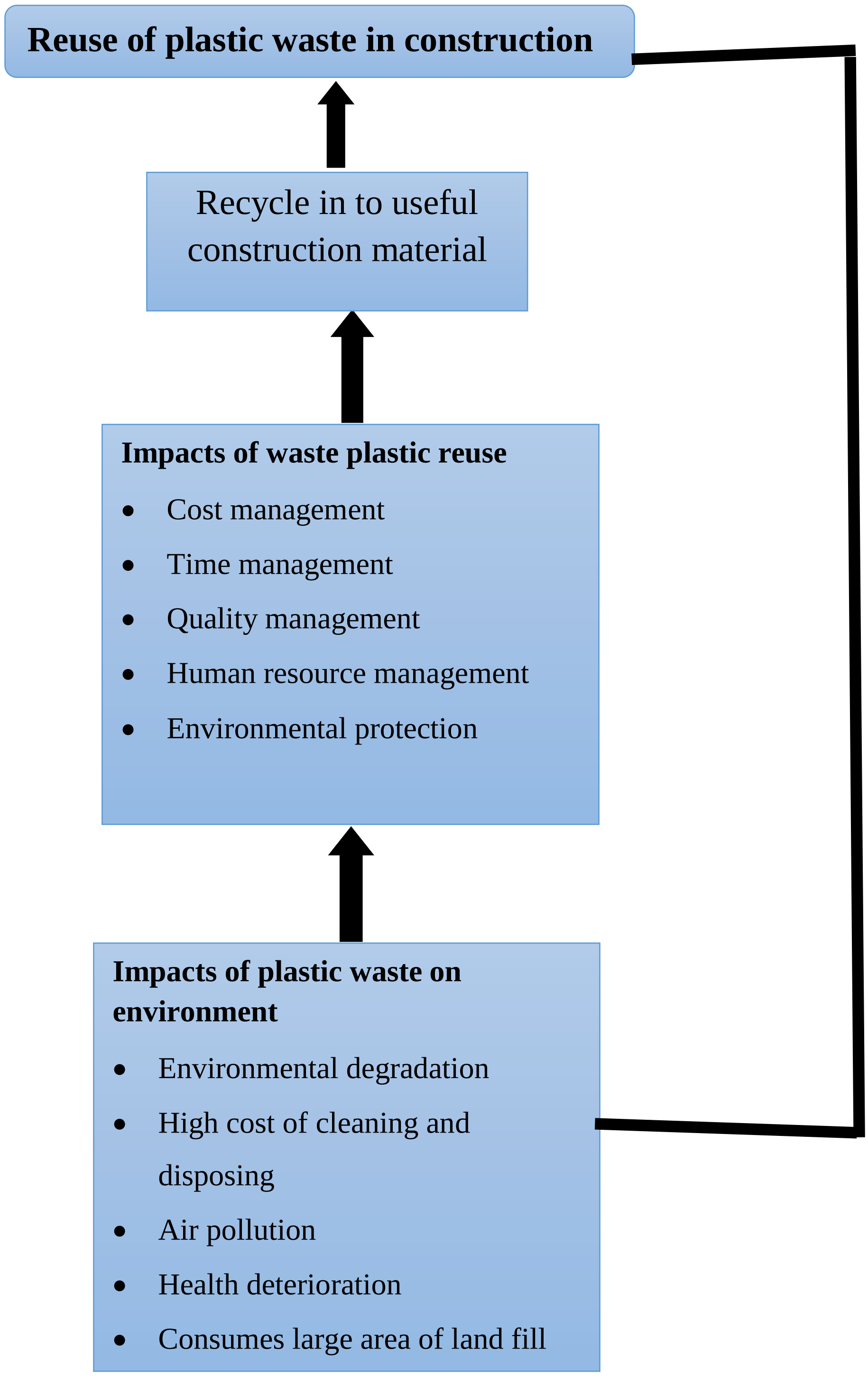

Figure 3 Conceptual framework

CHAPTER THREE

METHODOLOGY OF THE STUDY

3.1. Study area description

This chapter of the research includes the methodologies used in order to meet the objective of the study. It specifically contains research approach and design, population and samples, data collection tools data analysis and ethical considerations.

3.2. Research approach and design

Research Design provides a comprehensive coverage of the design concepts and statistical principles required for making sense of real data (Well *et al.*, 2010). This study was based on existing literature on the topic and with the relevant data obtained from experiments; the study is thus designed as a qualitative and quantitative study, aiming to understand the preferable practice aiming to reduce plastic wastes and managing it for reuse in construction.

The chapter covers the assessment of plastic construction waste material using both the qualitative and quantitative approach. For this questionnaires are distributed and collected. The advantage of using a mixed approach is to cover the weakness of one approach with the strength of the other approach (Mark, 2009).

Quantitative research approach count things, analyses data statistically and quotes results in numeric forms. This approach is used to find facts based on evidence or records. The method relies on experiments and surveys to collect measurable data (Creswell, 2002). Therefore a quantitative research approach was adopted to rank the causes, impacts of plastic waste reuse and to find out in what way the reuse helps in the construction.

This being said, Creswell also described that a qualitative research measures based on opinions, view, and perceptions measurement. As the objective of the research is to assess the management and reuse practices of plastic wastes in to construction, qualitative research approach was adopted to explain the plastic waste reuse practice in Addis Ababa construction.

This chapter assesses the waste management practices in order to meet the objectives of the research using both qualitative and quantitative research methods.

As a research design, descriptive design was selected based on the research questions. According to (Naoum, 2007), descriptive research is used to describe a specific population or a phenomenon and to answer the “what” question. As it is stated earlier, the objectives of this study are mainly to assess waste plastic material and its management practice as a reuse for construction and its optimization with respect to cost and time efficiency. So the reason for using the descriptive design is because all of the research questions are towards answering the “what” and are explaining plastic recycle and reuse phenomenon.

3.3. Population and sampling

This study was focused on recycling plastic wastes for production of suitable building materials in building construction. As a result, the population of the study was mainly building contractors in Addis Ababa. According to the list which was collected from the Addis Ababa construction bureau, there are a total of around 1720 building contracting companies who are registered from grade one to grade six. So it’s not possible to take all of these groups so it is a must to decide which group to take as a sampling frame.

From the general population of the study, grade 1 contractors were selected as a sampling frame for the study.

Based on the obtained list of registered contacting companies from the Addis Ababa Construction Bureau, the total number of registered contracting companies as level 1 contractors is 133.

Therefore, the sampling frame selected was contracting companies of level one who are registered by the Addis Ababa construction bureau. So the targeted respondents of the questionnaire were construction professionals who are working on these construction companies. This includes project managers, site engineers, and office engineers.

Since it is impractical and costly to take all of the targeted population, it was a must for this study to take a sample. Due to this the sample size for this study was calculated using Yamane’s formula (1967). This equation is applicable to calculate a sample size with a known sampling frame. The sample size was calculated as follows

$n_{Yamane} = N / (1 + Ne^2)$

Where, n = sample size

N= known population size

e = error level (in this case it is 5%)

Level 1 Contractors (C)

Total Number of C= 133

$n_{Yamane} = N / (1 + Ne^2)$

= 133/ (1+133*0.0025)

= 99.8 approximately 100

The probability sampling method was used to give equal opportunity for the targeted population of the study. This sampling method is most commonly associated with survey research strategies (Mark *et al.*, 2016). As opined by the authors, selecting random numbers allows us to select a sample without bias. So the sample which is selected randomly can be said it is representative to the targeted population. Besides, the authors stated that simple random sampling is best used when there is an easy and accessible sampling frame that lists the population and for a few hundred target population. Otherwise, the sample selected will have a probability of being biased. As a result, to give the targeted population an equal probability of getting into the sample, its high accuracy of representation and the availability of the lists of contracting companies, simple random sampling was used to select the sample for this study.

3.3.1. Data collection tools

I. Questionnaire

For this research a questionnaire is used as a method in surveying the qualitative and quantitative aspects. It consists same closed end questions which helps to collect more effective responses from large sample for qualitative analysis. To obtain the needed data, questionnaire will be used as a data collection tool, due to the sample size and the quantitative approach of the study.

Questionnaire design

The questionnaire was undertaken as a data collection tool to identify the major plastic waste types, uses and applicability impacts in the construction firm. The questions were prepared to be filled by construction professionals who are directly involved in the construction process. Based on the objective of the study the questions were classified into three sections.

Part I: General characteristics of waste management practice of the study respondents

This section is included to inquire information about the respondent’s experience in using plastics. The questionnaire includes the twelve important questions which are; the day to day use of plastics, the purpose, reason they use plastics instead of other products, and more questions to assess their level of knowledge in the nature and effects of plastic wastes and also future suggestions for the plastics to be used.

Part II: Existing waste management and reuse practice in the construction company

This section is of the questionnaire describes the properties of the new construction material (Waste plastic and sand mix floor tile) and asks construction professionals the practices used to their experience in construction firms. It also asked their suggestions in the replacement of the material in reuse. 5 simple questions were asked in this section. So generally this part mainly asks if the professionals agree with the replace ability of the material according to the properties given.

Part III: Prospects for reuse of plastic waste materials for the company

This section of the questionnaire was added to answer the fourth question of the study. In this section, all impacts collected from the literature review and modified in the pilot study were listed. The respondents were asked to identify which of the impacts more affect the performance of the material if it is used as constructions material and the effects of the material use in the different management practices, like cost, time, Quality, human resource and in addition environmental protection.

3.4. Procedures of data collection

The first step taken to data collection was preparing the questionnaire. So, based on the reviewed literature, advantages and effects of managing waste plastic recycle and reuse in construction were identified. After that, the content validity and reliability of the questionnaire were checked using the following two tests.

A. Validity

"Validity, in essence, refers to the appropriateness of the measures used, the accuracy of the analysis of the results and generalizability of the findings" (Mark *et al.,* 2016). According to the authors, validity in terms of questionnaire refers to the ability of the instrument to measure what was intended to measure. Among the different types of validity, content validity is one of the types which show whether the investigated questions are covered by the instrument or not. To do this a pilot study was carried out before distributing the questionnaire. The process involves giving the questionnaire to some number of respondents who have knowledge of that area to give comments on it. To test the content validity, the questionnaire was distributed by attaching it with the objective and research questions to ten experienced professionals who are currently working on the construction industry and academic areas. For this research case 10 % sample was taken for pilot study. After that, the questionnaire was modified based on the received comments and distributed to the targeted populations.

B. Reliability

As stated by Mark Saunders *et al.,* (2016: p.202) reliability refers to "replication and consistency" which means if a study can be replicated by an earlier design and one can achieve the same results, that study can be seen as reliable. According to the authors, Cronbach's alpha is a value that ranges between 0 to 1 and used to measure the internal consistency by checking if the items in the data collection instrument measure similar things or not. In this study, this coefficient was used to measure the reliability of the questionnaire. As shown in the table below, the alpha coefficient was calculated for each scaled group factors and the entire questionnaire.

Table 2 Summary of Cronbach's Alpha results

Question bases	**Cronbach's Alpha Coefficient**
General characteristics of waste management practice of the study respondents	0.778
Existing waste management and reuse practice in the construction company	0.533
Prospects for reuse of plastic waste materials for the company	0.616
Effect related to cost management	0.790
Effect related to time management	0.718
Effect related to quality management	0.647
Effect related to human resource management	0.863
Effect related to environmental protection	0.863
All	0.832

Source: Own Survey (2021)

3.5. Methods of data analysis

Since the research design used to meet the objectives was descriptive, descriptive statistics that involve both measures of central tendency (mean) and measures of dispersion (standard deviation) was used to analyze the ordinal data using SPSS software. At last, the collected data were presented in tables.

Relative Importance Index (RII)

The RII method was implemented to determine the ranks of all factors that was listed in the questionnaire. The score for each impact was calculated by summing up the scores given to it by the respondents. After calculating the RII value, the factors were ranked based on their respective values. The relative importance index (RII) can be calculated using the following formula (Sambasivan, *et al.*, 2007).

$$RII = \frac{\sum PiUi}{N\ (n)}$$

$(0 \leq RII \leq 1)$ Where,

RII = Relative Importance Index

Pi = respondent’s rating of impacts of waste plastic material (From 1 to 5, one being the lowest impact and 5 the highest)

Ui = number of respondents placing identical weighting/rating

N = sample size

n = the highest attainable score on cause construction material waste (i.e. 5 in this case)

3.6. Ethical Considerations

Throughout the process of doing the study, the ethical requirements of a study were carried out. First, when reviewing secondary data from journals, articles, proceedings and related sources, every source used was acknowledged both in-text citation and referencing. Secondly, making any interaction with participants was carried out after giving the letter the university prepared for this purpose. It is specifically declared on the questionnaire that the participation of the respondents is purely voluntarily. Finally, the respondent's name and the organization were not stated in any of the study parts, so every respondent was anonyms and their response were confidential.

2.7. Methodology for experimental analysis

This part of the research explained plastic waste recycled in to floor tile. Experiment analysis was used for this in order to compare the effectiveness of the plastic tile with the ordinarily used concrete floor finish material. It shows the production to the testing of the material

2.7.1. Manufacturing

For this research the component manufactured was made from the waste plastic bags and plastic bottles collected from different places in Addis Ababa. Following are the steps involved in its manufacturing:

A. Selecting and collecting the right plastic

It is important to only select the correct and unique type of plastic. This is because different types of plastic melt and burn at different temperatures and have different physical properties as mentioned in the literature review (Sepe, 2011). The process described here works well with PETE Water bags. It is important that other types of plastics are not added in the process unless they have the same physical and chemical properties. Time and technology in the country limits the ability to study these properties but to use literatures and other studies. So for the research, same types of products without any other impurities/different kind plastics were used. Therefore PETE water bags were used for the whole process.

These plastic wastes were collected from office wastes, dump sites by plastic collectors and also bought from the market.

B. Shredding:

The plastic bags were then cut into smaller pieces using scissors and cutters. In the developed countries this cutting process is made using a machine made to cut and grind the plastic in to more simplified and fine pieces (Josef B. et al., 2012). But for this research cutting was made manually by scissors and cutters in to small pieces for easy melting process.

Figure 4 Selected and Shredded plastic

C. Washing:

The plastic chunks were then washed to remove glue, paper labels, dirt and any remnants of the product they once contained.

D. Drying

This process is for both the washed plastic and sand. An average sand is filled with humidity which makes it impossible to bond with plastic (Abdulla, 2016). For the sand, oven drying system or sun drying can be used. For this research, sun drying was used for 24 plus hours for both materials.

E. Making of the mold:

For this research, to give the molten plastic and sand mix its final shape of the tile, a mold was prepared. This is to have the same size (15cm*15cm) as our comparison specimens of concrete tiles. This was manufactured by welding Mild Steel (MS) plates together.

F. Manufacturing

In developed countries there are plastic shredding, mixing and melting machineries available. But for this research purpose melting and production are made traditionally by burning wood, and then mixing and melting using iron bowl or plate.

G. Melting

This was done by gradually adding shredded plastic pieces in the melting plate. The source of heat was fire wood. As the plastic reached glass transition temperature, more plastic is added. When it gains some significant amount of plastic body formation, start adding sand to the molten plastic that plays the role of a binder.

Figure 5 Melting plastic and mixing with sand

2.7.2. Experimentation

For checking the properties of PETE made floor tiles following test were done on the component:

A. Compression test:

Compression test was conducted as per the ASTM D 695-2015 (Standard test method for compressive properties for rigid plastics). For this, the standard specimen size is 15 x 15 x 25.4mm. The specimen is placed between compressive plates parallel to the surface. The specimen is then compressed at a uniform rate. The maximum load is recorded along with stress-strain data. Compressive strength was calculated using the following equation.

$$Compressive\ strength = \frac{maximum\ compressive\ load}{minimum\ cross - sectional\ area}$$

B. Water Absorption Test:

In this test, tiles were weighed in dry condition and soaked in fresh water for 24 hours. After 24 hours of immersion, specimens were taken out from water and wiped out with clean dry cloth. Then, tiles were weighed in wet condition. The difference between weights is the water absorbed by tiles. The percentage of water absorption is then calculated. The less water absorbed by tiles the greater its quality. Good quality tiles doesn't absorb more than 3% water of its own weight.

2.7.3. Material constituents

A. Waste Plastic

Different shapes and sizes of plastic can be produced when they are heated. This material can be made into various forms such as cups, furniture's, and plastic bags. Due to their hazardous effects on the environment, they have to be properly handled.

Waste management with respect to plastic can be done by recycling. If they are not recycled then they will become big pollutant to the environment as they do not decompose easily, do not allow water to percolate in to the soil and as they are also poisonous. As mentioned in the literature review, there are around seven main types of plastic among them for this research only Polyethylene Terephthalate (PETE) type was used. For this research purpose the plastic wastes were collected from governmental office and bought from the market those were collected by waste collectors.

Figure 6 Waste plastic bottles collection in governmental institution

Table 3 Properties of waste plastic bottles

No	Experiment	Result
1	Specific Gravity	0.88
2	Density (Kg/m^3)	386.7
3	Colour	Light blue
4	Absorption	zero percentage
5	Thickness	to 1 mm

B. River Sand

Basically Fine aggregate (Natural Sand) is result of the natural disintegration of rock and which has been deposited by streams or glacial agencies. It is distinguished from gravel only by the size of grain or particle, but it is distinct from clays which contain organic minerals.

Figure 7 River sand

Table 4 Physical properties of sand

Properties	Limit
Type	River sand
Silt content	5%
Absorption (%)	2.71
Max size (mm)	2.36mm
Density (kg/m3)	1688
Specific gravity	2.62

Sieve analysis Test result

Sieve analysis is a procedure used in engineering to assess the particle distribution of granular materials by allowing the material through series of sieves (Alam et al., 2020)

Table 5 Sieve analysis Test result

Sieve size	Sieve w.t (A)	Sieve w.t + ret. (B)	Ret. (c)	% ret. (D)	% cumm. (E)	% pass. (F)
9.5 mm	0.490	0.525	0.035	3.5%	3.5%	96.5
4.75 mm	0.415	0.460	0.045	4.5%	8%	92
2.36 mm	0.455	0.545	0.09	9%	17%	83
1.18 mm	0.450	0.640	0.19	19%	36%	64
600 µm	0.405	0.715	0.31	31%	67%	33
300 µm	0.370	0.595	0.225	22.5%	89.5%	10.5
150 µm	0.270	0.360	0.09	9%	100%	0
Pan	0	0	0	0	-	-

B - A = C

C / CT *100=D

FM=Summation of % comm./100=321/100=**3.21**

Has to be ranged between “2.25-3.25” (EBCS) our result is 3.21….ok

D1 + 0 = E1, D2 + E1= E2, D3 + E2 = E3…….

100 - E1 = F1, 100 - E2 = F2, 100 - E3 = F3……

Silt Test

S.C = S.H / T.SAMPLE *100…Has to be less than or equal to 6%.

S.C=4/80*100=5% ………OK

2.7.4. Apparatus used.

A. Melting plate

Figure 8 Melting barrel

B. Mold

Table 6 Mold

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSION

4. Introduction

This chapter clarifies the in depth results and discussion of the waste plastic management and reuse in construction using collected data using survey. The effects of the recycled waste plastic material management in cost management, time management, quality management, human resource management and environmental protection were studied.

The questionnaire consists of four major parts those are general question part which investigates the general plastic waste removal and management use in constructions in Addis Ababa region, second that investigates about plastic wastes in the construction sites and the third part which surveys the effects of availability and use of recycled plastic wastes in construction and at last open end question to gather the waste plastic reuse practice in the respondents respective construction site.

4.1. General characteristics of waste management practice of the study respondents

This section of the questionnaire was prepared to determine the general plastic waste management and disposal system randomly in Addis Ababa construction. This included groups which mainly use and have direct contact to construction materials, Grade 1 contractors.

It contains 12 questions asking general questions to investigate the usage, nature and disposal system of plastic wastes in their area and experience of the respondents.

Table 7 below presents the percentage of use of plastics in Addis Ababa. Accordingly, it appeared that most people use plastic materials on their day to day activity in a wide range. 93.1 percent or 67 out of 72 respondents use plastics daily.

Table 7 General Plastic Usage

Use		Frequency	Percent	Valid Percent
Valid	YES	67	93.1	93.1
	NO	4	5.6	5.6
	3	1	1.4	1.4
	Total	72	100.0	100.0

Source: Own Survey (2021)

This observation shows that the increase in the daily use of plastic among most respondents means increase in plastic wastes to the environment.

Table 8 depicts for what purpose people use plastics mostly. As shown in the table wide range of people use plastics for water containers (34 out of 72 respondents) and as plastic bags to hold materials (35 out of 72 respondents). Since these types of plastics are made of LDPE and PETE which are considered the highest plastic pollutants (Martinko, 2017).

Table 8 Plastic Purpose

Purpose		Frequency	Percent	Valid Percent
Valid	WATER BOTTLE	34	47.2	47.2
	PLASTIC BAGS	35	48.6	48.6
	BUCKETS AND BINS	3	4.2	4.2
	Total	72	100.0	100.0

Source: Own Survey (2021)

According to Katherine Martinko, writer and expert in sustainable living, food wrappers and containers (LDPE Products) contribute to 31.14% of pollution, which are single-use disposable packaging like cookie containers, candy bar wrappers, potato chip bags, and so on, and the second most pollutant plastic to be bottles and container caps (PETE products), contributing to 15.5% pollution, plastic bags (LDPE products) contributing to 11.18% pollution, beverage bottles (PETE products) contributing 7.27% pollution to the environment.

Plastics are used for many reasons. People mostly use plastics because they are cheap and easily available for multiple purposes (Table 9). 45.8% of respondents use plastics for the cheapness and 48.6% for its easy availability. As per Brandon Miller, plastics provide a safe way to transport our needed items (Miller, 2020). The cost of production and its reuse makes is a very cheap and favorable material to use every day.

Table 9 Reason for using plastics

Reason for use		Frequency	Percent	Valid Percent
Valid	CHEAP	33	45.8	45.8
	LIGHT WEIGHT	4	5.6	5.6
	EASY AVAILABLITY	35	48.6	48.6
	Total	72	100.0	100.0

Source: Own Survey (2021)

Table 10 presents the toxicity/hazardous nature of plastic wastes as described by respondents. The plastic cannot be considered as a non-hazardous product because more than 50 per cent of plastics contain chemicals that are toxic and they are released into the environment after they are discarded (Sambyal, 2013).

Table 10 Nature of plastic

Nature of waste		Frequency	Percent	Valid Percent
Valid	HAZARDOUS	60	83.3	83.3
	NON HAZARDOUS	12	16.7	16.7
	Total	72	100.0	100.0

Source: Own Survey (2021)

Moreover Sambyal (2013) described, plastic debris is not biodegradable, it is photo-degradable, making all the plastic debris fragment into smaller and smaller pieces that can easily be confused by organisms in seawater or freshwater as food. In turn affects the whole eco system.

As per the table 10, plastics were considered hazardous by 83.3% or 60 out of 72 respondents and 12 out of 72 respondents do not think plastic wastes are nonhazardous and their reason was because plastic wastes can be recycled in to another useful form.

Most plastics in Addis Ababa region come from house wastes (Table 11). Among the respondents 52.8 % replied most of the plastic wastes came from house hold wastes and 44.4 % responded that it came from factory wastes.

Table 11 Sources of plastic wastes

Sources of plastic waste		Frequency	Percent	Valid Percent
Valid	FACTORIES	32	44.4	44.4
	OFFICES	2	2.8	2.8
	HOUSES	38	52.8	52.8
	Total	72	100.0	100.0

Source: Own Survey (2021)

Better Meets Reality, (Reality, 2021), mentioned in its journal, "East Asia and the Pacific contribute to 60% of global mismanaged plastic (improperly disposed of or not fully contained plastic), and Asia is responsible for 86% of rivers that carry plastics into the ocean."

Further the journal describes that factories and sectors generate most plastic wastes making packaging sector waste on top, i.e. packaging-141 mil. Tones, other sectors-42 mil. Tones, textile-38 mil. Tones, consumer and institutional products-37 mil. Tones, building and construction-13 mil. Tones and industrial Machinary-1 mil. Tones as per the data taken in 2019 and updated in February 2021.

As per the respondents, table 12 shows the plastic disposal practice of the community. 49 out of 72 of the respondents replied that they dispose their wastes by giving it to house to house waste collectors. 10 out of the 72 incinerate their wastes and 10 of them dump it in open area that is on the road, in water bodies or in sewerage systems.

Table 12 Plastic waste disposal practice

Disposal		Frequency	Percent	Valid Percent
Valid	WASTE COLLECTORS	49	68.1	68.1
	OPEN DUMPING	13	18.1	18.1
	BURNING	10	13.9	13.9
	Total	72	100.0	100.0

Source: Own Survey (2021)

As studies show, in 2015, 55% of the global waste was discarded to landfill, 25.5% was incinerated and 19.5% was recycled (Reality, 2021).

The repetition of the waste disposal shows that 65.3% of the respondents dispose their wastes in daily basis either by giving it to waste collectors, burning it or open dumping (Table 13).

Table 13 Disposal Recurrence

Disposal Recurrence		Frequency	Percent	Valid Percent
Valid	DAILY	47	65.3	65.3
	WEEKLY	19	26.4	26.4
	MONTHLY	6	8.3	8.3
	Total	72	100.0	100.0

Source: Own Survey (2021)

Waste plastics harms the environment in many ways. As shown in table 14, animal death takes the top effect. 33 or 45.8% of the respondents responded it causes animal death, 20 or 27.8% health problems, 2 or 2.8% sewerage system blockage and 17 or 23.6% environmental destruction.

Table 14 Effects of waste plastics

Waste problems		Frequency	Percent	Valid Percent
Valid	ANIMAL DEATH	33	45.8	45.8
	HEALTH PROBLEMS	20	27.8	27.8
	SEWERAGE SYSTEM BLOCKAGE	2	2.8	2.8
	ENVIRONMENTAL DISTRUCTION	17	23.6	23.6
	Total	72	100.0	100.0

Source: Own Survey (2021)

Most wastes in the world are considered to be dumped in marine environment which find their way to water bodies and it has a terrible impact on marine species.

Land-based plastic waste can get stuck in trees, fences, and other structures. It can kill an animal if it gets into its stomach and ingests the plastic. Air pollution is caused by the burning of plastic. It can cause respiratory problems among humans and animals (Madan, 2018).

These wastes collected from house to house collecting in Addis Ababa mostly go to Koshe area around Ayertena that is according to the table below, the region of origin.

Table 15 Plastic waste destination

Waste destination		Frequency	Percent	Valid Percent
Valid	REGION OF ORIGION	61	84.7	84.7
	OTHER REGION	4	5.6	5.6
	DONOT KNOW	7	9.7	9.7
	Total	72	100.0	100.0

Source: Own Survey (2021)

Table 16 answers the question if wastes in the Addis Ababa are reused, recycled or recovered. 63.9% of the respondents answered these plastics are mostly reused. For instance if a plastic container is used once it can be used as storage of another thing in the house. These materials are not mostly thrown away, but used for different purpose other than its original purpose.

Table 16 Practice of Plastic reuse, Recycle or Recover

RRR		Frequency	Percent	Valid Percent
Valid	REUSED	46	63.9	63.9
	RECYCLED	25	34.7	34.7
	RECOVERED	1	1.4	1.4
	Total	72	100.0	100.0

Source: Own Survey (2021)

25 out of the 72 respondents answered that they are recycled in to other use. In which this section of the question will be answered in the final open end question.

As per the respondents, table 17 shows respondents thoughts whether plastics should be reused, recycled or recovered. 63.9% of them proposed it should be reused, 34.7% recycled and 1.4% recovered.

Table 17 Can Plastic be Reused, Recycled or Recovered

RRR2		Frequency	Percent	Valid Percent
Valid	REUSED	46	63.9	63.9
	RECYCLED	25	34.7	34.7
	RECOVERED	1	1.4	1.4
	Total	72	100.0	100.0

Source: Own Survey (2021)

Plastics can be reused or recycled to be in different forms and used for different purposes. Among the 72 respondents 64 of them responded that the plastics can be reused as construction materials, 7 for land filling and 1 person as textile/garment (Table 18).

Table 18 Alternative use of plastic wastes

Alternative use		Frequency	Percent	Valid Percent
Valid	CONSTRUCTION MATERIALS REPLACEMENT	64	88.9	88.9
	GARMENT	1	1.4	1.4
	LAND FILLING	7	9.7	9.7
	Total	72	100.0	100.0

Source: Own Survey (2021)

4.2. Existing waste management and reuse practice in the construction company

This section was designed to obtain data about the plastic wastes in construction sector and their practices.

Table 19 Plastic waste availability in construction site

Waste availability		Frequency	Percent	Valid Percent
Valid	YES	60	83.3	83.3
	NO	12	16.7	16.7
	Total	72	100.0	100.0

Source: Own Survey (2021)

Table 19 shows the availability of plastic wastes in construction area with 83.3% responding yes to the availability, and Table 20 illustrates where plastic wastes in construction sites originate from. According to the respondents most of the plastic wastes come from plastic construction material wastes. Construction material packaging takes the second place while cut offs and unused materials take up the last place.

Table 20 Origin of Plastic wastes in the construction site

Origin of waste		Frequency	Percent	Valid Percent
Valid	PLASTIC CONSTRUCTION MATERIALS	40	55.6	55.6
	PACKAGING	23	31.9	31.9
	OFF CUTS AND UNUSED MATERIALS	9	12.5	12.5
	Total	72	100.0	100.0

Source: Own Survey (2021)

Plastic wastes can be used in different ways in construction, like insulating material to building blocks production. In developed countries now recycled waste plastics are used as floor tiles, roof tiles, water proofing system, wall and block construction as described in the literature review.

Table 21 Experience of plastic waste usage in construction sites

Experience		Frequency	Percent	Valid Percent
Valid	FLOOR TILES	18	25.0	25.0
	ROOF TILES	11	15.3	15.3
	WALLS	22	30.6	30.6
	WATER PROOFING	21	29.2	29.2
	Total	72	100.0	100.0

Source: Own Survey (2021)

"Development of new construction materials using recycled plastics is important to both construction and plastic recycling industries" (Rebeiz, 1995).

In the next section respondents were asked if they think plastic materials replace ordinarily used construction materials. As shown in the next table (Table 22) response of experts, there are not much use of recycled waste plastics in construction in Ethiopia, 47.2% of the respondents suggest that with further study and vast production, plastic waste based construction materials can replace the existing materials and practices, 51.4% of the respondents do not know if it can or cannot replace and suggested for further study and experiment in the area because of the little information and experience in the country.

Table 22 Waste plastic materials replace ordinarily used materials

Replace ability		Frequency	Percent	Valid Percent
Valid	YES	34	47.2	47.2
	NO	1	1.4	1.4
	DONOT KNOW	37	51.4	51.4
	Total	72	100.0	100.0

Source: Own Survey (2021)

As per the experts response for the most expected property to fulfill for the waste plastic material to be accepted as suitable construction material; compressive strength (25%), Low Cost (20.8%), Environmental Friendliness (15.3%), less weight (12.5%), easy shaping, easy shaping and recyclability (5% each), and durability (4%) acceptability rate (Table 23).

Table 23 Most expected property to fulfill as construction material

Most expected Property as a construction material		Frequency	Percent	Valid Percent
Valid	COMPRESSIVE STRENGTH	18	25.0	25.0
	DURABLITY	4	5.6	5.6
	LOW COST	15	20.8	20.8
	RECYCLABLITY	5	6.9	6.9
	LOW WATER ABSORPTION AND PENETRATION	5	6.9	6.9
	ENVIRONMENTAL FRIENDLY	11	15.3	15.3
	LESS WEIGHT	9	12.5	12.5
	EASY MOLDING	5	6.9	6.9
	Total	72	100.0	100.0

Source: Own Survey (2021)

4.3. Prospects for reuse of plastic waste materials for the company

This section shows the degree of impact of the reuse of waste plastics as construction material and its management practice in a construction company.

Table 24 Assessment of plastic wastes reuse as construction materials

Reuse of waste plastics as construction materials	Mean	SD	RII	Rank
Plastic wastes can be reused as construction materials replacement	3.93	1.053	0.786	3rd
The above described Waste plastic floor tiles can replace floor tile	3.46	0.963	0.692	6th
Waste plastics reuse in construction is useful in minimizing cost	4.44	0.837	0.889	2nd
Waste plastics reuse in construction is useful in minimizing time of construction	3.61	0.761	0.722	4th
Waste plastics can increase productivity	3.57	0.728	0.714	5th
Waste plastic reuse in construction is useful in minimizing the Environmental degradation	4.58	0.645	0.917	1st
Waste plastic can be the future of construction	2.90	0.995	0.581	7th

Source: Own Survey (2021)

4.3.1. Reuse of plastics related to cost management

Data were obtained about the top major impacts in using the plastic waste floor tile factors among the grade 1 contractors in terms of selected management practice areas. In order to obtain that, a list of impacts in management subjects were identified from literature review and modified based on the feedbacks collected from the pilot study. After that, a list of 24 impacts were selected and grouped in to five categories as effects/impacts related to cost management, time management, quality management, human resource management and environmental protection.

The rank of the categories in each 24 effects were analyzed using descriptive analysis and ranked using Relative Importance index value (RII).

According to the obtained results the effects of the plastic waste floor tile construction related to cost management as shown in the table below, five effects were selected under cost management category. Respondents were asked to indicate their level of agreement on the effect of the material from very low to very high.

Table 25 Cost management and plastic waste reuse in construction

Reuse of plastics as construction materials related to cost management	**Mean**	**SD**	**RII**	**Rank**	**Overall Rank**
Reduced Consumption of financial resources to purchase products	4.38	0.971	0.872	1st	1st
Reduction of foreign currency	3.69	0.914	0.731	5th	19th
Increase of economic security by using domestic source of materials	4.01	1.028	0.797	4th	12th
Lower transportation cost	4.14	0.969	0.822	2nd	10th
Minimized cost of maintenance	4.08	0.946	0.811	3rd	11th

Source: Own Survey (2021)

Respondents were asked to rank the impact of reusing plastic wastes as construction materials in cost management. The result showed that reduced consumption of financial resources to purchase products": as the best impact the material can cause with regard to cost management with RII value of 0.87 and mean value of 4.38. This is also the very first impact form the total 24 effects.

Compared to other costs, material purchase cost has a major financial impact in construction. Using locally and easily available plastic waste construction materials as replacement for the ordinarily used materials is one way to reduce construction costs.

The second ranked effect with mean of 4.14 from the cost management category is "Lower Transportation cost" and tenth from the overall rank out of the 24 impacts. Costs in the form of transportation from the point of extraction and/or production to the point of consumption or construction is one of the factors contributing to cost in construction (W. Shakantu *et al.*, 2003). One way to decrease the transportation cost is by decreasing the weight of materials. Since plastics have small density, the partial or full replacement of construction materials with plastics will be one way to reduce weight.

Using domestic sources of materials impacts in decreasing the cost of material. As per the response, "Increase of economic security by using domestic source of materials" ranked 4th with a mean of 4.01. The local availability of these plastic wastes also has a major role in reducing foreign currency. These are costs of material import, machinery, and so on. As per the table 21 responses, "Reduction of Foreign currency" with mean value of 3.69 ranked 5th from its category and 19th from the total 24 impacts.

4.3.2. Reuse of waste plastics related to time management

Time management has high level of impact in the use of waste plastic construction material. From the selected five categories time management is one of it. Under it four impacts are stated.

According to the respondents from the four time impacts less maintenance time ranked first, with mean value of 4.19 and RII value of 0.898 making it eighth place from all the 24 impacts. From the experimental analysis, there is zero waste because of the full recyclability of the plastics in construction materials and full maintainability without the need of additional new material needed.

For instance, if a floor finish tile is made with the mixture of waste plastic PETE bottles and sand, it is easier to maintain the damaged material just by re melting and re-molding it in the desired shape without additional material cost. In case of the ordinary concrete floor finish material maintenance, in case of breakage or damage, the full process of producing the material should be done. Starting from the crushing and mixing of new raw materials, vibrating and compacting to painting for better final outcome. But in case of waste plastic floor tile maintenance, the only thing needed is melting and re molding it to the desired shape.

Table 26 Time management and plastic waste reuse in construction

Reuse of plastics as construction materials related to time management	**Mean**	**SD**	**RII**	**Rank**	**Overall Rank**
Reduced time of production	3.92	0.835	0.783	3rd	15th
Minimized construction time	3.86	0.939	0.736	4th	18th
Locally available for reduction of hauling and transportation time	4.17	0.904	0.831	2nd	9th
Less time of maintenance	4.19	0.898	0.836	1st	8th

Source: Own Survey (2021)

The other impact identified based on the respondents was "Locally available for reduction of hauling and transportation time" with mean of 4.17 and RII value of 0.831. This effect ranked 9th from the total impact factors. Transportation factor is a major impact in all management studies.

Among the responses, the those ranked third and fourth are “reduced time of construction” with mean value of 3.92 and RII value of 0.783 and “minimized construction time” with mean of 3.86 and RII 0.736 respectively.

4.3.3. Reuse of waste plastics related to Quality Management

Respondents ranked “easy to use and maintain” as the first impact of the plastic waste reuse in construction with mean value of 4.29 and RII of 0.856 making it third place of all the other impacts. High durability ranked third with mean of 2.96 and RII value of 0.786 and 20th place overall, “Better strength with low weight” and “Better Aesthetics” ranked third place of their category with the mean value of 2.26 and RII of 0.394, with overall rank of 23rd place.

Table 27 Quality management and plastic waste reuse in construction

Reuse of plastics as construction materials related to quality management	**Mean**	**SD**	**RII**	**Rank**	**Overall Rank**
High durability	2.96	0.879	0.786	2nd	20th
Easy to use and maintain	4.29	0.777	0.856	1st	3rd
Better strength with low weight	2.26	1.075	0.394	3rd	23rd
Better aesthetics	2.26	1.075	0.394	3rd	23rd

Source: Own Survey (2021)

4.3.4. Reuse of waste plastics related to human resource management

Based on the results obtained from survey, respondents ranked “Increased work Opportunity”, “Lesser labor energy consumption” and “Minimum cost of Labor” first with 4.29 mean value, 0.856 RII and overall rank of 3rd place.

“Minimum degree of skill needed” ranked 4th with mean of 3.99 and RII of 0.800 with overall rank of 14th. The result shows that with the increased use of plastic wastes in construction material production there will be decreased weight of material which in turn helps labourers to easily transport materials with low energy, with low skill and work effectively.

Table 28 Plastic waste reuse in construction related to Human Resource management

Reuse of waste plastics as construction materials related to human resource management	**Mean**	**SD**	**RII**	**Rank**	**Overall Rank**
Minimum degree of skill need	3.99	0.880	0.800	4th	14th
Increased work opportunity	4.29	0.777	0.856	1st	3rd
Lesser labor energy consumption	4.29	0.777	0.856	1st	3rd
Minimum cost of labor	4.29	0.777	0.856	1st	3rd

Source: Own Survey (2021)

In managing human resources, while using recycled plastic waste materials in the construction material production, degree of need of skill will be lesser whether it is during production, collection, transportation or construction. Other impact is in terms of creating new work opportunities. Nowadays even in Ethiopia, it normal to see people collecting plastics on the road as a daily routine. If the country increases its capacity of recycling plastics, many more opportunities will be open.

The other thing is the less labor consumption due to the less density of the material. As discussed earlier the less weight of plastic based construction materials, will decrease the energy and time of labors consumed during production or construction. This also decreases the cost of labor per the amount of work done because of the ease of the procedure.

4.3.5. Reuse of waste plastics related to environmental protection

Plastics are one of the most useful multipurpose material of modern times. It's a term that refers to a product that can provide a number of beneficial effects and that is pliable and easily shaped, but can also be harmful to the environment (Miller, 17 Biggest Advantages and Disadvantages of Plastics, 2020).

As per the respondents, the factor ranked first in this category was "Less plastic in the environment" with mean value of 4.38and RII value of 0.872.This impact also ranked 1st from the total identified 24 factors. Logically plastic recycling contributes in decreasing the plastic wastes remaining in the environment as land fillers, marine pollutants, and so on.

Table 29 Environmental protection and plastic waste reuse in construction

Reuse of plastics as construction materials related to environmental protection	**Mean**	**SD**	**RII**	**Rank**	**Overall Rank**
Less plastic waste in the environment	4.38	0.863	0.872	1st	1st
Increased health and living condition for both animals and human beings	4.28	0.843	0.850	2nd	7th
Less water pollution (from landfilling) and air pollution (from incineration)	3.88	1.020	0.769	4th	16th
Saves land fill space	2.93	0.939	0.581	6th	21st
To see Waste Plastic free world	2.92	1.451	0.544	7th	22nd
Local availability for Decreased pollution emitted during transportation	4.01	1.014	0.797	3rd	12th
Conservation of natural resources such as timber, water and minerals	3.87	1.020	0.769	5th	17th

Source: Own Survey (2021)

In the plastic waste reuse as construction materials impact related to environmental protection category, the second ranked factor was “increased health and living condition for both animals and human beings” with mean value of 4.28 and RII value of 0.85, being ranked seventh overall. According a study by Condor Ferries (Ferries, 2020-2021) sourcing WorldOceanNetwork,WWF,NRDC, 300 million tons of plastics created yearly, 2.5 trillion Pieces of plastic estimated waste in the ocean by which 269,000 tones float, 4 billion/ KM^2 microfibers dwell below the surface. Most animals in the marine do not differentiate their food from plastic garbage. These animals die of starvation clogging their stomachs with plastic so they cannot eat real food. People and other animals who live eating these marine animals are affected by the waste. Making the cost of health care much higher. So it can be said, plastic waste is the most expensive garbage.

Thirdly ranked in this category is “Local availability for decreased pollution emitted during transportation” with a mean value of 4.01 and RII of 0.797, fourthly ranked “Less water pollution (from landfilling) and air pollution (from incineration)”, ranked fifth “Conservation of natural resources such as timber, water and minerals” with mean of 3.87 and RII of 0.769.

Respondents ranked sixth and seventh for the category "Saves land fill space" and "To see Waste Plastic free world" with mean value of 2.93 and 2.92 and RII of 0.581 and 0.544 respectively.

Even though plastic materials can take a long time to break down in landfill, they do not take up as much space as other items (Miller, 17 Biggest Advantages and Disadvantages of Plastics, 2020).

4.4. Responses of open ended question

At the end respondents were asked to give recommendations on to what purpose plastic wastes can be used for construction projects in Ethiopia. According to the responses, the following results were gained. For the ease of the labelling, the responses were classified in to ten categories. These are: plastic wastes can be used as wall construction materials, floor finish or pavement making material, for water proof system, for roof tile making, for replacement of cement as binding material, skirting material, as filler material, as insulating material, road and asphalt construction and others.

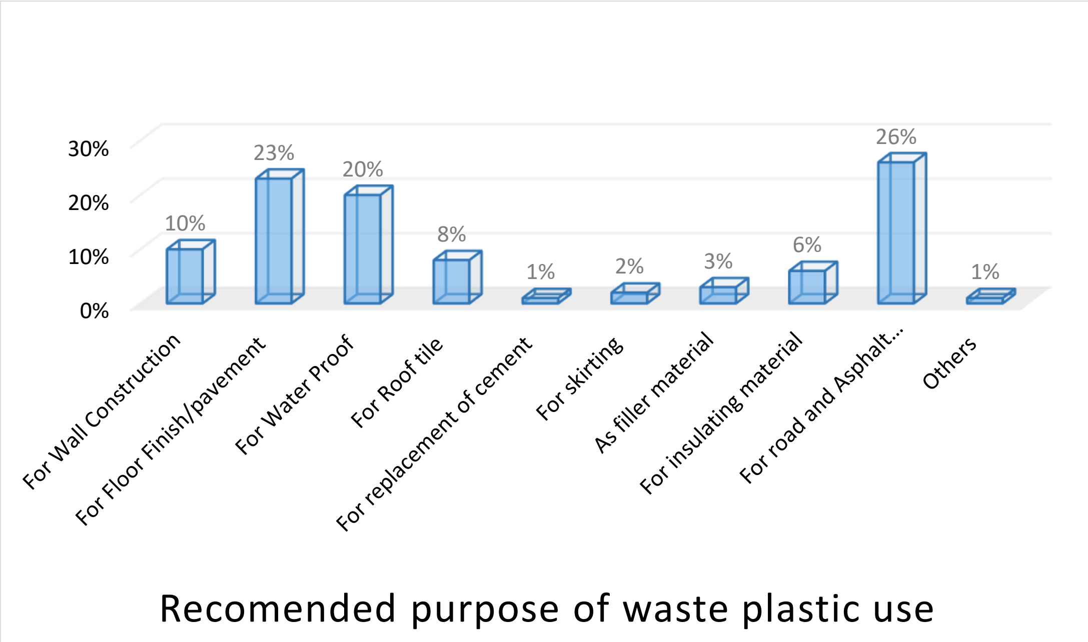

Figure 9 Responses of open ended questions

Source: Own Survey (2021)

4.5. ANALYSIS, RESULT AND DISCUSSION OF LABORATORY TEST RESULTS AND FINDINGS

4.5.1. Introduction

This chapter of the research includes the findings that are found by laboratory test of the produces waste plastic based construction materials.

Plastic tiles should not contain voids it decrease strength of tiles. Contain cellular distributed voids, which eventually reduces density of concrete. This chapter provides feasibility statement of producing plastic tiles from waste plastics which were collected from different places. Ingredients identified in chapter 3 were mixed. Next approach was to mix above materials to ensure waste plastic-sand floor tiles production which have good strength, quality and low cost.

4.5.2. Mix design

As described earlier the mix ratios of plastic and sand are important to its property. The difference in the ratio makes a change in the strength and density of the material. The 50:50 ratio is lighter in weight and have low strength. The 40:60 ratio is denser than the first one and the strength is greater than the first. The 30:70 ratio is much denser than those two ratio and have good strength. We can see the effects of the ratio changes on the material strength.

Figure 10 Different ratio plastic tiles

Comparison parameters analysis

A. Compressive strength test

There were several variables that could affect the performance of plastic tile. These include plastic type, size and type of sand and mixing ratio. During the experiment all variables were important in conducting the experiment. For this test the researcher prepared 3 sample for each ratio. For the experiment 15*15*4 cm specimens were used which differ in density, strength, plastic ratio.

Figure 11 Compressive strength of different plastic proportion of floor tiles

B. Effects of plastic ratio

The different ratios have varying effects on the strength and other aspects of the material tests.

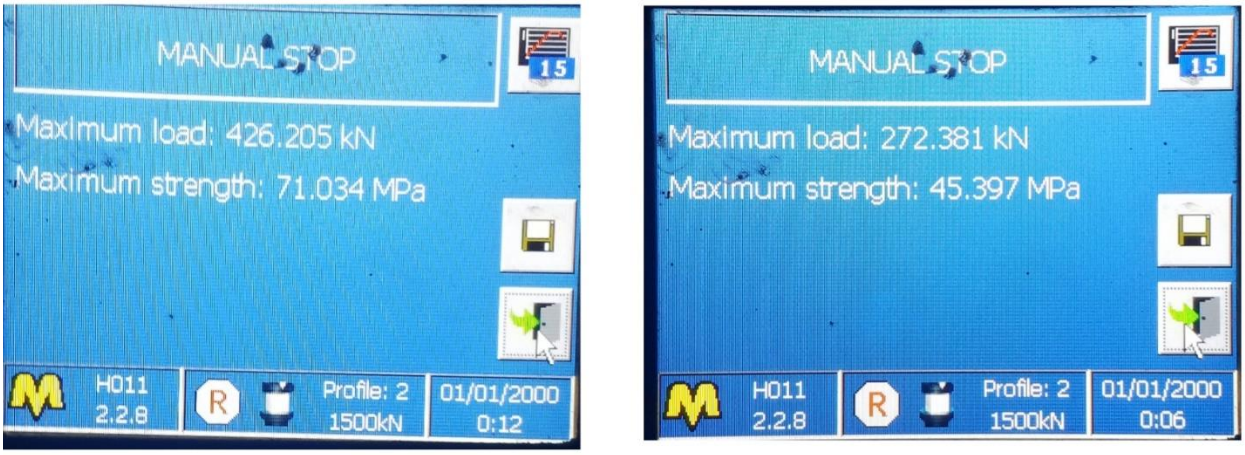

Figure 12 Result for compressive strength.

Ratio one: this ratio is different plastic to sand ratio. These specimens have 50:50 plastic to sand ratio.

Table 30 Compressive strength test for 50:50 plastic-sand ratio

Trial	Testing days	Mass (kg)	Compression strength (MP)	Average compression (MP)
One	1	1.62	12.10MP	12.89MP
Two	1	1.61	12.93MP	
Three	1	1.59	13.656MP	

Ratio Two: This ratio was also different in plastic to sand ratio. These specimens had 40:60 plastic to sand ratio.

Table 31 Compressive strength test for 40:60 plastic-sand ratio

Trial	Testing days	Mass(kg)	Compression strength (MP)	Average compression (MP)
One	1	1.51	16.63MP	15.84MP
Two	1	1.50	15.168MP	
Three	1	1.53	15.736	

Ratio Three: - These specimens had 30:70 plastic to sand ratio.

Table 32 Compressive strength for 30:70 plastic-sand ratio

Trial	Testing days	Mass(kg)	Compression strength (MP)	Average compression(MP)
One	1	1.57	23.140MP	22.18MP
Two	1	1.58	22.042MP	
Three	1	1.55	21.376MP	

In this research the values of compressive strength for different replacement of plastic contents (30%, 40% and 50%) was studied. There was an abrupt increase in compressive strength from 20% – 33%. Between 33% - 40%compressive strength decrease gradually. Above 45% the compressive strength has the steepest slope with a decrease from 40% to 50%.

The compressive strength of 22.18 MPa, 15.84 MPa & 12.89 MPa average was observed for 30%, 40% and 50% plastic respectively. According to IS 15622:2006, a minimum of 1500 KN breaking force is required to pass the test. The manufactured PETE components showed 426.205KN, 357.967KN & 217.56K N breaking force. So, these tiles can be used in pavements and where there is no high weight bearing requirement like walkways, in door floors, pavements, and so on.

C. Absorption test

This test shows the amount of water absorbed under specific conditions.

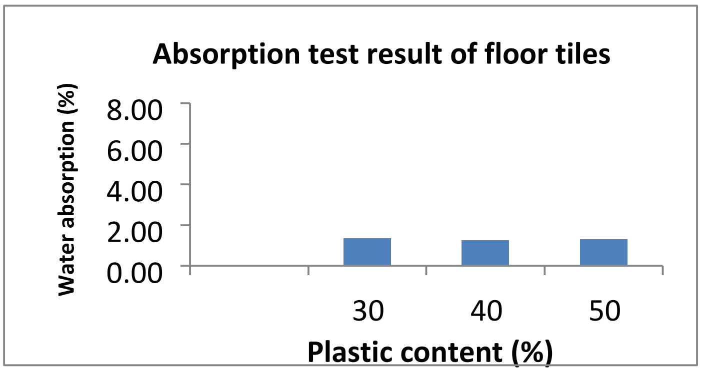

Figure 13 Water absorption result for different plastic content of plastic floor tile

As shown in the above figure the absorption rate for the standard sample contained 30% waste plastic was 0.95% and as the plastic content increases to 40%, then to 50%, water absorption rate continued to decrease. Tile with 30% plastic and above is impervious tile On ASTM C373 Vitreous tiles: (0.5-3%).

Based on ASTM C373 floor tiles are classified according to Water absorption percentage as follows

Impervious tile : ≤ 0.5 %

Vitreous tiles :0.5-3%

Semi-Vitreous tiles :3-7%

Non vitreous: ≥ 7%

From the above test result most part of the trial specimen are under Vitreous tiles which is between 0.5-3% water absorption.

D. Cost analysis

The cost estimation of plastic tiles had many factors; hence production play the major role. In this section the chosen specimens for the cost analysis were those which had better strength i.e. 30:70 plastic sand ratio. Cost for this result is shown as follows:-

1m^3 sand =500birr

0.0001m^3 sand used for one pc=0.35birr

1kg plastic =2birr

0.53kg used for one pc=1.06birr

The cost of the materials to produce one pc plastic tile is:-

Sand used in m^3 for 1 pc = 0.35birr,

Plastic used in kg for 1 pc =1.06birr,

Labour = 0.20birr

Transport =0.10 birr

Other cost(fire wood, lubricant oil,…)=0.30

Table 33 Cost analysis

Material used	**Unit price Per Pc**	**Total cost for one pc**	**Amount used for 1m²**	**Total cost**
Sand	0.35birr		17.15 birr	
Plastic	1.06birr		51.94 birr	
Labor cost	0.20birr	2.01birr	9.8 birr	98.49 birr
Transport cost	0.10birr		4.9 birr	
Other cost	0.30birr		14.7 birr	

Table 34 Cost comparison of plastic and concrete tile

Tile type	**Unit price**	**Amount of birr in m²**
Plastic tile	2.01 birr	98.49 birr
Concrete tile	3.9 birr	190 birr

Total cost of one pc was 2.01 birr since one m^2 has 49 pcs for 15*15*0.4 mold so total cost became 98.49birr. The objective of this project was to study high cost effectiveness of material, Cost of plastic tile is lower than concrete tiles which was approximate to two times higher of plastic waste tiles.

In general the next table shows the total comparison result of the ordinary concrete floor tile to waste plastic floor tile.

Table 35 Comparison of ordinary concrete floor tile and Waste plastic floor tile

No.	Properties	Ordinary concrete floor tile	Plastic waste floor tile
1	Compressive strength	8.5-15 mpa	12.89- 23.14 mpa
2	Cost	190 birr/m^2	98.49 birr/m^2
3	Time consumption	Production- 45-60 minutes Curing- 24 hrs minimum	-Production- 25 minutes -Curing- 30 minutes maximum
4	Durability	-can live as long as 100 years and more with good treatment	-can live as long since it does not decompose or deteriorate easily
5	Water absorption	-1.5-3%	-0.95%
6	Environmental friendliness	-Can be recycled with different process of production -makes no difference in plastic waste reduction	-Can be recycled with the same process when broken or old -Less plastic waste to the environment
7	Weight	-3.15 kg (average 15*15 cm size tile) -increased transportation cost due to weight	-1.58 kg (average 15*15 cm size tile) - reduce in transportation cost
8	Molding process	- can be molded easily using table vibrator	- easily molded in any shape without any additional equipment
9	Manufacturing waste	-wastage occurs during mixing and production	- zero

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

This chapter is consisted of three sections. The first section presented summary of major findings of the study. The second section explained about the general conclusions reached depending on the findings and finally gave recommendations for concerned bodies who can contribute towards reusing plastic wastes for construction materials.

5.2. Summary of major findings

This section shows the major findings according to the collected data through questionnaire

- Plastic wastes can be mixed with different construction materials, being base materials to produce new plastic waste construction materials which can replace costly and time taking materials.
- The major impacts of using plastic waste in production of construction materials was seen in construction cost reduction and environment protection.
- The second major impact of recycled plastic waste material usage was in human resource management. The material was anticipated to have high impact in increasing work opportunities, decreasing cost of labour and decreased labour energy consumption.
- The least chosen impact of plastic waste construction material was its use with regard to quality management.
- The produced plastic waste based construction floor tile gained a maximum compressive strength of 23.14mpa, average cost of 99 Birr, 0.95 % of water absorption, negligible to zero amount of waste and less time consumption compared to the ordinarily used concrete floor tile.

5.3. Conclusions

Plastic waste based construction material is a resource efficient construction material that can transform waste plastics into a valuable local resource.

The use of plastic-sand tiles can have major economic, social, public health and environmental benefits. By transforming waste plastics into a valuable resource has potential to generate local employment, clean-up the environment, produce new construction materials and significantly reduce the production cost and time of conventional building units since it can be used in various fields of applications.

The purpose of this study was to assess waste plastic material and its management practice as a reuse for construction Material and its optimization with respect to its impacts in the construction management fields. The study identified the major impacts of the plastic floor finish material and its application in the construction industry in reducing the main problems of the sector. Nowadays finishing construction process at its estimated time and within budget has been a major problem.

Implementing new and suitable materials which will mitigate the problems the firm is facing is one step forward. As per the research, recycling plastic wastes for reuse in the construction is a major step which helps the construction sector, the environment, and the eco system. Removing plastic wastes from our environment has been a big issue for a long time since plastics are toxic and the enormous amount of plastics disposed and produced daily has been increasing daily.

Plastic-sand floor finishing tile is a resource efficient construction material that can transform waste plastics into a valuable local resource. In its production process no water is used at all and mainly particle size of the sand, plastic/sand ratio, melting temperature and cooling rate are critical to attain optimum properties. The compressive strengths of Plastic-sand tiles in our case are registered as 18Mpa, 15Mpa & 12Mpa for 30:70, 40:60 & 50:50 plastic/sand ratios respectively. The compressive strength, thermal resistance and water absorption properties of these tiles vary as the ratio of plastic to sand varies. The production of plastic-sand tiles can have major economic, social, public health and environmental benefits. By transforming waste plastics into a valuable resource this simple technology has potential to generate local employment, clean-up the environment, produce new construction materials and significantly reduce the production cost of conventional building units since it can be used in various fields of applications.

Till recent times the final destinations of plastic wastes were in the marine, land fill, incineration or the open field. This practice was gradually killing our planet. Reusing this plastic materials for the now huge industry, Construction, will definitely solve this problem. Since plastics take a lot of time to degrade, its application gives longer life time to buildings or constructions.

Finally giving attention to plastic waste materials is very important in many aspects. Recycling plastics will save our ecosystem as well as it will save lives of human race.

5.4. Recommendations

Construction technology is believed to consume high amount of resource, (Finance, material, labor & time), which rise the total cost invested in the industry much higher than intended. So that, some construction materials & techniques have to be partially or fully replaced by other cost efficient materials to reduce construction/production period, minimize the cost, &

improve strength. Environmentally hazardous waste plastics are nowadays becoming a good replacement of cement through recycling processes.

The construction sector needs new materials that can minimize the major problems of the sector. Among the problems are cost overrun and time overrun. Plastic sand mix construction materials are among these products that can be produced in quick and simple procedures with good quality to overcome these problems.

Plastic waste materials help to reduce cost and time taken and increase the efficiency of the human resources of the sector.

Production of plastic-sand tiles need to owe the cost & time benefits through devising wise and economical procedures. The results of our tests for these tiles has been so positive that the technology has to be adopted in our country in wide range of application areas. The compressive strengths of the tiles vary as the plastic/sand ratio varies. Among different trial mixes we've tried, it is the 30:70 ratio that yield the maximum results in terms of compressive strength, the 40:60 ratio for good density & stiffness, and the 50:50 ratio for highly appreciable absorption rates but relatively lower strength & thermal resistance as compared to the above ratios. So that, the 30:70 ratio is the preferred proportion in terms of strength and cost reduction. During production process care must be taken on selecting plastic types, sand qualities, safe procedures while melting these plastics as well as casting the molten plastic-sand mix, wearing safety protective systems to avoid possible injuries during production work.

5.5. Recommendations for further study

Based on the results of the experiment and the questionnaire, the following recommendations were given by the researcher and respondents:

- There should be further study on the production of good quality plastic waste based construction materials in terms of replacing the ordinarily used materials of construction.
- The study was only focused only on Grade 1 contractors, so further studies should be made on the rest of the stakeholders to gather additional recommendations and insights.
- Further impacts of the material in the construction should be studied other than cost management, time management, quality management, Human Resource management and environmental protection.
- Further laboratory tests should be made other than the compressive strength and water absorption like thermal resistance, tensile strength and so on.
- Experimental studies should be made on plastics and their replace ability, applicability in to Ethiopian constructions and their properties.

References

Abdulla, A. I. (2016). *Thermal properties of sand modified resins used for bonding CFRP to concrete substances.*

al., A. S. (2020). *sieve analysis and gradation of coarse and fine aggregates.*

Almeshal, b., A.Tayeh, B., Alyousef, R., Alabduljabbar, H., & Mohamed, A. M. (2020). Eco-friendly concrete containing recycled plastic as partial replacement for sand. *Materials research and Technology*, 4631-4643.

Andreas, F. (2001). Plastic bottles in construction .

Banskota, A. P. (2015). *Effective management of plastic wastes and other solid waste in Nepal (A case of Kathmandu Valley).*

Behera, D. (2018). *Experimental Investigation on recycling of plastic wastes and broken glass in to Construction material.* Debrebrehan University, Ethiopia.

Bhoot, P. K., Malviya, K., & Prajapat, T. K. (2012). POTENTIAL REUSE OF PLASTIC WASTE IN ROAD CONSTRUCTION: A REVIEW . *Journal of scientific research in engineering*.

Brouwers, H., & Bossinik, B. (1996). Construction waste: quantification ans source evaluation. *journal of construction engineering and management*, 122.

Chamas, A., Moon, H., Zheng , J., Qui, Y., Tabassum, T., Jang, J., & Abu-Omer, M. (2020). Gradation rates of plastics in the environment.

Consoli, Montardo , J., Pasa, g., & Prietto, P. (2002). Engineering behavior of sand reinforced with plastic waste. *Journal of geotechnical and Geoenvironmental Engineeriing*.

Crawford, C. B. (2017). *Microplastic pollutants.*

Creswell, J. W. (2002). Research Design: Qualitative,Quantitative and Mixed Approaches (2nd ed.).

Delz, S. (2011). Ethiopia's low cost housing program, how concepts of individual home ownership and housing bllocks still walk abroad.

Estil, K. (2019). *From Waste to Housing: Using plastic waste to build sustainable housing in Haiti.*

Ferries, C. (2020-2021). Marine and ocean Pollution: statstics and facts.

group, J. r., Andrady, J. R., Geyer, A. R., Wilcox, T., & Lavender, C. (2015). *Plastic waste inputs from land into the ocean.*

Gu, L., & Ozbakkaloglu, T. (2016). Use of Recycled Plastics in Concrete: A criitical Review. *waste management 51*.

Ilyas, M., Ahmed, w., Khan, H., Yousaf, s., Khan, K., & Nazir, S. (2018). plastic waste as a significant threat to the environment- A systematic literature review. *Reviews on environmental health*.

Ishaiba, A. A. (2015). *Mechanical properties of concrete Using Recycled Plastic.*

Ismail , Z. Z., & Al-Hashmi, E. A. (2008). Use of waste plastics in concrete mixture as aggregate replascement.

Kamsouloum , P., Kumi-Larbi, A., Yuanana, D., & Webster , M. (2018). Recycling waste plastics in developing countries:use of low-densitypolyethhylene water sachets to form oplastic bonded sand blocks. *waste management*.

Madan, S. (2018). What is plastic pollution? *Earth Eclipse*.

Mark, s. (2009). Research Methods for Business Students (5th ed.).

Martinko, K. (2017). Single Use Plastics.

Mertes , A. (2020). What are different types of plastics?

Mertes, A. (2019). Types of plastics and their Recycle codes.

Miller, B. (2020). 17 Biggest Advantages and Disadvantages of Plastics. *GreenGarage*.

Miller, B. (2020). 17 biggest advantages of and disadvantages of plastics.

Moulders, L. (2013). *High Quality recyclig of construction and demolition waste in Netherlands.*

Naoum, S. G. (2007). *Dissertation Research and writing for Construction Students* (2nd edition ed.). Butterworth-Heinemann, Cambridge.

Parangi, B., Gagan, Hallur, M. S., & Mh, P. (2020). Reuse of plastic waste for the production of floor tiles. *Journal of seybold report*.

Reality, B. M. (2021). Where Does Most Plastic Come From, & End Up? *Where does most plastic come from and end up?*

Rebeiz, K. a. (1995). *Plastic waste management in construction: technoological ad institutional issues.*

S, J. B. (2012). Research development of plastic wastes grinding in recycling.

S. Shilpi, S. M. (2013). Eco-Architecture: PET Bottle Houses. *International Journal of Scientific Engineering and Technology*.

S.S.Sambyal. (2013). Plastics can be classified as hazardous.

Sambasivan, M., & Soon, Y. W. (2007). Causes and effects of delays in Malasian construction industry. *international journal of project management*, 517-526.

Sebille , D. V., spathi, D., & Gilbert , A. (2016). *The ocean plastic pollution challenge: toowards solutions in the UK.* Grantham Institute.

Sepe, M. (2011). The importance of Melt and MOld temperature. *Plastics Technology*.

Stoler , j., Weeks, J. R., & Fink, G. (2012). Sachet Drinking water in Ghana's Accra- Aema Metropolitan area: Past, Present and Future. *Journal of Water, sanitation and Hygiene Development*.

Trimbakwala, A. (2017). Plastic Roads, Use of Waste Plastic in Road Construction . *Journal of Scientific and Research Publications*.

Vasudevan, R., Sekar, R. C., Kannan, S., & Velkennedy, R. (2012). A Technique to dispose waste plastics in an ecofriendly way-Application in construction of flexible pavements.

W. Shakantu, D. J. (2003). THE HIDDEN COST OF TRANSPORTATION OF CONSTRUCTION MATERIALS: AN OVERVIEW. *emerald insight*.

Wahid, S. A., Rawi, S. M., & Desa, N. M. (2015). Utilization of plastic Bottle waste in Sand bricks.

Webster, L. a. (2017). Building capacity for community waste management in low and MIddle-income countries.

Well, A., & Myers, J. L. (2010). *Research Design and Statistical analysis.*

Wikipedia. (2011, 07 01). *Life cycle of a plastic product* . Retrieved 07 13, 2021, from en.m.wikipedia.org: https://web.archive.org/web/20100317004747/http://www.americanche

Wikipedia. (2020, January 6). Retrieved from askinglot: https://askinglot.com/open-detail/50045

Wilson, D. C. (2007). Development Drvers for waste management. *Sage Journals*.

Wilson, D. c. (2015). Waste management- still a global challenge in the 21st century: an evidence -based call for action. *Sage Journals*.

Appendix I: Questionnaire

Project Management Department

M.A thesis on Project Management

Dear Respondent,

My name is Bethelhem Solomon, and I am currently studying for masters in project management at St. Mary's University. I am conducting a research on recycling plastic waste materials management and their reuse in construction.

The objective of this research to assess waste plastic materials management practice in Addis Ababa selected construction sectors.

I am kindly requesting your willingness to participate in this research "PLASTIC WASTE MATERIALS MANAGEMENT AND REUSE IN THE CONSTRUCTION INDUSTRY: THE CASE OF SELECTED FIRST GRADE CONTRACTORS IN ADDIS ABABA" by filling this questionnaire. The questionnaire consists of 23 questions which will take no longer than 15 minutes to complete and a short and brief explanation of the new waste plastic product made for this specific purpose.

All responses will be kept anonymous and no one will be identifiable in this research and all the data collected will only be used for academic purpose only. Any information you are willing to provide will be greatly appreciated.

If you have any inquiry or to submit your responses, please feel free to contact me through the provided addresses.

Thank you for giving 15 minutes of your time and your kind cooperation for the research.

Contact Address

Bethelhem Solomon

E-mail : betttysolomon46@gmail.com

Phone No: 0922360134

PART I

GENERAL QUESTIONS

Fill the general questions here under about waste plastic management in your area and to your experience by making a mark on the space provided. Select more than one answer if you find it very necessary to respond to the questions. Please note that it is very important that each question is read carefully and answered consciously.

No.	Information required	Questions	Answers		Description
1	Usage	Do you use plastics in your day to day activity?	☐	Yes	
			☐	No	
2	Purpose	For what purpose do you mostly use Plastics?	☐	Plastic Water containers	
			☐	Plastic bags	
			☐	Plastic wears/shoes	
			☐	Plastic Buckets/ Bins	
			☐	Others (Specify)	
3	Reason	Why do you use plastic products?	☐	They are cheap	
			☐	They are light in weight	
			☐	They are easily available	
			☐	Others (Specify)	
4	Nature of plastic waste	Do you think the waste is hazardous or non-hazardous?	☐	Hazardous	
			☐	Non-hazardous	
5	Highest source of plastic wastes	Where do these plastic wastes mostly come from?	☐	Factories	
			☐	Offices	

				Houses	
				Others (Specify)	
6	Disposal	Where do people in your area dispose these used plastics?		Waste collectors	
				Open dumping	
				Burn it	
				Others (Specify)	
7	Recurrence of disposal	How often do you think these plastics are disposed?		Daily	
				Weekly	
				Monthly	
				Yearly	
				Others (Specify)	
8	Waste problems	Do you think plastic wastes cause problems? If yes what are the problems?		Animal Death	
				Human Health Problems	
				Blockage of sewerage systems	
				Environmental Destruction	
				Others (Specify)	
9	Destination of waste	Where do you think the plastic waste is managed?		In the region of Origin	
				Other region	
				Don’t know	
10	Reused, recycled or recovered			Reused	
				Recycled	

		In Ethiopia Do you think these wastes are reused recycled or recovered?		Recovered	
				Don't know	
11	Reused, recycled or recovered (2)	Do you think these wastes can be reused recycled or recovered		Reused	
				Recycled	
				Recovered	
				Don't know	
12	Alternative use	For what Alternative purpose do you think Plastic wastes can be used?		For construction materials replacement	
				For garment	
				Land filling	
				Others (Specify)	

Part II

Please read carefully the following questions regarding plastic waste management practices in your area of expertise and answer them accordingly.

No.	Information required	Questions	Answers		Description
1	Waste availability	Are there construction plastic wastes in your work area or experience?		Yes	
				No	
2	Origin of waste	Where do Plastics wastes in construction come from?		plastic construction materials	
				Packaging	
				Disposed off-cuts and unused materials	
				Others (Specify)	

3	Plastic use experience	In what form have you, in your experience, used recycled waste plastic as replacement of construction materials?		Plastic floor tiles	
				Plastic roof tiles	
				Plastic walls (blocks, bricks)	
				Water proof system	
				Others (Specify)	
4		Do you think recycled waste plastic based construction materials can replace the ordinarily used materials?		Yes	
				No	
				I do not know	
5		What is the most expected property expected from recycled plastic waste material to fulfil to be accepted as construction Material?		Strength	
				Durability	
				Low cost	
				Recyclability	
				Low water absorption and penetration	
				Environmental friendliness	
				Less time of production, strength gaining and construction	
				Less weight	
				Easily molded in to many shapes	
				Others (Specify)	

Part III

The following are selected waste plastic material impacts that might affect in the construction. Please indicate your level of agreement on the following statements regarding to your experience.

Reuse of waste plastics as construction materials		**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**
1.	Plastic wastes can be reused as construction materials replacement					
2.	Recycled Plastic waste material can replace different construction material in your construction site					
3.	Waste plastics reuse in construction is useful in minimizing cost					
4.	Waste plastics reuse in construction is useful in minimizing time of construction					
5.	Waste plastics can increase productivity					
6.	Waste plastic reuse in construction is useful in minimizing the Environmental degradation					
7.	Waste plastic can be the future of construction					

Effects of waste plastic floor tiles					
Reuse of waste plastics related to cost management	**Very low effect (1)**	**Low effect (2)**	**Neutral (3)**	**High effect (4)**	**Very high effect (5)**

1.	Reduced Consumption of financial resources to purchase products					
2.	Reduction of foreign currency					
3.	Increase of economic security by using domestic source of materials					
4.	Lower transportation cost					
5.	Minimized cost of maintenance					

Reuse of waste plastics related to time management		**Very low effect (1)**	**Low effect (2)**	**Neutral (3)**	**High effect (4)**	**Very high effect (5)**
1.	Reduced time of production					
2.	Minimized construction time					
3.	Locally available for reduction of hauling and transportation time					
4.	Less time of maintenance					

Reuse of waste plastics related to quality management		**Very low effect (1)**	**Low effect (2)**	**Neutral (3)**	**High effect (4)**	**Very high effect (5)**
1.	High durability					
2.	Easy to use and maintain					
3.	Better strength with low weight					
4.	Better aesthetics					

Reuse of waste plastics related to human resource management		Very low effect (1)	Low effect (2)	Neutral (3)	High effect (4)	Very high effect (5)
1.	Minimum degree of skill need					
2.	Increased work opportunity					
3.	Lesser labor energy consumption					
4.	Minimum cost of labor					

Reuse of waste plastics related to environmental protection		Very low effect (1)	Low effect (2)	Neutral (3)	High effect (4)	Very high effect (5)
1.	Less plastic waste in the environment					
2.	Increased health and living condition for both animals and human beings					
3.	Less water plollution (from landfilling) and air pollution (from incineration)					
4.	Saves land fill space					
5.	To see Waste Plastic free world					
6.	Local availability for Decreased pollution emitted during transportation					
7.	Conservation of natural resources such as timber, water and minerals					

Part IV: Open end questions

1. Do you have any recommendations to what use plastic wastes in Ethiopian construction projects can be used?

____

____

____

____

____

____

____________.

Appendix II: Overall results of impacts of waste plastic materials in construction

Factors	No.	Category	Mean	SD	RII	Rank
Reduced Consumption of financial resources to purchase products	72	related to cost management	4.38	0.971	0.872	1st
Less plastic waste in the environment	72	related to environmental protection	4.38	0.863	0.872	1st
Easy to use and maintain	72	related to quality management	4.29	0.777	0.856	3rd
Increased work opportunity	72	related to human resource management	4.29	0.777	0.856	3rd
Lesser labor energy consumption	72	related to human resource management	4.29	0.777	0.856	3rd
Minimum cost of labor	72	related to human resource management	4.29	0.777	0.856	3rd
Increased health and living condition for both animals and human beings	72	related to environmental protection	4.28	0.843	0.85	7th
Less time of maintenance	72	related to time management	4.19	0.898	0.836	8th
Locally available for reduction of hauling and transportation time	72	related to time management	4.17	0.904	0.831	9th
Lower transportation cost	72	related to cost management	4.14	0.969	0.822	10th
Minimized cost of maintenance	72	related to cost management	4.08	0.946	0.811	11th
Increase of economic security by using domestic source of materials	72	related to cost management	4.01	1.028	0.797	12th

Local availability for Decreased pollution emitted during transportation	72	related to environmental protection	4.01	1.014	0.797	12th
Minimum degree of skill need	72	related to human resource management	3.99	0.88	0.8	14th
Reduced time of production	72	related to time management	3.92	0.835	0.783	15th
Less water pollution (from landfilling) and air pollution (from incineration)	72	related to environmental protection	3.88	1.02	0.769	16th
Conservation of natural resources such as timber, water and minerals	72	related to environmental protection	3.87	1.02	0.769	17th
Minimized construction time	72	related to time management	3.86	0.939	0.736	18th
Reduction of foreign currency	72	related to cost management	3.69	0.914	0.731	19th
High durability	72	related to quality management	2.96	0.879	0.786	20th
Saves land fill space	72	related to environmental protection	2.93	0.939	0.581	21st
To see Waste Plastic free world	72	related to environmental protection	2.92	1.451	0.544	22nd
Better strength with low weight	72	related to quality management	2.26	1.075	0.394	23rd
Better aesthetics	72	related to quality management	2.26	1.075	0.394	23rd