2020-03-17

Application of Plastic Waste Materials for Construction purpose

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BAHIR DAR INSTITUTE OF TECHNOLOGY

SCHOOL OF RESEARCH AND POSTGRADUATE STUDIES

Faculty of Chemical and Food Engineering

Application of Plastic Waste Materials for Construction purpose

MSc. Thesis

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Program: Environmental Engineering

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July, 2018

Bahir Dar, Ethiopia

Application of Plastic Waste Materials for Construction purpose

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A thesis on Application of Plastic Waste Materials for Construction purpose

Is submitted to the school of Research and Graduate Studies of Bahir Dar Institute of Technology, BDU in partial fulfillment of the requirements for the degree Master of science in the Environmental engineering in the Faculty of Chemical and food engineering.

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BahirDar,Ethiopia

January 23, 2019

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Acknowledgement

My special thanks to my advisor Dr Alemayehu kifilu for his support and advice throughout the accomplishment of the research my heart-felt gratitude goes to the Addis Ababa IOT library staff.

I would like to extend my appreciation also for Bahirdar university lectures to assist me in documents, and for their cooperation and provision of valuable information.

Abstract

Plastic waste, which is increasing day by day, becomes eyesore and in turn pollutes the environment, especially in villages where no garbage collection system exists. Plastic is a non-bio-degradable substance which takes thousands of years to decompose and hence creating land pollution as well as water pollution. Taking into account the increase of pollution new concept of eco bricks has been introduced. Eco bricks are also knows as bottle bricks .These bricks are manufactured by using the non-bio-degradable wastes such as plastic bottles, plastic bags and other non-bio-degradable substances. The research demonstrates that it is possible to solve major problems in the construction replacement of Hcb with a new ecological building material which is manufacturing of bricks by using plastic and Styrofoam wastes by mixing with sand. The study presented in this paper is finalized with the development of new building materials which is ecological building material. Hence, these waste plastics and Styrofoam’s are to be effectively utilized. Plastic wastes and Styrofoam’s are cleaned and added with sand at various ratios to obtain high strength bricks that possess thermal and sound insulation properties to control pollution and to reduce the overall cost of construction; this is one of the best ways to avoid the accumulation of plastic waste which is a non-bio-degradable pollutant. This alternatively saves the quanta of sand/clay that has to be taken away from the precious river beds/mines. Finally the output of this project is to develop a new cost effective, a resource conserved, time and space saving and strong with quality and other strength parameters product which is the Pss product.

Table of Contents

List of abbreviations

AFRP	Fiber-reinforced polymer as a reinforcement or pre-stressing tendon
FRP	Fiber-reinforced polymer
CSA	Central Statistical Authority of Ethiopia
HCB	Hollow concrete block
ENDA	Environmental Developing Action in the Third World
EPA	Environmental Protection Authority
EPRDF	Ethiopian People's Revolutionary Democratic Forces
FAO	Food and Agriculture Organization of the United Nations
MFA	Material Flow Accounting
MSE	Micro and Small Enterprise
MSWM	Municipal Solid Waste Management
NTNU	Norwegian University of Science and Technology
NUPI	National Urban Planning Institute
OSCALDC	Office of Special Coordinator for Africa and the Least Developed Countries
SBPDA	Sanitation, Beautification and Park Development Agency
SWMS	Solid Waste Management System
UMAS	Urban management advisory service
PS	Polystyrene
PSS	Plastic, Styrofoam and sand
EPS	Expanded polystyrene
GPS	General Purpose polystyrene
EBCS	Ethiopian Building Code of standard

List of symbols

^{0}C degree centigrade

% percent

W water absorption

M1 mass1

M2 mass2

List of figures

List of table

1 Introduction

Plastic is one of the daily increasing useful as well as a hazardous material. At the time of need, plastic is found to be very useful but after its use, it is simply thrown away, creating all kinds of hazards. They are non-biodegradable and researchers have found that the plastic materials can remain on earth for 4500 years without degradation. Hence, these waste plastics are to be effectively utilized. Today, it is impossible for any vital sector to work efficiently without usage of plastic starting from agriculture to industries. Thus, we cannot ban the use of plastic but the reuse of plastic waste in building constructions, industries are considered to be the most practicable applications.

Building materials like bricks, concrete block, tiles, etc. are popularly used in construction. However, these materials are expensive and hence common people find it difficult to easily afford them. Moreover, these building materials require certain specific compositions to obtain desired properties. Plastic is one of the recent engineering materials, which have appeared in the market all over the world. It is a material consisting of a wide range of synthetic or semi-synthetic organic compounds that are malleable and can be molded into solid objects. It exists in the different forms such as cups, furniture, basins, plastic bags, food and drinking containers they become waste material and Styrofoam which has a good capacity for insulation purpose for huge structures it is also found in our environment as a waste material. Accumulation of such wastes can result into hazardous effects to both human and plant life. Therefore, need for proper disposal, and if possible, use of these wastes in their recycled forms arises. Plastic waste is increasing day by day throughout the world. Where proper garbage collection system is not available, waste plastics are strewn everywhere, which becomes eyesore. It also pollutes the environment. A large amount of waste plastic is discarded or burned which leads to the contamination of environment. The large volume of materials required for infrastructure construction is potentially a major area for the reuse of waste materials. Recycling the plastics has advantages since it is widely used worldwide and has a long service life, which means that the waste is being removed from the waste stream for a long period. Reuse of waste plastics has environmental benefits not only related to the safe disposal of bulk waste. Use of waste plastics in infrastructure construction has been tried and reported.

1.1 Background

Ethiopia is believed to be one of the most beautiful countries in East Africa. However, the country's image is tainted by a multitude of man-made problems; one of which is poor garbage disposal. Every day, tons and tons of biodegradable and non-biodegradable waste most of it coming from the National Capital Region end up in poorly facilitated landfills. Take into account wastes that are not disposed properly, coupled with the country's climatic condition, and you have a recipe for disaster. Floods, communicable diseases, and pest (rat, cockroach, mosquito, etc.) infestation are a few of the many consequences of high volumes of waste and poor waste management. Sadly, most Ethiopians, particularly those in the cities, pass these problems off as part of daily living. From a larger perspective, effective waste management is something that many cities, throughout the years, have been struggling to achieve with only a few ever being remotely successful. Many ordinances have been tried and tested, ranging from waste segregation schemes to increased rounds of waste collection. But out of the multitude of waste management programs developed, recycling seems to be the most viable option. Recycling non-biodegradable materials is an effective way to not only reduce wastes that end up in landfills, but also to create something functional. For instance, biodegradable waste can be recycled and turned into fertilizers that farmers can use.

However, from a construction point of view, the end product of this project the bricks is still subject to extensive analysis. Given the overabundance of plastic products and derivatives lying around landfills, bricks made from recycled plastic and Styrofoam are already a promising option as construction materials. The only question that remains is whether or not it is durable, tensile, and strong enough to construct a sturdy and solid building and that is what this study aims to find out.

1.2 Problem Statement

Plastic is a non-bio-degradable substance which takes thousands of years to decompose and hence creating land pollution as well as water pollution. Taking into account the increase of pollution new concept of eco bricks has been introduced. Now a day's construction materials such as pavement tiles and building bricks that are made from local materials are not cost effective, not conserve resources, they are time consuming for curing and constructing, they are heavy and not comfortable for transport, not supporting the environment to be safe from pollution and also they utilize more space for production and curing. Therefore, to solve this and other problems the introduction of this newly emerged material is the best option for the construction industry and also for our environment.

1.3 Objectives of the study

1.3.1 General objective

The general objective of this project is the Plastic Waste Materials for Construction purpose as Ecological Mortar.

1.3.2 Specific objectives

Specifically, this research is to solve a problem of our environmental pollution by plastic wastes by introducing a new ecological building material, with a good compression resisting capacity, with a good durability, with good thermal insulation properties and a good aesthetical appearance of the structure while ensuring plastic waste recycling and reduce raw material consumption from our environment.

- ✓ To evaluate the cost variance between Hcb and Pss.
- ✓ To analyze inputs of production and to evaluate the impact on environmental resource consumption of Hcb and Pss.
- ✓ To compare production area and time consumption of producing Hcb and Pss.
- ✓ To test and compare the strength of Hcb and Pss against specific strength parameters and quality standards based on EBCS.

1.4 Scope of the study

This study is delimited to the advantages in using used plastic and Styrofoam mixed with sand that are made into bricks used for constructing residential buildings and pavement structure works that are constructed in residential building and pavement work projects.

1.5 Significance of the Study

The significance of this project is to find a modality to recycle plastic waste for the manufacture of efficient ecological building materials. In any kind of construction, materials are always a major consideration; good materials, yield good buildings. However, high-quality construction materials don't come cheap. And with rising economic pressures, the cost of construction materials has been steadily on the rise. In light of this, it has been the collective goal of many to discover viable alternatives to the most common materials used in construction. These alternatives should possess relatively the same quality and durability to those of conventional materials, but at much lower price.

The results of this research study may be beneficial for the following:

To The Government – This research study can help the government to promote recycling by using this bricks for government structures and establishments.

To The Residents of the working area – The results of this research study may give them insights that could encourage them to plan more relevant projects designed to improve the quality of structures in their community with the use of recycled materials.

2 Literature Review

2.1 Overview

Most of the times the word ‘waste’ is used interchangeably with ‘refuse’ for clear understanding, it is important to differentiate the two words. When waste is disposed of in the same container and mixed together, causing unpleasant odor and pollution and making it impossible to reuse it is known as ‘refuse'. On the other hand, when the disposed objects are handled properly they can have value and are known as ‘waste’.

The scope of solid waste management encompasses planning management systems, waste generation processes and organizations, procedures and facilities for waste handling. Developing strategies comprise specific objectives and measures in these areas. They need to consider the specific interests, roles and responsibilities and numerous factors including households; community based organizations and other service users, local and national government authorities and non – governmental organizations. As a result, effective solid waste management depends upon an appropriate distribution of responsibilities between national, provincial and local governments. To keep the household and environment clean and to reduce health problems, solid waste should be disposed properly. Untreated refuse degrades both the quality of the environment and the quality of life in the community and it also provides a breeding ground for disease causing vectors such as mosquitoes, flies and rats. Solid waste generated by household may contain organic waste (for example from the kitchen and gardens), recyclable waste (for example, plastics, paper, cans, etc.), non-recyclable waste and household hazardous waste (for example, batteries, some oils etc.

According to the polymer used, the synthetic and semi-synthetic plastics can be designed with a broad variation in properties that can be modified by the addition of such additives. Some additives include the following:

- Antioxidants – added to reduce the effects of oxygen on the plastics during the ageing process and at elevated temperatures.
- Stabilizers – in many cases used to reduce the rate of degradation of polyvinyl chloride (PVC).

- Plasticizers or softeners- used to make some polymers more flexible, such as PVC.
- Blowing agents –used to make cellular plastics such as foam.
- Flame retardant –added to reduce the flammability of plastics.
- Pigments –used to add color to plastic materials.

The volume of polymeric wastes, such as high and low density polyethylene (HDPE, LDPE), PET bottles, polyvinyl chloride (PVC), rigid polyurethane foam, rubber particles…is increasing at a fast rate around the world. PET bottles consumed each year represent more than 300.000 million units. The majority of the PET waste is sent to landfills. Attaché et al. reported that Algeria is one of the countries in the world in which the quantity of household wastes is about 8.5 million tons per year (0.75 kg per inhabitant and per year) and is in continuous increase. In the city of Algiers, it reaches 1 kg per inhabitant and per year. In Algeria, and all over the world, the use of packed products has induced an increase in dumped plastic wastes and a difficulty of their removal from grounds. Since PET waste is not biodegradable, it can remain in nature for hundreds of years. Various studies have been carried out so far in order to identify safe and eco-friendly ways to dispose of plastics. Actually, various forms of plastics have been incorporated in composite mortars and concretes in order not to let these plastics in direct contact with the environment, because concrete has a longer service life. Review of previous investigations have already confirmed the potential of PET waste in replacing aggregates in concrete; this represents a better option than sending it to landfills. Sharma et al. presented an interesting overview of some published research regarding the use of plastic waste in mortars and concretes. It can be seen from the literature that PET waste has also found application in the production of building composites as a substitute for traditional aggregates and as reinforcing fibers in concretes and mortars. In previous works, it was shown that this waste can also be used as a substitute for blended Portland cement. In addition, various research centers are trying to make new polymer-modified mortars and concretes which can successfully protect buildings against the adverse effect of corrosive media along with better sound and thermal insulation .Overall, the decision of using recycled waste plastic as aggregate, filler or fiber in the design of structures

2.2 Foreign studies

In concrete structures, a major problem in terms of durability is that the steel bars and tendons are vulnerable to corrosion. One pf the most promising development to overcome this problem is the use of fiber-reinforced polymer as a reinforcement or pre-stressing tendon in concrete structures. FRP reinforcement or tendons consist of aligned continuous fibers, mainly carbon (CFRP), aramid (AFRP), glass, embedded in a resin matrix such as epoxy, polyester or vinyl ester by pultrusion process. There are many advantages of FRP over steel as reinforcement or tendons. The high strength and low density of FRP results in a specific strength that is 10-15 times higher than that of steel. CFRP and AFRP have good fatigue strength, as much as three times that of steel. They also have good corrosion resistance. Their low thermal expansion gives another advantage in widely varying climatic conditions. Other advantages are their electromagnetic neutrality, high resistance against abrasion and excellent chemical resistance. These properties can lead to maintenance-free durable concrete structures. FRP is easy to handle in construction due to its light weight. There are a number of manufacturers producing FRP reinforcements and tendons. However, to fully utilize the potential of FRP, it is necessary to investigate its properties, particularly the long-term properties of FRP and its ability to transfer the pre-stressing force to concrete.

Testing on FRP

In order to grip the FRP tendons without slippage during testing, Steel pipe 500 mm long was placed at each end of the tendon and filled with expansive cement material. Tensile tests, creep tests, and relaxation tests were carried out. In the tensile tests, the tensile strength, elastic modulus, and stress-strain relationship of the tendons were evaluated. An extensometer was used to monitor the strain of a tendon while a dial gauge was used to monitor the movement of the cross head of the test machine. The extensometer was removed at a loading level of 90% of the guaranteed tensile strength to avoid damage, because the failure of FRP was relatively brittle without any yielding.

Testing rig, which uses a lever arm principle, was designed and used to carry out the creep test. The dead load in the form of steel plates was applied to the tendon through a lever arm with an arm ratio of 1 to 14. Two extensometers were used to measure the tendon strain. The sustained stress levels were between 40 and 70% of the guaranteed tensile strength and were maintained for a period of at least 1,000 hours. The tests were carried out under normal room temperature and humidity conditions. The creep strain of FRP tendons was measured and the creep coefficient was then derived.

Tests were also carried out to evaluate the relaxation of FRP. Each test lasted at least 1,000 hours as commonly specified by codes of practice. The tests were carried out in a controlled room with a constant temperature of 23+/- 1 degree Celsius and a humidity of 50%. The stress level applied to the tendon was about 50% of the guaranteed tensile of pre-stress was in the range of 75-125 kN. Two Lead line rods, 8 mm in diameter, with double fiber spiral indentation on the surface were used. Two beams with two 9.3 mm-diameter steel seven-wire strands were also cast for comparison purpose. An 8-m long pre-stressing bed and the position of demec targets glued at the ends of the beams for measuring the concrete strains at this region.

Causes of waste

Rao (2009) mentions various causes responsible for wastes. An illustrative list is given Below. The highest waste causing factors are considered to be critical.

1) Faulty planning and policies systems and procedures;

2) Faulty organization structure;

3) Environmental pressures;

4) Tardiness (slow to act);

5) Lack of accountability;

6) Unawareness of technological advances;

7) Non-responsiveness to automation / computerization;

8) Wrong specifications, standard, codes;

9) Wrong raw materials

10) Lack of inventory control;

11) Lack of proper storage, layout of facilities, handling of material;

12) Communication gaps;

13) Faulty work method;

14) Less emphasis on PPC

15) Lax supervision and control;

16) Wrong recruitment /selection policies;

17) Lack of motivation / incentives;

18) Poor working conditions;

19) Unsafe practices;

20) Poor IR: Industrial Relations;

21) Maintenance failure;

22) Power failure;

23) Distribution problems;

24) Less attention to waste segregation and collection;

25) Technological obsolescence;

26) Miscellaneous causes;

27) Information asymmetry

2.2.1.1 Increase of waste on a global scale

The amount of waste discharge is increasing on a global scale. On entering the 21st century, this trend got only stronger. According to the World Bank report cited earlier, the amount of municipal solid waste (MSW) was about 680,000 kt per year ten years ago but 1,300,000 kt at present with a forecast of 2,200,000 kt by 2025. This growth in waste discharge is particularly noticeable in Asia, where many countries in the region experienced a rapid demographic shift to the cities and stimulation of production activities over a relatively short period of time accompanying economic growth. As a result, finding a means of processing this massive amount of waste is now a major issue in these countries. Failure to suitably process this waste will trigger a wide variety of problems on a global scale, such as soil, air, ocean, and river pollution, global warming, nature and ecosystem destruction, and wasting of finite resources. Of these, concern about marine litter has been growing in recent years. Much research is focusing on plastics that turn into marine litter, and it is said that marine litter from land-based sources is considerable as a result of outflows from landfills or inflows to rivers as a result of flooding. Meanwhile, it is said that marine litter from ocean-based sources is caused by the disposing of fishing gear such as nets and the illegal ocean dumping of waste. Many international organizations such as United Nations Environment Program (UNEP) and NPOs are actively engaged in solving this problem. Furthermore, at the 2015 G7 Summit held at Schloss Elmau, Germany, an agreement was reached on a "G7

Action Plan to Combat Marine Litter" in which advanced economies would take the lead on addressing the marine litter problem. This initiative was reaffirmed at the 2016 G7 Ise-Shima Summit held in Japan. To appropriately manage waste and to promote the reduction, reuse, and recycling of waste, individual transformation of behavior is desired.

2.2.1.2 Plastics and Environment

Modernization and progress has had its share of disadvantages and one of the main aspects of concern is the pollution it is causing to the earth be it land, air, and water. With increase in the global population and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily by each household. This waste is ultimately thrown into municipal waste collection centers from where it is collected by the local municipalities for further disposal into the landfills and dumps. However, either due to resource crunch or inefficient infrastructure, not all of this waste gets collected and transported to the final dumpsites. Added to this if the management and disposal is improperly done, it can cause serious health impacts. Plastic waste is a major environmental and public health problem in India, particularly in the urban areas. Plastic shopping or carrier bags are one of the main sources of plastic waste in our country. Plastic bags of all sizes and colors dot the city‘s landscape due to the problems of misuse and overuse and littering in India. Besides this visual pollution, plastic bag wastes contribute to blockage of drains and gutters, are a threat to aquatic life when they find their way to water bodies, and can cause livestock deaths when the livestock consume them. Furthermore, when filled with rainwater, plastic bags become breeding grounds for mosquitoes, which cause malaria. In addition, plastics take many years (20-1000) to degrade and hence pose a disposal challenge. We have become so accustomed to the ubiquitous presence of plastic that it is difficult to envision life when woods and metals were the primary materials used for consumer products. Plastic has become prevalent because it is inexpensive and it can be engineered with a wide range of properties. Plastics are strong but lightweight, resistant when degraded by chemicals, sunlight, and bacteria, and are thermally and electrically insulating. Plastics have become a critical material in the modern economy; the annual volume of plastics produced exceeds that volume of steel. The world's annual consumption of plastic materials has increased from around 5 million tons in the 1950s to nearly 100 million tones today. The

Lifecycle and Ecological Impact of Plastics The lifecycle of plastics involves three stages: manufacturing in the first stage, usage in the second, and recycling and/or disposal in the third. The utilization of plastics ranges from toys to aircrafts, from hosepipes to dolls, from soft drink bottles to refrigerators, from gramophone records to television sets. Packaging represents the largest single sector of plastics use. The sector accounts for 35% of plastic consumption and plastic is the material of choice in nearly half of all packaged goods

2.3 Effects of plastic pollution on environment

Accumulation of plastic products in the Environment that adversely affects wildlife, wildlife habitat, or humans is a major concern for the governments now. Plastic Pollution occurs in many forms, including but not limited to littering, marine debris (man-made waste that has released in a lake, sea, ocean, or water way), plastic particle water pollution, plastic netting and friendly Floaters. A large percentage of plastic produced each year is used to make single-use, disposable packaging items or products which will get permanently thrown out within one year. Often, consumers of the various types of plastics mainly use them for one purpose and then discard or recycle them. Chlorinated plastics can release harmful chemicals into the surrounding soil, which can then seep into ground water or other surrounding water sources. This can cause serious harm to the species that drink this water. Nurdles are plastic pellets that are shipper in this form, often in cargo ships, to be used for the creation of plastics products. A significant amount of hurdles are spilled into oceans, and it has been estimated that globally, around 10% of beach litter is nurdles. Plastics in oceans typically polystyrene can leach into waters from some plastics. Polystyrene pieces and nurdles are the most common types of oceanic debris. Animals can be significantly harmed or killed by plastic pollution. Plastic pollution has potential to poison animals, which can then affect human food supplies. Plastic pollution has been described as being highly detrimental to large marine mammals Plastics contains many different types of chemicals, depending on the type of plastics. The addition of chemicals is the main reason why these plastics have become so Multipurpose, however this has problems associated with it. Some of the chemicals used in plastic production have the potential to be absorbed by human beings through skin absorption. The world population is living, working, vacationing, increasingly conglomerating along the coasts, and standing on the front row of the greatest, most unprecedented, plastic waste tide ever faced. The amount of plastic manufactured in the first ten years of this century will approach the total produced in the entire last century. The plastic pollution involves the accumulation of plastic products in the environment that adversely affects wildlife habitat, or humans. We absorb many types and forms of plastic pollution exist. The plastic pollution can adversely affect lands, waterways and oceans. The prominence of plastic pollution is correlated with plastics being inexpensive and durable, which lends to high levels of plastics used by humans. Animals can be significantly harmed or killed by plastic pollution. The environmental tools of plastics, i.e. cell phones and computers to bicycle helmets and hospital IV bags, plastic has molded society in many ways that make life both easier and safer. Plastic are very long lived products that could potentially have service over decades and yet our main use of these lightweight, inexpensive materials are as single-use items that will go to the garbage dump within a year. In 2008, our global plastic consumption worldwide has been estimated at 260 million tons. Plastic is versatile, lightweight, flexible, moisture resistant, strong, and relatively inexpensive. Those are the attractive qualities that lead us, around the world, to such a voracious appetite and over-consumption of plastic goods. However, durable and very slow to degrade, plastic materials that are used in the production of so many products all, ultimately, become waste with staying power. Our tremendous attraction to plastic, coupled with an undeniable behavioral propensity of increasingly over-consuming, discarding, littering and thus polluting, has become a combination of lethal nature. A simple walk on any beach, anywhere, and the plastic waste spectacle is present. All over the world the statistics are ever growing, staggeringly. Tons and tons of plastic debris (which by definition are waste that can vary in size from large containers, fishing nets to microscopic plastic pellets or even particles) is discarded every year, everywhere, polluting lands, rivers, coasts, beaches, and oceans. Last year, an estimated 150,000 tons of marine plastic debris ended up on the shores of Japan and 300 tons a day on India's coasts. Lying halfway between Asia and North America, north of the Hawaiian archipelago, and surrounded by water for thousands of miles on all sides, the Midway Atoll is about as remote as a place can get. However, Midways' isolation has not spared it from the great plastic tide either, receiving massive quantities of plastic debris, shot out from the North Pacific circular motion of currents (gyre). Midways' beaches, covered with large debris and millions of plastic particles in place of the sand, are suffocating, envenomed by the slow plastic poison continuously washing ashore. Types of plastic pollution: Plastic pollution occurs in many forms, including but not limited to littering, marine debris (man-made waste that has been released in a lake, sea, ocean, or waterway), plastic particle water pollution, plastic netting and Friendly Floatees. A large percentage of plastic produced each year is used to make single-use, disposable packaging items or products which will get permanently thrown out within one year. Often, consumers of the various types of plastics mainly use them for one purpose and then discard or recycle them. Effects on the environment as follows:

- **Land**: Chlorinated plastics can release harmful chemicals into the surrounding soil, which can then seep into groundwater or other surrounding water sources. This can cause serious harm to the species that drink this water. Landfill areas are constantly piled high with many different types of plastics. In these landfills, there are many microorganisms which speed up the biodegradation of plastics. Degradation of plastics leads to the release of methane which is a major contributor green house effect.

  Some landfills are taking initiative by installing devices to capture the methane and use it for energy, but most have not incorporated such technology. Release of methane does not only occur in landfills, biodegradable plastics also degrade if left on the ground, in which case degradation takes longer to occur.
- **Ocean**: Nurdles are plastic pellets (a type of micro plastic) that are shipped in this form, often in cargo ships, to be used for the creation of plastic products. A significant amount of nurdles are spilled into oceans, and it has been estimated that globally, around 10% of beach litter is nurdles. Plastics in oceans typically degrade within a year, but not entirely, and in the process toxic chemicals such as bisphenol A and polystyrene can leach into waters from some plastics. Polystyrene pieces and nurdles are the most common types of plastic pollution in oceans, and combined with plastic bags and food containers make up the majority of oceanic debris. In 2012, it was estimated that there was approximately 165 million tons of plastic pollution in the world's oceans. Plastic pollution has the

potential to poison animals, which can then adversely affect human food supplies. Plastic pollution has been described as being highly detrimental to large marine mammals, described in the book Introduction to Marine Biology as posing the "single greatest threat" to them. Some marine species, such as sea turtles, have been found to contain large proportions of plastics in their stomach. When this occurs, the animal typically starves, because the plastic blocks the animal's digestive tract. Marine mammals sometimes become entangled in plastic products such as nets, which can harm or kill them. Over 260 species, including invertebrates, have been reported to have either ingested plastic or become entangled in the plastic. When a species gets entangled, its movement is seriously reduced, therefore making it very difficult to find food. Being entangled usually results in death or severe lacerations and ulcers. It has been estimated that over 400,000 marine mammals perish annually due to plastic pollution in oceans. In 2004, it was estimated that seagulls in the North Sea had an average of thirty pieces of plastic in their stomachs.

- **Effects on humans**: Plastics contain many different types of chemicals, depending on the type of plastic. The addition of chemicals is the main reason why these plastics have become so multipurpose; however this has problems associated with it. Some of the chemicals used in plastic production have the potential to be absorbed by human beings through skin absorption. A lot is unknown on how severely humans are physically affected by these chemicals. Some of the chemicals used in plastic production can cause dermatitis upon contact with human skin. In many plastics, these toxic chemicals are only used in trace amounts, but significant testing is often required to ensure that the toxic elements are contained within the plastic by inert material or polymer. Plastic pollution can also affect humans in which it may create an eyesore that interferes with enjoyment of the natural environment.

- **Effect of plastic on wildlife:**
  - Birds get caught up in plastic bags and ultimately dies due to starvation
  - Plastic bags , one ingested cannot be digested or passed by animals so it stays in the gut , leading to the very slow and painful death of the animals
  - Thousands of whales, birds, seals and turtles are killed every year from plastic litter as they mistake plastic bags for food such as jellyfish.
- **Impact of plastic on environment:**
  - Chlorinated plastic can release harmful chemicals into the surrounding soil, which can then seep into groundwater or other surrounding water sources and also the ecosystem. This can cause serious harm to the species that drink the water.
  - Components of plastics currently being studied for their health effects include polyhalogenated flame retardants, poly-fluorinated compounds (known as PFOS or PFOA) and antimicrobial compounds such as triclosan and trichlrocarban.
- **Reduction efforts**: Efforts to reduce the use of plastics and to promote plastic recycling have occurred. Some supermarkets charge their customers for plastic bags, and in some places more efficient reusable or biodegradable materials are being used in place of plastics. Some communities and businesses have put a ban on some commonly used plastic items, such as bottled water and plastic bags.

✓ **Collection**: The two common forms of waste collection include curbside collection and the use of drop-off recycling centers. About 87 percent of the population in the U.S.A. (273 million people) have access to curbside and drop-off recycling centers. In curbside collection, which is available to about 63 percent of the U.S.A. population (193 million people), people place designated plastics in a special bin to be picked up by a public or private hauling company. See

  ✓ Great Pacific garbage patch, an area of exceptionally high concentrations of pelagic plastics, chemical sludge and other debris

  ✓ Plastic particle water pollution

The plastic pollution can adversely affect lands, waterways and oceans. The prominence of plastic pollution is correlated with plastics being inexpensive and durable, which lends to high levels of plastics used by humans. Animals can be significantly harmed or killed by plastic pollution. Animals can be significantly harmed or killed by plastic pollution. The environmental tools of plastics, i.e cell phones and computers to bicycle helmets and hospital IV bags, plastic has molded society in many ways that make life both easier and safer. A large percentage of plastic produced each year is used to make single-use, disposable packaging items or products which will get permanently thrown out within one year. A significant amount of nurdles are spilled into oceans, and it has been estimated that globally, around 10% of beach litter is nurdles. Some of the chemicals used in plastic production have the potential to be absorbed by human beings through skin absorption. Efforts to reduce the use of plastics and to promote plastic recycling have occurred.

2.4 Plastic wastes as a construction material

Plastics are commonly used substances which play an important role in almost every aspect of our lives. The widespread generation of plastics waste needs proper end of-life management. The highest amount of plastics is found in containers and packaging's (i.e. bottles, packaging, cups etc.), but they also are found in durables (e.g. tires, building materials, furniture, etc.) and disposable goods (e.g. medical devices). Diversity of plastics applications is related with their specific properties, low density, easy processing, good mechanical properties, good chemical resistance, excellent thermal and electrical insulating properties and low cost (in comparison to other materials). Post-production and postconsumer plastics are utilized in a wide range of applications.

2.5 Plastics Recycling

According to the 2000 State of Plastics Recycling, nearly 1700 companies handling and re claiming post-consumer plastics were in business in 1999. This was nearly six times greater than the 300 companies in business in 1986. The primary market for recycled PET bottles continues to be fiber for carpet and textiles and the primary market for recycled HDPE are bottles. However, a recently updated Recycled Plastics Products

Source Book lists over 1,300 plastic products from recycled content, including waterproof paper products and plastic lumber for structural applications. New ASTM (American Society for Testing and Materials) standards are paving the way for plastic lumber that could be used in framing, railroad ties, and marine pilings (State of Plastics Recycling). The use of recycled plastics for such applications could mean longer life and less maintenance, which translated to lower cost over the life of the product. There is however a need to increase the reuse and recycling rates for plastics, which are currently much lower than other major construction materials steel, concrete, and wood. The construction industry uses 60 per cent of global PVC, which is difficult to recycle and can contaminate recycling of other commonly recycled plastics. There was only a 1.7% increase in the pounds of plastic collected in 2005 (0.96 MMT) compared with that of 2004 (0.87 MMT) (State of Plastics Recycling).

2.6 Construction of bricks using waste plastics

Building materials like bricks, concrete block, tiles, etc. are popularly used in construction. However, these materials are expensive and hence common people find it difficult to easily afford them. Moreover, these building materials require certain specific compositions to obtain desired properties. Plastic is one of the recent engineering materials which have appeared in the market all over the world. It is a material consisting of a wide range of synthetic or semi-synthetic organic compounds that are malleable and can be molded into solid objects. By definition, plastics can be made to different shapes when they are heated. It exists in the different forms such as cups, furniture, basins, plastic bags, food and drinking containers and they become waste material. A plastic compactor is a machine used to compress plastic materials into a large bale for storage or shipping purposes. This machine can vary in design, but generally, it will feature some sort of hopper or container into which plastic can be loaded, as well as one or more hydraulic arms that will compress that plastic into one large bale. Once the bale is created, another arm or system will be used to remove the bale from the container, as the bale is likely to be quite heavy. Some machines do not create bales; instead, they may create bricks of plastic that can be cut, either by hand or by the machine, into pre-set lengths. This allows for easy stacking or storage, as well as easier handling. The plastic compactor may also heat the plastic while it is in the chamber to essentially melt the plastic into the desired shape. This can reduce or eliminate the need for a hydraulic arm for pressing materials, though some plastic compactor models will use a combination of the hydraulic arms and heating elements to create the plastic bricks. Some machines will feature a conveyor on which materials can be loaded; the machine can then load the plastics at a steady rate into the container or hopper. Recycling processing plants commonly use plastic compactor machines to compress various plastic materials into bricks or bales for shipping, storing, or for moving to the next phase of the recycling process. In some cases, the plastic is loaded into the compactor and forced into brick form, which essentially ends the recycling process. The raw material can then be sold to manufacturers or otherwise used for fueling purposes or other manufacturing purposes. The size of the machine will usually dictate how much material can be processed at one time, and a recycling plant is likely to feature more than one plastic compactor to improve productivity. Our machine is different from other compactor machines as it does not produce bales but a brick of high strength. It has many parts which include parts for heating, mixing, compacting etc. It mixes M-sand, thermocol and all types of plastics to form brick. Plastic brick manufacturing machine (PBMM) is different from other compactor machines as it does not produce bales but a brick of high strength. It has many parts which include parts for heating, mixing, compacting etc. It mixes M-sand, thermocol and all types of plastics to form brick. Thermocol acts as the binder and so it has very high strength. Other compactor machines just compress it to a reduced volume for easy transportation to recycling unit. But our machine itself recycles the plastics into a useable form. The machine was designed to approach the limit of possible volume reduction via compaction methods.

- Mixing Unit: The type we used is the drum mixer, which can be classified as non-tilting, split drum, or titling drum mixers, as well as truck mixers or reversing drum mixers.
- Motor: Here the motor is used as the rotary equipment. The specifications of the motor used were 0.5 Hp and 150 rpm

- Burner: The fuel used was kerosene. It provided the necessary heat of the flame for the plastic to melt.

Fig 1. Sample bricks made by plastic wastes with sand mixture

2.6.1 Plastics – Building & Construction

The second main category where plastics are used is in the building and construction industry. This industry consumes over 15 billion pounds of plastics in the form of pipes and fittings, plumbing, bathroom fixtures, interior/exterior building materials and air supported structures. “Unlike packaging, these uses of plastics do not immediately impact the waste stream, but their eventual disposability must be considered in waste management planning for the intermediate and long term.” (Wolf, Nancy & Ellen Feldman, page 21). Post-consumer plastic wastes from the building and construction sector is projected to be well over 3.9 billion pounds or 8.9 percent of all post-consumer plastic waste these days and figures are projected to continually rise. The one good note about plastic building and construction materials is that their life span last 25 to 50 years.

2.6.2 Benefits of plastics in building and construction

Meeting ambitious targets on the energy efficiency of buildings would be difficult, if not impossible, without the solutions provided by plastics. The use of plastics in building and construction saves energy, reduces costs, enhances quality of life and helps to protect the environment at the same time. Plastics applications also tend to be easy to install and require minimal maintenance. As such very limited additional consumption over energy and resources is needed to ensure their continued functionality. There are over 50 different families of plastics and most have something different to offer the construction industry. Among other things:

- **Within the structure of a building, plastics contribute**

To insulation, window installation, wiring, piping and roofing.

- **Inside the home, plastics provide wallpapering**

Flooring, awnings, laminated kitchen and bathroom furniture. Not only do plastics offer great practical solutions, they make a huge contribution to improving the energy efficiency of buildings which is necessary in order to tackle climate change and preserve resources. In fact, in terms of its whole life-cycle, plastic is one of the most energy-efficient materials.

2.6.3 Plastics applications

- **Plastics from roof to cellar**

Affordable, quality, energy-saving and environmentally-friendly living can be achieved by equipping our homes with plastics. Their versatility, functionality, performance and aesthetics are such that they can be found throughout the house, from the roof to the cellar:

- **Plastics are used outside a building:**

• To weather-proof, coat and insulate the exterior facades of the building.

• To channel rain water in gutters and downpipes.

• To insulate the underside of the roof.

• To provide draft-proof and highly insulated window frames.

• To landscape the outside space.

- **Plastics are used in the structure of a building:**

• To insulate and sound-proof walls.

• To insulate the cellar.

• To bring clean water and evacuate sewage through pipes.

• To bring fresh air or heating through ventilation or heat recovery systems.

- **Architects and engineers use plastics:**

• To give shape to their imagination; all over the world architects design innovative building structures which could only come true with plastics.

• To tailor-fit buildings to their surroundings.

• To strengthen structures such as bridges that must withstand very heavy loads.

• To enable new technologies which harness renewable energy?

- **Plastics are used inside a building:**

• To enable economic and energy-efficient lighting solutions.

• To paint, tile and clad living spaces, particularly those that must remain hygienic such as kitchens and bathrooms.

• To sheath wires and cables.

• To enable a myriad of features, furnishings, textiles and appliances.

- **Less material – better insulation**

The use of plastic insulation materials enables significant long-term financial and energy savings. Over its lifetime, plastic insulation saves more than 200 times the energy used in its manufacture. In addition to being energy-efficient; it is resource efficient and makes optimum use of space. This is because, intrinsically, many plastics are very good insulators - whether it is to sheath the cabling in domestic appliances or the inner walls of buildings. Plastic insulation materials are simple to install, highly durable and perform at the same high level over the whole life of the building. Beyond its practical benefits, plastic insulation brings Europe closer to its goal of energy security by reducing its overall demand for energy. It does that by enabling renewable energy technologies but also by enhancing the insulation of newly built and old buildings.

- **Windows – saving energy for decades**

The heat savings offered by modern plastics window profiles, as a result of huge technological progress in recent years, make them the application of choice in low-energy buildings. In addition, their durability and hardiness means that high-quality plastics windows can last for over 50 years with little or no upkeep required. This cuts out the cost and time needed to fix or re-paint them, as well as the financial and energy resources involved in replacing them. A further advantage is the variety of design possibilities that plastics window profiles offer. They can come in almost all colors, styles and settings to suit any kind of architecture, from the cutting edge of modern design to renovated historical buildings. At the end of their lives, plastic window frames can be recycled or handled in a waste-to-energy scheme. Almost 83,000t of window profiles and other profiles were recycled in 2009 as a part of the schemes funded by the PVC industry.

2.6.4 Flexural tensile strength

Flexural strength is defined as the material's ability to resist deformation under flexural load and is measured in terms of stress. It represents the highest stress experienced within the material at the collapse load. The transverse bending test is most frequently employed, in which a specimen with either a circular or rectangular cross-section is bent until fracture using a three or four point flexural test technique.

There is not much difference in flexural strength of control beam is compared to that of PET concrete beam RP1B and concrete beam reinforced with two PET bars RP2B, whereas the flexural strength of concrete beam reinforced with one PET bar (RP1B) is slightly less than that of the control beam. The flexural strength of concrete beam reinforced with steel bars (RSB) is almost similar to that of concrete beam reinforced with steel and PET bars (RSPB) and the flexural strength of beams reinforced with both steel and PET long Strips (RSPSB) exhibited exceptionally higher strength in flexure and flexural strength of these beams is far greater than that of control beams (CB), PET concrete beam (PC), concrete beams reinforced with only PET bars (RP1B).

The maximum flexural strength is attained by concrete beam reinforced with steel and PET long strips (RSPSB) above all the beams casted in the present investigation i.e. nearly 25 N/mm.

2.6.5 Plastics in the future

Plastics have changed our lives like no other material. Even though they can often be taken for granted, modern construction without plastics is simply unimaginable! Since plastics are the material for the 21st century, let's see what the future could hold for it…

•In the very near future, highly transparent photovoltaic cells will be printed onto plastic films as window glazing bringing about high-efficiency power-generating windows.

•In the future, architects and designers will use acrylic panels and fiber-reinforced plastics to mould buildings into any shape.

•The resistance to corrosion, light weight and strength of fiber-reinforced plastics composites will enable the construction of durable load bearing concrete structures like bridges.

2.6.6 Tests to be used

- **Compression Test**: This test is done to know the compressive strength of brick. It is also called crushing strength of brick. Four specimens of bricks were taken to laboratory for testing and tested one by one. In this test, a brick specimen is put on crushing machine and applied pressure till it breaks. The ultimate pressure at which brick is crushed is taken into account. All four brick specimens are tested one by one and the load at crushing was noted.
- **Water Absorption Test**: In this test, bricks are weighed in dry condition and let them immersed in fresh water for 24 hours. After 24 hours of immersion, those are taken out from water and wipe out with cloth. Then, brick is weighed in wet condition. The difference between weights is the water absorbed by brick. The percentage of water absorption is then calculated. The less water absorbed by brick the greater its quality. Good quality brick doesn't absorb more than 20% water of its own weight.
- **Efflorescence Test**: The presence of alkalis in bricks is harmful where it forms a gray or white layer on brick surface by absorbing moisture. To find out the presence of alkalis in bricks, this test is performed. In this test, a brick is immersed in fresh water for 24 hours. Then, it is taken out from water and allowed to dry in shade. If the whitish layer is not visible on surface, it proofs that absence of alkalis in brick. If the whitish layer visible about 10% of brick surface, then the presence of alkalis is inacceptable range. If that is about 50% of surface, then it is moderate. If the alkali's presence is over 50%, then the brick is severely affected by alkalis Procedure:
- **Heat /temperature test;** this is the most important test for this material because of that plastic materials are more susceptible to heat or fire hazards.

  Fire behavior waste plastic products of bricks According to SR EN 998-1:2011, the standard mortar falls into fire reaction class A1 because it does not contain organic materials. This is why fire reaction testing of the standard mortar specimens was not required. The figure below shows the fire behavior of mortars with 25%, 50% and 100% sand replaced with PVC. These determinations were performed by exposing the mortar specimens to the action of a direct flame generated by a gas lamp.

Sample	At 60 s	At 300 s	After the removal of the flame
Sample 1			
Sample 2			
Sample 3			

[1] Fig. 2: Observation of fire resistance test samples

The above figure shows that the samples containing PVC have high combustibility, which manifests by the almost instantaneous appearance of flames resulting from ignition of PVC granules, concomitantly with an emission of toxic black smoke. Although flames are high, these only propagate within a concentrated area around the flame applied directly to the surface of the material. Outside the circle of influence of this flame, the material does not ignite. On removal of the directly applied flame, after 300 s, the ignited granules burn until

[1] Source: Claudiu Aciu et al. / Procedia Manufacturing 22 (2018) 274–279

consumption of the entire inflammable material, after which burning stops. The increase in the PVC proportion in the recipe positively influences the heat transfer from the surface exposed to the flame to the surface on the opposite side of the flame. This supports the good thermal insulation property of the PVC mortar.

- **Albedo effects**

Albedo is a measure of the reflectivity of a surface. The albedo effect when applied to the Earth is a measure of how much of the Sun's energy is reflected back into space. Overall, the Earth's albedo has a cooling effect The albedo value ranges from 0 to 1. The value of 0refers to a blackbody, a theoretical media that absorbs100% of the incident radiation. Albedo ranging from0.1 – 0.2 refers to dark-colored, rough soil surfaces, while the values around 0.4– 0.5 represent smooth, light-colored soil surfaces. The albedo of snow cover, especially the fresh, deep snow, can reach as high as 0.9. The value of 1refers to an ideal reflector surface (an absolute white surface) in which all the energy falling on the surface is reflected. The mean albedo of the earth system is0.36^0.06. The intensity of albedo temperature effects depend on the amount of albedo and the level of local insulation. Buildings are finished with white exteriors to keep them cool, because white surfaces reflect the sun’s energy. In terms of insulation effects of this material is since we can produce in different colors needed this kind of insulation effects can be controlled. Therefore, the albedo effect on this product is to be controlled but generally the albedoo of plastic materials is about

0.03-0.05 ^{o}F when the color is dark black,0.05-0.3^{o}F when the color is black,0.3-0.5^{o}F when the color is smooth light coloured,0.5 and above when the color is white. A low albedo means a surface reflects a small amount of the incoming radiation and absorbs the rest. For instance, fresh snow reflects up to 95% of the incoming radiation. Therefore, fresh snow has a high albedo of .95.

Generally, dark surfaces have a low albedo and light surfaces have a high albedo. Albedo varies diurnally and seasonally due to the changing sun angle. In general, the lower the sun angles the higher the albedo. Besides the sun angle, many of the Surface characteristics have large impact on the albedo. The most significant factors affecting the soil albedo are the type and condition of the vegetation covering the soil surface, soil moisture content, organic matter content, particle size, iron-oxides, mineral composition, soluble salts, and parent material. The type and the condition of the vegetation have a strong impact on the surface albedo. Forest vegetation with multilevel canopy has a low albedo because the incident radiation can penetrate deeply into the forest canopy where it bounces back and forth between the branches and leaves and get trapped by the canopy. The albedo for grassland and cropland ranges between 0.1 and 0.25. Changes in soil moisture content change the absorbance and reflectance characteristics of the soil. Increase in soil moisture content increases the portion of the incident solar radiation absorbed by the soil system. This relationship is well known and used for soil color differentiation when the Munsell color chart is used. The colors of dry and moist soil samples are always different. The higher the soil moisture content, the darker the color and lower the albedo. However, this relationship is valid only for soil moisture contents up to the field capacity. Beyond field capacity, the increase in soil moisture content does not darken the color any more, but starts building up a water sheet on the aggregate surface, creating a shiny and better reflecting surface, which increases the reflectance and thus the albedo. This phenomenon is the major reason for differences in the albedo among soils of different textural classes. Clayey soils can maintain high moisture content in the presence of water supply, while the sandy textured soils drain and dry out much more rapidly. Due to the differences in the resulting soil moisture content between the texture classes, there are differences in the reflectance and absorbance characteristics and so in the albedo. Surface roughness defines the type of reflection. Shiny, smooth surfaces, like water body, plant leaves, or wet soil surfaces may be near-perfect, secular reflectors, which may reflect well and show relatively high albedo for lower sun angles. Rough surfaces represent lower albedo values, especially when sun angle is low and the shading effect lowers the reflection. There is a measurable difference in the surface roughness among soil textural classes. Fine textured, dry soils with small particle size produce high albedo due to relatively smooth surface. However, clayey soils are often wet, and soil moisture absorbs the incident radiation and decreases albedo.

Conversely, dry, coarse textured soils with relatively large particles (sand grains) reflect larger portions of the incident radiation than clayey soils. Surface color is determined by the interaction of the surface material with the visible spectra of the incident solar radiation.

Soil color is a differentiating factor in all the soil classification systems. It reflects many of the most important soil physical and chemical characteristics. One of the most significant coloring agents of the soils is the soil organic matter content. Soil organic matter content increases the absorbance of the soil. Thus the higher the organic matter content, the lower the albedo. Iron oxides increase the reflectance in the red portion of the spectrum while causing a decrease in the blue– green and infrared portion. Salt crust on the surface increases the albedo dramatically. That is why mapping of salt-affected area with remotely sensed images is a very powerful tool for soil surveyors.

Generally, to conclude about albedo. Albedo measures the overall reflectance of the surface, providing lots of useful information about the soil system and better understanding of the soil energy balance. But different wavelengths of sunlight are normally not equally reflected, which gives rise to a variable color of surfaces and differences in reflectance of certain wavelengths due to differences in physical or chemical characteristics of the soil surface. Differences in soil albedo can be measured with radiometers.

When the researcher finds Related works done by scholars especially in our country Ethiopia there is no related works with this idea but there are some related works in the world specially in Indian and also Africa by taking their practice and growing the idea of scholars making it better and adding some new items bring it to our country as a new construction material which is an ecological, economical, aesthetical, durable and safe building material by using plastic wastes and Styrofoam's by mixing with sand so as a new idea for our country when it expands it is also practicable in the world.

s/n	Author or source	Research work	Findings
1	Bjerkli camilla louise,2005 Norwegian University of Science and technology department of geography.	The cycle of plastic waste	An analysis on the informal plastic recovery system in Addis Ababa, Ethiopia. Trondheim, Norway:
2	Dr AN Bhat of ICPE March 15, 2001 Bharati Chaturvedi, Director, Chintan Environmental Organisation, New Delhi.	Collection and disposing of plastic wastes	The source of this information is the letter written by Tim Krupnik of the Berkeley Ecology Center to supporting the attempt to ban disposable plastics in India.
3	Puttaraj MH et al india, newdelhi	Manufacturing bricks with soil and plastic wastes	Manufacturing bricks with soil and plastic wastes by mixing after heating .
4	Rojer millan foundation Cameroon	Production of brick by using plastic wastes by adding sand	They produce a good standard of brick by using plastic and sand with heating by simple mechanical hand tools.

Table 1- related scholar's researches and findings

3 Methodology

Research Design

This research is employed laboratory test analysis which studies condition as they exist, to determine the advantages of using used plastic and Styrofoam mixed with sand that are made into bricks used in constructing residential buildings and pavement structures.

Sampling Technique

This research is carefully chosen a sample of 4 representative samples for each tests it is shown in detail.

Data Gathering Procedure

This procedure discusses the strategies we used in assessing the advantages of using used plastic and Styrofoam that are made into bricks used in constructing residential buildings and pavement structures.

Research Instruments

This research is constructed laboratory analysis for the selected sample tests. Books from our school library were used and also web based searches are provided unlimited information.

3.1 Materials and procedures

- **Materials needed for the production of Pss**

List of equipment needed for making Plastic Waste Pavement bricks and Bricks for construction

- A stainless steel preparation tank
- A scale (from 0 to 20 Kg minimum)
- A steel or concrete table
- Round spades and shovels
- Brushes
- Trowels, compactors and manual mixers
- Molds in desired shapes
- Individual protective equipment (glasses, mufflers, gloves, boots)

- **Procedures to produce Pss**

The process of making Plastic Waste Pavement Brick sand Bricks for construction

- ✓ Step 1- Collecting and sorting of the plastic waste (plastic bags)
- ✓ Step 2- Sorting the collected waste and weighting the raw materials before production (characterize plastics based on their type)
- ✓ Step 3- Adding the plastic waste and Styrofoam to the drum, melting the plastic bags, adding the river sand.
- ✓ Step 4- Mixing in the sand, working up the bricklaying mixture, lubricating the molds.
- ✓ Step 5- Putting the mixture in the molds, compacting the paving bricks, leaving them to dry.
- ✓ Step 6- Finished products, the stock of paving bricks ready to be delivered.

4 Result and discussion

This Chapter includes the presentation, interpretation and analysis of data gathered in relation to the findings of the study in the Laboratory results.

This part is an identification of the strength and other parameters through experiments and some practical calculations with theoretical suggestions.

A. Coast comparison between Hcb and Pss

Coast analysis of Hcb production

- 10 cm thick hollow concrete block wall bedded in cement mortar 1:4
  - Hollow block with 5% wastage = 13 pcs/m2
    - Cement = 5 kgs/m2
    - Sand = 0.023 m3/m2
    - Red ash= 0.011 m3/m2
    - Pumices= 0.013m3/m2

no	item	quantity	amount in birr	unit amount in birr/m3	for Hcb class B 40x20x20=0.016 birr/m3	for Hcbclass B40x20x15=0.012 birr/m3	for Hcbclass B40x20x10=0.008 birr/m3
1	cement	50kg	125	0.0347	0.00057	0.00042	0.00028
2	sand	14m3	7000	500.00	8.15	6	4
3	red ash	14m3	4000	285.71	4.66	3.43	2.286
4	pumice	14m3	5000	357.14	5.82	4.29	2.86
			total	1142.8919	18.6291	13.70	9.1431

Table 2 cost analysis of Hcb production

Therefore, for general purpose we mostly use class B of 40x20x15 Hcb so for 1pcs of Hcb the cost is 13.70 birr and for 1m2 construction of Hcb is 13.70x13=178.10 birr/m2 plus mortar joint plastering cost which is shown below.

- Mortar 10mm joints & 20% wastage = 0.0135m3/m2
  - Cement = 5 kgs/m2
  - Sand = 0.014 m3/m2

1kg cement=2.5 birr

1m3 sand=500birr

So, 502.5 birr/m2 is needed.

Materials required to produce 1m3 mortar for 1:3 ratio is

Cement (kgs) =450 kg=2.5x450=1,125birr

Sand (m3) =0.99m3=0.99x285=282.15birr

So, 1,407.15birr/m2 is needed.

Therefore, totally for 1m2 of Hcb construction without finishing and production expence of man power we spend 2,087.75birr/m2.

When we see the Pss product we use the same size and the materials we use are in ratio of (Styrofoam: plastic: sand) (1kg: 2kg: 5kg)

Styrofoam=1kg x 5 birr=5birr

Plastics=1kg=3birr x 2kg=6birr

Sand=1kg=2.5birr x5kg=12.5birr

Totally we spend 23.5birr, so the amount of the ratio shown above can produce 3 pcs of Pss blocks therefore, 23.5/3=7.83 birr/pcs x 13pcs/m2= 101.79birr/m2

Finally, when we compare it with Hcb =178.10birr/m2 without jointing mortaring and man power expenses is greater than that of the Pss=101.79 birr/m2 which is also no need of jointing and mortaring for finishing since the surface is rough it is suitable for gypsum chalking wall finish left for paint.

B. Natural resource consumption and environmental consideration comparison between Hcb and Pss

In case of natural resource consumption in comparison with the Pss product the Hcb product consumes more natural resources like sand, red ash, pumices, cement is also one part of natural resource and also water consumption is critically considered. When we come to the Pss product the consumption of sand is an issue but it is not significant when we compare with Hcb product, the other constituents that are plastic and Styrofoam's are considered as a waste for our environment so the consumption of this items is to be a good practice for environmental pollution by minimizing the area of spreading of the wastes by collecting and using for usable purpose rather than the depletion of natural resources from environment.

C. Saving of time and space utilization and ease of movement comparison between Hcb and Pss

- The production area needed
    - For Hcb production on average of 10x10=100m2 area needed without production area for curing (12-24hrs) purpose.
    - For Pss production on average of 5x5=25m2 area is enough to cure(30min-1hr) purpose without the production area.

D. Compression Test:

This test is done to know the compressive strength of brick. It is also called crushing strength of brick. Four specimens of bricks were taken to laboratory for testing and tested one by one. In this test, a brick specimen is put on crushing machine and applied pressure till it breaks. The ultimate pressure at which brick is crushed is taken into account. All four brick specimens are tested one by one and the load at crushing was noted but the four specimens are tested two times so our samples were eight samples.

Fig 3HYDRAULIC TESTING MACHINES

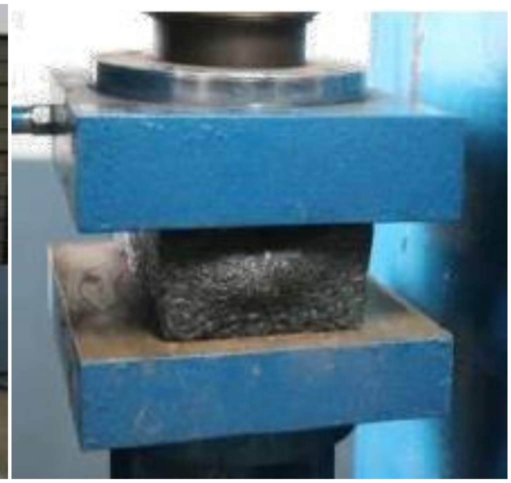

Fig 4 BRICK TESTING MACHINE

<u>Procedure:</u>

1) Sample bricks with different proportions are manufactured.

2) Each sample is placed in the test area in the ascending order of plastic content ratio.

3) Then Load is applied until the brick broke.

4) The maximum load at crushing in KN is noted under the machine.

Here we have: 4 samples

Effect of Different Ratio of Plastic Waste on Compression Test:

Brick Sample Number	Sample 1	Sample 2	Sample 3	Sample 4
Ratio (styrofoam:plastic:sand)	(1kg:2kg:2kg)	(1kg:2kg:3kg)	(1kg:2kg:4kg)	(1kg:2kg:5kg)
Length(mm) ***(1)***	172.5	172.5	172.5	172.5
Breadth(mm) ***(2)***	100	100	100	100
Area(mm2) ***(3)=(1x2)***	17250	17250	17250	17250
Max.load on crushing(KN) ***(4)***	170.00	180.00	190.00	200.00
Compressive strength (kN/cm2) ***(4/3)***	9.86	10.43	11.01	11.43

TABLE 3 Effect of Different Ratio of Plastic Waste on Compression Test

From the compression test result, it clearly shows that the value of compressive strength decrease as the ratio of plastic waste increase and sand decreases. Even though the compressive strength increases up to a proportion of (1kg: 2kg: 5kg), from the next composition. It can be summarized that the increase in plastic content and decreased in sand content has caused the brick to be much flexible, which in turn reduces the compressive strength and also if the content of sand is increased the compressive strength will increase also.

E. Water Absorption Test:

In this test, bricks are weighted in dry condition and let them immersed in fresh water for 24 hours. After 24 hours of immersion, those are taken out from water and wipe out with cloth. Then, brick is weighed in wet condition. The difference between weightsis the water absorbed by brick. The percentage of water absorption is then calculated. The less water absorbed by brick the greater its quality. Good quality brick doesn't absorb more than 20% water of its own weight.

Fig 5 WATER ABSORBTION TESTING EQUIPMENTS

Effect of Different Ratio of Plastic Waste on Water Absorption Test

This test is done to assure that what amount of water is absorbed in the sample

Sample	Weight Before	Weight After
1	1.6	1.6
2	2.0	2.0
3	2.3	2.3
4	2.6	2.6

Table 4Ratio of Plastic Waste on Water Absorption Test

The samples were immersed in a bucket of water for 24 hours, and then cleaned with a dry cloth. The weight measured after the emersion measured and it didn't show any variation. The lower the %of water absorbed, the greater the quality of the brick. The results showed zero percent water absorption.

F. Efflorescence Test:

The presence of alkalis in bricks is harmful where it forms a gray or white layer on brick surface by absorbing moisture. To find out the presence of alkalis in bricks, this test is performed. In this test, a brick is immersed in fresh water for 24 hours. Then, it is taken out from water and allowed to dry in shade. If the whitish layer is not visible on surface, it proofs that absence of alkalis in brick. If the whitish layer visible about 10% of brick surface, then the presence of alkalis is inacceptable range. If that is about50% of surface, then it is moderate. If the alkali's presence is over 50%, then the brick is severely affected by alkalis.

Procedure:

1) Distilled water to be filled in a dish of suitable size. The dish should be made of glass, porcelain or glazed stone ware.

2) Place the end of the bricks in the dish, the depth of immersion in water being 25mm. Place the whole arrangements in a warm (for example,200 C to 300 C) well ventilated room until all the water in the dish is absorbed by the specimen and the surface water evaporate

3) Cover the dish with suitable cover, so that excessive evaporation from the dish may not occur.

4) When the water has been absorbed and bricks appear to be dry, place a similar quantity of water in the dish and allow it to evaporate as before

5) Examine the bricks for efflorescence.

Effect of Different Ratio of Plastic Waste in Efflorescence Test:

Brick Number	Null	Low	Medium	High
Sample 1	√			
Sample 2	√			
Sample 3	√			
Sample 4	√			

TABLE 5 Effect of different ratio of plastic waste in efflorescence test

In the test for efflorescence, the bricks were immersed in water for 24 hours and then dried in shade. Each brick was carefully examined, for fungus or mold. No such kind of problems was noticed.

In the case of Hcb this effect is clearly shown

A combination of three common circumstances causes efflorescence:

• Soluble compounds in the masonry or adjoining materials

• Moisture to pick up the compounds and carry them to the surface

• Evaporation or hydrostatic pressure that causes the solution to move

If any one of these conditions is eliminated, efflorescence will not occur. All masonry and concrete materials are susceptible to efflorescence.

During the construction process, water used to achieve a workable mortar or flowable grout constitutes available source of moisture in the masonry system. Additional moisture is often introduced into exposed masonry by rain or snow. Water-soluble salts that appear in chemical analyses as only a few tenths of one percent are sufficient to cause efflorescence when leached out and concentrated at some point on the surface. The amount and character of the deposits vary according to the nature of the soluble materials and the atmospheric conditions. According to ASTM 5-35% from the total volume of the build area will appear visually.

Generally, the machine was completed to the corrected specifications. It was tested in the workplace to find the errors. It can be concluded that the machine effectively converts plastic into useable shapes such as bricks and pavement tiles, and also reduces the amount of plastic waste resulting due to throw away culture. The compressive strength decreases with increasing waste plastic ratios. The various proportions of (1kg: 2kg: 2kg), (1kg: 2kg: 3kg), (1kg: 2kg: 4kg) and (1kg: 2kg: 5kg) had maximum load at crushing as 170 KN, 180 KN, 190 KN and 200 KN respectively. Also the compressive strength of the bricks were 9.86, 10.43, 11.01, 11.43 kN/cm2. This may be attributed to the decrease in the adhesive strength between the waste plastic, Styrofoam and the M-sand (mixed sand). It is the bonding between the plastic particles, Styrofoam and the M-sand is weak after a certain limit. However, the mixes of sand bricks and plastics waste are possible because water absorption was null. Furthermore, there isn't any salt/alkalis presence in the manufactured brick. The reduced compressive strength values of waste plastic bricks mixes show that it can be used only in situations that required low-degree workability. However, at the specific proportion, the brick showed higher compressive strength and durability. The applications are numerous in civil engineering, namely, precast bricks, partition wall panels, canal linings, and so forth. Recommendation for further study, it will emphasize on grind the waste into fine powder and mix into such proportion to achieve maximum packing density. It may result to increase in compressive strength and binder, or plasticizer should be added to the mixture to increase the bind between plastic and Styrofoam surface and M-sand particle.

G. Temperature Test:

Fire behavior waste plastic products of bricks

The Plastic is highly susceptible to fire but in case of Plastic sand bricks/Paver blocks the presence of sand imparts insulation. There is no change in the structural properties of block of bricks up to 180˚C above which visible cracks are seen and the bricks deteriorate with increase in temperature.

Therefore the sample that is good for other tests can be used so the plastic brick that is produced with this ratio which is (styrofoam:plastic:sand)(1kg:2kg:5kg) safe to use it as a construction material.

Brick Sample Number	Sample 1	Sample 2	Sample 3	Sample 4
Ratio (styrofoam:plastic:sand)	(1kg:2kg:2kg)	(1kg:2kg:3kg)	(1kg:2kg:4kg)	(1kg:2kg:5kg)
Length(mm)	175	175	175	175
Breadth(mm)	100	100	100	100
Area(mm2)	17500	17500	17500	17500
Max. Temperature(0C)	145.52	149.66	167.44	180.00

TABLE 6 Effect of Different Ratio of Plastic Waste on Temperature Test

H. Albedo effects

Albedo is a measure of the reflectivity of a surface. The albedo effect when applied to the Earth is a measure of how much of the Sun's energy is reflected back into space. Overall, the Earth's albedo has a cooling effect. The intensity of albedo temperature effects depends on the amount of albedo and the level of local insulation. Buildings are finished with white exteriors to keep them cool, because white surfaces reflect the sun’s energy in terms of insulation effects of this material is since we can produce in different colors needed this kind of insulation effects can be controlled. Therefore, the albedo effect on this product is to be controlled so we don’t need to be worried about this effect. A low albedo means a surface reflects a small amount of the incoming radiation and absorbs the rest. For instance, the literatures states that fresh snow reflects up to 95% of the incoming radiation. Therefore, fresh snow has a high albedo of 95%. Generally, dark surfaces have a low albedo and light surfaces have a high albedo. Therefore, for our product we will arrange the colors as we want so it hasn't been worried for albedo effect.

I. Soundness test

The soundness test is also done in the field. After the manufacturing of the brick are allowed to dry in air for 2days.Then the bricks are made to hit each other the ring sound produced during the process, which denotes the quality of the brick that it is good. Good quality bricks produce the clear ringing sound. In our project both fly ash bricks and plastic sand bricks clear ringing sound produced. As we know from experiences and previous researches Styrofoam has mostly used as an insulation material for a big and huge structures for our project it is seemed to be used as an insulator for any single pieces based on the ratio that is selected and provided. But the ratio is based on the preconditioning ratio selected which is the ratio that is best for the requirements that are stated in the test results, which is (Styrofoam :plastic: sand)(1kg:2kg:5kg) safe to use it as a construction material.

5 Conclusion and recommendation

5.1 Conclusion

The main intention of this thesis was to design a project that could be applicable in the real life situation. The analysis has shown that it is possible to ensure the sustainability and applicability of the project. The initial investment and operational costs are not too high. A start-up company providing only collection and separation of waste plastic and Styrofoam's waste and heating with sand together is not difficult. Plastic, Styrofoam and sand brick possess more advantages which includes cost efficiency, resource efficiency, reduction in emission of greenhouse gases, etc., Plastic, Styrofoam and sand brick is also known as "Eco-Bricks" made of plastic waste which is otherwise harmful to all living organisms can be used for construction purposes. It increases the compressive strength when compared to fly ash bricks and Hcb. By use of plastic sand bricks, the water absorption presence of alkalies was highly reduced. Owing to numerous advantages further research would improve quality and durability of plastic sand bricks. The most important thing here is beside the production of this product is the plastic waste end of life management is used for the prevention of our environment hazardous pollution from plastic wastes by using them for other usable purposes especially for construction materials as eco mortar.

Bricks made from used plastic and Styrofoam by mixing with sand can only used for light materials or designs but Hcb is used for all types but it is not as a load bearing element. There is a specific ratio for the plastic and Styrofoam by mixing with sand bricks, which is 1 kilos of Styrofoam, 2 kilo of plastic, 5kilos of sand which comprises 11 kpa compressive strength, mostly all of the samples satisfy the efflorescence and moisture content test, heat resistance 64.690C ,36-41Mpa flexural strength and 29-32Mpa of tensile strength exhibits which is best among the sample tests therefore according to these and other experimental parameters the researcher chooses (SAMPLE 4) which is the ratio recommended by this research (Styrofoam: plastic: sand)=(1kg:2kg:5kg).

Bricks made from used plastic and Styrofoam by mixing with sand is accepted by the public in comparison with Hcb product according to this research investigation. and bricks made from used plastic and Styrofoam by mixing with sand are durable to any type of weather because its main component is plastic.

5.2 Recommendation

In line with the conclusions reached and came up with a list of recommendations from the objectives:

For the Local Government of Addis Ababa

- Encourage other cities besides Addis Ababa in the country to start a project like this to reduce the amount of plastics that clogged their drainages and pollutions of our environment from plastic material wastes and also to save our natural resources like water, naturally found materials that uses for the production of bricks and finally we can also save our space for production area and time since the setting time of the product is quicker than the local market available recent products which is Hcb.
- Increase the production and start selling it to the market with a considerable amount.

For the Residents of the working area

- Supporting the recycling project of the newly emerging this cost effective, easily and quickly producible construction material.
- Help the project area Local Government in promoting the Bricks made from used plastic and Styrofoam by mixing with sand by using it on their backyards (condominiums).
- Bricks made from used plastic and Styrofoam by mixing with sand is an effective way to lessen the garbage sent to the dumpsites so by creating awareness on the society the Addis Ababa government should support the project.

Reference

1. Professor yalew endaweq mulu :2009: basic research principles and practice: bahirdar university: tefera seyoum printing enterprise፡
2. "History of bricks."The history of bricks. Brien Walker, 17 Sept. 2007. Web. 30 Nov. 2013. <http://www.propertydrum.com/articles/20090330_21>.
3. Project Profile on Cement Concrete Hollow Blocks, Retrieved from http://www.dcmsme.gov.in/reports/glass/HollowConcreteBlocks.pdf
4. Wilmot, C. Mei B., 2005, Journal of Construction Engineering and Management, 1801 Alexander Bell Drive, ASCE Reston VA 20191-4400
5. The History of Polystyrene, Retrieved from November 2013, http://suite101.com/a/the-history-of-polystyrene-a125878
6. Bank L., 2002, Journal Composites for Constructions, 1801 Alexander Bell Drive, Journal Dept. ASCE
7. Construction Technology 4th Edition, Great Britain: Dorset Press
8. Marikina's paving blocks help solve styrofoam waste. N.p., 26 Apr. 2012. Web. 30 Nov. 2013. <http://news.pia.gov.ph/index.php?article=241335405192
9. Bank L., 2002, Journal Composites for Constructions, 1801 Alexander Bell Drive, Journal Dept. ASCE
10. http://www.plasticsresource.com/plastics_101/manufacture/how_plastics_ are_made.html
11. The source of this information is the letter written by Tim Krupnik of the Berkeley Ecology Center to Dr A N Bhat of ICPE supporting the attempt to ban disposable plastics in India, March 15, 2001. Bharati Chaturvedi, Director, Chintan Environmental Organisation, New Delhi.
12. Narayan, P. (2001), ―Analyzing Plastic Waste Management in India: Case study of Polybags and PET bottles‖ published by IIIEE, Lund University, Sweden, pp 24-25 accessed at http://www.iiiee.lu.se/information/ library/publications/reports/2001/Priya-Narayan.pdf
13. Shah, P. ―The Plastic Devil: Ecological Menace‖ accessed at http://www.makingindiagreen.org/plastic.htm

14. The source of this information is a press release of NoPE (No Plastics in the Environment) titled ―Imports Versus Surplus: A Glut of Plastics in India Today,‖ January 10, 2002. Bharati Chaturvedi, Director, Chintan Environmental Organisation in New Delhi.
15. http://www.plasticsindustry.org/
16. http://plasticulture.psu.edu
17. Understanding Plastic Films: Its uses, benefits and Waste Management Options. Prepared for the American Plastics Council by Headley Pratt Consulting. Dec 1996.
18. http://www.sdplastics.com/plastics.html
19. Brydson, JA, Plastics Materials. Butterworth-Heinemann, 1999, 103-104. Daniel D Chiras, Environmental Science: Creating a Sustainable Future. Jones & Bartlett Learning, 2004, 517-518.
20. Hill, Marquita K, Understanding Environmental Pollution, Cambridge University Press, 1997, 257. Karleskint, George, Introduction to Marine Biology, Cengage Learning, 2009, 536.
21. Brannen, Julia 1992: Mixing methods: Qualitative and quantitative research. Aldershot, Avebury.
22. Central Statistical Authority (CSA), 2004: The 1994 population and housing census of Ethiopia. CSA, Addis Ababa.
23. Bjerkli Camilla Louise, 2005, The cycle of plastic waste: An analysis on the informal plastic recovery system in Addis Ababa, Ethiopia. Trondheim, Norway: Norwegian University of Science and technology department of geography. Available at: http://wiego.org/sites/wiego.org/files/publications/files/Bjerkli-Cycle-of-Plastic-WasteAddis-Ethiopia.pdf
24. Bjerkli Camilla Louise, 2014, Urban services and governance: The case of solid waste management in Addis Ababa, Ethiopia. Trondheim, Norway: Norwegian University of Science and technology department of geography. Available at: https://brage.bibsys.no/xmlui/handle/11250/265502

25. Chaib Fadela, Setiogi Sari, Osseiran Nada, Taveau Veronique, 2008. Poor sanitation threatens public health. [online] World Health Organization. Available at: http://www.who.int/mediacentre/news/releases/2008/pr08/en/ [Accessed May 2016]

26. CWG (Collaborative Working Group on Solid Waste Management in Low- and Middle - income Countries), 2003. Solid waste collection that benefits the urban poor. [pdf] The SkatFoundation,Switzerland.Availableat:
27. Hasheela Raili, 2009. Municipal Waste Management in Namibia: The Windhoek Case Study. [pdf] Universidad Azteca. Available at: < http://www.the-eis.com/data/literature/Municipal%20Waste%20Management%20in%20Namibia.pdf> [Accessed June 2016]
28. Lindell Arvid, 2012. Achievement of sustainable solid waste management in developing countries [pdf] Environmental and Energy System Studies Department of Technology andSociety Lund University. Available at < http://www.sysav.se/globalassets/media/filer-och-dokument/informationsmaterial-broschyrer-arsredovisningar-faktablad-rapporter-etc/rapporter/rapporter-2014/achievment-of-sustainable-solid-waste-management-in-developing-countries.pdf>
29. Wikipedia,2016.AddisAbaba.[online]Availableat:< https://en.wikipedia.org/wiki/Addis_Ababa> [Accessed April 2016]

30. Wikipedia, 2016. Demographics of Ethiopia. [online] Available at: < https://en.wikipedia.org/wiki/Demographics_of_Ethiopia> [Accessed April 2016]

31. ENDA Ethiopia, 1999: The cycle of waste in Addis Ababa.

32. ENDA Ethiopia, 2003: Proceeding of the experience sharing workshop on solid waste management in Addis Ababa

33. Kaseva, M.E. & Gupta, S.K. 1996: Recycling – an environmentally friendly and income generating activity towards sustainable solid waste management. Case study-Dar es Saalam City, Tanzania. Resource, Conservation and recycling. No.17:200-309.
34. Medina, Martin 1993: Collecting Recyclables in Metro Manila. BioCycle International 51:53.