# ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY


## SCHOOL OF CIVIL AND ARCHITECTURAL ENGINEERING

## DEPARTMENT OF CONSTRUCTION MANAGEMENT

## MSC PROJECT

ON

# MAKING OF FLOOR TILE BY USING WASTE GLASS AS PARTIAL REPLACEMENT CONCRETEAGGREGATE

**SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE DEGREE OF MSC IN CONSTRUCTION MANAGEMENT TECHNOLOGY TEACHERS EDUCATION**

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**Adama**

**APPROVAL SHEET**

**ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY**

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## CANDIDATE'S DECLARATION

We hereby declare that the work which is being presented in this project entitle **"**Making of floor tile by using waste glass as partial replacement concrete aggregate**",** is our original work and has not been presented for a diploma / degree of any other Institution/University and all the materials used for the project have been duly acknowledged.

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Last, but not least, we would like to thank our friends and colleagues, for their encouragement and contributing important ideas when we were preparing practical work.

# ABSTRACT

*Concrete is most widely used man made construction material and its demand is increasing day by day. In order to make concrete industry sustainable, the use of solid waste materials in place of natural resources is one of the best approaches.*

*Waste glass is a major component of the solid waste stream in many countries. It can be found in many forms, including container glass, flat glass. In Ethiopia the problems and impacts of solid waste materials has become one of the major environmental, economic, and social issues. The main objective of this project was to produce floor tile by using waste glass as a partial replacement of concrete aggregate (25%, 50%, 75% and 100%). The main significant of this project is to contribute to the construction industry in saving the environment, to encourage the government to find solutions regarding the disposal to landfills of waste materials and to find the alternative aggregate resources from local waste glass materials. The scope of this project were intended to produced floor tiles by using of waste glass as partial replacement with color full and the durability of its at least without losing of the standard and this project was cover the amount of waste glass in Adama city. In this project, the research or the data collection was only focused on broken bottles in specific enterprises or excluded any bottles in residencies and other type of glasses. Concerned of this data above 286 tons waste glass/broken bottles/ are generated from enterprises per year. For to produced of the waste glass floor tile(20×20×2cm) should be used fine waste glass and natural aggregate, ordinary Portland cement, sand, water, plasticizer admixtures materials and equipments. The experimental method process was included the percentage of waste glass used to replacement of the aggregates in making tiles and compared the compressive strength of the existing and new tiles. For this reason number of samples were manufactured and tested, each has a different percentage of waste glass and added plasticizer admixture for only 50% of waste glass fine aggregate. The result of the project was shown when the % replacement of waste glass aggregate increased their water absorption and compressive strength was decrease. It concluded that floor tile make from waste glass could be give environmental, social and economic advantages. It is recommended to extend research on the area of recycling and reusing techniques of waste glass materials in building construction to induct or introduce feasibility studies, including cost/benefit and payback period analysis for each technique.*



**Key words:** -Waste glass aggregate, broken bottles, floor tile and concrete

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## ABRIVATION

FA= fine aggregate

FM = fineness modulus

BS = British standard

ES = Ethiopian standard

ASTM = American standard test machine

UK = United Kingdom

$Sio_{2=}$ silica

$Na_2co_{3=}$ soda ash

$Caco_{3=}$ lime

ASR = alkali silica reaction

CFGF = continues filament glass fibers

CRT = cathode ray tube

TFT = thin film transistor

LCD = liquid crystal display

# CHAPTER ONE

## 1. INTODUCTION

The human population of Ethiopia is continuously growing in number, because of this; there is a great demand of constructing material and more structures to facilitate for the needs of the community. Quarry operations become rampant/uncontrolled/ to satisfy the need for gravel and sand for construction material industry. As a consequence there will be luck of natural aggregates.

In addition to that, the people of Ethiopia is continuously growing and improve their incomes and also increase their need to use glass products the same to that to increase waste of glass disposals, because of Glass is an important industrial material, with its main uses in glazing and packaging of foods or container glass/bottles/ and others.

Concrete is the world's most consumed material. Production of concrete relies to a large extent on the availability of cement, sand and aggregates such as granite, the costs of which have risen astronomically or extremely large over the past few years. The negative consequences of the increasing demand for concrete include depletion of aggregate deposits; environmental degradation and ecological imbalance.

In order to make concrete industry sustainable, the use of waste materials in place of natural resources is one of the best approaches. An enormous quantity of waste glass is generated all around the world. In India, 0.7% of total urban waste generated comprises of glass [11]. UK produces over three million tons of waste glass annually [11]. Waste glass is crushed into specified sizes for use as aggregate in various applications such as water filtration, grit plastering, sand cover for sport turf and sand replacement in concrete [11].

Rising construction materials costs and the need to reduce environmental stresses to make construction sustainable, has necessitated this project into the use of alternative materials, especially locally available ones which can replace conventional ones used in concrete production. The waste glass materials are finding suitable in concrete making with use of waste glass floor tiles. In generally, using waste glass in the concrete construction sector is advantageous, as the production cost of concrete will go down. The amount of waste glass is gradually increased over the years due to an ever-growing use of glass products.

Most of the waste glasses have been dumped into landfill sites [3, 9 and 11].The land filling of waste glasses is undesirable because they are not biodegradable, which makes them environmentally less friendly.

This project was conducted what is believe to be the widest-ever study of the performance of crushed or waste glass in real concrete products as a replacement for other existing concrete aggregate for making of floor tile. The effects of waste glass on workability and strength of the products should be analyzed.

Recent research findings have shown that concrete made with recycled glass aggregate are capable to provide better long term strength and better thermal insulation due to its better thermal properties of the glass aggregates [9]. The use of recycled glass as aggregate can also greatly enhance the aesthetic appeal of the concrete the project should also be conducting a very wide parametric laboratory study into the effects of glass aggregates in concrete [9].

The most common type of glass is formed by melting a mixture of **silica** ($SiO_2$), **soda ash** ($Na_2CO_3$), and **lime** ($CaCO_3$) at high temperatures, followed by cooling during which solidification occurs without crystallization. The main raw material for glass production is sand or quartz, which is the crystal form of silica ($SiO_2$) [1].

It consists of a continuous framework of $SiO_4$ silicon–oxygen tetrahedral, with each oxygen atom being shared between two tetrahedral. Glass can be applied for the production of various products such as [1 and, 2]

- Container glass or packaging glass: Bottles and other containers (for packaging of food, drinks, pharmaceuticals, cosmetics, etc.
- Flat glass: Mainly windows in buildings and vehicles.
- Continuous filament glass fibers: Continuous filament glass fibers are produced and supplied in a variety of forms such as mat, chopped strand, roving, yarn, tissue or milled fiber
- Domestic glass, also called tableware: Used for tableware, glassware, decorative glass etc.
- Insulation mineral wool: Insulation mineral wool is made of short fibers of glass (typically borosilicate glass or alkaline earth – alumina- silicate stone wool) and ceramic materials.
- Special glass: The category of special glass covers a wide variety of glass, for example: optical/ophthalmic glass, glass in laboratory equipment (partly made of borosilicate glass), glass in tubing, glass ceramics, lighting glass,

But this project is focused on Container glass or packaging glass, because of those materials is more available in disposal sites and suitable to as fine aggregate will be used to make floor tiles.

There are different colors of glass mainly used in container glass production those colors are to be used for making of color full floor tiles.

Crushed glass or cullet, if properly sized and processed, can exhibit characteristics similar to that of gravel or sand [9]. When used in construction applications, waste glass must be crushed and screened to produce an appropriate design gradation. Glass crushing equipment normally used to produce a cullet is similar to rock crushing equipment. Because glass crushing equipment in glass sector has been primarily designed to reduce the size or density of the cullet for transportation purposes and for use as a glass production feedstock material, the crushing equipment used is typically smaller and uses less energy than conventional aggregate or rock crushing equipment [9].

In recent, researches are shows use admixtures in concrete for the purpose of to add properties of fresh and harden concrete. Admixture is a material other than water, aggregates, and hydraulic cements used as an ingredient of concrete or mortar and added to the batch immediately before or during mixing [5].

### 1.1 Rational of the project

The rationale behind the preparation of this project is to improve conservation of natural resources and preservation of environment from waste materials like waste of glass and to substitute it for the purpose of making floor tiles to be used as fine aggregate. This project is to motivate the other developers and to introduce the alternative material for making of floor tiles in tile factories. Using waste glass in the concrete construction sector is advantageous, as the production cost of concrete will go down. The amount of waste glass is gradually increased over the years due to an ever-growing use of glass products.

## 1.2. Statement of the problem

Many studies have been emerging worldwide highlighting the reuse of waste glass in construction technology. In Ethiopia the problem of disposing and managing solid waste materials has become one of the major environmental, economic, and social issues. The problem arising from continuous technological and industrial development is it will increase the disposal of waste material. In addition of that, the demand of aggregate is increase in order to satisfy the construction industries. If some of the waste glass materials are will be suitable in floor tile making, it is not only cost of construction materials can be cut down, but also safe disposal of waste materials can be. The idea is that the glass can be used as an aggregate in the concrete mix by replacing some of the natural aggregates such as gravel and sand.

Few kind of virgin and waste materials are widely used in concrete composites as substitute materials for construction. But waste of glass is not used as alternative of aggregate for making of floor tiles in Ethiopia .One major advantage of Concrete Recycled Bottle is environment friendly causing of less garbage that will be thrown in the dump site area.

Most a decorative and attractive surface tile as well as ceramic tiles is imported from external countries. In the case of this it needs to substitute those materials in our country.

## 1.3. General objective of the project

The main objective of this project, to produce floor tiles by using waste glass as a partial replacement of fine aggregate So that environmental friendly technology will be tested and recommended for future tile manufacturing industry.

**Specific objectives**

- To produce floor tile of competitive strength floor tiles from waste glass fine aggregate by using plasticizer admixture.
- To identify the impact of adding waste glass fine aggregate on the fresh and harden concrete with varying percent.
- To compare and contrast the properties of normal or conventional concrete and new concrete.

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## 1.4. Significance of the project

It had been create job opportunity for the collector of waste glass. To make recycling glass markets were sustainable. Generally in the collection of waste glass as well as in the production of floor tiles skilled and unskilled person's have been involved.

The main significant of this project is :

- To find other source of aggregate aside from the conventional gravel and sand for making floor tiles.
- To reduce cost by using local available materials.
- To Increase productivity in the construction concrete production
- To contribute to the industry in saving the environment, to encourage the government to find solutions regarding the disposal to landfills of waste materials
- To propose amendments to standards for aggregates and cementations materials to accommodate glass as a fit-for-purpose material in a range of floor tile products.
- To create job opportunities with the chain of glass waste collectors and to increase income of tile factories.
- To learn collaboration skills and encourage technology transfer in Ethiopia.
- The government and non-government sectors are given new ideas of maximizing their waste glass and others resources materials on construction projects.
- Continuously other students could be provided with a reference and it can give them knowledge about recycled glass bottles as a partial replacement fine aggregate for similar construction products. This study will encourage them to study other waste materials that can be used as a construction material and awaken their minds regarding environmental protection

## 1.5. Scope of the project and target groups

The scope of this project were intended to design and making of floor tiles by using of waste glass/bottles/ as partial fine aggregate with better attractive surface and durability.

to cover and analysis of waste glass costs and its amount in **Adama** city. Our target group is tile factories, hotels, bars, alcohol wholesalers, municipal, disposal areas and waste collectors.

## 1.6. Limitation

- Lack of laboratory test equipments in our university.
- Due to limitation of time there were lack of detail information's about waste glass in Adama and Addis Ababa cities with concerned bodies.
- Lack of well practical experience related to this project.
- Limitation of awareness during the data collection from few respondents .

# CHAPTER TWO

## 2. LITERATURE REVIEW

### 2.1 Theoretical Background

For many years, the recycling and waste management industry has struggled with the problem of identifying or developing reliable markets for mixed-color broken glass [9].To date, only low value applications are available, which do not utilize the physical and other inherent properties of the glass

Considering the size of the cement industry (over 10 million tones/annum in the UK) this would appear to be a potential high volume, economic and environmentally friendly solution to part of the waste glass problem [1].

Alternatively, waste glass could be used as a concrete aggregate; either as a direct replacement for normal concrete aggregates (low value) or as an exposed, decorative aggregate in architectural concrete products (high value).

Expansive alkali-silica reactions (ASR) can occur between glass particles and cement paste, particularly in moist conditions and with high alkali cements. Of course, this reaction is not confined to glass aggregates but can occur whenever aggregates contain reactive silica. However it is now fairly-well accepted that by controlling the reactive silica, cement alkali level and moisture, the reaction can be reduced or totally mitigated [1 and 2].

The construction industry has shown great gains in the recycling of industrial by-products and waste, including waste glass materials. Quantities of waste glass have been rising rapidly during the recent decades due to the high increase in industrialization and the considerable improvement in the standards of living, but unfortunately, the majority of these waste quantities are not being recycled but rather abandoned or no longer wanted causing certain serious problems such as the waste of natural resources and environmental pollution [1].

The reuse of waste glass is one of the most important issues around the world due to the increase of solid wastes in the landfill and non-degradable nature of its disposal. The use of recycled waste glass in concrete has attracted much interest worldwide and numerous researches have been carried out, showing the possibility of use of waste glass as building materials by partially replacing concrete mixtures [3].

Crushed glass cullet that has been used as aggregate in road construction or bituminous concrete pavement is popularly known as "glass asphalt" [9].

Recycling of this waste by converting it to aggregate components could save landfill space and also reduce the demand for extraction of natural raw material for construction activities [9].

The previous research studies concerned with the waste glass as an aggregate material, but from different points of view and perspectives.

## 2.2. Historical Use of Waste Glass in Concrete

There has been a general perception in the concrete construction industry that glass aggregates should be excluded from concrete because of their potential for alkali silica reaction (ASR), even although early research did not draw definite conclusions. Recent publications, at the same time not specifically supporting the use of glass in concrete, have led to a great understanding of ASR parameters and methods by which it can be suppressed and major recent research in the USA and UK, has made it possible for recycled glass to be viewed as a potentially "fit-for-purpose" concrete construction material. Early researches in 1960s, 1970s and 1980s on the study of ASR of glass aggregate were conducted without definite conclusions. In parallel to these scientific advances, changes in environmental legislation are positively encouraging the use of secondary aggregates in concrete and waste glass is becoming available in larger quantities as container; end-of-life vehicle and waste electrical goods legislation take effect [1].

## 2.3. Identification and general description of glass

There is no exclusive definition of the term "glass", a term describing a variety of inorganic materials with different mechanical and optical properties [1]. What all glass materials have in common is a vitreous or amorphous state, originated by the relatively fast cooling and solidification of an initial molten state [1]. The fast cooling prevents atoms, molecules or ions to organize into a more thermodynamically favorable crystalline structure. Therefore, glasses are not arranged in an orderly repeating pattern in all three dimensions like crystals but are characterized by an amorphous structure.

As a consequence, glass does not melt at a certain temperature like other solids but softens slowly when heated up.

The most common type of glass is formed by melting a mixture of **silica** ($SiO_2$), **soda ash** ($Na_2CO_3$), and **lime** ($CaCO_3$) at high temperatures, followed by cooling during which solidification occurs without crystallization. In the glass industry the term "glass" is predominantly used for silicate glasses, i.e. materials containing a high share of silica ($SiO_2$), formed under ambient cooling conditions from the molten state into an amorphous glass structure. The main raw material for glass production is sand or quartz, which is the crystal form of silica ($SiO_2$) [1, 2 and 7].

### 2.3.1.Chemical and physical properties of glass

In its simplest chemical form, glass can consist of pure silica, in which case it is called *"*quartz *glass* "or*"* fused quartz*"*. However, the production of amorphous glass from pure silica is highly energy intensive, requiring temperatures of around 1900 °C. As such, quartz glass is only produced for applications requiring high chemical resistance and hence belongs to the special glass types [1 and 2].

In order to lower the energy requirements for glass production, most of the glass is composed of silica ($SiO_2$) plus other compounds. Silicon has the role of a so-called "network former", and it is the main element used as network former. Alternative network formers are boron or germanium. The network formers create a highly cross-linked network of chemical bonds [1].

Aside from network formers, glass contains also "network modifiers", which are alkali-oxides added as fluxing agents for lowering the melting point of glass (sodium, potassium, lithium, etc.), alkaline earth metal oxides (calcium, magnesium, barium, strontium, etc.), and other metal oxides (i.e. aluminum oxide). The network modifiers change the bonding relationships and structural groupings, resulting in changes in the physical and chemical properties of the glass [1 and 2].

### 2.3.2. Glass production and use

The European glass industry is very diverse and covers a variety of very different types of products and technologies, including bottles & jars, flat glass, continuous filament glass fibers (CFGF – not to be confused with insulation mineral wool), tableware, insulation mineral wool, optical fibers and special glass (cathode ray tubes, glass for televisions and monitors, lighting glass, optical glass, laboratory and technical glassware, borosilicate and glass ceramic cookware, etc [1]. The specific products that the glass industry can produce are very diverse, ranging from tiny jewelers products to huge swathes of architectural flat glass for buildings [1]. The common factor among these industries is that they all need glass melting furnaces to manufacture their products [1].

The raw materials they need, the size and type of furnace, the amount of energy needed, the type of fuel used, the amount of cullet that can be used, the length of time needed to melt and produce a finished product vary considerably from one sector to another. Glass can be applied for the production of various products [1]. A typical classification is based on the six broad sectors of the glass manufacturing industry are listed below [1]:

1. Container glass or packaging glass**:** Bottles and other containers (for packaging of food, drinks, pharmaceuticals, cosmetics, etc.).

2. Flat glass: Mainly windows in buildings and vehicles are included in this type of glass. The flat glass products can be roughly categorized into two types: float glass and rolled glass. Float glass is used for a huge number of applications including glazing for building and transportation, industrial applications, electronics, furniture, appliances, etc. Rolled glass is used principally in the manufacture of glass doors, partitions, shower enclosures, and photovoltaic panels. Float and rolled glass are produced with different manufacturing processes. Rolled glass installations have much smaller furnaces than float glass, with lower load.

3**.** Continuous filament glass fibers: Continuous filament glass fibers are produced and supplied in a variety of forms such as mat, chopped strand, roving, yarn, tissue or milled fiber. The main end use (approximately 75%) is the reinforcement for many polymer materials. The main markets for the resulting composite materials are the building industry, the automotive and transport sectors, and the electrical and electronics industry. Continuous-filament glass fibers are predominantly made of E glass.

**4.** Domestic glass, also called tableware**:** Used for tableware, glassware, decorative glass, etc. Most important components are soda-lime, lead crystal, crystal glass and opaque and glass ceramics.

**5.** Insulation mineral wool**:** Insulation mineral wool is made of short fibers of glass(typically borosilicate glass or alkaline earth – alumina- silicate stone wool) and ceramic materials. It is used for insulation, filtering and fire stop applications.

6.Special glass**:** The category of special glass covers a wide variety of glass, for example:

optical/ophthalmic glass, glass in laboratory equipment (partly made of borosilicate glass), glass in tubing, glass ceramics, lighting glass, glass composing cathode-ray tubes (CRT) in computer monitors and TVs, as well as glass in other electronic equipment such as in TFT LCD screens (thin film transistor - liquid crystal display). There is no more production of CRT glass in the EU, but there is some recycling activity of CRTs (companies such as GRIAG and CRT Recycling Ltd).

### 2.3.3. Waste glass terminology

#### I. Cullet

In general, the word cullet can be used to refer either "broken glass" or “waste glass".

A distinction should be made regarding internal vs. external cullet: this distinction is important because internal cullet is not regarded as waste, while external cullet (which can be pre- or post-consumer) is classified as waste. When using the word "cullet" in the context of end-of-waste it will always refer to external cullet [1].

**Internal cullet:** Is composed of defective products detected and rejected by a quality control process during the industrial process of glass manufacturing, transition phases of product changes (such as thickness and color changes) and production off cuts.

The basis of the definition of internal cullet is the fact that these materials are immediately absorbed by the respective industrial process as a raw material for a new melting operation, not leaving the glass manufacturing plant. Internal cullet cannot be considered as waste as it was never a product.

**External cullet:** is a waste glass it throws or identifies after produced from the industry and to use the consumers.

The majority of cullet is container glass and flat glass cullet. However, cullet can also come from insulating mineral wool, or from continuous-filament glass fibers. In these cases, especially for the case of High Temperature Insulation Wools (HTIW), the waste glass has a fibrous structure rather than the crushed-glass appearance that is usually associated with the word cullet.

### 2.3.4. Waste glass classification

There are two classification of waste glass according to its source: pre- and post-consumer waste glass [1].

**Pre-consumer waste glass**: is generated during manufacturing (*before* reaching the consumer), and has exclusively an industrial origin.

**Post-consumer waste**: is generated *after* the manufactured products are used by the consumers. The approximate share of waste glass from this origin is approx. the remaining 75%. The main source of Post-consumer waste glass is:

- Municipal solid waste (from household and commercial waste collection)
- Industrial waste
- Construction and demolition waste (C&D)
- End-of-life vehicles (ELV)
- Waste from electric and electronic equipment (WEEE)

In general, pre-consumer glass is more homogeneous. Waste glass from post-consumer origins will almost always need different degrees of sorting, collection and treatment, while some pre-consumer streams may not need any treatment at all [1 and 9].

### 2.3.5. Color of waste glass/bottles/

There are different colors of container glass such as: Clear or flint, Green, Brown or amber, and mixed cullet.

Color requirements are related to commercial, not environmental, requirements.

Maximum accepted levels of false colors in a given colored cullet differ according to the desired product quality by the manufacturer. The strictest requirements apply for the manufacture of flint glass, whereas mixed glass (followed by green glass) has the highest tolerance for other colors.

## 2.4. **Waste glass management**

### 2.4.1. **Description of management options:**

Glass can be an example of reused as returned bottles with deposit, in which case it is not defined as waste [1]. Post-consumer waste glass can be recovered with the purpose of recycling in the glass manufacturing industry, to make products such as container glass, flat glass or insulation mineral wool, and also for uses that do not imply re-melting, e.g.:

- Additive (fluxing agent) in brick and ceramics production
- Filter media (e.g. for water purification)
- Aggregate in civil works (loose fill, asphalt, backfill)
- Abrasive, e.g. for sandblasting
- Sports turf (rooting medium, top dressing)
- Decorative applications (tiles, flooring, synthetic marble).

The process of recycling consists of a series of steps to condition the waste glass for further use. Typical steps are collection, crushing, sorting, contaminant removal, transport, and final use. Some of these steps can, if appropriate, be by-passed. When no use is found for glass, it is stored or disposed of. The most frequent disposal options are land filling and incineration. Incineration implies that glass is mixed with other materials in slag, which then can be either used (e.g. in civil works) or land filled [1].

### 2.4.2 .Waste glass generation

It is estimated [1] that the total amount of waste glass generated in the EU [1] was 25.8 Mt. This resulted from a total production of glass in the EU-37.4 Mt [1]. The extra-EU trade of manufactured glass represented only 5-10% of production. In addition, in 2007, extra-EU imports and exports of glass products approximately balanced each other, with a total imports volume of 3.6 Mt and total exports of 3.5 Mt [1].

## 2.5. **Concepts of floor tiles**

Tiles are classified in to different classification based on their functions, their properties, construction materials and their styles. Such as, ceramic tile, stone tile, plastic tile, waste glass tile, concrete tile, wood tile etc.

Ceramic tiles are nothing more than beautiful, baked clay. They are a mixture of clays that are shaped, dried and fired at high temperatures resulting in a hard body, called bisque, can then be treated (glazed) or left untreated (unglazed).

To make the selection of tiles easier, a rated system classified them by group depending on the intended use of the tile.

- Group 1: Tiles suitable only for residential bathrooms where softer footwear is worn.
- Group 2: Tiles suited to general residential traffic, except kitchens, entrance halls, and other areas subjected to continuous heavy use.
- Group 3: Tiles suited for all residential and light commercial areas such as offices, reception areas and boutiques.
- Group 4: Tiles suited for medium commercial and light institutional applications such as restaurants, hotels, hospital lobbies and corridors.
- Group 5: Tiles suitable for heavy traffic and wet areas where safety and maximum performance are a major concern. Used in exterior walkways, food service areas, building entrances, shopping centers and around swimming pools.

The strength of the tile is determined by its density and its construct materials. The density is measure by the amount of water or moisture that is absorbed by the tile. The strongest bisques have the greatest density, which is characterized by the smallest and fewest number of air pockets in the clay, less porosity will mean lower moisture absorption. High-density tiles are suited for heavy commercial installations as well as residential projects.

Low-density tiles that are too porous and absorb more than 3% moisture will freeze and crack if installed outdoors in cold climates.

Dimensions: The size of most made concrete flooring tiles shall be as follows:

| Length (mm) | Length (mm) | Length (mm) |
|---|---|---|
| 200 | 200 | 20 |
| 250 | 250 | 22 |
| 300 | 300 | 25 |

### 2.5.1. Environmental purpose

Eco-Friendly tiles are generally man-made tiles that recycle or reuse materials from other tiles or industrial products with a nod to an environmentally-conscience manufacturing process. Especially solid waste materials like waste glass material is most impacted on the societies, because of it cannot decompose [1].

### 2.5.2. Advantages of floor tiles

- Color Permanence or stability: The colors in most floor tiles like ceramic tiles especially glassed tiles are not fade from light exposure.
- Dirt Resistance: most tiles are not retains dust or residues. Plain water or a damp cloth is generally all that is required to keep the tile clean.
- Stain Resistance: glassed tiles are among the most stain-resistant building products.
- Fire Resistance: glassed tiles will not burn or feed a fire easily.
- Abrasion Resistance: Commercial areas, as well as areas of the home subject to heavy use as kitchens, entries and require good abrasion resistance.
- Water Absorption and Frost/cold/ Resistance [1].

# CHAPTER THREE

# 3. RESEARCH METHODOLOGY

## 3.1. Description of the Study area

Adama city was selected as a case study during the investigation. Adama is a city in central Ethiopia and forms a Special Zone of Oromia Region and is surrounded by East Shewa Zone. It is located at 8.54°N 39.27°E at an elevation of 1712 meters, 99 km southeast of Addis Ababa. The city sits between the base of an escarpment to the west, and the Great Rift Valley to the east. Based on the 2007G.C Census conducted by the Agency of Ethiopia (CSA), this city has a total population of 220,212, an increase of 72.25% over the population recorded in the 1994 census, of whom 108,872 are men and 111,340 women.

The map of Adama city is shown in Fig.


Figure 3.1 Google map of Adamacity

## 3.2. Overview of the Research Process

Research is a logical and systematic search for new and useful information on a particular topic.

It is an investigation of finding solutions to scientific and social problems through objective and systematic analysis. Because of the investigators' wish to take on an applied research which aims at contributing knowledge, skills and attitudes towards solving a practical problem. Considering experience, observations and results of previous backgrounds, we design the research problem statements and the research questions.

Based on the related to our project, we examined and assessed the details of information about waste glass in Adama city how much amount waste glass? How can these to dispose or to collect? Those questions are the basic and more essential information have been provided to the project. Thus, results of the investigation gave clear idea of the waste glass problems in environment and social health and to introduce the new technology for making of tiles by using of waste glass as partial replacement of aggregate in concrete work.

The research methodology to make the project successfully or to achieve, it was included qualitative and quantitative approaches or techniques:

- Collected the required information and documents related to the waste glass.
- Visited the Adama City of alcohol wholesalers, hotels, bars, garbage areas, tile factories and Adma municipal administration to obtain related information and collect samples.
- Undertaken a comprehensive literature review on relevant subjects focused on the usage of waste glass in construction field.
- Developed an adequate experimental program to study the use of waste glass in concrete mixtures, which used to make floor tile.
- Analyzed the experimental output test results to draw conclusion.

- To achieve successfully, the project was included the following parameters.
    I. Instrument development
    II. Sample selection
    III. Data Collection
    IV. Data Analysis and Interpretation

## 3.3. Instrument development

For the purpose of the project to be successful, we are using exploratory research method which is used to identify key issues and key variables. Exploratory research might involve a literature search or conducting focus group interviews.

## 3.4. Sample selection

A total of 10 numbers of alcohol wholesalers, hotels, bar and restaurants are randomly selected from the number of 18, 415, 236 respectively at Adama city those are currently working.

## 3.5. Data Collection

The Primary and secondary sources of information were used for data collections. The secondary source of information data collected through written by other researchers, books, journals, newspapers and any reference must be acknowledged.

Initial primary data related to the overall solid waste management system especially waste glass issues in Adam city were collected from adama Municipal Administration (AMA),to understand the existing practices and to collect data from trade and industry office in order to obtained information how many enterprises in adama city. Mainly to obtain information this is estimation of quantity waste glass to dispose from enterprise. Other important information is to collect data from the practice of tile factories.

In-depth information related to the type of collection systems, waste disposal system, and location of disposal sites, if there is the recycling of waste glass specially.

On the behalf of restored data from concerned bodies we are observed waste glass in adama city.

Considering the indigenous environmental conditions and behavior of the local dwellers, technical suggestions are also discussed as the research findings.

The data that have been collected are analyzed through the most common forms of statistical analysis Frequency Mean and percentage.

In detailed, data is collected through:

- Questionnaires (closed and open questionnaires),
- Interviewing
- Direct observation.

## I. Questionnaires:

The questionnaire designed based on the needs to identify while observing on the various enterprises or have been focus on the consumers of bottle glass/drink containers/. Basically, the questions were closed and opened type questions. The questionnaire is clear and to find the amount of waste glass in adama city and to know whether waste glass used for any purpose by the society. This questionnaire forms also built in to cover different point of views such as costs to dispose and social impact that arise due to in proper placement of waste glass..

### II. Direct observation:

In order to know and clearly understand the information concerned of the amount, way of dispose waste glass, impacts on environment and if there is recycled the waste glass it should be observe focused around bars, alcohol hole sellers, garbage areas and tile factories in order to understand the process of making tile and used materials.

In Adama city, we observed some amount waste glass or broken bottles were collected separately from other solid waste materials in enterprises and some amount were uncollected or throw around its area.

When to observe in the some landfills all solid waste materials were in one.

The waste glass materials used throughout this experimental study were gathered from the disposals of garbage areas, hotels, bars, alcohol wholesalers and others in Adama city. These materials were primarily originated from container glass or bottles.

Figure 3.2 collected waste glass or broken bottles in alcohol whole sellers in Adama city

Figure 3.3 uncollected waste glass or broken bottles around bars in Adama city

## 3.6. Data Analysis and Interpretation

Data Analysis and Interpretation involves a number of closely related operations which are performed with the purpose of summarizing the collected data and organizing these in a manner that they answer the research questions (objectives).

The collected data through the means of questionnaires, interviews, and direct observation of documents concerned waste glass materials are analyzed & interpreted.

The findings indicate that, there are availabilities of waste glass; these are throwing to local area disposal or landfills and having its environmental and social impacts at Adama town.

The first data collection analyzed was started to edited and summarized data collections as the following tables:

**Distributed and returned questionnaires**

| No | Kind of enterprises | Questioner | Respondents | |
|---|---|---|---|---|
| | | | Frequency | Returned in (%) |
| 1 | Alcohol whole seller | 10 | 10 (returned) | 100 |
| 2 | Hotels | 10 | 10 (returned) | 100 |
| 3 | Bar and restaurant | 10 | 9 (returned) | 90 |
| | Total | 30 | 29 | 96.66 |

Table 3.1 Distributed and returned questionnaires

### 3.6.1. Quantities of waste glass (broken bottles) in Adama city:

This research or the data collection was concerned to the amount of waste glass in Adama city, only focused on broken bottles in specific enterprises or excluded any bottles in residencies and other type of glasses. According to the data collected from respondents, there are no enterprises or persons to recycling process of waste glass in Adama city currently. Therefore, additional feasibility study of potential reuse or recycling was recommended. But based on gained information's from municipal administration of adama city, other solid waste materials like plastic and metal materials are already onrecycling process by other enterprises.

**The amount of waste glass or broken bottles is listed as below table.**

| s/no | Kind of enterprises | No enterprise | Amount of waste glass Per a day /kg/ | Amount of waste glass Per a month/kg/ | Amount of waste glass per a year /kg/ | Remark |
|---|---|---|---|---|---|---|
| 1 | Alcohol whole sellers | 18 | 1.5 | 810 | 9,720 | |
| 2 | Hotels | 415 | 1 | 12,450 | 14,9400 | |
| 3 | Bar and restaurants | 236 | 1.5 | 10,620 | 127,440 | |
| | Total | 669 | 4 | 23,880 | 286,560 Or above 286 tons | |
| | Not included other source of waste glass, it's used to only container glass. | | | | | |

Table 3.2 amount of waste glass (broken bottles) generated in Adama city

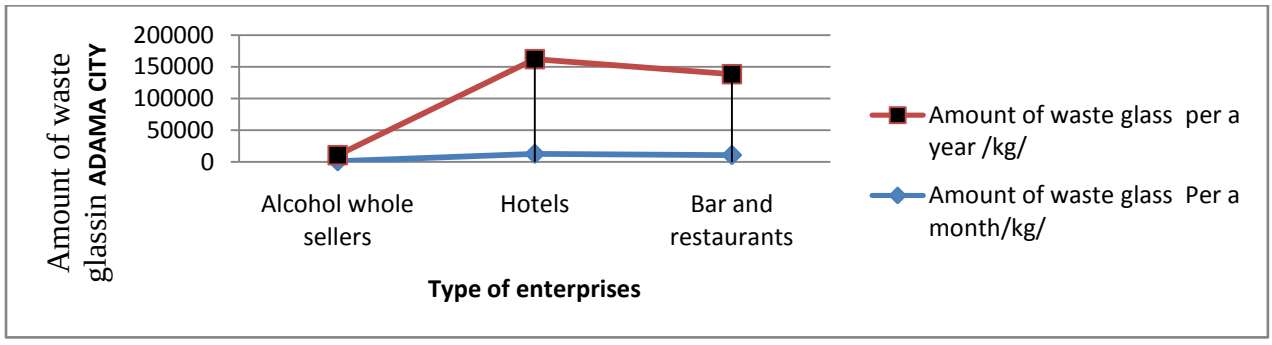


**Figure 3.4 amount of waste glass in adama city**

### 3.6.2. Analysis of Solid waste material management in Adama

Now a day's in Adama city the human population, size of different industries, enterprises becoming increasing and the amount of solid waste in this city becoming very high. The management of solid waste is a great importance due to its potentially environmental hazards and public health risk but the way these wastes are handled, stored, collected, and disposed that can pose risks to public health and environmental impact. In large number of areas of the city, solid waste management services are insufficient. Waste glass is one of the solid waste materials in every city.

In Adama city, one can observe a low awareness of the problem of waste treatment especially with dangerous wastes like waste glass materials. Locally waste of glass produced by peoples is one of the problems that require attention. Everybody knows that glass is not biodegradable material. It does not dissolve, that is why it affects the environment. Waste glasses like other solid wastes are being collected manually by sweeper using wheel borrows, hand carts and finally disposed by municipal of a city to the land fill area. There is increasing concern about the disposal of waste, the amount of which has increasing dramatically in the recent years.

Transporting this waste to land-fill site can be expensive and dangerous.

In generally, there are some elements in the process of solid waste materials management in adama city as showed below figures.

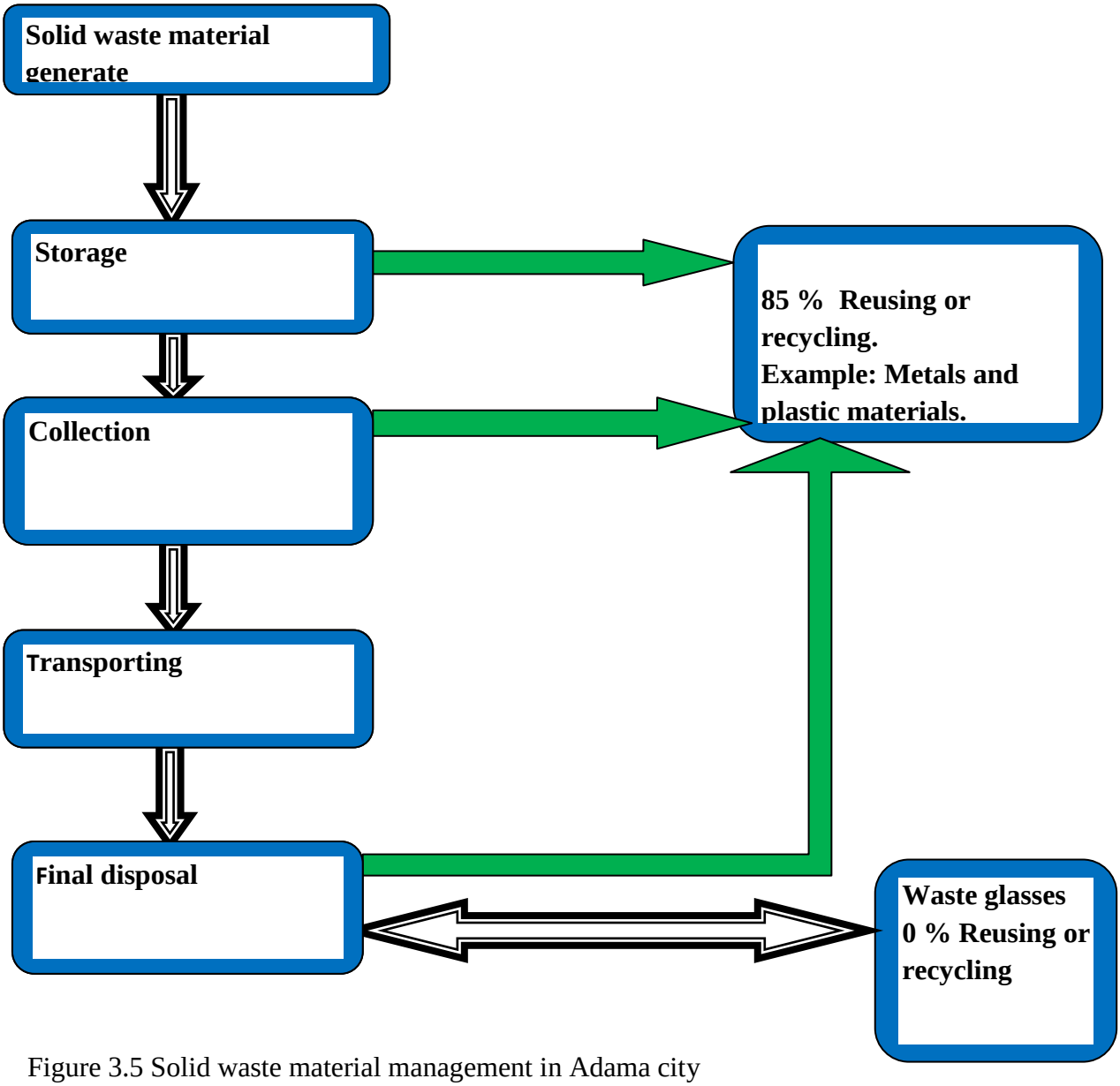


Figure 3.5 Solid waste material management in Adama city

# CHAPTER FOUR

# 4. PRODUCTION PROCESS OFFLOOR TILE BY USING WASTEGLASS

## 4.1. Project design

The primary objective of this project is to make floor tiles from waste glass fine aggregate as partial replacement of natural aggregate with having color full surface and durability.

The project design needs to account for both the live loads of tiled areas and the dead loads of the floor system.

The main consideration of this project design is:

- Consider standard dimension of tile
- Used to different color of waste bottles aggregate.
- Use the grade particle size of waste glass aggregate from 2.36mm up to 0.60mm
- Selection of materials
- Sieve analysis process
- Mix proportion.
- Sample test consideration

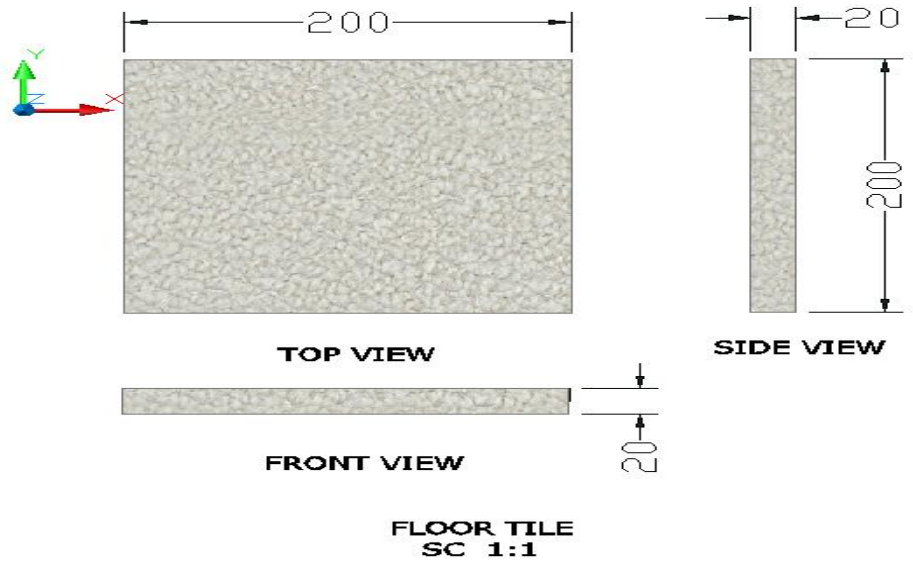


Figure 4.1 Design of waste glass floor tile

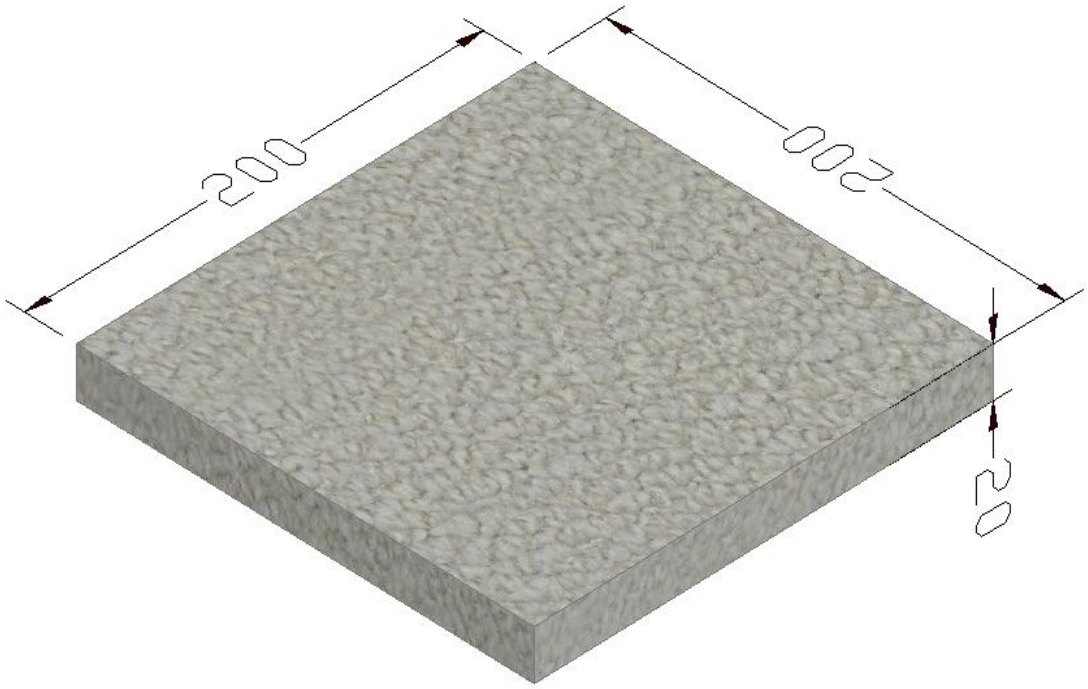


Figure 4.2 3D drawing of waste glass floor tile (20*20*2cm)

For making of floor tile by using of waste glass as partial fine aggregate was stated as the following procedure:

- Collect different color waste glass bottles
- Cleaned the collected broken bottles
- Waste glass crushed
- Screened to produce an appropriate design gradation or make sieve analysis.
- Mix design or make proportion of materials.
- Making of floor tile with consider of engineering application

The most process are the same standard procedure applied to conduct with the existing sieve analysis representative samples of waste glass and according to the international standard (IS) specifications, the samples we were grouping under coarse and fine sized crushed glass. Glass crushing equipment normally used to produce a cullet /waste glass/broken glass/ is similar to rock crushing equipment.

The crushing equipment used is typically smaller and uses less energy than conventional aggregate or rock crushing equipment.

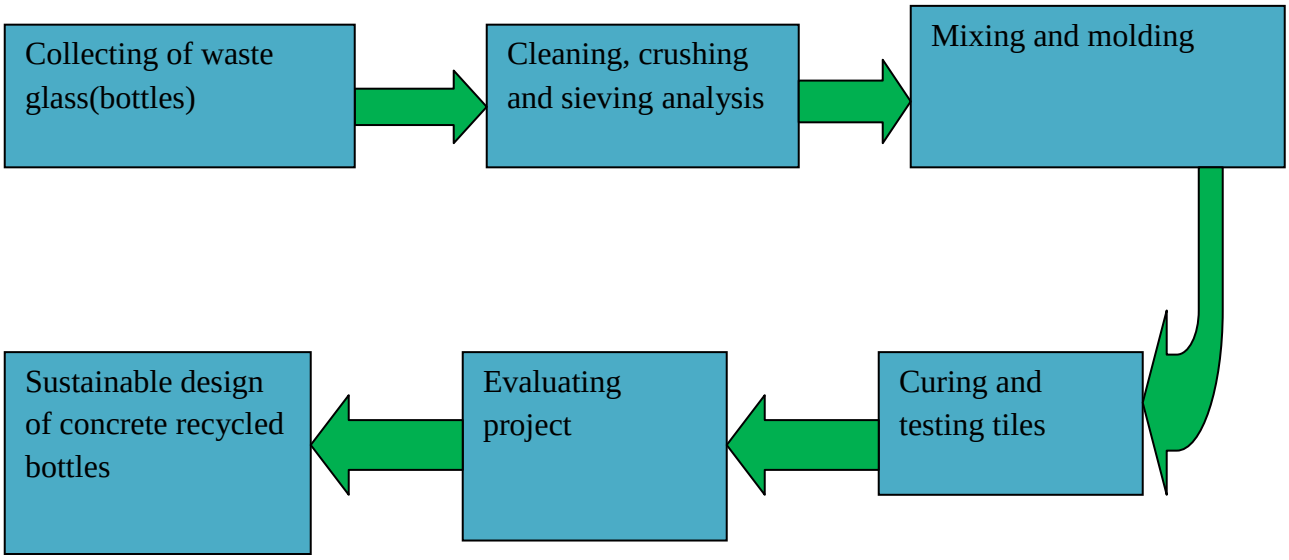


Figure 4.3 project design

In order to make colored floor tile we were collected and prepared different colors waste glass or bottles from different areas. The collected wastes glasses are cleaned from contaminate materials and to crushed and standardize into coarse aggregate and fine aggregate.

## 4.2. Materials

The main materials for making of this floor tile made from waste glass is stated as follows: crushed waste glass (bottles), Portland cement, sand, natural fine aggregate, water, crushing tools, admixture, mixing tools, tile molds and, experimental and testing equipment. The fine aggregate waste glass materials are used from d/t color waste glass or broken bottles.

**I. Cement:**

Cement is a very important part of the concrete because it is the cement, which gives the concrete its strengths. Because of the importance of cement, the ASTM has set guide lines to follow for the make-up of cement [10]. Cement contains limestone, clay, cement rock and iron ore blended and heated to 1200 to 1500 C° [10]. Portland cements are hydraulic cements, meaning they react and harden chemically with the addition of water. Raw material for Portland cement is Calcium & Silica [10].

Calcium: Limestone, chalk, etc ($CaO+CO_2$)

Silica: Clays and shale's ($SiO_2+Al_2O_3+Fe_2O_3+H_2O$)

**II. Waste glass as an aggregate**

Glass is a fully recyclable material; it can be recycled without any loss of quality. There are many examples of successful recycling of waste glass. Waste glass can also be produced from empty glass bottles and other cylindrical container, and come in several distinct colors containing common liquids and other substances. This waste glass is usually crushed into small pieces that resemble the sizes of gravels and sands. Therefore - as an alternative - there is a potential to partially replace the concrete mix aggregate with waste glass due to the lack of natural recourses in Ethiopia.

In its original form, glass comes as a balanced combination from three main raw natural materials: sand, silica, and limestone, in addition to a certain percentage of recycled waste glass utilized in the manufacturing process.

The glass recycling process produces a crushed glass product called "cullet.

Technically, glasses are usually manufactured in the form of tubes, rods, hollow vessels and a variety of special shapes, as well as flat glass and granulate for use mainly in chemistry, laboratory technology, pharmaceuticals, optoelectronics, various domestic uses, and household appliance technology.

Figuer 4.4 prepared brown color broken bottles

Figure 4.5 prepared clear or white color broken bottles

Figure 4.6 prepared green color broken bottles

Figure 4.7 coarse aggregate made from different color of waste glass/bottles/

Figure 4.8fine aggregate made from different color of waste glass/bottles/

### III. Water

Water is one of the most important elements in concrete production. Water is needed to begin the hydration process by reacting with the cement to produce concrete. There has to be a sufficient amount of water available so that the reaction can take its full course but if too much water is added, this will in fact decrease the strength of the concrete. The water-cement ratio is an important concept because other than the recipe for the concrete mix, the amount of water used would also determine its final strength.

In more details, if too little water were added, there would not be enough water available to finish the reaction, thus some of the cement would harden and bond with other dry cement shorting the hydration process. On the other hand, if too much water were added then while the cement is undergoing hydration the cement would be in a slurry solution, and the probability of cement bonding with aggregates would decrease. And as a result, when the hydration process is completed, the cement content would still be in a slurry solution and with no strength.

Potable water is used for mixing and curing. On addition of higher percentage of demolished waste the requirement of water increases for the same workability.

### IV. Natural aggregate

Aggregates are broken down into two main categories, which are coarse aggregate and fine aggregates. But for making of this waste glass floor tile is use fine aggregate. Normally fine aggregates called sand, this component can be natural sand or crushed stone, and represents particles smaller than 2.36mm.

Fine aggregate/sand is an accumulation of grains of mineral matter derived from the disintegration of rocks. Aggregates that are used in concrete have to pass the standards set in IS.

Sands that have been sorted out and separated from the organic material by the action of currents of water or by winds across arid lands are generally quite uniform in size of grains. Usually commercial sand is obtained from river beds or from sand dunes originally formed by the action of winds.

### V. Plasticizer admixtures

It has been used for concrete for the effective use and improvement in concrete properties through their utilization.

This project was used the Plasticizers admixture type, because it makes possible to achieve a given strength with a lower cement content, improved workability and provides a more even distribution of the binder particles through the mix, usually increase the slump of concrete with a given water content and improve pump ability. Generally the main objective of this plasticizer admixture used on this project to increase the bond formation of waste glass aggregate. As a result of this waste glass floor tile had been better strength than the existing one.

### VI. Concrete

Concrete is one of the most important materials employed in public works and building construction projects.

Concrete is a mixture of cement, fine aggregates, coarse aggregates and water and air.

Portland cement, water, sand, and aggregates are proportioned and mixed to produce concrete suited to the particular job for which it is intended.

Figure 4.9 Materials used in this project

### 4.2.1. Specification of the materials and equipment's of the project:

In the production of this floor tile made by using of waste glass as partial fine aggregate required specific materials and equipments in order to achieve the objective of this project. The main essential materials and equipment's are described as below table:

| S.N$^{o}$ | Items | Specification | Unit | Qty |
|---|---|---|---|---|
| 1 | Fine aggregate from Waste glass | From 2.36 mm-0.60mm size and crush for white, green and brown colors bottles | $M^3$ | 0.012 |
| 2 | Sand | Medium | $M^3$ | 0.04 |
| 3 | Cement | Portland cement | Kg | 10 |
| 4 | Natural fine aggregate | From 2.36 mm-0.60mm size | $M^3$ | 0.01 |
| 5 | Plastic mold | 200mmx200mmx20mm | Pcs | 1 |
| 6 | Admixture | Plasticizer | Liter | 1 |
| 7 | Pans | Opening size 4.75,2.36, 1.18,0.60,0.30, and 0.15 mm | pcs | 5 |
| 8 | Vibrate machine | | pcs | 1 |

Table 4.1 specification of materials and equipments

In addition to the above specified materials and equipment's it is also necessary safety equipment's like eye protection or goggle, hand glove, helmet and wear clothes. Because during collecting, crushing, sieve analysis and mixing operations it may be occurred dangers.

### 4.2.2. Cost analysis

The cost analysis is used to determine the overall costs of the existing floor tile and new floor tile before producing in order to compare b/n those. Assume the waste glass aggregate will collect or available from local area or city and the cost of it's only for collecting and crushing operation process. The total cost of floor tile to produce can be determined by the following:

1. The cost of raw materials
2. Operation process
3. Cost of power consume
4. Labor cost

| No | Item | Description | Quantity | Unit | Unit price | Total price |
|---|---|---|---|---|---|---|
| 1 | Cement | Portland cement | 15 | Kg | 2.50 | 37.25 |
| 2 | Sand | Medium | 0.075 | $M^3$ | 250.00 | 18.75 |
| 3 | Natural aggregate | From 2.36mm-0.60mm | 0.113 | $M^3$ | 300.00 | 33.9 |
| 4 | Labor cost | Daily labor | 4 .00 | No | 3.75 | 15.00 |
| 5 | Overhead cost | Transportation ,water and electric ( vibrator ) , gloves, dust mask | - | - | 34.16 | 34.16 |
| 6 | Administration cost | Coordinator and security | - | - | 3.47 | 3.47 |
| | Total cost | | | | | 142.53 |

Table 4.2 cost estimation of exist tile for 1 $m^2$ gloves and a dust mask

**Selling price = production cost**$\times 15/100$

= 142.53 × **15/100**

= **163.90 Birr**

| No | Item | Dnescription | Quantity | Unit | Unit price | Total price |
|---|---|---|---|---|---|---|
| 1 | Cement | Portland cement | 8.25 | Kg | 2.50 | 20.63 |
| 2 | Sand | Medium | 0.042 | M3 | 250.00 | 10.50 |
| 3 | Waste glass aggregate | From 2.36mm-0.60mm | 0.0312 | M3 | 125.00 | 3.90 |
| 4 | Natural aggregate | From 2.36mm-0.60mm | 0.057 | $M^3$ | 300.00 | 17.10 |
| 5 | Plasticizer admixture | Plasticizer | 0.033 | liter | 100 | 3.30 |
| 6 | Labor cost | Daily labor | 3 | No | 3.75 | 11.25 |
| 7 | Overhead cost | Transportation ,water and electric ( vibrator ) , gloves, dust mask | - | - | 34.16 | 34.16 |
| 8 | Administration cost | Coordinator and security | - | - | 3.47 | 3.47 |
| 9 | Roller bar | Diameter 12 mm bar and height of 1meter | 1 | pcs | 10.00 | 10.00 |
| 10 | Cylindrical tube | Height 400 mm plastic Cylindrical tube | 1 | pcs | 10.00 | 10.00 |
| | Total cost | | | | | 124.31 |

Table 4.3 cost estimation of new tile for 1 $m^2$

**Selling price = production cost×15/100**

**= 124.31×15/100**

**= 142.96 birr**

## 4.3. Experimental methods

## Introduction:

Experiments shall be conducted to acquire the necessary data needed in the analysis. Each experiment shall be conducted in accordance with the standards which are applicable in our country and international standards. This project was used different color bottles. These bottles are crushed and use as a replacement for fine aggregates for concrete mixture. In this project experiment used manually crushed and clean bottles and chosen bottles with the same property for uniformity. The crushed samples were passed through sieve analysis to ensure that the size of the cullet will be less than 2.36 mm but greater than 0.60 mm with accordance to ASTM and Ethiopian standard.

**Health and Safety:** Protective clothing including gloves and a dust mask should be wear. Care should be taken not to inhale fine particles of glass in any circumstances. There is danger of cutting injury from larger glass particles that have been split or broken by impact during storage – in the case of injury seek medical help. In the case of eye contact, wash out the eye and seek medical help.

**Setting time:** The glass aggregates shall not contain any substance because that increases the setting time of concrete. And the glass aggregates shall not contain any substance that decreases the compressive strength of concrete. The requirements for fine glass aggregate in this specification are related to factors that may affect the setting time, rate of hardening or durability in cementations systems.

### 4.3.1. Crushing of waste glass

Bottles are collected from alcohol whole sellers, bars and others to use in this project. These bottles are crushed and use as a replacement for fine aggregates for concrete mixture. These bottles were chosen with the same property for uniformity and clean bottles and manually crushed. The process of crushing this waste glass was used similar to natural stone crushing equipments. But in addition to these it need round hole metal having 400mm up to 600 mm and 120 up to200mm diameter, because it is used to protect the chip of waste glass from flying. In addition to the natural crushed stone aggregate with a maximum size of 2.36 mm and with the minimum size of 0.60 mm fine aggregate crushed waste glass is to be used in this work as a portion of 50%, 25%, 0%, 75% and 100% in the concrete. See on the Appendix II (fig 4.10)

### 4.3.2. Sieve analysis of aggregate:

It is a process of dividing of aggregate in to various fractions, each consists of particles same nominal size. The result particle size distribution is called the gradation. The gradation of aggregate is very important not only for concrete strength but for workability also. In fact the gradation of FA (fine aggregate) has much greater effect on concrete qualities. FA should not be very coarse as it may cause segregation or bleeding and also result in to harsh concrete. It should not be very fine also; otherwise it will have more water demand. The gradation of FA can be represented by a mathematical index called "fineness modulus" (FM) which determines relative of material.

**FM =** Cumulative % of aggregates retained on each standard sieves.

All aggregates and pans are must be free from impurities materials. All sieve analysis was implemented according to the international standards such as American Standard test material (ASTM) and British standard. During the process of sieve analysis must be record the weight of retained aggregates and put with percent of retained and passing aggregates. See on the Appendix II (fig 4.11)

## SIEVE ANALYSIS OF AGGREGATE

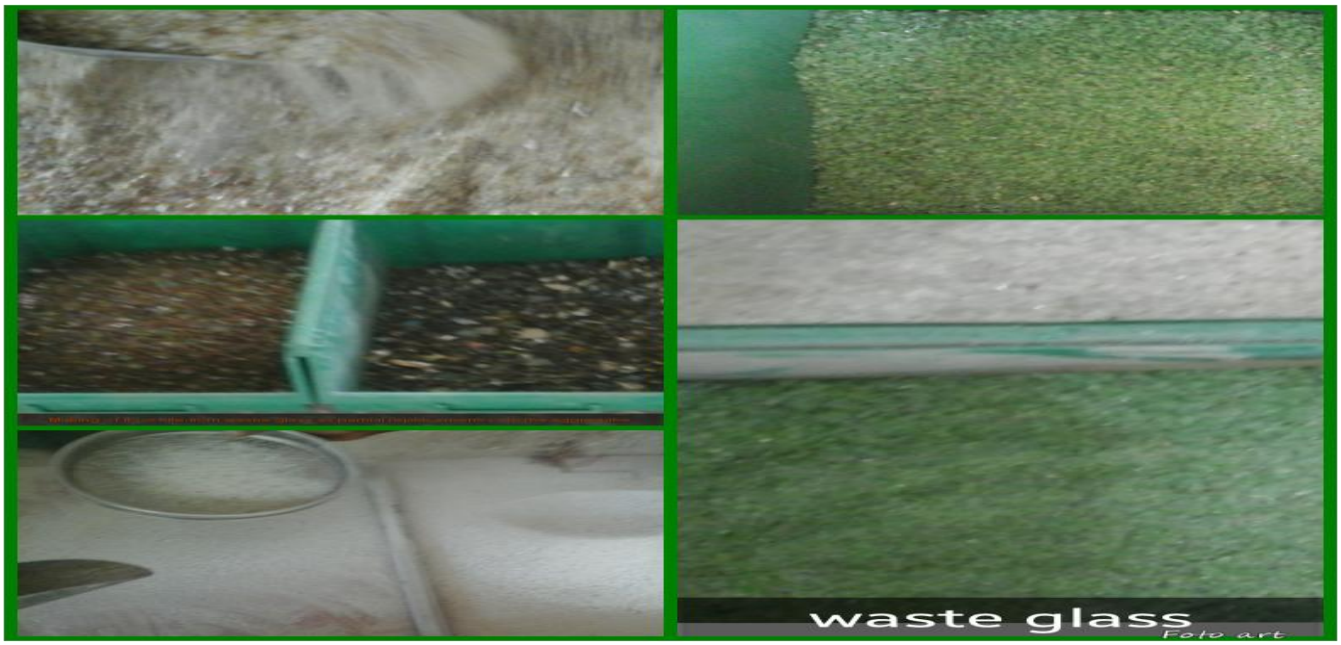


**Figure 4.12 Separated waste glass aggregates by standard particle size**

| Sieve size(mm) | Mass Retained (gm) | Retained% | Passing% | Cumulative Retained % | ASTM Standard Specification |
|---|---|---|---|---|---|
| 4.75 | 0 | 0 | 100 | 0 | 95-100 |
| 2.36 | 1.7 | 0.17 | 99.83 | 0.17 | 80-100 |
| 1.18 | 357.7 | 35.77 | 64.04 | 35.94 | 50-85 |
| 0.60 | 230.9 | 23.09 | 40.97 | 59.03 | 25-60 |
| 0.30 | 200.2 | 20.02 | 20.95 | 79.05 | 5-30 |
| 0.15 | 113.2 | 11.32 | 9.63 | 90.37 | 0-10 |
| Pan | 96.3 | 9.63 | 0 | 0 | 0 |
| Fineness modulus of glass, ΣF/100 = 264.56/100 = 2.64 | | | | 264.56 | |

Table 4.4 sieve analysis

| Sieve size(mm) | Mass Retained (gm) | Retained% | Passing% | Cumulative Retained % | ASTM Standard Specification |
|---|---|---|---|---|---|
| 2.36 | 1.7 | 0.17 | 99.83 | 0.17 | 80-100 |
| 1.18 | 357.7 | 35.77 | 64.04 | 35.94 | 50-85 |
| 0.60 | 230.9 | 23.09 | 40.97 | 59.03 | 25-60 |

Table 4.5 good gradation standard for the project

### 4.3.3.Experimental procedures of samples or specimens

Preparing sample is a process which should be done follow a specific way to assure that all specimens have been produced and exposure to the same condition of production. The first step was to prepare all necessary materials used to produce the samples .The experimental method process was included the percentage of waste glass used to replacement of the aggregates in making tiles and compared the compressive strength of the existing and new tiles. For this reason number of samples were manufactured and tested, each has a different percentage of waste glass and added plasticizer admixture for only 50% of waste glass fine aggregate. Replacing aggregate with waste glass at specific percentages was the main action. Five specimens were produced to study and analysis the effect of adding waste glass in samples. Samples with 0% waste glass have been mixed to be the reference for other samples with different percentages. The percentages of glass used in the specimens are 50%, 25%, 0% 75% 100%. Waste glass was determined as a percent of aggregate.

The percentage replacement of 50%, 25 %, 0%, 75% and 100% of aggregates with fine waste glass, were considered. The experimental program for this project work was primarily concerned with investigating the potential usefulness of using waste glass in the concrete mixes. Currently, the waste glass generated in Adama or generally in Ethiopia is thrown away into the dump areas like any other solid waste material. Waste glass usually is produced from empty glass containers and different construction and reconstruction remains and other glass products.

This experiment was used three color broken bottles for fine aggregate of the concrete as partially. A testing program and timetable were scheduled for preparation and processing of samples, after which all results were recorded and compared.

All tests were implemented according to the Ethiopian standard (ES) and international standards. The main action was partial replacing aggregate by waste glass/broken bottles and to produce the tile as much as possible to be durable than the other existing tiles.

Many researches were made mix ratio in order to get the ideal percentage of the components. The best mix content was found to be, (1: 2: 3) for cement: sand: aggregate respectively, accordingly this result was adopted in this study. In Table4.3 shows 1, 2, 3 ratio of cement, sand and aggregate respectively where used for their placement of percentages (50%, 25%, 0%, 75% and 100%) of the waste glass aggregate.

All specimens were subjected to the same conditions during production process.

First cement and sand were mixed properly, then adding aggregates (natural and waste glass) to the mixture with continuous adding of water and add the plasticizer admixture 0.5 % of the cement. The specimens were produced using tile making 20*20*2 cm plastic mold and vibrating machine. Both surface leveling and curing should be done accurately.

Below table is show the amount and kind of materials used to produce for each the tested sample**:**

| Sample | Waste glass fine aggregate in % | Waste glass fine aggregate weight in kg | Natural aggregate Weight in kg | Cement Weight in kg | Sand weight in kg | Water in Litre |
|---|---|---|---|---|---|---|
| A | 50 | 0.50 | 0.50 | 0.33 | 0.67 | 0.60 |
| B | 25 | 0.25 | 0.75 | 0.33 | 0.67 | 0.65 |
| C | 0 | 0 | 1.8 | 0.60 | 1.2 | 0.75 |
| D | 75 | 0.75 | 0.25 | 0.33 | 0.67 | 0.60 |
| E | 100 | 1 | 0 | 0.33 | 0.67 | 0.60 |

Table 4.6 Amount of materials for to produce each sample tile

The procedures of the production of sampletiles are stated as follows:

- Prepared all necessary materials and equipments
- Prepared the cleaned area and record or write each specimens
- Mix materials based on the proportion needs and make concrete
- Slump test process
- Add concrete into prepared plastic mold

- Leveling the surface of fresh concrete sample
- Place those on to vibrate machine
- After 48 hours remove from the mold
- Curing samples
- Absorption test process
- Grinding the finishing surface and polish the samples to get the final appearance
- Compressive test procees
- Evaluting

### 4.3.4. Slump test

The slump test is the most well-known and widely used test method to characterize the workability of fresh concrete. The apparatus consists of a mold in the shape of a frustum of a cone with a base diameter of 200mma top diameter of 100mm, and a height of 300mm. The mold is filled with concrete compacted with 500mm height and 200 mm diameter steel rod or steel bar. Four types of slumps test or sample test fresh concrete is commonly measured with the same cement- water ratio but with different proportion or percentage of waste glass fine aggregate (50%, 25%, 0%, 75% and 100% waste glass fine aggregate). Concrete is compacted by Roding25 times in an even pattern with a steel rod. Slumping cone is leveled off with the steel rod and surplus concrete is cleared from steel plate and slumping cone. The slump cone mold is lifted vertically upward and the change in height of the concrete is measured and recorded it.

A steel rule placed in the center of the sample to which the conformity of the slump is tested. Then find out the decreasing dimension of sample height of fresh concrete. See on the Appendix II (fig 4.14)

Figure 4.13 Raw materials and equipments used for slump test of the project

### 4.3.5. Sample Identification

The identification for the specimens is started by prepared of the same squaring molds (200*200*20mm) marked on the edge of its and were coated with oil coating to ensure that no water escaped during filling and to prevent any adhesion of cement. And give a letter which starts from “A” to “E” to be have the percentage of waste glass A=50%, B=25%, C=0%, D=75% and E=100%. Record or write the code of sample on the edge of specimens during the operation of concrete molding and curing age of the specimens. Those all specimens were produced in the same day tested at its $7^{th}$ day of curing period. Because of for easily know properties or strength of those specimens made by different percentage of waste glass. All specimens or samples were treated with the same procedure except the replacement of percentage of waste glass fine aggregate instead of natural fine aggregate and (code “A” 50% ) of waste glass was treated by adding of plasticizer admixture. Because due to compare and know the effectiveness of its admixture. Noted with letter “ C ” was produced without waste glass or it indicated the existed tile and noted with letter “A”,”B” and “D” ”E” were produced with waste glassor indicated the new tile . After the letter, it is followed by a numerical value which ranges from “25” to “100” with an increment of twenty-five (25), which represents the percentage of crushed bottle present in each specimen. The specimens were noted with “50”, “25”, “75” and “100” based on the percentage of crushed bottle as against to fine aggregate stone. The sample of “A” was only used plasticizer admixture by the proportion of 0.5 % of cement. Because to identify the purpose or the effective of admixture in harden concrete property .Below figures are show codes to identification the samples:


Figure 4.15 sample identification of floor tile made by waste glass aggregate as different %

### 4.3.6. Water Absorption Test

Absorption test is an important characteristic of tiles. The pieces or tiles were first dried in an oven at a temperature of about 110°C for period of 24 hour, then cooled to room temperature and weighed. This weight was recorded as dry weight W (d). Next, these samples were immersed into a water tank at room temperature and left for 24 hour after which the samples were removed from the water and blotted dry to remove the shiny surface and were weighed again to get the saturated weight, W(s). The weight of water absorbed divided by the dry weight equals the percentage of absorption [7] as shown in below Equation:

- $\%oAbsorption=W(s)-W(d)/W(d)\times 100\%$
- Where W(s) is the saturated weight
- W(d) is the dray weight


Figure 4.16 water absorption tests process

### 4.3.7. Compressive strength

The main goal of this project is to introduce the waste glass materials into the concrete mix to make floor tiles for the purpose economical and environmental benefits, but with the improvement of the concrete compressive strength, or at least without losing the expected level of standard concrete mixes. ). Specimen tiles of 200 mm X 200 mm X 20 mm size was tested for flexural with two opposite edges simply supported and the other two were free. Each specimen was rested on a 12 mm diameter of high carbon steel bar. These tiles were subjected to a center line load exerted by the 12 mm bar. Before applying the loads, the specimen were properly leveled and centered. The load was applied gradually. The load readings were recorded until the tile was crushed In this project compressive strength has been found out at the ages 7 days ,14 and 28 days, after moist curing and dried the sample of tiles continuously. The Strength of concrete mainly depends on different factors such as Strength of fine aggregate, curing time, dry time, strength of concrete matrix; Bond strength between concrete part, proportion of materials, making procedures, and using of admixture. In the case of those influences, to understand the effectiveness of admixture it had been used plasticizer admixture only for sample cod "A" (with 50% of waste glass aggregate).


Figure 4.17 operation of compressive strength in SABA engineering laboratory.

# CHAPTER FIVE

## 5. RESULTS AND DISCUSSION

### 5.1. SLUMP TEST

The result of the slump test is can be seen that the slump values decrease as the waste glass content or replacement percentage increases with the same Water, cement and sand ratio. The values of slump test were 45, 42, 40, 48 and 52mm for the concretes with 50%, 25%,0%, 75% and 100% of waste glass respectively. This reduction is due to more sharper and irregular geometric and smooth forms of the glass particles compared to crushed stone fine aggregate particles. See on appendix (figure 5.1)

| No | CODE OF SAMPLES | SLUMP TEST(MM) |
|---|---|---|
| 1 | A | 45 |
| 2 | B | 42 |
| 3 | C | 40 |
| 4 | D | 48 |
| 5 | E | 52 |

Table 5.1 slump test result

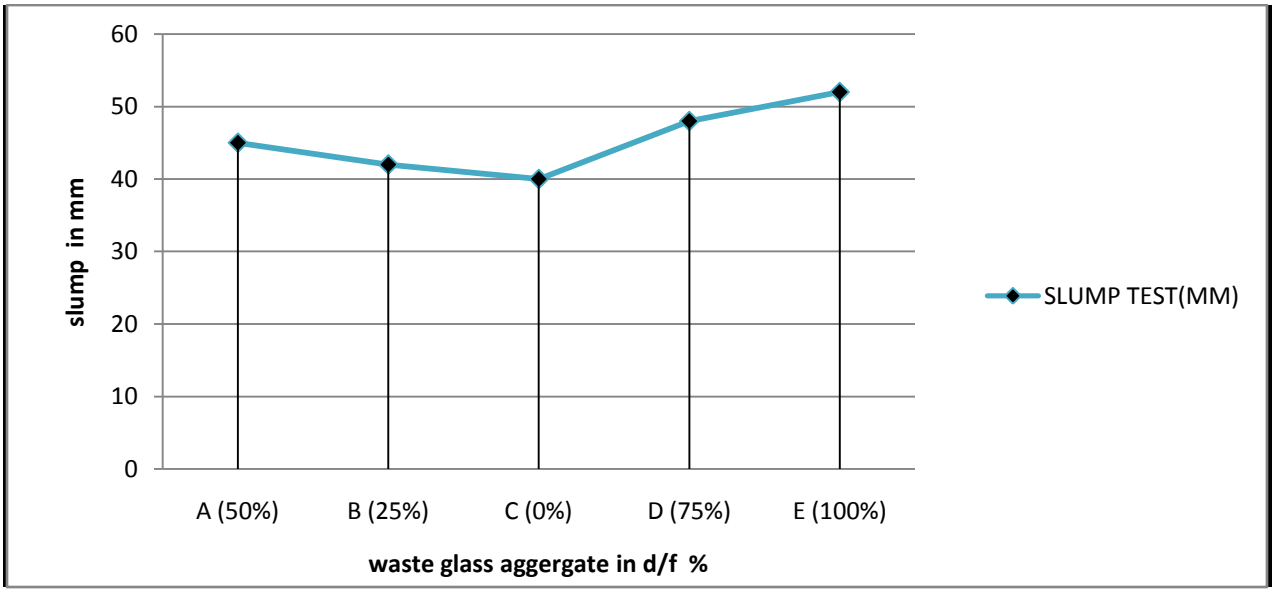


Figure 5.2 slump test result

### 5.2.Water absorption

The absorption rate for having dimensions 20*20*2cm tile samples which contained 50%, 25%, 0%,75% and 100% waste glass were3.76%, 3.95%,4.27%, 3.35%, and 3.24%,decreased for the samples contained waste glass aggregate respectively.

Example1: 75% waste glass fine aggregate replacement

$\%oAbsorption=(s)-W(d)/W(d)\times 100\%$

(1.605-1.495)/( 1.495)×100% **= 3.35%**

Example2: 100% waste glass fine aggregate replacement

( 1.490-1.540)/(1.540)×100% =**3.24%**

The replecment of waste glass incerse the water absorption test decrese . As a result of this the compresive strength become decrese , which had shown from the test due to this using plasticizer add mixture is the only alternetive to improve its strength.

| No | CODE OF SAMPLES | WATER ABSORPTION % |
|---|---|---|
| 1 | A | 3.76 |
| 2 | B | 3.95 |
| 3 | C | 4.27 |
| 4 | D | 3.35 |
| 5 | E | 3.24 |

Table 5.2 water absorption test result

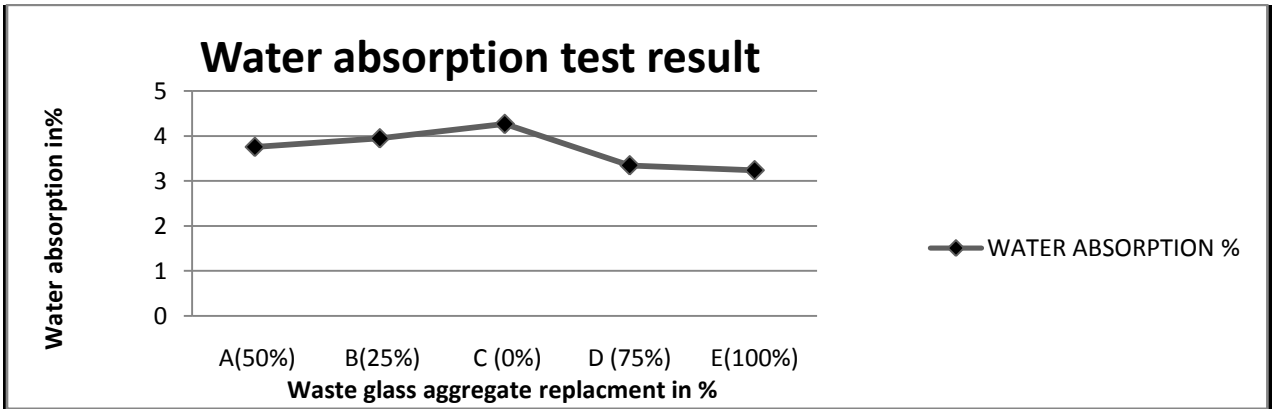


Figure 5.3 water absorption results

### 5.3. Compressive strength

The compressive strength of the sample tiles were decrease as the replacement of crushed stone aggregate by crushed waste glass aggregate percent increased. As shown in the table 5.3, the test results of samples are presented and code "A" was better strength than the other because it was produced by adding of plasticizer admixture..

| Samples code | Replacment waste glass fine aggregete in % | Compressivestrength in $N/mm^2$(MP) | |
|---|---|---|---|
| | | 7 Days | 14 Days |
| A | 50% | 2.15 | 3.23 |
| B | 25% | 0.75 | 1.13 |
| C | 0% | 1.40 | 2.1 |
| D | 75% | 0.86 | 1.29 |
| E | 100% | 0.68 | 1.29 |

Table 5.3 Compression strength test result.

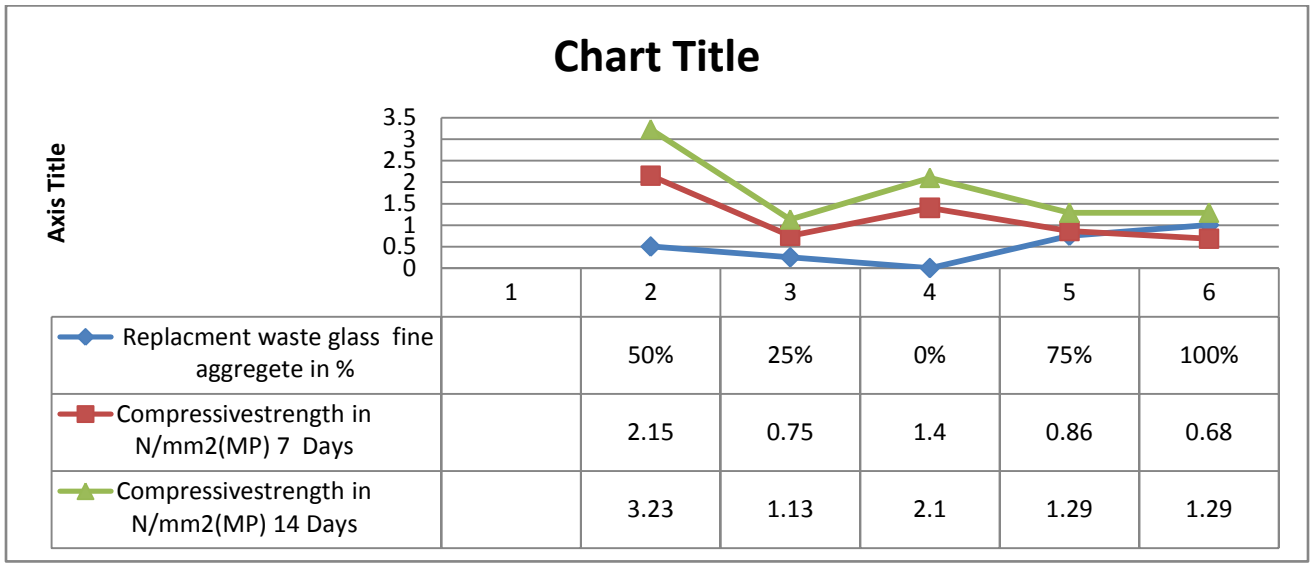


Figure 5.4 Compression strength test resul

# CHAPTER SIX

## 6. CONCLUSION AND RECOMMENDATION

### 6.1. Conclusion

The aim of this project is to produce floor tile by using of waste glass as partial replacement of an aggregate which is provide the standard strength of the tile. This contributes to reducing the cost of concrete and increases its appearance. It is also to contribute on the reduction of environmental pollution.

From the result of tests it concluded when increase the percent of waste glass aggregate water absorption, compressive strength and weight of tile was decreased. Overall Performance of the waste glass floor tiles showed with 50% waste glass aggregate replacement was very good compression strength and absorption properties , Because it was made by adding of plasticizer admixture. The plasticizer admixture was played big role for to maximize the compressive strength of the waste glass sample tile. Floor tile make from waste glass could be give environmental and social advantages and it has economical purposes.

In generally it concluded that the following are some advantages of floor tile made from waste glass partially in concrete:

- Environmental friendly: Use of waste glass in concrete will preserve natural resources particularly river sand and natural granite. Thus it make concrete construction industry sustainable. Concrete Recycled Bottle is environment friendly causing of less garbage that will be thrown in the dump site area.
- Local availability material: No need more money to collect those materials from so far areas or local resource. which means are locally available..
- Economical effect: Due to the scarcity of the resources for construction added with the present economic status in our country, the material cost for construction continuous to go up. This project has a solution on this problem.
- Less cost: Use of waste glass in concrete can prove to be economical as it is non-useful waste and free of cost compare stone
- Had good water resistance capacity:
- Easily clean or resist dirty materials:

- Reasonable durability if well treated
- Create color full tiles ( it can be made by different color of waste glass)
- Fade resistance: it couldn't easily fade by any factors.
- Create job opportunities in Ethiopia
- It need skilled and unskilled persons during the collection, crushing and sieve analyses process .
- Temperature resist: The use of tiles aggregate shelled in keeping the interior cooler, when the outside temperature is raised, as compared to the corresponding control concrete.
- It is lighter than the conventional concrete mixture

## 6.2. Recommendation

This project was tried to make successful, what we want to recommend about the using of waste glass as follows:

- Very coarse aggregate waste glass is not recommended to produce floor tiles. Which means did not make good bond formation.
- The use of crushed bottles as an alternative for fine aggregate is not recommended for structural members such as columns, beams and suspended slabs. which means used course aggregate in concrete mix.
- Waste glass materials will be use to make other construction products like roof tile, terrazzo tile, pavement tile, wall tile and hollow block e.t.c.
- It is also recommended to extend research on the area of recycling and reusing techniques of industrial materials in building to induct or introduce feasibility studies, including cost/benefit and payback period analysis for each technique.
- Increased awareness, acceptance and proactive government policies are critical in order to continue the upward trend of recycling and reusing solid waste materials including of all types waste glass whenever possible.
- Reusing solid waste martial before distracting it, this needs the segregation and separation of value able material from that of none valuable materials.
- The current condition of collecting and obtaining of waste glass materials cost is low but during mass production the cost of those will be increased. But also increase the availability or generate of waste glasses.
- It recommends the test of compressive strength should be test on the age of 28th day is more effective results had given , but due to limitation of time no more test conducted on this stage.

## 6.3. Future study:

This new project is aiming to use the waste glass for making floor tile as partial of fine an aggregate, considering reduction of caused waste materials impact in environment and to give aggregate alternative for the demands construction industry in **Ethiopia.**

Since the design project is concerned only on the use crushed bottles for making floor tile as partial of fine an aggregate. it doesn't include other types of waste glass like window, vehicles and other waste glass. So for the future the study can be improving this project with different perspectives.

This project is to show directions for future studies for extending similar studies concerning of waste glass materials with a wider perspective in order to be able to consider more parameters and different combinations of parameters governing the effect on the behavior and engineering properties of fresh and hardened concrete containing different types and sizes of waste glass materials.

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# GLOSSARY

**Recycled glass:** A broad term, generally applied to any type of glass product containing to some degree secondary raw material from waste glass, which is used as input substituting raw materials used to manufacture glass.

**Glass consumption:** Glass that is purchased and consumed in the market within a country or group of countries, plus imports from the outside, minus exports to the outside.

**Cullet:** The word cullet can be used to refer to either "broken glass" or to "waste glass".

**Impurities:** Also called "non-glass content", or "non-glass components" (see non-glass components)

**Separate collection:** The collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment.

**Collection:** The gathering of waste glass, including the preliminary sorting and preliminary storage ofwaste glass for the purposes of transport to a waste treatment facility

# APPENDEX

## **APPENDEX–I:** QUESTIONNAIRE

## Adama Science and Technology University

School of engineering

Department of Construction Management

**Questionnaire to be filled by hotels, bars and alcohol wholesaler:**

The purpose of this questionnaire is to collect relevant data related to your experience in how to dispose waste glass/broken bottles in **Adama city.** The aim of this study is to know the **amount** and how to manage waste glass in Adama city. After you have to give your responses; we will use to make floor tile from waste glass. On the other way round your responses will have dual effects of making the study complete and the findings focused , So, the researchers request you to give genuine responses, there by promising to keep the responses confidential. If you have direct question, or something unclean, please feel free to ask.

Instruction:

- For ethics of secrecy, do not write your name.
- Where alternative answers are given put ( √) at your appropriate choice or put your answers on the space provided.
- For the open ended questions, try to give precise answers

Thanks in advance!

1. Do you reuse any broken bottle or waste glass for any another purpose

   □ YES □ NO

2. If your answer for question number one is no, How do you dispose waste glass bottles

   □ Damp to pit □ Damp to open space □ Land fill □ add in plastic fiber(sack)

   Other (specify) _____

3. Is there any problem encountered on the environment and society? ----------

   If yes specify_____

4. Is there sufficient garbage area can to collect all wastes glass bottles in the city?

   □ YES □ NO

5. Is there enough transportation to avoid waste glass in the garbage area as quickly as possible in the city?

□ YES □ NO

6. How much refuse broken bottles do you collect in a day?

□ 1 kg-2kg □ 3kg-4kg □ 5kg-6kg

Other specify) _____

7. How often is the waste glass bottle from your business center removed for disposal?

□ Once a day □ Once in two days □ Once in three days □ Once in four days

□ Once a week

Other (specify) _____

8. Ways removes the refuse from your business center for disposal?

□ Collection of solid waste by sweeper

□ Dump to direct municipal garbage

□ No collection service used

□ Other (specify) _____

9. How much do you pay in Birr (ETB) for sweeper each month for removing refuse?

□ 15-20 □ 21-25 □ 25-30 □ 30-35 □ 36-40 □ 41-45 □ 46 -50

□above 50 □ None

10. What type shortage of waste glass disposal service in the city

□ Shortage of garbage

□ Shortage of transportation

□ No shortage service

11. Please state the major problems you have been facing in using inappropriate waste glass disposalsystem._____
_____
_____

12. What mechanisms do you suggest to improve the waste glass bottles management and its re used system in Adam acity?

_____
_____
_____
_____

**III. Interviewing:**

Depending on the objective of this project, interview is used to gather the necessary information to understand the existing situation in order to identify the amount of waste glass, demand and availability of materials for making of this project. We conduct an interview directly with municipal administration and trade and industry office concerned bodies and other people that give some information about waste glass disposal at Adama town.

**A. Municipal administration of adama city:**

7. How do you collect the broken glass from different enterprise (hotel, bars, alcohol wholesaler and others)?_____
   _____
8. How money waste glass bottles dispose in ADAMA city for a month?_____
   _____
9. Do you separate the waste glass from other waste materials?_____
   _____
10. Have you a right place to dispose the waste glass in ADAMA city? if yes ,where
    _____

11. Is there anybody (enterprise) to reuse those waste glasses for any purpose?

    _____

    _____

12. Is there any problem encountered on the environment and society?_____

---

## B. Trade and industry office:

1. Have you data concerned how money enterprises in adama city?
2. If the question 1 your answer is yes
   2.1 How many hotels?
   2.2 How many bars?
   2.3 How many wholesalers?

# APPENDEX–II

## CRUSHING OF WASTE GLASS

Figure 4.10 crushing waste glasses by group member of the project

## SIEVE ANALYSIS PROCESS

Figure 4.11 sieve analysis process

## SLUMP TEST PROCESS OF THE PROJECT


Figure 4.14 slump test process of the project

Figure 5.1 measuring of slump test

## OUTPUT OF THE PROJECT WASTE GLASS FLOOR TILE (AFTER GRINDING AND FINISHING)


**Figure 5.5 Output of the project waste glass floor tile (after grinding and finishing)**

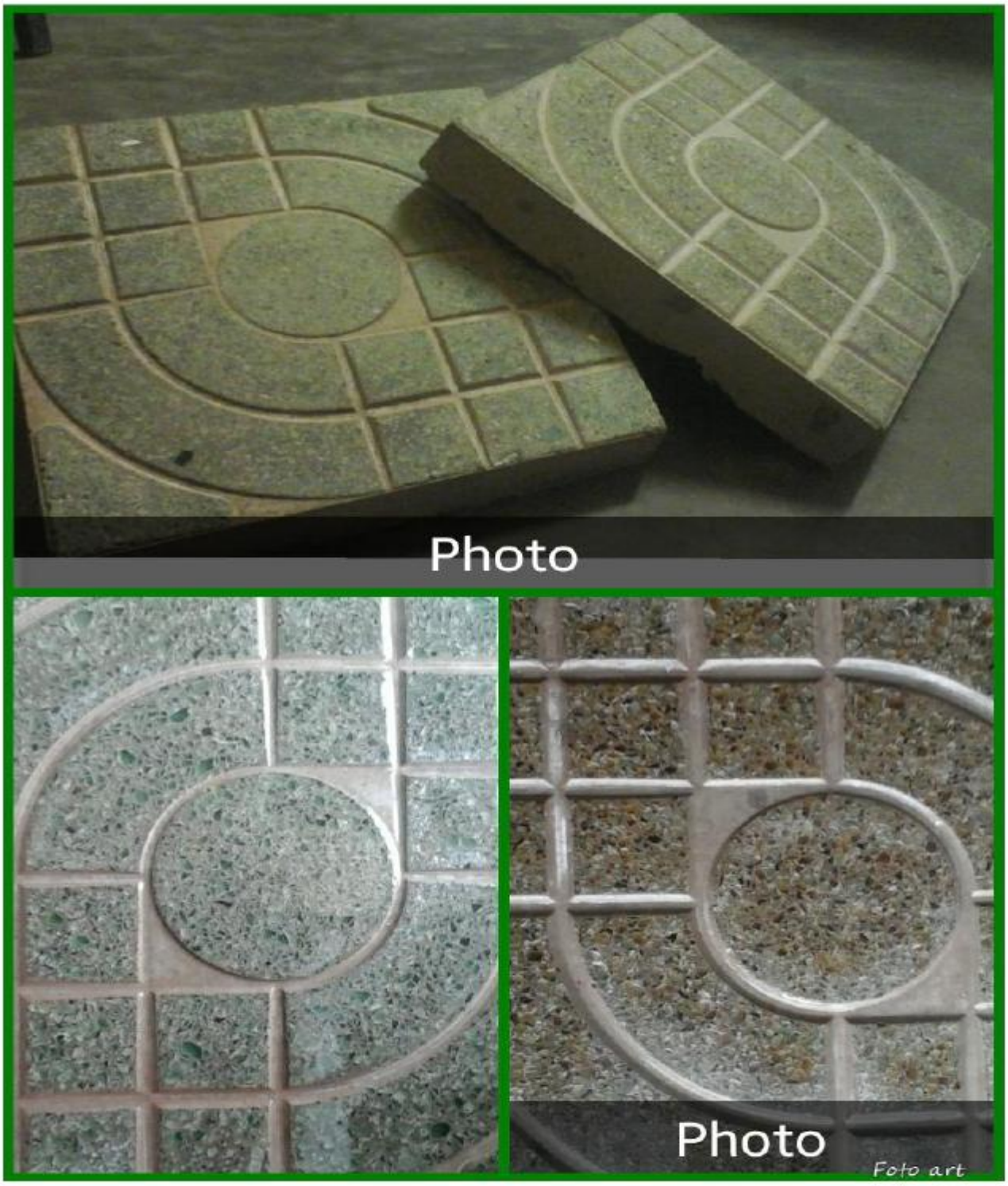


Figure 5.6 Using 75% Waste glass aggregate pavement floors tile (additional of this project with brown color waste glass).

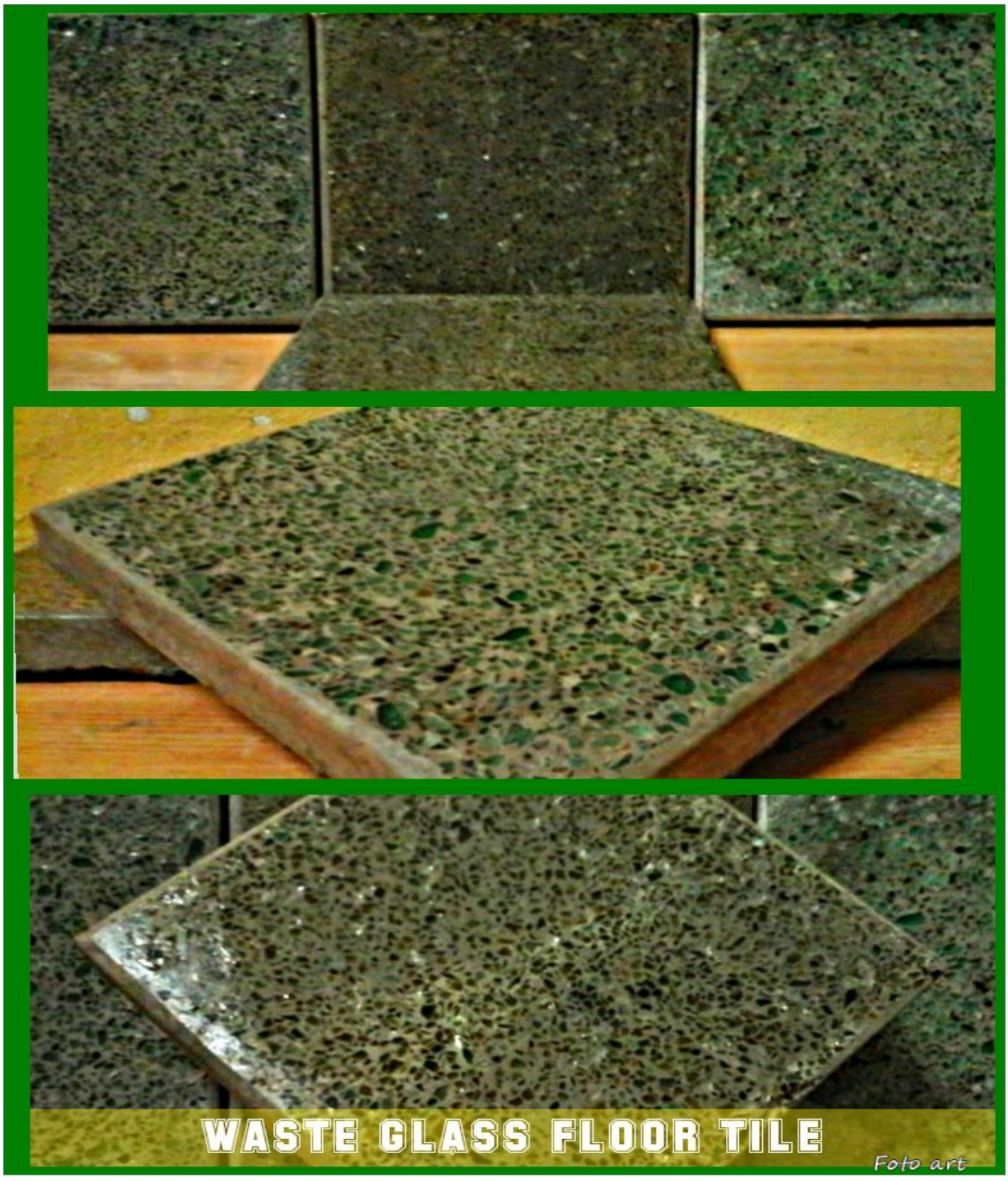


**Figure 5.7 Output of the project waste glass floor tile (after grinding and finishing)**