JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

EFFECT OF POND ASH ON PROPERTIES OF C-25 CONCRETE

A Thesis submitted to School of Graduate Studies of Jimma University, Jimma Institute of Technology, Faculty of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree Master of Science in Construction Engineering and Management

By

Yeshi Abebe Yimam

January, 2020

Jimma, Ethiopia

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EFFECT OF POND ASH ON PROPERTIES OF C–25 CONCRETE

YESHI ABEBE YIMAM

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DECLARATION

I declare that this thesis research entitled "EFFECT OF POND ASH ON PROPERTIES OF C-25 CONCRETE" is my original work and has not been submitted as a requirement for the award of any degree in Jimma University or elsewhere.

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ABSTRACT

Nowadays construction of infrastructure is growing rapidly becoming a serious problem in this world, particularly in the developing countries due to high material consumption. So, there are high demands in the construction industry using the river sand as fine aggregate in the production of concrete. This has created scarcity of river sand (fine aggregate). To minimize this scarcity alternative material used as river sand for the production of concrete; such as industrial by-product is mandatory. Pond ash is an industrial waste product from the thermal power plant, such material can be used as a partial replacement of fine aggregate in C-25 grade of concrete which can reduce depletion of natural river sand (fine aggregate) as well as minimizing the negative impact on the environment which released from industrial waste disposal as land fill. The objective of this study was to investigate the effect of pond ash as a partial replacement of fine aggregates on concrete properties.
In this study, the pond ash sample was collected from Ayka Addis textile factory. To achieve the objective of this study, the experimental laboratory such as gradation, specific gravity, unit weight, moisture content, silt content, and water absorption, workability, density, and compressive strength tests were conducted in the laboratory of Jimma institute of technology.

In this research work, the workability of each mix was measured before the concrete cast and the slum was 25 to 50mm. Also, the concrete cubes of size (150mm x150mm x 150mm) were prepared with seven different sampling containing from 5% to 30% pond ash by the variation of 5% along with the control concrete mix for fine aggregate by weight for tested the harden concrete such as density and compressive strength at 7, 14 and 28 days of curing respectively.

From the result obtained, the workability and density of concrete containing pond ash decrease with increase percentage content of pond ash in the mix. On the other hand, the compressive strength of pond ash concrete containing 5% and 10% have shown improvement compared to the control concrete by about 0.13%,3.74%,2.46% and 0.04%, 1.14%,0.70% respectively at 7, 14 and 28 days of curing. In addition to this, the pond ash concrete containing 15% , 20%, 25% and 30% the compressive strength have shown reduction compared to the control concrete by about4.20%,4.33%,3.04%,7.16%,9.47%,7.53%,13.04%,14.43%,13.68%and17.33%,17.80%,19. 15% respectively at 7, 14 and 28 days.

Finally, in this study the percentage replacement of fine aggregate concrete up to 10% by pond ash was better result in compressive strength of concrete was found to be 34.75N/mm2 at 28 days. Therefore, the optimum replaced fine aggregate by pond ash is 10%.

Key words: Compressive strength, Density, Pond ash and Workability

ACKNOWLEDGEMENT

First of all, I would like to thanks the Almighty for the grate grace given to me to complete my Master's thesis successfully on time.

I would like to express my sincere thanks to my advisor Eng. Getachew Kebede for his intellectual guidance, valuable suggestions and spending his time for successful completion of my Master's thesis. I would like to extend my gratitude to my co-advisor Eng. Abay Legesse for his helpful comments during my research.

Secondly, my deepest appreciation goes to Jimma University, Jimma Institute of Technology, School of Graduate Studies, Faculty of Civil and Environmental Engineering Department, Construction Engineering and Management stream.

Finally, special thanks to my parents, who provided me with financial support during my studies.

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ACRONOMY

ACI	American concrete institute
Al_2O_3	Alumina oxide
ASTM	American society for testing and materials
BS	British standards
C-25	25 Mega Pascal compressive strength
CaO	Calcium oxide
EBCS	Ethiopian building code of standard
Fe2O3	Iron oxide
FM	Finesse modulus
IS	Indian standards
JIT	Jimma institute of technology
K2O	Potassium oxide
LOI	Loss of ignition
MgO	Magnesium oxide
Mpa	Mega Pascal
Na2O	Sodium oxide
OPC	Ordinary Portland cement
PA	Pond ash
Si2O	Silicon dioxide
SO3	Sulphur trioxide
SSD	Saturated surface dry
TiO2	Titanium dioxide
W/C	Water to cement ratio

CHAPTER ONE

INTRODUCTION

1.1. Background

Concrete is the most versatile and widely used material in the world construction industry. It is consists the mixture of fine aggregates, coarse aggregates and cement which is proportionally mixed with certain percentage of water. From the total volume of concrete the volume of fine aggregate and coarse aggregate takes the major part. Fine aggregate is one of the main constituents of concrete making about 35% by volume of concrete used in construction industry and it can be classified as natural aggregates and artificial aggregates(Tomas, 2014).

Natural sand is mainly excavated from river beds and most of the time contains high percentages of inorganic materials, chlorides, sulphates, silt, and clay. According to BS 882, the presence of any of these unwanted materials could slow down the hydration process by affecting the overall performance of concrete. Fine aggregates such as river sand used in concrete production may contain excessive silt and clayey contents as well as organic impurities that have a negative impact on the quality of concrete (Ngugi, et al., 2014).

According to Shewaferaw, (2006) due to various reasons, good sand is not necessarily readily available and it should be transported from long distances. Transportation is one of the major factors in the delivered price of construction sand. Moving construction sand to the market increases the sale price of the market significantly, due to the cost of transportation is high. So, to reduce the use of river sand as natural fine aggregate, the utilization of industrial waste materials is quite effective. There are various types of industrial wastes that can be considered for usage in concrete. The most commonly used industrial waste to replace sand and cement in concrete is Fly Ash, coal bottom ash, Pond Ash, Rice Husk Ash, Blast Furnace Slag, Red Mud and Phosphor, Gypsum, Silica Fume, Fumed silica, Crushed glass. Fly ash and coal bottom ash are produced every day in Thermal Power Plants. The combination of fly ash and bottom ash is known as pond ash. Most of them are being dumped at the waste disposal site near the factory. This will pollute the environment and creating a disposal problem because a large dumping space is required (Rafieizonooz, 2017).

Pond ash is industrial by-product generate from a thermal power plant by burning of coal and consists of a fused coarser and fine particle which is slightly pozzolanic nature it has the potential to be used as an alternative material in the construction industry. The use of pond ash in concrete will not only result in the conservation of natural aggregate but also solve the problem of disposal of pond ash produced regularly(Kumar, 2015). The objective of this research was investigated on the compressive strength and workability of concrete that was made with pond ash as partial replacement of sands.

Therefore, this research was investigated the effects of pond ash to use as an alternative fine aggregate in concrete production.

1.2. Statement of the Problem

The worldwide consumption of natural sand is very high, due to the wide use of concrete. The demand for natural sand is high in developing countries to satisfy the rapid infrastructure growth, in this condition developing country facing a shortage of good quality natural sand (Naheem, 2014). So, there are excessive demands within the construction industries for river sand as fine aggregate used in the production of concrete. This has created a very difficult condition a natural sand deposit is being short and greatly disturbs the river water ecosystem. Finding new alternative materials for sustainable development to substantially decrease the consumption of natural resources became imperative. So, researchers increased to utilize industrial waste materials as a replacement of natural resources in the construction industry (Rafieizonooz, 2017). A major portion of the energy is generated by Thermal Power Plants. Under such conditions, the pond ash which is a residue and by-product of the thermal power plant can be used as an alternative construction material in concrete production to natural sand helps to minimize the depletion of natural resources. The use of industrial by-products like Pond Ash (PA) is an important eco-friendly construction material in concrete production. It is also the researchers have a social responsibility to encourage the beneficial use of industrial by-products to preserve resources, conserve energy and reduce or remove the need for disposal of industrial waste in landfills (Kumar, 2017).

Coming to Ethiopia's, most thermal power plants especially, Ayka Addis Textile using coal as a source of energy in our country due to high industrial development and release large ash disposal in land as a waste material every day this causing environmental problems around the Ayka Addis Textile factories. So, reuse or recycling of industrial wastes (pond ash) became vital for our country.

Therefore, this research study focuses on the use of pond ash as an alternative fine aggregate material to solve depletion of natural river sand and to minimizing the environmental impact of pond ash which released from industrial waste as a land fill.

1.3. Research Question

1. What are the physical properties of pond ash?
2. What effect does pond ash have on the workability of fresh concrete?
3. What effect does pond ash have on compressive strength and density of hardened concrete?
4. What is the optimum percentage of pond ash as a replacement of fine aggregate in concrete production?

1.4. Objectives

1.4.1. General Objective:

The general objective of this study was to investigate the effect of pond ash in c-25 concrete as partial replacement of fine aggregate on the properties of concrete.

1.4.2. Specific objective

- To determine the physical properties of pond ash.
- To determine the effect of pond ash on the workability of fresh concrete.
- To determine the effect of pond ash on compressive strength and density of hardened concrete.
- To determine the optimum percentage of pond ash as a partial replacement of fine aggregate in concrete production.

1.5. Significance of the Study

Now days the increasing of construction activity in the country creates depletion in most of concrete making materials especially fine aggregate. On the other side, coal combustion residue released from thermal power plant and their disposal as land fill has become a serious environment problem. So, this research results will provide helpful information to various stake holders as a source of information use of industrial waste as alternative material for building construction projects to reduce the depletion of natural sand for the concrete production and reduce its environmental impact with proper utilization of wastes. In addition, other researchers will use the findings of the study as a reference for further research on eco-friendly alternative construction materials of concrete.

1.6. Scope and Limitation of the Study

This study was conducted to investigate the effects of pond ash for the production of C-25 concrete on the workability and compressive strength of concrete as fine aggregate replacement. Physical properties, slump test, compressive strength and density were conducted. The percentage replacement interval of pond ash replacing fine aggregate is depending on previous studies. The research was done by different percentage level of pond ash by 5% increment rate from 5% to 30% by weight of sand on the concrete mix of C-25 grade of concrete and also the researchers was not be include flexural, permeability and fire resistance test due to lack of money.

CHAPTER TWO

LITERATURE REIVEW

2.1. Concrete

Concrete is produced by mixing fine and coarse aggregates, hydraulic cement, water and additives in a certain prescribed proportion. The aggregates are major components of the concrete consist about 70% of the total volume of concrete. Fine aggregates make up for approximately a quarter of the total volume of the concrete. However, such a bulky scale consumption of concrete has strained the natural sources of raw material procurement over the past few decades (Anshuman, et al., 2016).

Natural resources are continuously being depleted worldwide, while simultaneously the wastes thus generated from the industry are substantially increasing. Sustainable development for construction involves the use of nonconventional and advanced materials as well as the recycling of waste materials to compensate for the shortage of natural resources and the discovery of alternative methods of environment conservation. Aggregates are regarded as one of the main ingredients of concrete as they constitute more than 65% of the concrete matrix (Kadam and Patil, 2014). To reduce the use of river sand as natural fine aggregate, the utilization of local existing industrial waste materials can be considered for fine aggregate in the production of concrete.

2.2. Concrete making materials

2.2.1. Cement

ACI C116 defines cement as it is a finely pulverized material which by itself is not a binder, but develops the binding property as a result of hydration (i.e., from chemical reactions between cement minerals and water). Portland cements are mainly used for its adhesive characteristics and are stable in aqueous environments. Most cement was provided adequate levels of strength and durability for general use. It is usually satisfactory and advisable to use general-purpose cement that is readily obtainable locally. General-purpose cement is described in ASTM C 150 as Type I or Type II, in ASTM C 595. When such cement is manufactured and used in large quantities, it is likely to be uniform and its performance under local conditions will be known (ACI, 1999). The cement used in this experimental study is 43 grades Ordinary Portland Cement.

2.2.2. Aggregate

Aggregate is an important constituent in concrete. The aggregate occupies 70-80% of the volume of concrete. Detail studies are required to be made in respect of aggregate to understand their widely varying effect and influence on properties of concrete such as compressive strength, workability, and density, etc. cannot be underrated. The emphasis is given on the gradation and type of aggregate which influences the properties effectively. The grading curves are studied in detail to know the behavior of coarse as well as fine aggregate as properties of concrete (Chirag P. P., 2016). The use of a larger maximum size of aggregate affects the strength in several ways. First, larger aggregates have the less specific surface area and the aggregate–paste bond strength is less, aggregate fails along surfaces of aggregates resulting in reduced compressive strength of concrete. Next, using larger aggregate for a given volume of concrete results in a smaller volume of paste so, providing more restraint to volume changes of the paste. This may make additional stresses in the paste, creating micro-cracks before the application of load. Particle shape and surface texture influence the properties of fresh concrete more than the properties of hardened concrete. Rough-textured, angular, and elongated particles require more water to produce workable concrete than the smooth, rounded and compact aggregate. Generally, flat and elongated particles are avoided. The necessary requirement of aggregate in the concrete production is remains stable within the concrete and in the particular environment throughout the design life of the concrete without adversely affecting the performance of concrete in either the fresh or hardened state (Dinku, 2005).

Aggregate is divided into two main parts of fine aggregate and coarse aggregate.

2.2.2.1. Fine aggregate

River sand used as fine aggregate in concrete production may contain organic impurities as well as too much silt and clayey contents that influence the quality of concrete ingredients (Ngugi, et al., 2014). Fine aggregate is the aggregate passing the 9.5 mm (3/8 in.) sieve and almost entirely passing the 4.75 mm (No. 4) sieve and retained on the 75 µm (No. 200) sieve(Chirag P. P., 2016).

According to Prashant, et al., (2018) the fine aggregate which was used locally available river sand, which passed through 4.75 mm. The specific gravity of fine aggregate is 2.65 and fineness modulus is 2.67. The bulk density of fine aggregates is 1.29 and compacted bulk density is 1.48.

Table 2.1: Fine aggregate grading limit (ASTM33-93a)

Sieve size	Percentage passing
9.5mm(3/8in)	100
4.75mm (No.4)	95-100
2.36mm (No.8)	80-100
1.18mm (No.16)	50-85
600µm (No.30)	25-60
300µm (No.50)	5-30
150µm (No.100)	2-10

Table 2.2: Limitation of finesse modulus as a guideline for different sand category (Denamo, 2005)

Category of sand	Fineness modulus (FM) limit of sand
Fine sand	2.2-2.6
Medium sand	2.6-2.9
Coarse sand	2.9-3.2

2.2.2.2. Coarse aggregate

The aggregate which is the fraction of materials retained on I.S Sieve No.4 (4.75mm) is termed as coarse aggregate. The coarse aggregate used in this experimental investigation is 20mm, angular in shape. The aggregates should be free from any dust before used in the production of concrete.

According to ACI 211.1-81 Education Bulletin, E1-07 (2007) coarse aggregate can be obtained from natural sources or synthetic. Natural resources generally were from the granite and limestone. Artificial aggregates can be obtained from industrial waste likes pond ash, coal bottom ash, steel ball for weight concrete and clinker or slag concrete products of combustion to lightweight. Aggregate gradation determines the void content within the structure of aggregate and subsequently the amount of cement paste that is required to fill the void space and ensure a workable concrete. It is necessary to optimize the aggregate gradation in concrete using Portland cement, as it is the most expensive ingredient, to minimize the void content in the aggregate and the volume of cement paste required to achieve a workable, economical and an environmentally sound concrete for a given application. Proper aggregate gradation not only ensures a workable concrete mixture that can be compacted easily but also reduces problems associated with plastic concrete such as the potential for segregation, bleeding, and loss of entrained air and plastic shrinkage cracking.

Table 2.3: Properties of aggregate (ACI211.1-81 Education Bulletin E1-07, 2007)

Property	Fine Aggregate	CoarseAggregate20 mm
Fineness Modulus	2 - 3.3	6 – 8
Specific Gravity	2.38	2.76
Water Absorption	< 4%	< 0.5%
Moisture content	0% - 10%	0% - 2%

2.2.3. Water

Water is an important ingredient in the manufacture of concrete. Water has two functions used in concrete mixes: the first is to react chemically with the cement, which will finally set and harden, and the second is to lubricate all other materials and make the concrete workable. One of the most factors of poor-quality concrete is the use of too much mixing water. The strength of concrete is governed by the nature of the weight of water to the weight of cement in a mix, in case that it is plastic and workable, fully compacted, and adequately cured (Taylor, 2000). Therefore, Portable water was used for mixing and curing.

2.2.4. Pond ash

This study was tried to find a solution by utilizing pond ash materials for concrete manufacturing. The use of pond ash in concrete was found to have some effects such as reducing the production of ash waste, conserving the natural resources as well as reduce the negative environmental impact to the human health and ecosystem. Because much thermal power plant uses coal as energy, pond ash produced is dumped as waste into the landfill. If it is utilized in concrete manufacturing, address the issues related to disposal, as well as environmental and ecological problems. Pond ash, a waste product of Thermal Power Plants, is one such material that can be adopted as a suitable material as fine aggregate in concrete, replacing natural sand partially or fully is a responsibility of researchers for promoting sustainable construction. However alternative material and its characteristics play a substantial role in controlling the workability, strength, and durability of the concrete constructions (Ganesh, et al., 2012).

The bottom ash is that part of the residue which is fused into particles and is collected at the bottom of the furnace. Pond ash differs from fly ash collected from Electrostatic precipitators in a dry form in that it contains a significant amount of relatively coarser particles (greater than 45 µm and up to 150 µm). Pond Ash is potentially useable as Fine Aggregate, but the properties of Pond ash depend on various factors such as source of coal, and its type, design of coal-fired boilers, power plant operating parameters, point of disposal of coal ash and type of coal grinding processes adopted at the power plant (Swapnil, et al., 2017).

Ganesh, et al., (2012stated that effective utilization of pond ash as a constituent in different concrete constructions encouraged the large-scale utilization of industrial waste.

2.2.4.1 Physical properties of pond ash`

Pond ash consists of determining physical properties such as specific gravity, fineness modulus, grain size distribution and then the relevant properties as fine aggregate are compared with that of natural sand.

Specific gravity and Bulk density

The specific gravity of pond ash is lower than natural sand, indicates that it is slightly lighter than the sand and can be utilized as fine aggregate in concrete. Natural river sand compared to that of properties of pond ash as fine aggregate was conforming to Zone II having a specific gravity of 2.62, loose bulk density (LBD) of 1584kg/m3, rodded bulk density (RBD) of 1678kg/m3.The bulk density of pond ash is used as fine aggregate is between the range of 800 to 1350 kg/m3 which is less than that of natural sand is between the range of 1300 to 1800 kg/m3 (Bharathi Ganesh, 2012).

Fineness Modulus

The fineness modulus (FM) is an empirical number related to the aggregate grading with lower FMs corresponding to fine aggregates that are finer. ASTM C33 requires concrete fine aggregate to have an FM between 2.3 and 3.1. The amount of fine aggregate passing the 300 µm (No. 50) and 150µm (No.100) sieve has an influence on workability, finish ability, the potential for segregation and bleeding of concrete. In fine aggregate, the amount of material passing the 300-µm (No. 50) sieve should be 15 to 30% for good flow ability. Fine aggregate grading influences concrete performance more than the coarse aggregate (Bharathi Ganesh, 2012).

Table 2.4: Physical properties of pond ash (Kumar, 2015)

SI No.	Properties	Value
1.	Specific gravity	2.4
2.	Water absorption	15%
3.	Fineness modulus	2.79

Table 2.5: Physical properties of pond ash (Prashant Kumar Sharma, et.al, 2018)

SI No.	Properties	Value
1	Specific gravity	1.69
2	Water absorption	1.8
3	Fineness modulus	3.01
4	Bulk density (kg/l	1.15

2.2.4.2. Chemical properties of pond ash

The main constituents of Pond ash are silica (SiO2), ferric oxide (Fe2O3) and alumina (A12O3). Smaller quantities of calcium oxide (CaO), potassium oxide (K2O), sodium oxide (Na2O), magnesium oxide (MgO), and sulfur trioxide (SO3) are also present in coal ash. The chemical composition of Pond Ash shows that the major constituents in it are silica, alumina and iron oxide (SiO2+Al2O3+Fe2O3) and is 93.7%, further, silicon dioxide (60.08%), MgO (0.71%), SO3 (0.40%). Although these constituents are reported as oxides, they occur in Pond Ash as a mixture of silicates, oxides, and sulfates with small quantities of phosphates and other compounds (Bharathi Ganesh, 2012).

Table 2.6: Chemical properties of pond ash (Sreelakshmi R, 2016)

Compounds	% composition
Iron oxide (Fe_2O_3)	7.43
Aluminum oxide (Al_2O_3)	3.76
Sodium oxide (Na_2O)	1.42
Silicon dioxide (Si_2O)	81.37
Magnesium oxide (MgO)	1.44
Sulphur trioxide (SO_3)	0.69
Loss of ignition (LOI)	1.41
Potassium oxide(k_2O)	2.19

Table 2.7: Chemical properties of pond ash (Prashant Kumar Sharma, et.al, 2018)

Compounds	% composition
Si_2O+Al_2O_3+Fe2O_3percentbymass(minimum)	79.97
Silicon dioxide(si_2O)	36.22
Magnesium oxide (MgO)	2.73
Sulphur trioxide (SO_3)	0.69
Loss of ignition (LOI)	6.84
Moisture content by percent	1.78

2.3. Factors Affecting concrete properties

2.3.1. Water-to-cement ratio

One of the major variables influencing the performance of a concrete mixture is its water-to-cement ratio (w/c). From the earliest days of concrete, the major influence of w/c on compressive strength has been recognized. For ordinary concretes for the same degree of cement hydration, the strength does indeed depend primarily on the porosity. The porosity, in turn, depends mostly on the Water-to-cement ratio. Because the w/c directly controls the volume of water available for hydration per unit volume of cement (Arachchige, 2008).

The W/C ratio is one of the most important factors influencing concrete properties such as compressive strength, and workability. A lower w/c ratio will provide to a stronger and more durable concrete. A higher w/c ratio had results a lower compressive strength (AKH, 2003).

2.3.2. Cement content

When water is added to a concrete mix, cement paste will be formed. Cement paste in concrete has three functions: binding, coating, and lubricating. The cement content influences concrete workability in the fresh stage, heat release rate in the fast hydration stage, and volume stabilities in the hardened stage. The water-cement ratio is the main factor affecting concrete strength where lower water-to-cement ratio provides higher strength. However, it is also perceived that concrete strength is controlled by the cement content (Arachchige, 2008).

For a given w/c ratio, the larger the cement content, the higher the total water amount in the concrete; hence, the consistency of concrete will be enhanced. Workability is affected by paste volume due to the paste lubricates the aggregates. To prevent an adverse effect, appropriate cement content should be used to achieve the desired workability (Lamond, 2006).

High cement content in a mixture not contributes to higher strength than the required design strength. But the high cement content will cause the concrete to become sticky as well as have shrinkage and cracking problems. Therefore, cement content should be balanced to achieve Performance while minimizing the risk of these problems (Wassermann, 2009).

2.3.3 Mixing Procedure

Mixing procedures refer to the processing of putting raw materials into a mixer and the mixing time required for each step. Mixing procedures directly affect the workability of fresh concrete and indirectly influence some mature properties of concrete. To obtain concrete with certain desired performance characteristics, the selection of constituent's materials is the first step. The second step is mixture proportioning, which means achieving the right combination of components. The proportioning of concrete mixtures is the process of arriving at the right combination of cement, aggregates, water, and admixtures for making concrete according to given specifications (Neville, 2003).

2.3.4. Temperature and time

High temperature decreases the workability and increases the slump loss because the hydration rate is higher and the loss of water is faster at a higher temperature. The strength development of concrete is due to the hydration of cement. The hydration is influenced by temperature. At higher temperatures, the setting of concrete is very rapid and it may start even before the concrete is placed. The time-strength relations in concrete production generally assume moist curing conditions and normal temperatures. When the water/cement ratio, longer the moist curing period the higher the strength assuming that the hydration of anhydrous cement particles is still going on. In the temperature range 40 to 1150F, when concrete is cast and cured at a specific constant temperature, it is generally observed that up to 28 days, the higher the temperature the more rapid is the cement hydration and the strength gain resulting from it. At later ages, when the differences in the degree of cement hydration are reduced, such differences in concrete strength are not sustained. On the other hand, the higher the casting and curing temperature, the lower will be the ultimate strength (M.Monterio, 2001).

2.3.5. Maximum aggregate size

For normal-strength concrete, at the same w/c ratio and with the same cement content, the larger the maximum sizes, the better the workability; at the same workability, the larger the maximum sizes, the higher the strength. Mixtures with a large maximum size of coarse aggregates end to produce concrete with better workability, probably because of the decrease in the specific surface. In high-performance concrete with low water-cement ratio and high cement content, a high value of the maximum size of coarse tends to reduce strength. This can be explained by the observation that bond with large particles tends to be weaker than with small particles due to smaller surface area-to-volume ratios. Mixtures with coarse aggregate with large maximum size tend to have reduced shrinkage and creep and for a given water-cement ratio, the permeability increases as the maximum size of the aggregate increases (C. GonilhoPereira, 2009).

The maximum size of the coarse aggregate used in concrete has a bearing on the economy of concrete. Usually, more water and cement are required for small-size aggregates than for large sizes, due to an increase in total aggregate surface area. A given water-cement ratio; the amount of cement required decreases the maximum size of coarse aggregate increases. Moreover, aggregates of different maximum sizes may give slightly different concrete strengths for the same water-cement ratio. In some instances, at the same water-cement ratio, concrete with a smaller maximum-size aggregate could have higher compressive strength (Kosmatka, 2003).

2.3.6. Aggregate grading

According to ASTM C136, (2004) aggregate grading refers to the size distribution of the aggregate. It is as important as the quality of the aggregate. The grading of aggregate coarse to fine has a marked effect on the workability, uniformity and finishing qualities of concrete. The grading mainly influences the space-filling or particle packing. Well-defined grading with an ideal size distribution of aggregate will decrease the voids in the concrete and hence the cement content. As the price of the aggregate is usually only one-tenth that of cement, well-defined grading not only will lead to a better compressive strength.

According to ACI Committee E-701(2007) Aggregate Grading refers to the particle sizes distribution present in an aggregate. The aggregate grading is determined in accordance with ASTM C136, "Sieve Analysis of Fine and Coarse Aggregates." A sample of the aggregate is shaken through a series of wire- cloth sieves with square openings, nested one above the other in order of particle size with the sieve having the largest openings on top, the one having the smallest openings at the lowest, and a pan underneath to catch material passing the finest sieve. The results of a sieve analysis are typically presented on a graph in the form of a grading curve with the log of the sieve aperture on the x-axis and the percentage of the total mass of aggregates that pass a particular sieve aperture on the y-axis. ACI E-701 states that the portion of an aggregate passing the 4.75 mm (No. 4) Sieve and predominantly retained on the 75μm (No. 200) sieve is known as fine aggregate or sand, and larger aggregate is known as coarse aggregate.

There are several reasons for specifying grading limits and nominal maximum aggregate size: Because, they affect relative aggregate proportions, cement and water requirements, workability, pump ability, economy, porosity, shrinkage, and durability of concrete. Variations in grading can extremely affect the uniformity of concrete from batch to batch. Very fine sands are uneconomical; very coarse sands and coarse aggregate can produce harsh, unworkable mixtures. In general, aggregates do not have a large deficiency or excess of any size and give a smooth grading curve will produce the most satisfactory results (Kosmatka, 2003).

2.4. Effect of pond ash on properties of concrete

2.4.1. Workability

According to ACI116R-00, Workability is the property of freshly mixed concrete that determines the ease and homogeneity with which it can be mixed, placed, compacted and finished. And also, the term is defined in ASTMC125-93 as the property determining the effort required to manipulate a freshly mixed quantity of concrete with minimum loss of homogeneity. The term manipulate refers to the operations of placing, compacting and finishing the concrete.

According to Mindesset al., (2003), workability is the measure of how easy or difficult it is to place, consolidate and finish concrete. It contains in it different aspects like consistency, flow ability, mobility, compact-ability, finish-ability, and harshness. It can also be defined in terms of the amount of mechanical work, or energy required producing full compaction of the concrete without segregation. This property of concrete is affected by a number of factors like water content of the mix, mix proportions, aggregate properties, time, temperature, characteristics of the cement and admixtures.

Water content is the most important factor affecting the workability of concrete. Increasing the amount of water will increase the workability of the concrete. However, the increase in water content of the mix will decrease the strength and result in segregation and bleeding. According to ASTMC143/C143M, (2011) workability of concrete can be measured by slump test. The slump test is the most commonly used method of measuring the consistency of concrete which can be employed either in the laboratory or at the site of work.

According to Shekhar Mahat, et al., (2015) carried experimental studies on the use of Pond ash as Fine Aggregate the Workability of concrete decreases with the increase in Pond ash this is due to water absorption of pond ash.

According to Kumar, (2015) observed that workability of concrete made different percentage ratio of 0%,10%,15%,20% 25% and 30% pond ash slump test result was 35 mm,20 mm, 15 mm,15 mm,10 mm and 10mm respectively.it is shown that workability of concrete made using pond ash decreases within replacement level. The decrease in workability due to the increased volume of fine aggregate on an equal weight basis as PA is lighter than natural sand. For the increased volume of fine aggregate more water is needed for lubrication thereby decreasing the workability.

2.4.2. Compressive strength

The compressive strength of concrete is one of the most important and useful harden properties of concrete. Strength is most of the time determined by means of test either cylinders and cubic test made of fresh concrete on the job and tested in compression at various ages. The requirement is certain strength at an age of 28 days or at such earlier age as the concrete is to receive its full-service load or maximum stress (Neville, 2000).

The compressive strength is directly related to the ability of the material to support under the applied loads. Moreover, the compressive strength of concrete is affected by the constituent material so that the quality control of these materials, as well as composition in the concrete mix, must be composed carefully in order to obtain concrete according to the desired strength (Tumingan, 2017).

The compressive strength of the specimen shall be calculated by dividing the maximum compressive load taken by the specimen by its cross-sectional area. Values of compressive strength at different percentages of replacement at different ages were measured by the compression test. The strength of concrete is dependent on many things. The hydration reaction, water to Cement ratio, aggregate type, amount and size, water content, cement content, curing condition, cement type, compaction method used, etc. have an effect on the strength of concrete.

Pond ash replaced in concrete partially produces concrete to the same grade up to a certain percentage of replacement levels and strength decreases as the replacement level increases as per few studies. According to Arumugam, et al., (2011) observed that concrete samples having 20% sand replaced with pond-ash showed improved compressive strength over the control sample at all the curing ages. Compressive strength reduced with the further addition of pond ash as a sand replacement from 20%.

According to Chun, et al., (2008) reported that the strength of concrete differed by the content of pond ash collected from each disposal site. With the increase in the content of pond-ash, there was a relatively greater increase in compressive strength compared to normal concrete and such trend might be a consequence of decreased water/cement ratio induced by the absorption of mixing water.

Shekhar Mahat, et al., (2015) carried experimental studies on the use of Pond ash as Fine Aggregate in concrete. The properties of Pond Ash were compared to the natural sand. The pond ash replaced by weight is 10%, 20%, 30%, 40%, 50%, and 60% respectively as replacement of FA in concrete. The compressive strength of the concrete with 15% Pond ash replacement as fine aggregate has higher strength for 3, 7 and 28 days of curing but the strength is higher at 20% replacement for 56 days of curing.

According to Kumar, (2015), the addition of pond ash up to 20% replacement of fine aggregate increased the compressive strength at all ages as compared to the control concrete. However, the compressive strength had a maximum at a 15% replacement level. At this replacement, the compressive strength is 5.78%, 3.19% and 1.60% more than the control concrete at 7, 28 and 56 days respectively. The increase in compressive strength is due to the packing of voids in concrete by pond ash particles.

2.4.3. Density

According to Kalgal, et al., (2007) stated that the average density of concrete in both mix proportions ranges from 2000 Kg/m3 to 2200 Kg/m3, which is slightly lesser than the normal concrete density with sand as fine aggregate. This reduction in density is probably due to the lesser specific gravity of pond ash. It is also observed that the density exhibited is marginally lesser for 56 and 90 days due to probable evaporation of moisture from the pores in the surface layers.

Bhangale and Nemade, (2013) reported that the density of concrete decreases with the increase in the percentage of pond ash.

According to Nurzal, et al., (2018) the longer the drying time, the density increases, due to the chemical reaction between cement and water which causes the concrete become hard after some time, besides, water absorption increases. Drying time of 7^{th}, 14^{th} and 28^{th} days increased density value and reached maximum density value in 28^{th}days drying time.

According to Neville, (2000) revealed that the density of normal weight concrete within the range of 2200kg/m3 to 2600kg/m3.

CHAPTER THREE

RESEARCH METHODOLOGY AND MATERIALS

3.1. Sampling Area

The pond ash used for this study was collected from Ayka Addis Textile factory which is located at 20km west of Addis Ababa in Sebeta town around Alemgena.

3.2. Research Design

An experimental investigation was conducted for this research during the study period; in order to provide the most reliable result by study the quality of the raw material of concrete and identified their effect on concrete properties mainly workability, density and compressive strength of concrete and also the physical properties of pond ash. In this study, the slum test was used to determine the workability of concrete and compressive strength of C-25 concrete measured using a compression test machine at 7, 14, and 28 days of curing was investigated in the laboratory of JIT. In addition, the blended concrete specimens were prepared by weight replacement of the fine aggregate with pond ash and keeping the other ingredients are constant.

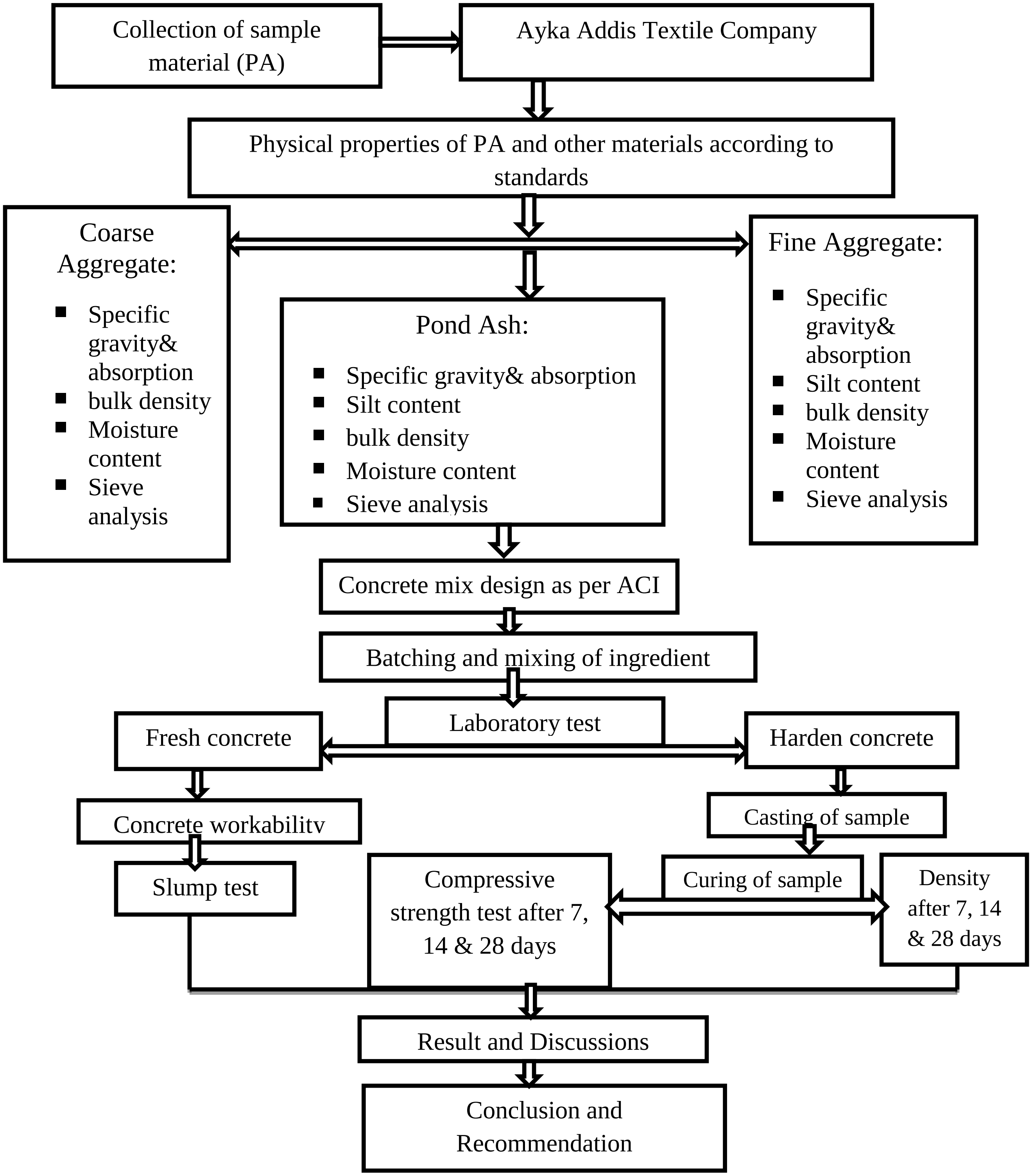


Figure 3.1: Experimental laboratory framework

3.3. Sample size and sampling Collection Technique

This study was determined the sample size of the test it needs standards and specifications. According to ASTM and ACI method, it requires a minimum of three samples of cub size of (150mm x 150mmx 150 mm) mold were prepared for each test of the characteristic strength of concrete.

In this study compressive strength tests were investigated at 7, 14 and 28 days with ratio of 0 %, 5 %, 10 %, 15 %, 20%, 25% and 30% pond ash (PA) for sand replacement. So, the researcher was taken 63 samples to achieve the objective of the study. The sample was collected using hand shovels and was kept in sacks and was taken to Jimma Institute of Technology laboratory for investigated physical property and mixed concrete.

Table 3.1: Sample size

Mix code	% of PA	Age of days			Total
		7	14	28	
PA0	0	3	3	3	9
PA5	5	3	3	3	9
PA10	10	3	3	3	9
PA15	15	3	3	3	9
PA20	20	3	3	3	9
PA25	25	3	3	3	9
PA30	30	3	3	3	9
Total		21	21	21	**63**

3.4. Study variable

3.4.1. Dependent Variable

- ✓ Properties of pond ash concrete

3.4.2. Independent Variable

- ✓ Percentage replacement of Pond ash
- ✓ Physical properties of Pond ash

3.5. Data Source

Both secondary and primary data sources were used. Secondary data needed for this research was collected from different journals, books, websites, etc. and primary sources of data for this study are laboratory experimental output.

3.6. Materials used

The following materials were used for this study.

- ✓ Cement
- ✓ Fine aggregate
- ✓ Pond ash
- ✓ Coarse aggregate and
- ✓ Water

3.6.1. The Physical property of materials

3.6.1.1. Cement

In this research work, the type of Cement used to produce the samples was Dangote Ordinary Portland Cement; class of strength 42.5R was used. The Dangote cement is manufactured by the Dangote Cement Manufacturing Company which is available in market, Jimma.

Figure 3.2: Dangote ordinary Portland cement (OPC) used in the research

3.6.1.2. Aggregates

3.6.1.2.1. Properties of Fine aggregate

The fine aggregate used for this investigation was obtained from the local source, Worabe, Gurage Zone of Southern Ethiopia which is located 343 km from Jimma town, it is extracted from the "omo" river was used to prepare the concrete samples. The aggregate is extracted from the riverside; it's full of dust film on their surface. For this reason, the fine aggregates were washed thoroughly and dried in the air outside the laboratory to saturated surface dry (SSD) state before any test was carried out. Tests related to the physical property of fine aggregates have been discussed below.

A. Silt content of fine aggregate

According to ASTM C117, the material in fine aggregates which is finer than 75µm is generally regarded as silt. This silt in the sand for the concrete has a severe impact on the quality of the concrete. Mainly it affects the workability of the concrete, and also results in the reduction of strength. Fine aggregates containing too much percentages of silt than the allowable limits are required to be washed. According to the Ethiopian standard it is recommended to wash or reject if the silt content exceeds a value of 6% (Dinku, 2002). In this study, after washing the fine aggregate that used have silt content was reduced to 2.5 % and this value was within the range of the standard and it passes the requirement.

B. Sieve Analysis of fine aggregate

This is a procedure for the determination of the particle size distribution of the aggregate. It is also used to determine the fineness modulus on the index to the fineness coarseness and uniformity of aggregates. These properties of the aggregate greatly affect the property of the concrete. According to ASTM C33 (standard specification for concrete aggregates), sand with a fineness modulus between 2.3 and 3.1 considered to be as good sand or a good fine aggregate. However, depending upon their size; crush sand can be classified as coarse sand when fineness modulus is between 2.9 to 3.1, medium sand with a fineness modulus of 2.6 to 2.9, fine sand with a fineness modulus of 2.3 to 2.6.

Table 3.2: Sieve analysis test result and the standard requirement for fine aggregate

Sieve	Cumulative passing %	ASTM Limit	
		Lower	Upper
9.5mm (3/4 in)	100	100	100
4.75mm (No.4)	100	95	100
2.36mm (No.8)	87.70	80	100
1.18mm (No.16)	66.95	50	85
600(No.30)	33.75	25	60
300(No.50)	12.25	10	30
150(No.100)	4.25	2	10

Depend on the above table Sieve analysis test result indicates that the Worabe sand used in this research have a fineness modulus categorized as coarse sand and this was within the range of ASTM standard.

C. Moisture content of fine aggregate

During the concrete mix design process, an aggregate was considered to be as free from water and never absorbing moisture from the environment. If sand was used without conducting a test for moisture content and water absorption, the initially considered water per cement ratio will be getting abnormal and the strength of concrete will be jeopardized. So, in order to know the required quantity of water that is necessary to get the desired compressive strength and the workability of fresh concrete, the tests should have to be conducted. The water to cement ratio of concrete affects the strength and the workability of the concrete. The increase of the water to cement ratio results in a decrease in the strength of the concrete and an increase of workability. The aggregates in concrete are assumed to be inert materials. As a result of this property of aggregates the design water to cement ratio of the mix changes. In order to correct these discrepancies, the moisture content of aggregates has to be determined (Dinku, 2002). Therefore, it is important to determine both the absorption capacity and the moisture content of the aggregate.

The moisture content of fine aggregates was determined by oven drying a sample of fine aggregate (500gm) in an oven at a temperature of 110 0c for 24hrs and dividing the weight difference by the oven-dry weight.

D. Unit weight of fine aggregate

Unit weight can be defined as the weight of a given volume of graded aggregate. It is a density measurement and is also known as bulk density. The unit weight tests of the fine aggregate samples were carried out according to ASTM C 29 and simply measured by filling a container of known volume and weighing it. Then, dividing the aggregate weight by the volume of the container provides the unit weight of the aggregate. The rodded bulk density of aggregates used for normal weight concrete generally ranges from 1200 to 1760 kg/m3 (ACI 318M, 2011). The compacted and loose unit weight of fine aggregate used in this study was fulfilling the requirements of aggregates for normal weight concrete shown in appendix1.

Figure 3.3: The compacted and loose unit weight of fine aggregate

E. Specific Gravity and Absorption Capacity of Fine Aggregate

The specific gravity is the ratio between the weight of the substance and that of the same volume of water. Aggregates, however, have pores that are both permeable and impermeable; whose structure affects water absorption, permeability, and a specific gravity of the aggregates (Dinku, 2002).

According to ASTM C 128-93 (Reapproved 2001), standard test method the bulk specific gravity (SSD) and the absorption capacity results obtained from the experiment are shown in appendix1. According to ASTMC33/C33M (2011), the limitation for absorption capacity ranges from 0.2 to 2 % for fine aggregates. As a result, the fine aggregate is within ASTM limitations.

3.6.1.2.2. Properties of Coarse Aggregate

The coarse aggregate used for this study was basaltic crushed rock obtained from Agaro, the Oromia Regional State of Ethiopia which is located 46.1km from Jimma town. The aggregate coming from the crushing was washed thoroughly and dried in the air inside the laboratory. The size of the coarse aggregate used for the experimental investigation was 20mm diameter aggregate used in all the concrete mix. In a similar manner like fine aggregate, laboratory tests were carried out to identify the physical properties of the coarse aggregate that have been discussed below.

A. Sieve analysis of coarse aggregate

Gradation refers to the particle sizes distribution present in an aggregate sample. The gradation of the sample is determined in accordance with ASTM C 136. A sample of the aggregate is shaken through a series sieves with square openings, nested one above the other in order of their size, with the sieve having the largest openings on top, the one having the smallest openings at the bottom, and a pan underneath to catch material passing the finest sieve(ACI Committee, 2007). The maximum size of the coarse aggregate also influences the paste requirements of the concrete, and the optimum grading of the coarse aggregate depends on the maximum aggregate size. As defined by ASTM C 125, the maximum size of coarse aggregate is the smallest sieve opening through which the entire sample passes.

The grading requirement for coarse aggregate according to ASTM and the grain size distribution of the coarse aggregate sample is as shown in table and figure below.

Table 3.3: Sieve analysis test result and the standard requirement for coarse aggregate

Sieve	Cumulative passing %	ASTM Limit	
		Lower	Upper
37.5	100	100	100
28	99.36	90	100
19	79	40	85
12.5	36.12	10	40
9.5	13.98	0	15
4.75	0.3	0	5

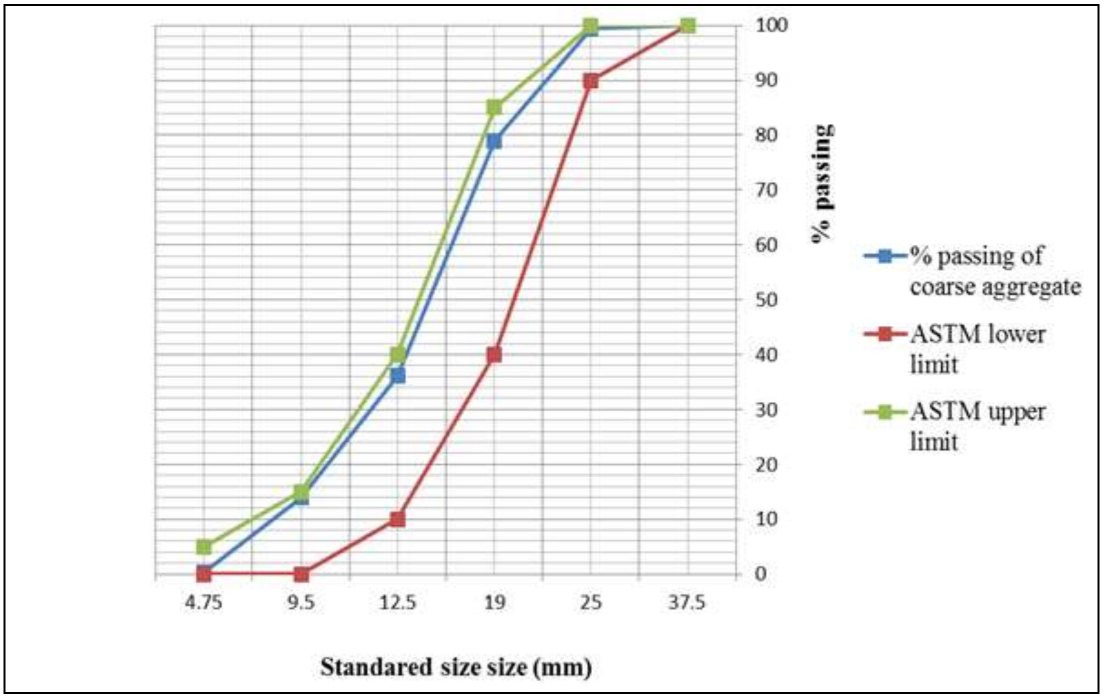


Figure 3.4: Particle size distribution of coarse aggregate

B. The moisture content of coarse aggregate

In a similar manner like fine aggregate, according to ASTM C 566-97, the moisture content of coarse aggregate was determined by oven drying a sample of coarse aggregate (2000gm) in an oven at a temperature of 110 0c for 24hrs and dividing the weight difference by the oven-dry weight.

C. Unit weight of coarse aggregate

The unit weight measurement for the coarse aggregate sample was followed the same procedure as in the case of fine aggregate. The compacted and loosed unit weight of coarse aggregate used in this study was fulfilled the requirements of aggregates for normal weight concrete shown in appendix1.

D. Specific Gravity and Absorption Capacity of coarse aggregate

The specific gravity and absorption capacity of coarse aggregate was determined in accordance with ASTM C 127-88 (Reapproved 2001). Since, aggregates generally contain pores both permeable and impermeable. The bulk specific gravity and the absorption capacity results obtained from the experiment are shown in appendix 1.

3.6.1.3. Pond ash

The pond ash used for this research was collected from Ayka Addis Textile and Investment Group PLC which is located Addis Ababa in Sebeta town around Alemgena. The pond ash used for this study was dried to saturated and surface dry (SSD) state before any test was carried out. The entire passing 4.75mm sieve size and retained on the 150 µm (No. 100) was used for experimentation. Then, tests related to the physical property of pond ash have been discussed below.

3.6.1.3.1. Properties of pond ash

A. Silt content of pond ash

Silt content of pond ash carried out according to ASTM C 117 and also permissible limit was checked according to the ES cited in (Dinku, 2002) which is recommended to wash the pond ash or reject if silt content is exceeds a value of 6%. From the test result obtained, the silt content of the pond ash used for this experiment before washing the value was under the permissible of Ethiopian standard.

B. Sieve Analysis

The sieve analysis tests of the pond ash samples were carried out according to ASTM C 136-84. The sieve analysis of pond ash used for the experiment is shown in Appendix 1.

Table 3.4: Sieve analysis test result and the standard requirement for pond ash

Sieve	Cumulative passing %	ASTM Limit	
		Lower	Upper
9.5mm (3/4 in)	100	100	100
4.75mm (No.4)	100	95	100
2.36mm (No.8)	87.25	80	100
1.18mm (No.16)	67.00	50	85
600(No.30)	36.50	25	60
300(No.50)	14.00	10	30
150(No.100)	5.25	2	10
FM	2.90		

C. Moisture content of Pond ash

In a similar manner like fine aggregate, according to ASTM C 566-97, the moisture content of pond ash was determined by oven drying a sample of pond ash (500gm) in an oven at a temperature of 110 0c for 24hrs and dividing the weight difference by the oven-dry weight.

D. Unit weight of pond ash

The unit weight tests of the pond ash samples were carried out according to ASTM C 29 and simply measured by filling a container of known volume and weighing it. Then, dividing the aggregate weight by the volume of the container provides the unit weight of the aggregate.

The unit weights of the material are classified as light unit weight, normal unit weight, and heavy unit weight. The range of light unit weight of the material is less than 1200 kg/m^3; the rodded bulk density of aggregates used for normal weight concrete generally ranges from 1200 to 1760 kg/m^3 and above it is heavy unit weight (ACI318M, 2011).

E. The specific Gravity and Absorption Capacity of Pond ash

According to ASTM C 128-93 (Reapproved 2001), standard test method specific gravity and absorption capacity of pond ash samples were determined. Since, aggregates generally contain pores both permeable and impermeable.

According to concrete technology book the specific gravity of material classified as light, normal and heavy specific gravity. The range of light specific gravity aggregate is under 2.4, the normal specific gravity of material of aggregate is from 2.4-2.9, and the heavy aggregate specific gravity is above 2.9. The pond ash used for this research was classified as light specific gravity.

3.6.1.3.2. Chemical properties of pond ash

Table 3.5: Chemical requirements (ASTM C618, 2012)

Compounds	Class" F"	Class "C"
Silicon dioxide (SiO_2) +Aluminum oxide (Al_2O_3) +Iron oxide (Fe_2O_3) minimum, %	70	50
Sulfur trioxide (SO_3), max, %	5	5
Calcium oxide (Cao)	-	>10
Na2O, max, %	1.5	1.5
Moisture content, max, %	3	3
Loss of ignition (LOI), %	6	6

The pond ash that was collected from the Ayika Addis textile factory was checked in its chemical composition in order to check the classes of pond ash either C or F. The result of chemical analysis of pond ash was determined in the laboratory of the geological survey of Ethiopia described in the table below.

Table 3.6: Chemical composition of pond ash test result of the geological survey of Ethiopia

Oxide composition %	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	MnO	P_2O_5	TiO_2	H_2O	LOI
Pond ash	60.96	27.65	2.40	<0.01	<0.01	<0.01	<0.01	<0.01	0.18	0.55	2.44	6.13

The chemical composition of pond ash in table 3.14 shows that the sum of SiO_2+Al_2O_3+ Fe_2O_3 in pond ash is greater than 70%. So that, the pond ash can be classified as a class F pozzolana as per ASTM C618. The loss of ignition value was 6.13% which is very slightly higher than the requirements and also the moisture content value was within the limit specified by the same standard which is 3%. Therefore, the pond ash used for this study was fulfilled the requirement of ASTM C 618.

3.6.1.4. Water

In this study water was used for mixing concrete and curing of the specimens was obtained from JIT of Civil Engineering Laboratory water supply. The water type that used was potable water.

3.6.2. Production of concrete samples

3.6.2.1. Mix Design and material proportion used to produce concrete specimen

In this research work, the concrete mix design and proportion calculation were used to design C-25 concrete grade done according to ACI 211.1 method. The quantity of concrete materials was calculated by using the physical properties of the materials and table 3.7 below shows the quantity of materials for one cubic meter for C-25 concrete grade. From the final design proportion of control concrete mix of 370 kg/m^3 cement, 812.94 kg/m^3 fine aggregate, 1004.828 kg/m^3 coarse aggregate and 188.27kg/m^3 water were required to produce a concrete specimen. Based on this value, the blended concrete specimens were prepared by weight replacement of the fine aggregate with pond ash and keeping the other ingredients constant.

Table 3.7: Mix proportion for control and pond ash blend concrete for 1m3

NO.	Mix code	OPC (kg/m^3)	Pond ash (kg/m3)	sand (kg/m3)	water (kg/m3)	W/C	Coarse aggregate (kg/m3)
1	PA_0	370	0	812.94	188.27	0.509	1004.83
2	PA_5	370	40.65	772.29	188.27	0.509	1004.828
3	PA_{10}	370	81.29	731.65	188.27	0.509	1004.828
4	PA_{15}	370	121.941	690.1	188.27	0.509	1004.828
5	PA_{20}	370	162.59	650.35	188.27	0.509	1004.828
6	PA_{25}	370	203.24	609.71	188.27	0.509	1004.828
7	PA_{30}	370	243.88	569.06	188.27	0.509	1004.828

Where: $PA_0$is a concrete mix with 100% fine aggregate and 0% pond ash by weight

$PA_5$is a concrete mix with 95%fineaggregate and 5% pond ash by weight

$PA_{10}$is a concrete mix with 90% fine aggregate and 10% pond ash by weight

$PA_{15}$is a concrete mix with 85% fine aggregate and 15% pond ash by weight

$PA_{20}$is a concrete mix with 80% fine aggregate and 20% pond ash by weight

$PA_{25}$is a concrete mix with 75% fine aggregate and 25% pond ash by weight

$PA_{30}$is a concrete mix with 70% fine aggregate and 30% pond ash by weight.

3.6.2.2. Concrete Specimen Preparation and Mixing Procedure.

Strength is the main quality controlling parameter for concrete, different specimens were prepared for studying the strength. The test specimens for compressive strength tests were cast in standard steel mold with 150mmx150mm x150mm cubes. To meet the required quality, simply the preparation of specimens and mixing of the concrete were according to the following procedures: - First, coarse aggregate was added in a laboratory batch mixer and add the fine aggregate and the pond ash mix after the coarse aggregate into the mixer and then the cement was added and dry mixed until it was thoroughly blended. Finally, the water was added to the ingredient and mixing was continued until fresh concrete gets complete homogeneity. The concrete molds were cleaned from all dust and coated with a releasing agent (oil) to smooth the surface and to prevent sticking of mixed concrete with the mold before casting shown in the figure below

Figure 3.5: Mixing of ingredients, Oiling of mold and casting of specimen

3.6.2.3. Workability test for each percentage replacement

Then mixed concrete was checked for workability by using the standard slump cone of 300mm high with a bottom diameter of 200mm and top diameter of 100mm size. Then fresh concrete was added to the prepared molds in three layers according to ASTM C 143 shown in figure 3.6 Then, compacting mixed concrete was filled into molds with three layers by rodding each layer 25 times using standard steel tamping rod of 16mm diameter and 600mm long with one end rounded. After compaction, the top layer of the concrete was smoothened using a trowel.

Figure 3.6: Slump test

3.6.2.4. De molding and curing

Then, the concrete molds are kept for 24 hours and then the casted concrete cubes were de mold and cured in water tank for the period of 7,14 and 28 days shown in the figure below.

Figure 3.7: Curing of concrete cubes

3.6.2.5. Density and Compressive strength test for the control and pond ash concrete

After the curing period, the cubes were brought out of the water curing tank and kept for 24 hours. They were later the cube specimen weighed on a weighing balance to determine the unit weight of the concrete cube and recorded for density and then taken to the digital compression test machine with a maximum capacity of 2000KN. Before each test, the compression test machine surface was wiped clean and the cube specimen was placed in the machine in such manner that the load was applied to the opposite side of the cubes. The cube specimen was carefully aligned with the Centre of the lower plate and the load was applied until the specimen failed. The failure load was recorded to obtain the failure stress. The compressive strength value was the average of the three concrete cubes. The compressive strength of the specimen was calculated by dividing the failure load by the cross-sectional area of the specimen and the compressive strength of the cube was determined at the curing period of 7, 14 and 28 days.

3.7. Data processing and analysis

After recording the laboratory results, compare the output with the available national and international standards and specifications. Finally, findings were discussed to achieve the research objectives and present the result obtained from the laboratory was analyzed both qualitatively and quantitatively using Microsoft excel according to set objectives.

3.8. Data quality assurance

The quality of the data was assured to replicate the samples by using standard operating procedures. To check the accuracy and validity of data instrument calibration and verification were checked. Laboratory test and fieldwork manual was prepared in order to avoid the error of data and also give attention during data collecting and recording carefully while performing experiments.

3.9. Plan for Dissemination

The finding of this study was presented by using power point to advisors, examiners and interesting parties by the researcher and the thesis was printed in four copies and was submitted both in hard and soft copy to examiner, advisors and to the department. Once the research is approved and signed by advisors and examiner, the paper was uploaded to the internet for other interesting parties about the title of the paper.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1. Physical Properties of pond ash

4.1.1. Gradation test for pond ash and fine aggregate

The particle size distribution of PA and fine aggregate was determined by sieve analysis test. The result of the sieve analysis of PA and fine aggregate are shown in table 4.1 and the graph shown in figures 4.1 and 4.2 respectively below.

Table 4. 1: Gradation test for pond ash and fine aggregate

Sieve Size[mm]	Pond Ash [2000g]	Fine aggregate[2000g]	ASTM Limit	
	Finer passing (%)	Finer passing (%)		
9.5	100	100	100	100
4.75	100	100	95	100
2.36	87.25	87.70	80	100
1.18	67.00	66.95	50	85
0.6	36.50	33.75	25	60
0.3	14.00	12.25	10	30
0.15	5.25	4.25	2	10

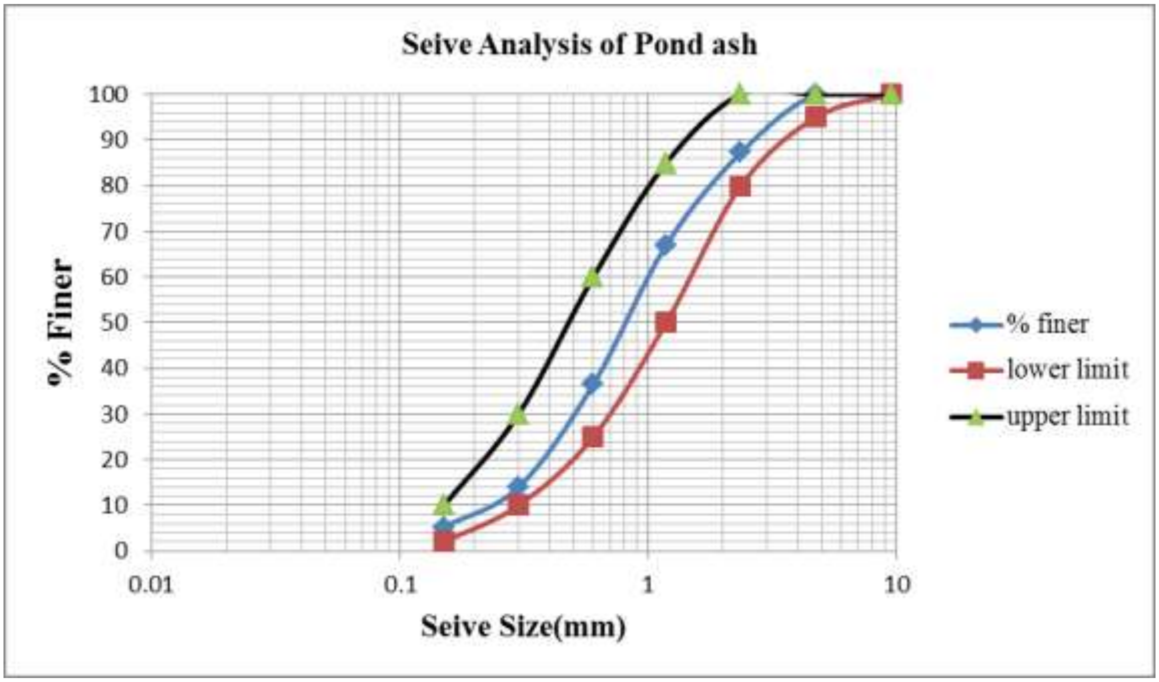


Figure 4.1: Particle size distribution for pond ash

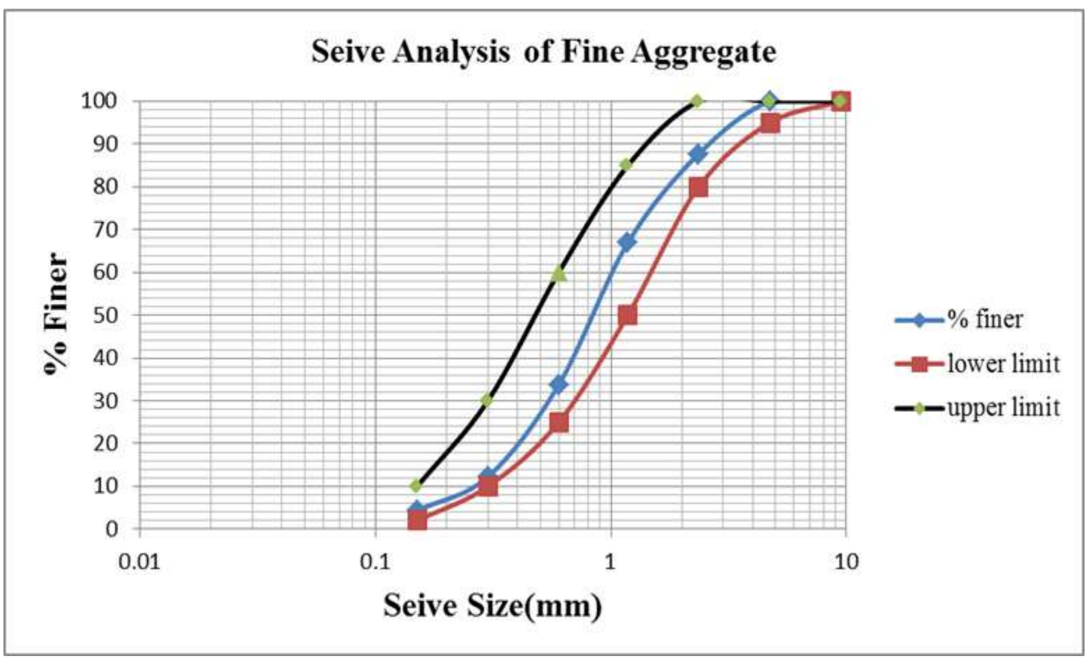


Figure 4.2: Particle size distribution for fine aggregate

From the above results, it can be seen that the particle size distribution analysis, all particles of pond ash and fine aggregate passed through 9.5 mm sieve size. This indicates that the particles size both pond ash and fine aggregate is less than 9.5 mm sieve size.

The particles of pond ash sample passed through 4.75mm and 2.36mm sieve size are 100% and 87.25% where as fine aggregate sample is 100% and 87.7% respectively. From the result of 4.75mm and 2.36mm sieve analysis, pond ash is coarser than the fine aggregate. On the other hand, the particles passed through 1.18mm, 0.6mm, 0.3mm, and 0.15mm were found to be 67%, 36.5%, 14% and 5.25% for pond ash were 66.95%, 33.75%, 12.25% and 4.25% for fine aggregate respectively. The result obtained from 1.18mm, 0.6mm, 0.3mm, and 0.15mm sieve analysis shows that pond ash is finer than the fine aggregate. Based on the result of 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm, and 0.15mm sieve analysis, pond ash is coarser than fine aggregate for higher sieves size and finer for lower sieves size than the fine aggregate. In addition to this, both PA and FA satisfied ASTM requirements.

Grading Curve of Pond Ash

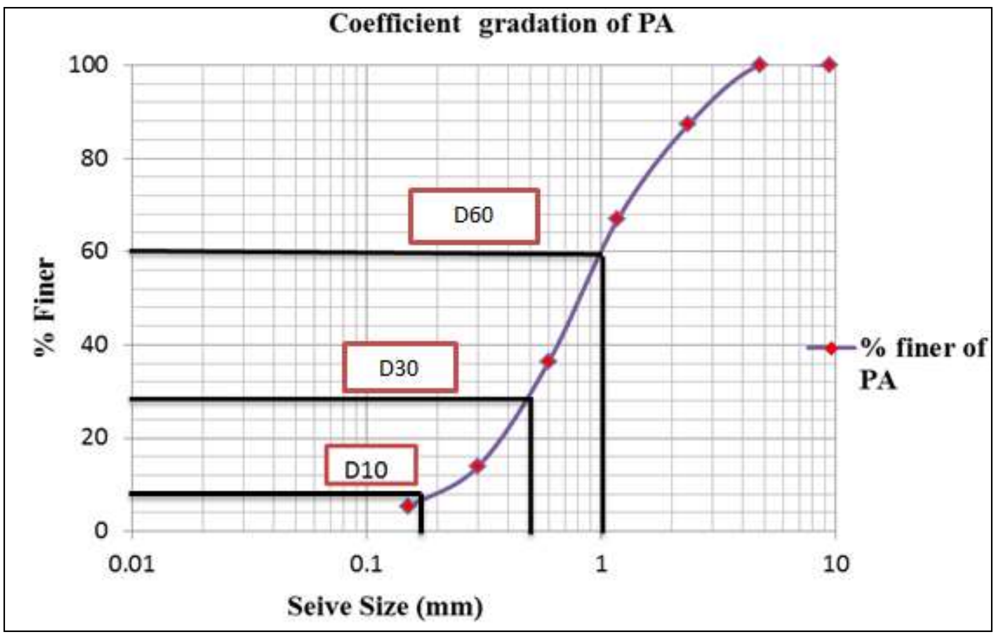


Figure 4.3: Grading curve for pond ash

To determine the value of the particle sizes D60, D30, and D10 that correspond to 60%,30% and 10% passing calculating the value of the coefficients of uniformity (cu) and coefficient of curvature (cc) and finally comparing these values to critical ranges to determines whether the material is well graded, gap graded and poorly graded. These coefficients are calculated as shown below:

$$Cu = \left[\frac{D_{60}}{D_{10}}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equ. 1$$

$$CC=\frac{(D30)^2}{D_{10}*D_{60}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equ. 2$$

From the above figure result, it can be seen that the grading curve of pond ash the D60, D, 30 and D10 passed through sieved sizes are 1.00, 0.5 and 0.25mm respectively. According to ASTM C32-82 when the materials are well graded, the Cu values greater than or equal to 5(Cu $\geq$5) and the CC values between the range of 1-3(1<cc<3). Therefore, the pond ash the Cu value was found to be which less than that was specified the same standard. The CC value was to be found 1.0 which is between the ranges that specified the same standard. As above figure shows that, the pond ash was classed as a gap graded material as per ASTM.

4.1.2. Specific gravity and absorption capacity of pond ash and fine aggregate

Table 4. 2: Specific gravity of pond ash test result

Specific gravity of pond ash			
Sample	1	2	Mean
Wt. of oven-dry sample(D)gm	490.3	490.4	
Weight of sample (A) gm	500	500	
Wt. of pycnometer + sample + water(B)[gm]	1757	1756.5	
Weight of pycnometer + water(C)[gm]	1555	1555	
Bulk specific gravity=D/(C+A-B)	1.64	1.64	1.64
Bulk specific gravity (SSD)=A/C+A-B	1.68	1.68	1.68
Apparent specific gravity=D/ C+D-B	1.70	1.70	1.70
Absorption capacity %) =[A-D/D] *100	1.98	1.96	1.97

Table 4.3: specific gravity of fine aggregate test result

Specific gravity of fine aggregate			
Sample	1	2	Mean
Wt. of SSD sample (A) [gm]	500	500	
Wt. of pycnometer + sample + water(B)[gm]	1853.4	1855	
Weight of pycnometer + water(C)[gm]	1555	1555	
Wt. of oven-dry sample(D)	490.5	493	
Bulk specific gravity=D/(C+A-B)	2.433	2.465	2.449
Bulk specific gravity (SSD)=A/C+A- B	2.48	2.5	2.5
Apparent specific gravity=D/C+D-B	2.55	2.55	2.55
Absorption Capacity (%) =[A-D/D] *100	1.94	1.42	1.68

From the above table results, it can be seen that the pond ash was determine using pycnometer have slightly high absorption capacity and a low specific gravity found to be 1.97% and 1.68% respectively when compared to that of fine aggregate. According to ASTMC33/C33M (2011, the limitation for bulk specific gravity (SSD) is from 2.4 to 3.0The range of light specific gravity aggregate is under 2.4, the normal specific gravity of material of aggregate is from 2.4-3.0, and the heavy aggregate specific gravity is above 3.0. So, the pond ash used for this research was classified as lightweight material and absorption capacity ranges from 0.2 to 2% for fine aggregates. A result indicates that, both the fine aggregate and the pond ash was satisfied the limitation requirements.

4.1.3. Bulk density (unit weight) of pond ash

Table 4.4: Compact unit weight test result of pond ash

Compact unit weight of Pond ash		
Sample	1	2
Weight of cylinder metal(kg)	1.054	1.054
Wt. of cylinder metal (kg) +wt. of sample	6.5205	6.521
Wt. of sample(kg)	5.4665	5.467
Volume of cylinder(m3)	0.005	0.005
Unit weight(kg/m^3)	1093.3	1093.4

Mean	1093.35

From the results of table 4.4 it can be seen that; the pond ash had a low bulk density when compared with that of fine aggregate. According to ASTM limits the aggregates with bulk densities less than 1120 kg/m3 are called lightweight. Depend on the above test result of pond ash was classified a lightweight material and lower bulk density compared to that of fine aggregate.

4.1.4. Moisture content of Pond ash

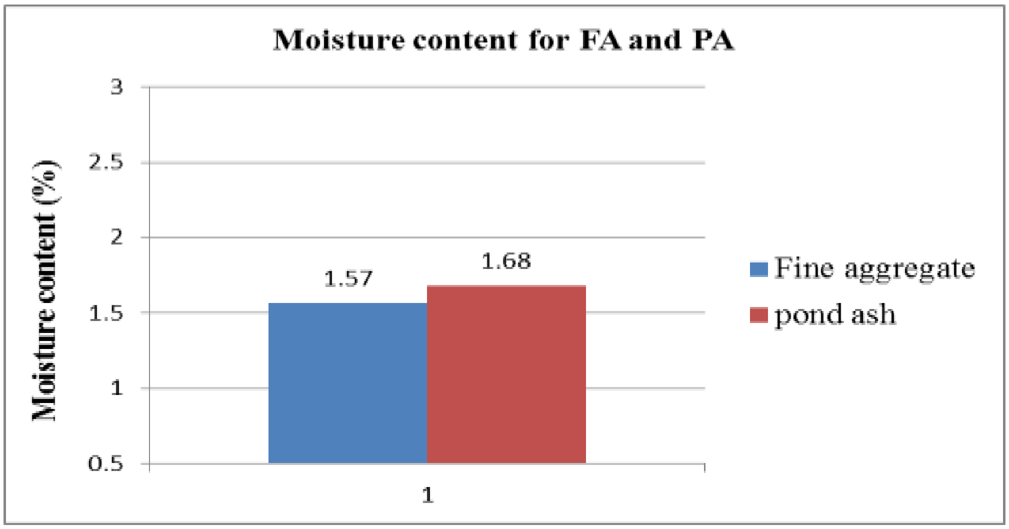


Figure 4.4: Test result of moisture content of pond ash

From the above figure, it can be seen that the pond ash had slightly higher moisture content when compared to that of fine aggregate.

4.1.5. Silt content for pond ash and fine aggregate

Table 4.5: Silt content of pond ash

Silt content of pond ash			
Sample	Amount of Silt deposit	Amount of clear sand	Silt content (%)
Sample 1	7ml	250ml	2.8
Sample 2	6ml	222ml	2.7
		Mean	2.8

Table 4.6: Silt content of fine aggregate

Silt content of fine aggregate after washing			
Sample	Amount of Silt deposit	Amount of clear sand	Silt content (%)
Sample 1	5ml	165ml	3.03
Sample 2	6ml	290ml	2.06
		Mean	2.5

According to the Ethiopian standard it is recommended to wash or reject if the silt content exceeds a value of 6% (Dinku, 2002). From the above table 4.5 test result obtained, the silt content of the pond ash used for this experiment before washing the value was under the permissible of Ethiopian standard and also the fine aggregate before washing the value was 7.95% but, after washing that used have silt content was reduced to 2.5 % and this value was within the range of the standard and it passes the requirement.

Table 4.7: Summary of the physical properties test result for fine aggregate and pond ash

Sr.No	Physical properties		Test result		
			Fine aggregate	Pond ash	Coarse aggregate
1	Unit weight	Compact	1565.6 kg/m3	1093.35	1666.05
		Loose	1347.75 kg/m3	922.25	1578.65
2	Moisture content		1.57%	1.68	0.934%
3	Absorption capacity (%)		1.68%	1.97	0.52%
4	Fineness modulus		3.02	2.9	3.38
5	Silt content		2.5%	2.8%	-
6	Specific gravity	Bulk	2.43	1.64	2.81
		Bulk (SSD)	2.5	1.68	2.75
		Apparent	2.55	1.7	2.83

4.2. Effect of pond ash on the workability of fresh concrete

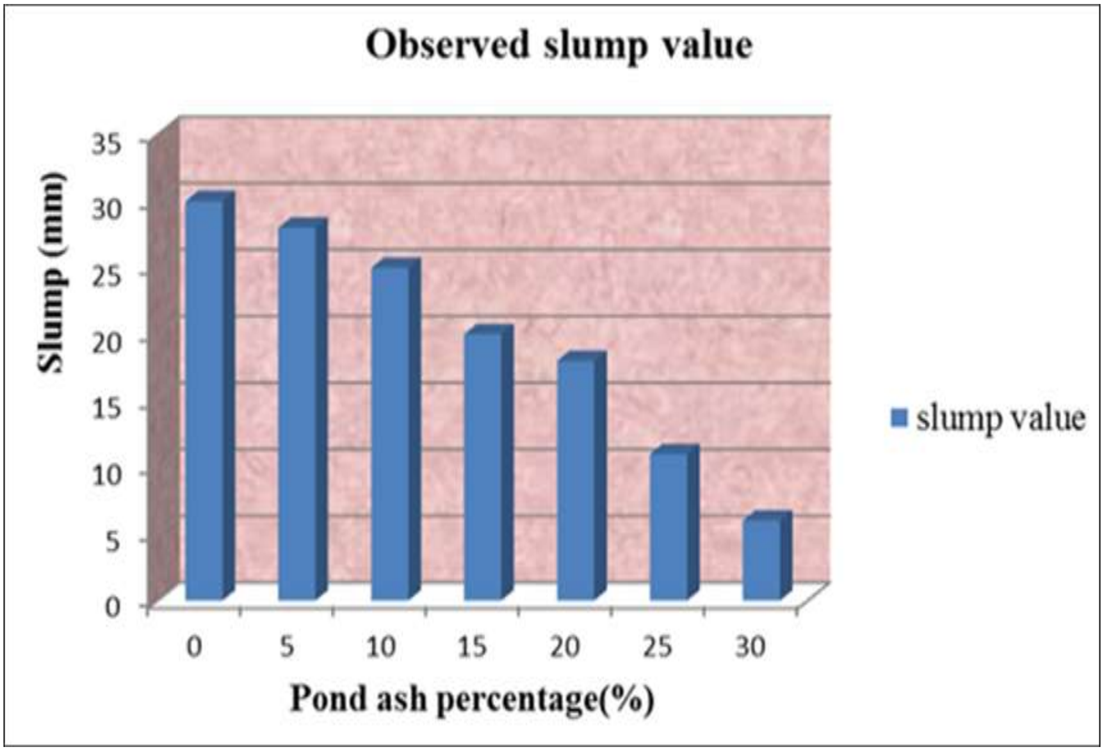


Figure 4.5: Workability of concrete with increasing PA replacement

Figure 4.6: Checking of workability of concrete by slump test

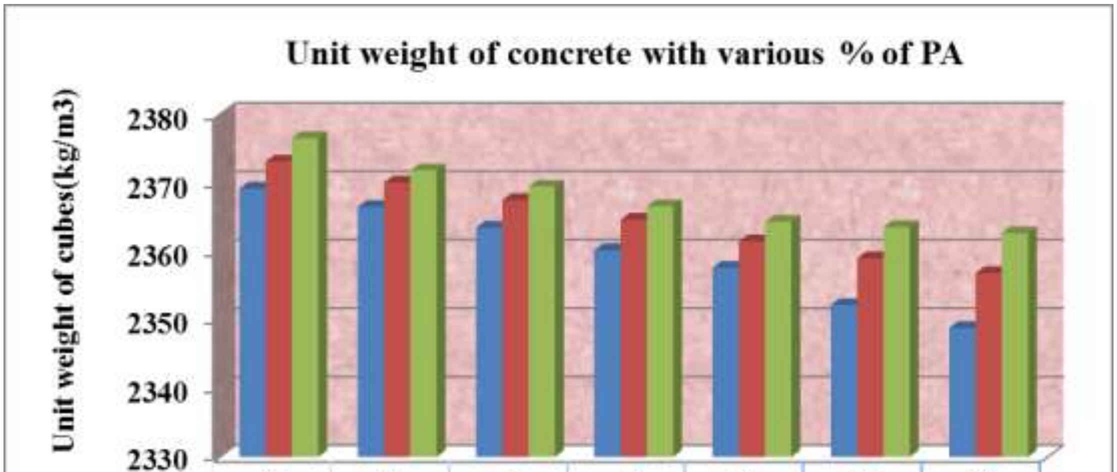
Based on the above table and figure test results, it can be seen that the slump value of concrete contains pond ash had shown a slight reduction as pond ash content increases. From the result, it was observed that the slump value of fresh concrete became less workable at 0%, 5%, 10%, 15%, 20%, 25% and 30% of pond ash was 30mm, 28mm, 25mm, 20mm, 18mm, 11, mm and 6mm respectively. As figure 4.5 indicated that the pond ash content had inversely proportion to the workability of fresh concrete mixes. Slump value was observed that pond ash content beyond 10% replacement by fine aggregate all concrete batches were low workable.

According to Kumar, (2015) observed that workability of concrete made different percentage ratio of 0%, 10%, 15%, 20% , 25% and 30% pond ash slump test result was 35 mm, 20 mm, 15 mm, 15 mm, 10 mm and 10mm respectively. It is shown that workability of concrete made using pond ash decreases with in replacement level. The decrease in workability due to the increased volume of fine aggregate an equal weight basis as PA is lighter than natural sand. For the increased volume of fine aggregate more water is needed for lubrication thereby decreasing the workability.

According to Shekhar Mahat, et al., (2015) carried experimental studies on the use of Pond ash as Fine Aggregate the Workability of concrete decreases with the increase in Pond ash this is due to water absorption of pond ash.

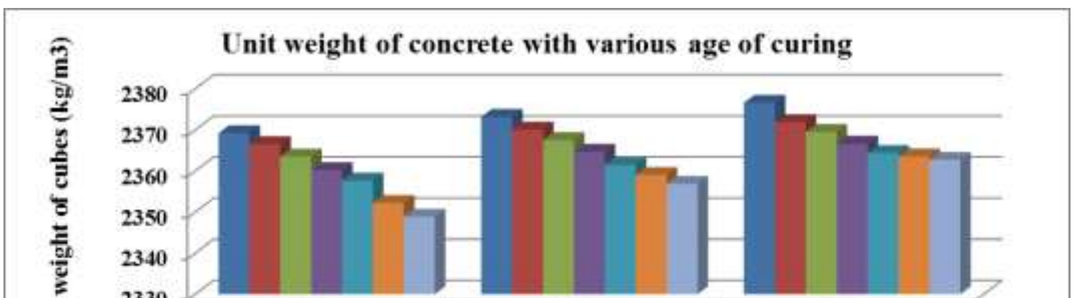
4.3. Effect of pond ash on the Unit weight of harden concrete

In this study, PA was used to replace fine aggregate in the production of concrete cubes. The specimens were prepared as described in section 3.6.2.5 of chapter three. The specimens were weighed at 7, 14 and 28 days just before testing compressive strength. The density of the specimens at these age results was presented in figure 4.7 below.



	0	5	10	15	20	25	30
7 day	2369.19	2366.51	2363.48	2360.2	2357.63	2352.2	2348.84
14 day	2373.14	2370.07	2367.51	2364.64	2361.48	2359.01	2356.84
28 day	2376.56	2371.85	2369.48	2366.62	2364.35	2363.56	2362.67

Figure 4.7: Unit weight of concrete with increasing PA replacement



	7 day	14 day	28 day
control	2369.19	2373.14	2376.56
5%	2366.51	2370.07	2371.85
10%	2363.48	2367.51	2369.48
15%	2360.2	2364.64	2366.62
20%	2357.63	2361.48	2364.35
25%	2352.2	2359.01	2363.56
30%	2348.84	2356.84	2362.67

Figure 4.8: Average unit weight of concrete with increasing curing age

From the above figure 4.7 results, it can be seen that the density of concrete specimens decreases as percentage content of pond ash increases. In addition to this, from figure 4.8 the results shown that the density of concrete specimens increases with an increase in the curing ages at 7^{th}, 14^{th} and 28^{th} days respectively. According to Nurzal, et al., (2018) the longer the drying time, the density increases, due to the chemical reaction between cement and water which causes the concrete become hard after some time, besides, water absorption increases. Drying time of 7^{th}, 14^{th} and 28^{th} days increased density value and reached maximum density value in 28^{th}days drying time.

According to Kalgal, et al., (2007) reported that the average density of concrete, which is slightly lesser than the normal concrete density with sand as fine aggregate. This reduction in density is due to lesser specific gravity of pond ash.

According to Prashant Kumar Sharma, et.al, (2018) revealed that due to lower bulk density and specific gravity of pond ash when compare to fine aggregate causes decrement in unit density of concrete.

4.4. Effect of pond ash on the compressive strength of harden concrete

The compressive strength test of concrete is the most common test type for the hardened concrete, the reasons for these are many codes and design manuals are based on this property and also other properties of concrete depend on the compressive strength when compare other tests. Figure 4.9 below shows a compressive strength test under progress.

Figure 4.9: Compressive strength of concrete being test

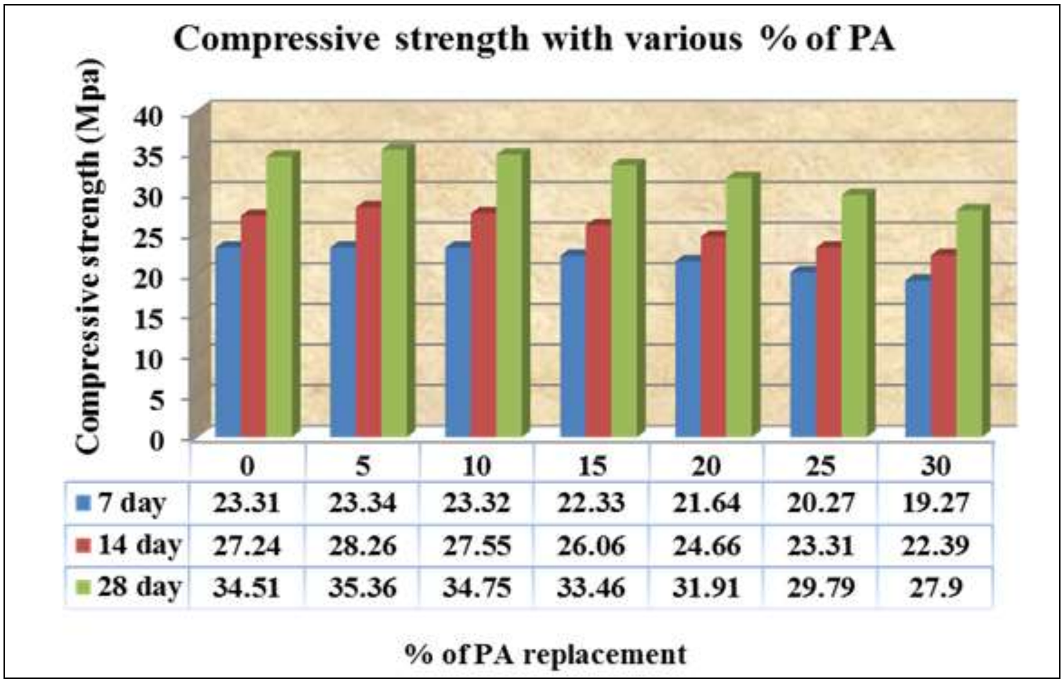
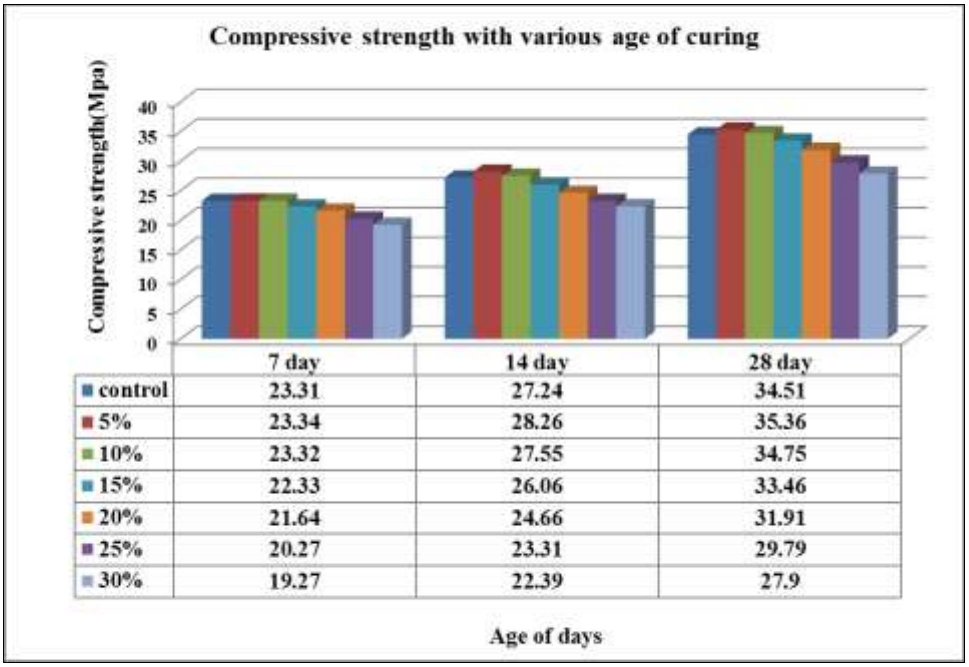


Figure 4.10: Average compressive strength with increasing PA replacement

From the above table and figure result, it can be seen that as the percentage of pond ash content in the concrete increase, the compressive strength decrease. From the pond ash concrete sample containing 5% and 10% the compressive strength has shown improvement compared to the control concrete by about 0.13%,3.74%,2.46% and 0.04%, 1.14%,0.70% respectively at 7, 14 and 28 days. On the other hand, the pond ash concrete sample containing 15% ,20%, 25% and 30% the compressive strength have shown reduction compared to the control concrete by about 4.2%, 4.33%, 3.04%, 7.16%, 9.47%, 7.53%, 13.04%, 14.43%, 13.68% and 17.33%, 17.80%, 19.15% respectively at 7, 14 and 28 days. Therefore, this shown that the compressive strength of concrete increased up to 10% partial replacement of natural sand by pond ash and beyond that percentage of pond ash there is reduction in strength of concrete compared to the control concrete.

According to Kumar, (2015) The addition of pond ash up to 20% replacement of fine aggregate increased the compressive strength at all ages as compared to the control concrete. However, the compressive strength was a maximum at 15% replacement level. At this replacement the compressive strength is 5.78%, 3.19% and 1.60% more than the control concrete at 7, 28 and 56 days respectively.

Shekhar Mahat, et al., (2015) carried experimental studies on the use of Pond ash as Fine Aggregate (FA) in concrete. The properties of Pond Ash were compared to the standard sand. The pond ash added by weight is 10%, 20%, 30%, 40%, 50% and 60% respectively as replacement of FA in concrete. The compressive strength of the concrete with 10% Pond ash replacement as Fine aggregate has higher strength for 3, 7 and 28 days of curing but the strength is higher for 20% replacement for 56 days of curing.



	7 day	14 day	28 day
control	23.31	27.24	34.51
5%	23.34	28.26	35.36
10%	23.32	27.55	34.75
15%	22.33	26.06	33.46
20%	21.64	24.66	31.91
25%	20.27	23.31	29.79
30%	19.27	22.39	27.9

Figure 4.11: Average compressive strength with increasing age of curing

From the above figure result, it can be seen that the percentage value of pond ash increases in the concrete production the compressive strength was decreased, but the compressive strength was increase at the age of curing increases.

4.5. The optimum percentage of pond ash as a partial replacement of fine aggregate in concrete production

In this research the optimum replaced fine aggregate by pond ash was obtained at 10% with the compressive strength was found to be 34.75N/mm^2 at 28 days and with further increases in the percentage of replacement there is decreases in the strength of concrete.

CHAPTER FIVE

CONCLUSIONS AND RECOMMANDATION

5.1. Conclusion

From the research made on effect of pond ash on properties of C-25 concrete, the following points can be concluded from the test result carried out:

From the test result, the pond ash of Ayika Addis Textile had a lower specific gravity, lower bulk density, lightweight and slightly high water absorption when compared to that of fine aggregate.

From the test results obtained, the workability of the pond ash replacement concrete containing up to 10% was good result but, beyond this percentage decreases the slump value of concrete as the pond ash content increases.

According to the observed test result, the unit weight of pond ash concrete sample containing has shown a slight reduction as the PA content increases due to the lower specific gravity of pond ash when compared to that of fine aggregate and also the density of concrete specimens increased with an increase in the curing ages.

From the test result obtained, the compressive strength of pond ash concrete containing with 5% and 10%have shown improvement compared to the control concrete respectively at 7, 14 and 28 days. On the other hand, the pond ash concrete containing 15% , 20%, 25% and 30% the compressive strength had shown reduction compared to the control concrete respectively at 7, 14 and 28 days.
In this research the optimum replaced fine aggregate by pond ash was obtained at 10% with the compressive strength was 34.75 N/mm^2 at 28 days.

5.2. Recommendations

The researcher recommends the following points based on the experimental studies carried out:

- ✓ From the test result of the study, the optimum recommended percentage of PA replacing sand for C-25 concrete production to produce acceptable strength is 10%.
- ✓ Construction company should be used this potential fine aggregate replacement material to enhance the properties of concrete.
- ✓ Through the problem of the reduction in workability of fresh concrete due to the water absorption of pond ash. However, to get better workability in the fresh concrete admixture should be used.

➢ Further studies should be required on the following points:

- Pond ash from different sources of processing factories
- Effect of pond ash on flexural and tensile strength of concrete.
- Study on partial replacement of fine aggregate by pond ash on properties of concrete with admixtures.
- Study on different percentage of pond ash in different properties of concrete to obtain the maximum benefits.
- Study Cost benefit analysis of pond ash over the conventional concrete.

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APPENDIX 1

MATERIALS TEST RESULT

1.1. Properties of Coarse Aggregate

Sieve analysis test result and the standard requirement for coarse aggregate

Sieve	Cumulative passing%	ASTM Limit	
	Coarse aggregate	Lower	Upper
37.5	100	100	100
25	99.36	90	100
19	80.44	40	85
12.5	36.12	10	40
9.5	13.98	0	15
4.75	0.3	0	5

Compact unit weight of coarse aggregate			
Sample	1	2	3
Wt. of cylinder metal(kg)	1.68	1.68	1.68
Wt. of cylinder metal (kg) +wt. Of sample	18.338	18.302	183815
Wt. of sample(kg)	16.658	16.622	16.7015
Volume of cylinder(m^3)	0.01	0.01	0.01
Unit weight(kg/m^3)	1665.8	1662.2	1670.15
Mean	1666.05		

Loose unit weight of coarse aggregate			
Sample	1	2	3
Wt. of cylinder metal(kg)	1.68	1.68	1.68
Wt. of cylinder metal (kg) +wt. Of sample	17.466	17.467	17.4665

Wt. Of sample(kg)	15.786	15.787	15.7865
Volume of cylinder(m3)	0.01	0.01	0.01
Unit weight(kg/m3)	1578.6	1578.7	1578.65
Mean	1578.65		

Moisture content of coarse aggregate		
Sample	1	2
Weight of original sample (g)	2000	2000
Weight of oven dry sample B (g)	1.981	1.9822
Moisture content (MC) %=[A-B/B] *100	0.959	0.908
Mean	0.934%	

Specific gravity of coarse aggregate			
Sample	1	2	Average
Sample mass	2000	2000	
Wt. of oven dry sample(A)	1995	1995.5	
Wt. of SSD sample in air(B)	2003.5	2008	
Wt of saturated sample in water(C) C= D1-D2	1291.5	1259.5	
Wt. of SSD sample in air	2003.5	2008	
Wt. Of sample and basket in water(D1) [gm.]	1755.5	1712.5	
Wt. of empty basket in water(D2) [gm.]	464	453	
Bulk specific gravity=A/(B-C)	2.802	2.666	2.74
Bulk specific gravity (SSD)=B/B –C	2.814	2.683	2.75
Apparent specific gravity=A/A –C	2.835	2.711	2.773
Absorption Capacity=[B-A/A] *100	0.426	0.626	0.52

1.1.2. Properties of Fine Aggregate

Sieve Analysis of fine aggregate			
Sieve Size[mm]	Fine aggregate[2000g]	ASTM Limit	
	Finer passing (%)	lower	Upper
9.5	100	100	100
4.75	100	95	100
2.36	87.70	80	100
1.18	66.95	50	85
0.6	33.75	25	60
0.3	12.25	10	30
0.15	4.25	2	10

Moisture content of fine aggregate		
Sample	1	2
Weight of original sample A (g)	500	500
Weight of oven dry sample B (g)	492.5	492
Moisture content (MC) %=[A-B/B] *100	1.523	1.626
Mean	1.57%	

Compact unit weight of fine aggregate			
Sample	1	2	3
Wt. of cylinder metal(kg)	1.054	1.054	1.054
Wt. of cylinder metal (kg) +wt. of sample	8.882	8.870	8.894
Wt. of sample(kg)	7.828	7.816	7.840
Volume of cylinder(m^3)	0.005	0.005	0.005
Unit weight(kg/m^3)	1565.6	1563.2	1568
Mean	1565.6		

Loose unit weight of fine aggregate			
Sample	1	2	3
Wt. of cylinder metal(kg)	1.68	1.68	1.68
Wt. of cylinder metal (kg) +wt. of sample	8.387	8.492	8.377
Wt. of sample(kg)	6.7075	6.8118	6.697
Volume of cylinder(m3)	0.005	0.005	0.005
Unit weight(kg/m3)	1341.5	1362.36	1339.4
Mean	1347.75		

Specific gravity of fine aggregate			
Sample	1	2	Average
Wt. of sample (A) [gm]	500	500	
Wt. of pycnometer + sample +water(B)[gm]	1853.4	1855	
Weight of pycnometer + water(C)[gm]	1555	1555	
Wt. of oven-dry sample(D)	490.5	493	
Bulk specific gravity=D/(C+A-B)	2.433	2.465	2.449
Bulk specific gravity (SSD)=A/C+A- B	2.48	2.5	2.5
Apparent specific gravity=D/C+D-B	2.55	2.55	2.55
Absorption Capacity (%) =[A-D/D] *100	1.94	1.42	1.68

Silt content before Washing			
Sample	Amount of Silt deposit	Amount of clear sand	Silt content (%)
Sample 1	20ml	280ml	7.14
Sample 2	25ml	285ml	8.77
		Mean	7.95
Silt content after Washing			
Sample	Amount of Silt deposit	Amount of clear sand	Silt content (%)
Sample 1	5ml	165ml	3.03
Sample 2	6ml	290ml	2.06
		Mean	2.54

1.1.3. Properties of Pond Ash

Sieve analysis test for pond ash			
Sieve Size[mm]	Pond Ash [2000g]	ASTM Limit	
	Finer passing (%)		
9.5	100	100	100
4.75	100	95	100
2.36	87.25	80	100
1.18	67.00	50	85
0.6	36.50	25	60
0.3	14.00	10	30
0.15	5.25	2	10

Compact unit weight of Pond ash		
Sample	1	2
Wt. of cylinder metal(kg)	1.054	1.054
Wt. of cylinder metal (kg) +wt. of sample	6.5205	6.521
Wt. of sample(kg)	5.4665	5.467
Volume of cylinder(m^3)	0.005	0.005
Unit weight(kg/m^3)	1093.3	1093.4
Mean	1093.35	

Loose unit weight of Pond ash		
Sample	1	2
Wt. of cylinder metal(kg)	1.054	1.054
Wt. of cylinder metal (kg) +wt. Of sample	4.665	4.666
Wt. of sample(kg)	4.611	4.6115
Volume of cylinder(m3)	0.005	0.005
Unit weight(kg/m3)	922.2	922.31
Mean	922.25	

Specific gravity of pond ash			
Sample	1	2	Average
Weight of sample(A) [gm]	500	500	
Wt. of pycnometer + sample + water(B)[gm]	1757	1756.5	
Weight of pycnometer + water(C)[gm]	1555	1555	
Wt. of oven-dry sample(D)	487	488	
Bulk specific gravity=D/(C+A-B)	1.63	1.64	1.64
Bulk specific gravity (SSD)=A/C+A-B	1.68	1.68	1.68
Apparent specific gravity=D/ C+D-B	1.71	1.70	1.71

Moisture content of Pond Ash		
Sample	1	2
Weight of original sample A (g)	500	500
Weight of oven dry sample B (g)	491.5	492
Moisture content (MC) %=[A-B/B] *100	1.73	1.63
Mean	1.68%	

Silt content of pond ash			
Sample	Amount of Silt deposit	Amount of clear sand	Silt content (%)
Sample 1	7ml	250ml	2.8
Sample 2	6ml	222ml	2.7
		Mean	2.8

Absorption capacity of pond ash		
Sample	1	2
Weight of SSD sample(A)	500	500
Weight of oven dry sample(B)	490.3	490.4
Absorption of pond ash (%) [[A-B/B] *100]	1.98	1.96
Mean	1.97%	

APPENDIX 2

LABORATORY RESULTS

SLUM TEST RESULT

Sr.No	Mix Code	Replacement percentage (%)	Observed slump value	w/c
1	PA_{0}	0	30	0.509
2	PA_{5}	5	28	0.509
3	PA_{10}	10	25	0.509
4	PA_{15}	15	20	0.509
5	PA_{20}	20	18	0.509
6	PA_{25}	25	11	0.509
7	PA_{30}	30	6	0.509

DENSITY TEST RESULT

Density of concrete in FA and different % of PA at 7th days curing

Mix code	% of PA	Age of days	Sample	Dimension(m)10^{-2}			Mass(kg)	Volume (10^{-3}) m^3	Unit weight (Kg/m3)
				L	W	H			
PA_0	0	28	1	15	15	15	8.083	3375	2394.96
			2	15	15	15	7.993	3375	2368.30
			3	15	15	15	7.912	3375	2344.30
								Mean	2369.19
PA_5	5	28	1	15	15	15	7.939	3375	2352.30
			2	15	15	15	7.926	3375	2348.44
			3	15	15	15	8.096	3375	2398.81
								Mean	2366.52
PA_{10}	10	28	1	15	15	15	7.978	3375	2363.85
			2	15	15	15	7.977	3375	2363.56
			3	15	15	15	7.975	3375	2362.96
								Mean	2363.46
PA_{15}	15	28	1	15	15	15	7.977	3375	2363.56
			2	15	15	15	7.959	3375	2358.22
			3	15	15	15	7.961	3375	2358.81
								Mean	2360.20
PA_{20}	20	28	1	15	15	15	7.939	3375	2352.30
			2	15	15	15	7.947	3375	2354.67
			3	15	15	15	7.985	3375	2365.93
								Mean	2357.63
PA_{25}	25	28	1	15	15	15	7.983	3375	2365.33
			2	15	15	15	7.868	3375	2331.26
			3	15	15	15	7.965	3375	2360.00
								Mean	2352.20
PA_{30}	30	28	1	15	15	15	7.876	3375	2333.63
			2	15	15	15	7.927	3375	2348.74
			3	15	15	15	7.979	3375	2364.14
								Mean	2348.84

Density of concrete in FA and different % of PA at 14th days curing

Mix code	% of PA	Age of days	Sample	Dimension(m)10^{-2}			Mass(kg)	Volume (10^{-3}) m^3	Unit weight (Kg/m3)
				L	W	H			
PA_0	0	14	1	15	15	15	7.988	3375	2366.81
			2	15	15	15	8.029	3375	2378.96
			3	15	15	15	8.011	3375	2373.63
								Mean	2373.14
PA_5	5	14	1	15	15	15	7.993	3375	2368.30
			2	15	15	15	8.018	3375	2375.70
			3	15	15	15	7.986	3375	2366.22
								Mean	2370.07
PA_{10}	10	14	1	15	15	15	8.091	3375	2397.33
			2	15	15	15	7.895	3375	2339.26
			3	15	15	15	7.985	3375	2365.93
								Mean	2367.51
PA_{15}	15	14	1	15	15	15	7.987	3375	2366.52
			2	15	15	15	7.964	3375	2359.70
			3	15	15	15	7.991	3375	2367.70
								Mean	2364.64
PA_{20}	20	14	1	15	15	15	7.986	3375	2366.22
			2	15	15	15	7.942	3375	2353.19
			3	15	15	15	7.982	3375	2365.04
								Mean	2361.48
PA_{25}	25	14	1	15	15	15	7.899	3375	2340.44
			2	15	15	15	7.998	3375	2369.78
			3	15	15	15	7.988	3375	2366.81
								Mean	2359.01
PA_{30}	30	14	1	15	15	15	7.956	3375	2357.33
			2	15	15	15	7.949	3375	2355.26
			3	15	15	15	7.958	3375	2357.93
								Mean	2356.84

Density of concrete in FA and different % of PA at 28th days curing

Mix code	% of PA	Age of days	Sample	Dimension(m)10^{-2}			Mass(kg)	Volume (10^{-3}) m^3	Unit weight (Kg/m^3)
				L	W	H			
PA_0	0	7	1	15	15	15	8.017	3375	2375.41
			2	15	15	15	8.018	3375	2375.7
			3	15	15	15	8.028	3375	2378.67
								Mean	2376.59
PA_5	5	7	1	15	15	15	8.003	3375	2371.26
			2	15	15	15	8.007	3375	2372.44
			3	15	15	15	8.005	3375	2371.85
								Mean	2371.85
PA_{10}	10	7	1	15	15	15	8.050	3375	2385.19
			2	15	15	15	7.966	3375	2360.30
			3	15	15	15	7.975	3375	2362.96
								Mean	2369.48
PA_{15}	15	7	1	15	15	15	7.989	3375	2367.11
			2	15	15	15	7.987	3375	2366.52
			3	15	15	15	7.986	3375	2366.22
								Mean	2366.62
PA_{20}	20	7	1	15	15	15	7.976	3375	2363.26
			2	15	15	15	7.988	3375	2366.81
			3	15	15	15	7.975	3375	2362.96
								Mean	2364.35
PA_{25}	25	7	1	15	15	15	7.974	3375	2362.67
			2	15	15	15	7.979	3375	2364.15
			3	15	15	15	7.978	3375	2363.85
								Mean	2363.56
PA_{30}	30	7	1	15	15	15	7.972	3375	2362.07
			2	15	15	15	7.976	3375	2363.26
			3	15	15	15	7.974	3375	2362.67
								Mean	2362.67

COMPRESSIVE STRENGTH TEST RESULT

Compressive strength of concrete in FA and different % of PA at 7th days curing

Mix code	% of PA	Age of days	Sample	Dimension(m) 10^{-2}			Mass(kg)	Volume (10^{-3}) m^3	Peak load (KN)	Compressive strength (Mpa)
				L	W	H				
PA_0	0	7	1	15	15	15	8.017	3375	521.10	23.16
			2	15	15	15	8.018	3375	524.93	23.33
			3	15	15	15	8.028	3375	527.40	23.44
									Mean	23.31
PA_5	5	7	1	15	15	15	8.003	3375	518.85	23.29
			2	15	15	15	8.007	3375	523.13	23.38
			3	15	15	15	8.005	3375	520.20	23.34
									Mean	23.34
PA_{10}	10	7	1	15	15	15	8.05	3375	519.98	23.45
			2	15	15	15	7.966	3375	519.75	23.21
			3	15	15	15	7.975	3375	517.73	23.29
									Mean	23.32
PA_{15}	15	7	1	15	15	15	7.989	3375	505.35	22.46
			2	15	15	15	7.987	3375	502.65	23.34
			3	15	15	15	7.986	3375	499.05	22.18
									Mean	22.33
PA_{20}	20	7	1	15	15	15	7.976	3375	490.50	21.80
			2	15	15	15	7.988	3375	500.40	22.24
			3	15	15	15	7.975	3375	470.03	20.89
									Mean	21.64
PA_{25}	25	7	1	15	15	15	7.974	3375	443.93	19.73
			2	15	15	15	7.979	3375	471.38	20.95
			3	15	15	15	7.978	3375	453.15	20.14
									Mean	20.27
PA_{30}	30	7	1	15	15	15	7.972	3375	412.43	18.33
			2	15	15	15	7.976	3375	445.95	19.82
			3	15	15	15	7.974	3375	442.58	19.67
									Mean	19.27

Compressive strength of concrete in FA and different % of PA at 14th days curing

Mix code	% of PA	Age of days	Sample	Dimension(m) 10^{-2}			Mass (kg)	Volume (10^{-3}) m^3	Peak load (KN)	Compressive strength (Mpa)
				L	W	H				
PA_0	0	14	1	15	15	15	7.988	3375	607.73	27.01
			2	15	15	15	8.029	3375	617.625	27.45
			3	15	15	15	8.011	3375	613.125	27.25
									Mean	27.24
PA_5	5	14	1	15	15	15	7.993	3375	635.625	28.25
			2	15	15	15	8.018	3375	641.25	28.50
			3	15	15	15	7.986	3375	630.45	28.02
									Mean	28.26
PA_{10}	10	14	1	15	15	15	8.091	3375	627.53	27.89
			2	15	15	15	7.895	3375	615.15	27.34
			3	15	15	15	7.985	3375	616.73	27.41
									Mean	27.55
PA_{15}	15	14	1	15	15	15	7.987	3375	593.78	26.39
			2	15	15	15	7.964	3375	571.28	25.39
			3	15	15	15	7.991	3375	594.23	26.41
									Mean	26.06
PA_{20}	20	14	1	15	15	15	7.986	3375	555.75	24.70
			2	15	15	15	7.942	3375	551.03	24.49
			3	15	15	15	7.982	3375	557.55	24.78
									Mean	24.66
PA_{25}	25	14		15	15	15	7.899	3375	521.10	23.16
				15	15	15	7.998	3375	524.93	23.33
				15	15	15	7.988	3375	527.40	23.44
									Mean	23.31
PA_{30}	30	1		15	15	15	7.956	3375	503.55	22.38
		2		15	15	15	7.949	3375	502.43	22.33
		3		15	15	15	7.958	3375	505.35	22.46
									Mean	22.39

Compressive strength of concrete in FA and different % of PA at 28th days curing

Mix code	% of PA	Age of days	Sample	Dimension(m)10^{-2}			Mass(kg)	Volume (10^3) m^3	Peak load (KN)	Compressive strength (Mpa)
				L	W	H				
PA_0	0	28	1	15	15	15	8.083	3375	785.52	34.91
			2	15	15	15	7.993	3375	778.51	34.60
			3	15	15	15	7.912	3375	765.12	34.01
									Mean	34.51
PA_5	5	28	1	15	15	15	7.939	3375	796.19	35.39
			2	15	15	15	7.926	3375	792.68	35.23
			3	15	15	15	8.096	3375	797.63	35.45
									Mean	35.36
PA_{10}	10	28	1	15	15	15	7.978	3375	782.55	34.78
			2	15	15	15	7.977	3375	787.73	35.01
			3	15	15	15	7.975	3375	775.13	34.45
									Mean	34.75
PA_{15}	15	28	1	15	15	15	7.977	3375	757.8	33.68
			2	15	15	15	7.959	3375	749.5	33.31
			3	15	15	15	7.961	3375	751.5	33.4
									Mean	33.46
PA_{20}	20	28	1	15	15	15	7.939	3375	720.23	32.01
			2	15	15	15	7.947	3375	703.35	31.26
			3	15	15	15	7.985	3375	730.58	32.47
									Mean	31.91
PA_{25}	25	28	1	15	15	15	7.983	3375	692.33	30.77
			2	15	15	15	7.868	3375	652.73	29.01
			3	15	15	15	7.965	3375	665.78	29.59
									Mean	29.79
PA_{30}	30	28	1	15	15	15	7.876	3375	617.63	27.45
			2	15	15	15	7.927	3375	620.78	27.59
			3	15	15	15	7.979	3375	644.63	28.65
									Mean	27.90

APPENDIX 3

SAMPLE PHOTO GALLERY

Pond ash sample

	GEOLOGICAL SURVEY OF ETHIOPIA	Doc.Number: GLD/F5.10.2	Version No: 1
	GEOCHEMICAL LABORATORY DIRECTORATE		Page 1 of 1
Document Title:	Complete Silicate Analysis Report	Effective date:	May, 2017

Issue Date: -20/09/2019

Customer Name:- Yeshi Abebe

Request No:- GLD/RN/621/19

Report No:- GLD/TR/527/19

Sample type:- Pond ash

Sample Preparation: - 200 Mesh

Date Submitted: - 10/09/2019

Number of Sample:- One (1)

Analytical Result: In percent (%) Element to be determined Major Oxides & Minor Oxides

Analytical Method: $LiBO_2$ FUSION, HF attack, GRAVIMETERIC, COLORIMETRIC and AAS

Collector's code	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	MnO	P_2O_5	TiO_2	H_2O	LOI
Y-A-01	60.96	27.65	2.40	<0.01	<0.01	<0.01	<0.01	<0.01	0.18	0.55	2.44	6.31

Note: - This result represent only for the sample submitted to the laboratory.

Analysts	Checked By	Approved By	Quality Control
Yirgalem Abriham	Dessie Abebe	Gosa Hailе	Negash Worku
Tihitna Beletkachew			
Tizita Zemene			
Bethelhem Tefera			
Lidet Endeshaw			
Yohannis Getachew			