JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

STRUCTURAL ENGINEERING STREAM

INVESTIGATION ON CONCRETE UTILIZING SECONDARY ALUMINUM DROSS AND CORN COB ASH AS A PARTIAL REPLACEMENT OF CEMENT

A Thesis Submitted to School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Structural Engineering

By

Mandefro Nega Tiruneh

August 2021

Jimma, Ethiopia

JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

STRUCTURAL ENGINEERING STREAM

INVESTIGATION ON CONCRETE UTILIZING SECONDARY ALUMINUM DROSS AND CORN COB ASH AS A PARTIAL REPLACEMENT OF CEMENT

A Thesis Submitted To School Of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Structural Engineering

Advisor: Engr.Elmer C. Agon (Asso.Prof.)

Co- Advisor: Engr. Menberu Elias (M.Sc.)

August 2021

Jimma, Ethiopia

DECLARATION

I certify that research work titled "Investigation on concrete utilizing secondary aluminium dross and corn cob ash as a partial replacement of cement" is my own work. The work has not been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledge/referred and cited.

Mandefro Nega	________	31/ 08 / 2021
Researcher	Signature	Date

Approved by Board of Examiners

1. Engr. Elmer C.Agon , Asso. Prof.________		/ 30 / 08 / 2021
Main advisor	Signature	Date
2. Eng. Menberu Elias , MSc.________		/ 31 / 08 / 2021
Co-advisor	Signature	Date
3. Dr. Binaya Patnaik , Asso. Prof.________		/ 29 / 08 / 2021
External Examiner	Signature	Date
4. Eng. Ibrahim Kedir , MSc.________		/ 31 / 08 / 2021
Internal Examiner	Signature	Date
5. Eng. Abinet Alemseged. MSc.________		/ 31 / 08 / 2021
Chair-Person	Signature	Date

ABSTRACT

Concrete is one of the most widely used construction materials in the world.it is a heterogeneous composite material consisting of cement, water, fine aggregate, and coarse aggregates. The binder of coarse aggregate and fine aggregate is cement. Now a day cost of cement is increased day by day in developing countries like Ethiopia. So it needs development of cementitious materials to replace cement in concrete production with locally available materials especially with those considered as waste namely secondary aluminum dross and corn cob. Corn cob is an agricultural waste product obtained from maize. Secondary aluminum dross is an industrial waste obtained from the secondary aluminum factory. The present study is investigated concrete utilizing secondary aluminum dross and corn cob ash as a partial replacement of cement. This study was a new finding for replacement of cement by hybrid of secondary aluminum dross and corn cob ash and checked its fresh and hardened properties of concrete. Cement has been partially replaced by SAD-CCA in different proportions to study the property of fresh and hardened properties of concrete. Four partial replacements 0%, 4%, 8%, and 12% of cement with SAD-CCA have experimented at constant water-cement ratio of 0.52. twenty-four cube samples of size 150mm×150mm×150mm, twenty-four cylinder samples of size 100mm diameter and 200mm height, and twenty-four beam samples of size 100mm×100mm and length of 500mm were molded and cured at ages of 7and 28 days. The study result revealed that the initial setting time of SAD-CCA blended samples was found to rise with increasing percentage replacement and decreasing final setting time with increasing percentage replacement. Also, the study revealed that beyond 4% replacements with SAD-CCA, the compressive strength was reduced and also flexural and tensile strength has been increased up to 8% when compared with control. Workability of concrete was decreased with increasing percentage replacement of SAD-CCA. The optimum replacement was found to be 4%. The compressive strength, tensile strength, and flexural strength have been increased by 9.63%, 30.52%, and 19.14% respectively for 4% SAD-CCA replacement in the concrete mix when compared with control concrete.

Keywords: *secondary aluminum dross, Corncob, compressive strength, split tensile strength & flexural strength*

ACKNOWLEDGEMENT

First and foremost, I would like to thank God for his blessings and for helping me achieve success in every endeavor of my life.

I would like to express my sincere gratitude to my advisor Engr.Elmer C. Agon (Asso.Prof.) for his useful suggestions and constructive and detailed comments throughout the research work. I also appreciate his expertise and continuous guidance he has given me throughout this study. The completion of this work would have not been possible without his invaluable support and knowledgeable advice.

I would like to extend my sincere gratitude to my co-advisor Engr.Menberu Elias (M.Sc.) who was instrumental in this thesis. He guided me along the entire of the study and continually fueled my knowledge of structural engineering with his experience.

The experimental works of the thesis wouldn't have succeeded the helps of the staff at construction material laboratory of Jit. The success of the experimental investigation was achieved with priceless assistance of Mr.Teklu and Mr. Habtamu. I would like to take this opportunity to express all my gratitude for their professional expertise and kind support.

I want to express my appreciation to my friends here at the Jimma institute of technology for their friendship, their suggestion on various aspects of my research and their generous assistance during the tests.

Last, but not least, I would like to express my deepest love and gratitude to my family and to all those who have directly and indirectly helped me throughout my study.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
BSG	Benshigual Gumiz
C -20 /25	Concrete Having 25 MPa Compressive Strength for cube
CCA	Corn Cob Ash
FM	Fineness Modulus
gm	Gram
ha	Hectare
kN	Kilo Newton
MPa	Mega Pascal
MT	Metric ton
mm	Millimeter
PPC	Portland Pozzolana Cement
RCC	Reinforced Cement Concrete
SSD	Saturated Surface Dry
SAD	Secondary Aluminum Dross
SDA	Saw Dust Ash
SSA	Sub-Saharan Africa
SNNP	Southern Nations, Nationalities and peoples of Ethiopia
IS	Indian standard
UTM	Universal Testing Machines
W/C	Water Cement Ratio

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

Concrete is one of the most widely used construction materials in the world. It is used in different structures that started from the past. In concrete technology, additional materials are needed to improve compressive, split tensile and flexural strength properties of strength.
One of the biggest issues, all over the world is getting affordable house to the community in developing countries, where it is difficult for most people to satisfy basic needs, construction of modern house is a big challenge. Different ways were tried by researchers and scholars to find alternative construction materials. One of the most construction materials is concrete. Concrete is a primary construction material used around the world most widely used in all types of civil engineering works. It is a man-made product, essential consists of cement, fine aggregate, coarse aggregate, water, and admixtures. The binder of coarse aggregate and fine aggregate is cement. Now a day cost of cement is increased day by day in developing countries like Ethiopia.

So one of the practical solutions to reduce cement cost, to enhance strength of concrete and to mitigate environmental impact due to industrial waste, it needs development of cementitious materials or fillers either to replace cement or fine aggregate in concrete production.

In concrete production, replacing the costly construction materials of cement with locally available materials, especially with those considered as waste and to replace cement with supplementary cementitious materials like aluminum dross, corn cob ash, rice husk ash and sawdust ash.

There are two type of aluminum production system ,which are primary and secondary aluminum production .primary aluminum is produced from aluminum oxide (alumina ,Al_2O_3) which is obtained from bauxite, a widespread mineral and secondary aluminum is produced by melting scrap (recycled) metal in furnace(Bird, 1984). Then for this study, we are going to waste from Secondary aluminum production what call it secondary aluminum dross incorporation with corn cob ash.

Corn cob ash (CCA) is agricultural waste obtained from corn cob. Secondary aluminum dross(SAD) is an inevitable byproduct from the secondary aluminum industry and has caused serious environmental issues and forms during the aluminum scrap melting process is an inevitable byproduct from the secondary aluminum industry(Feng *et al.*, 2020).

Corncob is the hard thick cylindrical central core on which are borne the grains or kernels of corn, usually in rows. It is the agricultural waste product obtained from maize or corn. The use of corncob ash will reduce the cost of production of concrete. Nowadays the knowledge of natural pozzolanic materials used as a partial replacement for cement has increased(Owolabi T.A., 2015).

The utilization of waste SAD-CCA in concrete and to enhance the property of concrete achieved if the SAD-CCA used in concrete and not only reduces the pressure on environment but also improved the compressive, tensile strength and flexural behavior of concrete.

1.2. Statement of the Problem

Reinforced concrete structures needs improvement and modification due to the failures occur by performance of the structure during their service life. Concrete structures are highly vulnerable to tensile cracking due to various kinds' effects and applied loading itself. Tensile strength of concrete is very low compared with its compressive strength. In addition to that concrete is a brittle material in nature.

Cement industry is a large contributor to global CO_2 emissions. CO_2 is emitted from the calcination process of limestone , from combustion of fuels in the kiln(Ahmed, Mallick and Abul Hasan, 2016).

The production of cement is one of the environmentally unfriendly processes due to the release of CO2 gases to the atmosphere. It is one of major greenhouse gas.

In addition to its negative environment impact, cement is also one of the most expensive materials when compared to the other constituents of concrete.

Aluminum waste pollutes the surrounding environment and leads to ecological imbalance and corn cob is an agricultural waste product obtained from maize (corn). In Ethiopia large amounts of maize (corn) is produced per year. From that corn there is waste material during the clutch of maize. This trend is also called corn cob. So use that cheap locally available material with incorporation of aluminum waste to improve the properties of concrete and so replace those waste materials for cement to improve strength properties of concrete, limit the pollution of environment and also reduce cost of cement.

Thus, this research has investigated the feasibility of the aluminum waste byproduct dust and corn cob ash which is left as a waste in aluminum factories and corn cob producers for using it as a partial cement replacement material in concrete production.

Past researchers in the world didn't investigate the hybrid of aluminum waste and corn cob ash as a partial replacement for cement. But the researchers did investigate as admixture and as partial replacement for cement separately (individually).

1.3. Research Question

- What is the strength of concrete using hybrid of secondary aluminum dross and corn cob ash?
- What percentage of cement shall be replaced by secondary aluminum dross and Corn cob ash powder to produce an effective concrete mix?
- What is the setting time of cement with and without hybrid of secondary aluminum dross and corn cob ash powder?
- What is the workability of concrete with hybrid of secondary aluminum dross and corn cob ash powder?

1.4. Objective of the Study

1.4.1. General objectives

The general aim of this study was investigation on concrete properties utilizing secondary aluminum dross and corn cob ash as a partial replacement of cement.

1.4.2. Specific Objectives

- To investigate the strength of concrete using secondary aluminum dross and corn cob ash.

- To determine the replacement rate at which secondary aluminum dross and Corn cob ash can be effectively put into service in concrete production.
- To determine setting time of cement with and without hybrid secondary aluminum dross and corn cob ash powder.
- To investigate the workability of secondary aluminum dross and corn cob ash concrete.

1.5. Significance of the Study

The significance of this study is improved strength of concrete and to help reduce the cost of concrete production arising from the rising cost of cement and reduce the volume of solid waste generated from aluminum factory and agricultural development company.

The result of the study could have great importance in addressing the environmental problems due to the aluminum dross and corn cob ash powder producing in aluminum processing factory and agricultural corn crop producer respectively and also minimizing the emission of CO2 to the atmosphere as the result of cement production.

It may also assist the aluminum processing industries, aluminum processing expertize and agricultural corn (maize) producers to plan well effective efficient use of natural resource in Ethiopia.it also believed that the user can grasp the knowledge of how the combination of aluminum waste and corn cob ash with cement can be used in concrete to what percentage it is effective in the production of concrete.
Therefore, the result of the study may have economical and environmental advantages upon successful utilization of aluminum waste and corn cob ash in concrete and improved strength of concrete.

1.6. Scope and Limitation of the Study

It is necessary to clarify the scope of the research topic since partial replacement of secondary aluminum dross and corn cob ash as cement is concerned with the effect, the possibility of utilization and mechanical strength properties in concrete production for C-25 grade of concrete. Through the investigation, the research is limited to secondary aluminum dross and corn cob materials obtained from B and C aluminum factory PLC and Gojeb agricultural development company respectively. Besides those, the research is limited up to 12% of hybrid waste mix.

Hybrid of secondary aluminum dross and corn cob ash in cementitious mix was done up to 28 days. Long term performance is one of the major limitations.

All beams, cubes and cylinders have similar geometry and the same water cement mix ratio. The total length of the test beam was 500mm and the cross section of 100mmx100 mm, for the cubes 150mm x 150mm x 150mm and a cylinder of 100mm x 200mm for split tensile tests. In all concrete mix the raw material was consist of Portland pozzolana cement, chewaka river sand and crushed coarse aggregate, SAD and CCA.

1.7. Structures of the Thesis

The research is organized into five chapters and each chapter contains a number of sections and further subsections. A general introduction provided along with the research objectives, statement of the problem, scope of the research and significance in the first chapter. In chapter two, comprehensive reviews which are related to this study are presented.

Chapter three used entirely to describe methodology and materials used in the research.it explains properties of materials, mix proportioning, mixing, casting and curing procedures used in the attempt to find out in a systematical and scientific study.

Chapter four cover the experimental program of the study, results and discussions of the tests carried out during this study. Conclusions are in chapter five together with recommendations for further research work. This followed by an extensive list of references. The appendix gives the result of individual tests and other relevant data and representative photo taken during the research work.

CHAPTER -TWO

REVIEW OF RELATED LITERATURE

2.1 General

In this section, previous research results are summarized about the topics related to this study.

The study of waste on concrete partial replacement as a cement is not a recent task by investigators. To mention some of literatures which are in connection of this study such as concrete properties, aluminum waste concrete, corn cob ash concrete& normal concrete ingredient materials.

2.2 Concrete

Concrete is a heterogeneous composite materials consisting of cement, water, fine aggregate and coarse aggregates. An aggregate occupy 60 to 80 percent of the volume of concrete. The paste which is formed from cement and water constitutes 20 to 40 percent of the total volume(Ansari and Ameen, 2020).

2.2.1 Major Ingredients of Concrete

The materials used in the manufacture of concrete are known as ingredient of concrete. The ingredient of concrete can be classified in to two groups Active Group: Cement And Water and the second groups is inactive group: Fine and Coarse Aggregate(Ansari and Ameen, 2020).

2.2.1.1 Aggregate

Dinku (2005) studied that Aggregates are known to be particles of rock or equivalent which, when brought together in a bound or unbound condition, form part or whole of an engineering or building structure. Aggregates, both fine and coarse, take about 65-75% by volume of concrete and are important ingredients in concrete production. The parent materials of aggregates are derived mainly from volcanic activity. The dominant rock for coarse aggregate production in Ethiopia is generally basalt while ignimbrite is most commonly used for masonry stone. On the other hand the majority of sand is collected from riverbeds. Compressive strength of concrete is influenced by, among other things, the quality and proportion of fine and coarse aggregate, the cement paste and the paste-aggregate bond characteristics.

According to(Ansari and Ameen, 2020),the size of aggregate shall depend on the types of work and reinforcement. And size should be less than the distance between two consecutive steel bars in RCC and noted that the particle that passes through 4.75 mm sieve and retain on 0.075 mm sieve is known as fine aggregate. The surface area of fine aggregate is higher. The voids between the coarse aggregate are filled up by fine aggregate. It reduces the cost of the concrete and increase the workability of concrete. The main characteristics of fine aggregate which affect in the properties of concrete is bulking. The phenomenon of increase in sand volume due to the increase of moisture content is called Bulking of sand.

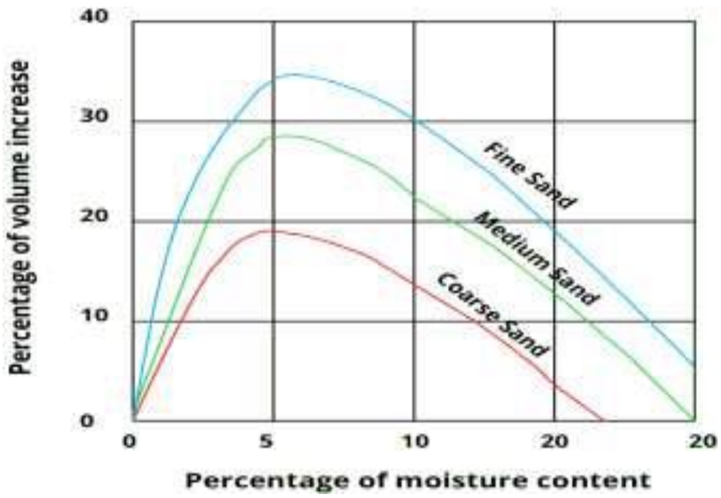


Figure 2.1 Bulking of Sand

According to ASTM C33/C33M-13 the standard sieve size are 75µm, 150µm, 300µm, 0.6 mm, 1.18mm, 4.75mm and 9.5mm for fine aggregate.

The demarcation between coarse aggregate and fine aggregate is a particle size of 4.75mm (in other words, coarse aggregate is defined as an aggregate comprising of particle lager than 4.75mm whereas fine aggregate is defined as an aggregate comprising of particles smaller than 4.75mm).

2.2.1.2 Cement

Cement is the most important ingredient of concrete act as a binding material having both adhesive and cohesive properties. Cement binds the coarse and fine aggregate by filling the voids and chemically reacting with water. It contains about 10% of the volume of concrete mix(Ansari and Ameen, 2020).

Portland cement is the name given to a cement obtained by intimately mixing together calcareous and argillaceous, or other silica-, alumina- materials, burning them at a clinkering temperature and grinding the resulting clinker. A combination of a calcareous material, such as limestone or chalk, and of silica and alumina found as clay or shale(Neville and Brooks, 2010).

The process of manufacture consists essentially of grinding the raw materials into a very fine powder, mixing them intimately in predetermined proportions and burning in a large rotary kiln at a temperature of about 1400 °C (2550 °F) when the material sinters and partially fuses into clinker. The clinker is cooled and ground to a fine powder, with some gypsum added, and the resulting product is the commercial Portland cement(Neville and Brooks, 2010).

Table2.1 The oxide composition limits of Portland cements are:-

Oxide	Content ,percent
CaO	60-75
SiO_2	17-25
Al_2O_3	3-8
Fe_2O_3	0.5-6
MgO	0.1-4.0
Alkalis	0.2-1.3
SO_3	1-3

2.2.1.2.1 Pozzolana Cement

Pozzolan is defined as ‘a siliceous and aluminous material, which in itself possesses little or no cementing property, but will in a finely divided form - and in the presence of moisture - chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. Pozzolans not only strengthen the concrete, they have many other beneficial features(FISSAC, 2016).

ASTM C125 defines pozzolan as'' a siliceous or siliceous and aluminous materials, which in itself possesses little or no cementitious value, but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.

2.3. Consistence of Standard Paste

Consistence is determined by the Vicat apparatus, which measures the depth of penetration of a 10 mm diameter plunger under its own weight. When the depth of penetration reaches a certain value, the water content required gives the standard consistence of between 26 and 33 (expressed as a percentage by mass of dry cement)(Neville and Brooks, 2010).

2.4. Setting Time

This is the term used to describe the stiffening of the cement paste. Broadly by temperature rises in the cement paste; initial set corresponds to a rapid mainly caused by a selective hydration of C3A and C3S and is accompanied speaking, setting refers to a change from a fluid to a rigid state. Setting is rise and final set corresponds to the peak temperature. For the determination of initial set, the Vicat apparatus is again used, this time with a 1 mm (0.04 in.) diameter needle, acting under a prescribed weight on a paste of standard consistence. When the needle penetrates to a point 5 mm (0.2 in.) from the bottom of a special mold, initial set is cement). Final set is determined by a needle with a metal attachment hollowed out so as to leave a circular cutting edge 5 mm (0.2 in.) in diameter and set 0.5 mm (0.02 in.) behind the tip of the needle. The initial and final setting times are approximately related: final time (min.) = 90 + 1.2 [initial time (min.)] (except for high alumina cement)(Neville and Brooks, 2010).

Since temperature affects the setting times, BS EN 196-3: 1995 specifies that the mixing has to be undertaken at a temperature of 20 + 2 °C (68 ± 4 °F) and minimum relative humidity of 65 per cent, and the cement paste stored at 20 + 1 °C (68 + 2 °F) and maximum relative humidity of 90 per cent.

2.5. Corn Cob Ash

2.5.1 Corn Cob Definition

Corncob is the hard thick cylindrical central core on which are borne the grains or kernels of corn usually in rows. It is the agricultural waste product obtained from maize or corn.

Maize is the most important cereal and most widely cultivated staple that plays a key role in the food security of sub-Saharan Africa (SSA)(Abate *et al.*, 2015).

Maize is the second most widely cultivated crop in Ethiopia and is grown under diverse agro-ecologies and socioeconomic conditions.(Abate *et al.*, 2015).

(Abate *et al.*, 2015), have shown that the current performance of maize in Ethiopia compares favorably with the main maize producing countries in SSA. Ethiopia is the only country in SSA outside South Africa that has attained >3 MT/ha yield; only Zambia and Uganda have achieved >2.5MT/ha, followed by Malawi, with >2 MT/ha. The SSA average is about 1.8 MT/ha.

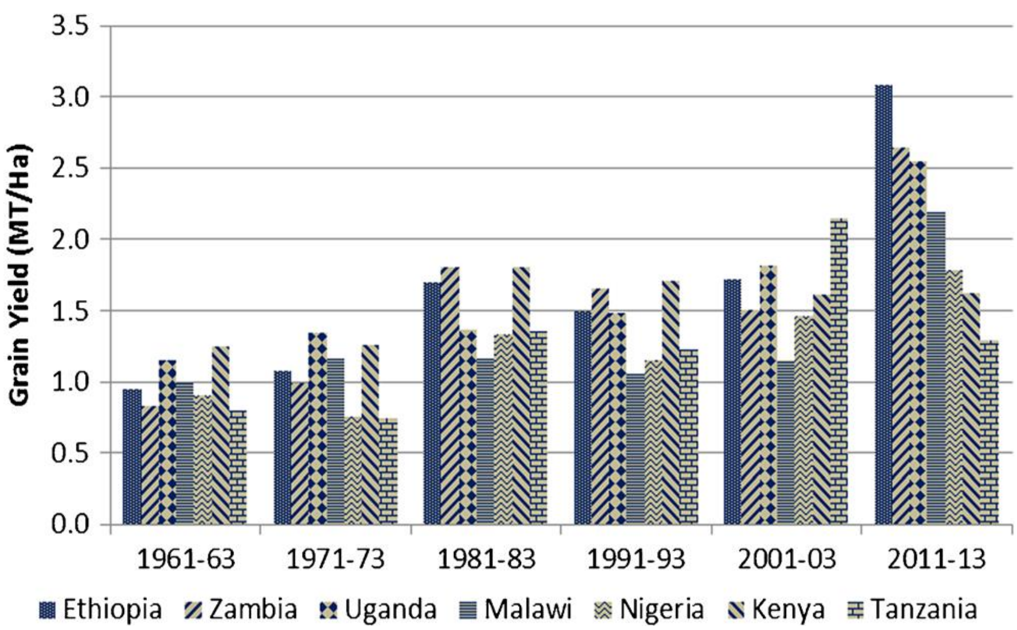


Figure 2.2 Maize yields in selected countries of SSA. Source: constructed by the authors from FASOSTAT, accessed on02/01/2015

Table2.2 Per cent maize area covered by modern varieties in selected administrative regions of Ethiopia (2004–13) (Abate et al., 2015).

Region	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Amhara	24	26	29	37	35	35	45	50	47	55
SNNP	17	23	10	17	20	18	25	32	33	43

Oromia	15	19	14	15	16	-	25	25	33	38
BSG	3	8	0	6	8	-	8	14	10	17
Tigray	1	2	0	0	1	-	1	1	2	3
Ethiopia	14	20	15	20	20	23	29	33	34	40

A) Shows corn crop (maize)   B) shows corn cob

Figure 2.3 Maize and corn cob

2.5.2. Strength of Corn Cob Ash Concrete

Patel *et al.*(2020) found that Corn Cob Ash (CCA) is a suitable pozzolana material because it meets the material requirements by making the combination of SiO2 and Al2O3 more than 70%.The results show that concrete becomes less workable (stiff) due to the increase in CCA percentage, which means that more water is needed to make the mixture more workable. As CCA percentage increase in cement mortar, the initial and final set times increase.

In addition to this,(Patel *et al.*, 2020), observed that the compressive strength of CCA-blended cement concrete is lower than that of plain concrete (the control) at early curing ages but improves significantly at later ages and in fact has higher percentage gain in strength than the later.

P Suwanmaneechot (2015) has observed that the effects of heat treatment on chemical composition, physical properties and engineering properties of corn cob ash. The results suggest corn cob ash that was heat treated at 600^{o}C for 4 h shows percentage of SiO2 + Al2O3 + Fe2O3 around 72%, which can be classified as Class N calcined natural pozzolan as prescribed by ASTM C618.

S and A (2012) observed that the specimens are dark colored with increasing percentage of corn cob ash, and setting time and water absorption took much longer in concretes with the ash content than the ones without the ash. They also showed that density increased as curing age increased and decreased with respect to increasing percentage of corn cob ash replacement in concrete samples and shown that increase in the characteristic strength of concrete cubes as per curing age and decreased as per ash content.

The researcher conclude that findings showed at 10% ash, compressive strength at 28days was 20N/mm² which was less than the control whose value of 24.69 N/mm² falls just below the designed 25 N/mm². However, an important pozzolan characteristic is the slow development of strength which implies that 10% corn cob ash concrete might develop the required strength over a longer period of time. Conclude that Concrete strengths increases with curing age and decreases with increasing percentage of corn cob ash.

Owolabi T.A. (2015) studied on the effect of corncob ash (CCA) as a partial replacement for cement in concrete mixes with CCA at 0, 5, 10, 15, and 20 percentage replacement levels. The researcher conclude that the optimum compressive strength of 21.44N/mm2 was obtained at 5% replacement at 28 days of age which was less than the control whose value of 23.8N/mm² falls just below the designed 25 N/mm².

Abu-lebdeh and Agricultural (2016) investigated compressive strength and workability performance of various CCA blended cements. The CCA was mixed with Portland cement and mixture contained 0% 5% 10% and 15% by weight. The mixture proportion of cement to sand was 1:3, 25% cement to 75% sand. Cubic shape steel molds (50×50×50 mm) were used to cast the mortar and make concrete cubes for compressive strength test. A total of 15 cubes were casted (three cubes for each CCA blend). The researcher concludes that up to 5% CCA found to increase the compressive strength of OPC and enhance insulation performance.

Mujedu, Adebara and Lamidi (2014) studied the workability and compressive strength properties of varying percentage of CCA and SDA cement concrete. They also carried out slump test to check the effect of combination of CCA and SDA on the workability of fresh concrete while also casting concrete cubes with different percentages by weight of combination of CCA and SDA to Portland cement in the order of 0%, 10%, 20%, 30%, 40% and 50%. The concrete cubes were tested at the age of 3, 7, 14, 21, 28, and 56 days. They conclude that the combination of CCA and SDA were a good pozzolan with combined SiO_2, Al_2O_3 and FeO_3 of 76.67% and that the slump value decreased as the combination of CCA and SDA contents increased indicating that concrete becomes less workable as the ashes content increased. They noted that the compressive strength of the concrete cubes increased as the day of curing increased and decreased with increasing ashes replacement. The compressive strength of concrete cubes with the combination of CCA and SDA was lower at early stages but improves significantly up to 56 days. The highest compressive strength was 25.52N/mm^2 and 23.99N/mm^2 at 56 days for 0% and 10% combination of CCA and SDA respectively. The researchers conclude that the use of combination of CCA and SDA as a partial replacement for cement in concrete, particularly in plain concrete works and non-load bearing structures, will improve waste to wealth initiative though only 10% CCA-SDA replacement is adequate to enjoy maximum benefits of strength gain. The researchers later recommended that subsequent studies should be done on 0-50% replacement of cement with CCA and in steps of 5%whiles concretes with the presence of ash content should be allowed to cure for 120 days, by which pozzolanic activity of ash would have been concluded.

Kamau *et al* (2016) experimentally study on corn cob ash powder as partial replacement of cement in concrete mixes with CCA at 10%, 20% and 30% steps. Used mix of 20 MPa was used throughout this study. The concrete samples were tested at the ages of 7, 28, 56 and 90. The researchers tested Compressive strength, Split Tensile strength and Flexural strength and reported that CCA provides a positive effect in the strength development at later ages. Noted that replace 10% of the concrete were good improvement in concrete production.

Owolabi T.A. (2015) examined that effect of corn cob ash as a partial replacement for cement in concrete. Concrete cubes were cast, cured and tested at curing ages of 7, 14, 21 and 28 days using 0, 5, 10 15, and 20 percentage replacement levels. The optimum compressive strength of

21.44N/mm^2 was obtained at 5% replacement at 28 days of age. They conclude that optimum compressive strength of concrete to be attained, a 5% replacement of cement with corncob ash is recommended beyond this it shows reduction of concrete strength.

Olafusi *et al.* (2016) studied that Flexural Performance of Self-Compacting Concrete Containing Corn-Cob Ash. They conclude that Stiffness of SCC beams containing CCA reduces with increased CCA content; while SCC specimens containing 5% CCA have comparable stiffness with the control specimens which can hereby be stated that 5% CCA is the critical amount structurally beneficial.

Taiwo et al(2019) experimentally studied the Partial Replacement of Cement with Corn Cob Ash in Concrete Production. Sixty concrete cubes of size 150x150x150mm with different percentages by mass of corncob ash to Portland cement in order of 0%, 3%, 6%, 9% and 12% corncob ash were cast and crushed. They examined that twenty eight day of compressive strength was satisfied at 3% replacement level, which shows that the 3% CCA replacement for cement is the optimum.

2.5.3 Chemical compositions of corn cob ash

P Suwanmaneechot (2015) experimentally investigated the development of waste CCA as supplementary cement replacement materials. They focused on the effects of heat treatment on chemical composition, physical properties and engineering properties of CCA. The result suggested that CCA that was treated at 600^{0}C for 4h showed percentage of SiO_2 +Al_2O_3 +Fe_2O_3 around 72% which can be classified as class N calcined natural pozzolan, as prescribed by ASTMC618. The x-ray diffraction patterns indicated that the amorphous silica phase increased with increasing calcining temperatures. The water requirement, initial setting time and final setting time of specimens increased with increasing replacement percentage of raw or treated CCA. The researchers observed that CCA that was treated at 600^{0}C for 4 h samples showed slightly higher effectiveness for improving the splitting tensile strength and compressive strength of concrete when compared to the untreated CCA.

Adebisi *et al* (2019) experimental investigated suitability of corn cob ash as partial replacement for cement in concrete. They focused on mechanical performance of corn cob ash concrete and heat treatment on chemical properties of CCA. The result suggested that was heat treated at 650

^{o}C up to converted in to ash and showed the percentage $SiO_2 + Al_2O_3 + Fe_2O_3$ around 89.23 (of above 70 %) . They examined the density and compressive strength of CCA - cement concrete using a 1: 2: 4 mix ratio and a water - cement ratio of 0.5. Cubes of 150 mm x 150 mm x 150 mm dimension with varying percentages by weight of CCA to cement combination in the order of 0 %, 5 %, 10 %, 20 % and 30 % were cast. Tests on concrete were carried out at ages 28, 56, 90 and 120 days. It was observed that concrete produced with up to 20 % CCA – cement replacement can be used for construction purposes.

2.6. Aluminum Waste

Aluminum is a chemical element in the boron group with symbol Al and atomic number 13.

According to(Demand, 2005), Aluminum is the world's most abundant metal and is the third most common element comprising 8% of the earth's crust. It is derived from the mineral bauxite. Bauxite is converted to aluminum oxide (alumina) via the Bayer Process. The alumina is then converted to aluminum metal using electrolytic cells and the Hall-Heroult Process. Pure aluminum is soft, ductile, and corrosion resistant and has a high electrical conductivity. When exposed to air, a layer of aluminum oxide forms almost instantaneously on the surface of aluminum. This layer has excellent resistance to corrosion. It is fairly resistant to most acids but less resistant to alkalis. In addition to this by utilizing various combinations of its advantageous properties such as strength, lightness, corrosion resistance, recyclability and formability, aluminum is being employed.

2.6.1 Production of Aluminum

Aluminum production can be generally separated into primary production based on bauxite from mining activities and secondary production from obsolete material or product flows (waste and scrap)(Schiel, 2020).

2.6.1.1 Primary Aluminum

The primary production of aluminum obtained from natural resources.

The primary aluminum production process consists of three stages: Mining of bauxite, followed by refining of bauxite to alumina by the Bayer process and finally smelting of alumina to aluminum(Rathod, Suryawanshi and Memade, 2014)

2.6.1.2 Secondary Aluminum Production

Aluminum dross (Al dross) is a by- product in the production of aluminum generated in electrolytic aluminum or cast aluminum production process. There are two types of dross.

(1) The "white dross" which is obtained from primary melting operations and may be comprised of oxides of aluminum, magnesium and silicon etc. with about 15 – 70% recoverable metallic aluminum and (2) The "black dross" which is obtained from secondary smelting operations and typically comprised of a mixture of oxides of aluminum / alloys and slag with smaller percentages (12 to 18%) of recoverable aluminum contents(Ramaswamy, Gomes and Ravichander, 2019). This black dross also called secondary aluminum dross.

Secondary aluminum production is the process of recycling aluminum scrap into aluminum that can be used again. So during the re melting of aluminum scrap the rest product formed is the secondary aluminum dross.

Secondary aluminum dross (SAD) is an inevitable by-product from the secondary aluminum industry and has caused serious environmental issues(Feng *et al.*, 2020).

2.7. Environmental Effects of Secondary Aluminum Dross

According to (Wayase *et al.*, 2018), Aluminum dross is toxic and hazardous waste for the environment and so the safe disposal of the aluminum dross as a waste is a burden to aluminum manufacturing companies because its improper and careless disposal affects the eco- system, surface and the ground water.

When these dross particles are allowed to escape into the atmosphere, inhalation can cause health such as

1) Alzeheimers Disease
2) Silicosis
3) Bronchitis

2.8. Strength of Secondary Aluminum Dross (SAD) Concrete

Nduka *et al* (2020) performed an experimental investigation on mechanical and water absorption properties of normal strength concrete (NSC) containing secondary aluminum dross (SAD). SAD was obtained and used to replace cement partially in specified ratios of 5%, 10%, 15% and 20% and concrete cubes and beam were cast and tested in ages of 7,14 and 28 days . it was ,achieving target strength of 25 N/mm2 with 0.55 w/c mix design normal strength concrete for structural elements by blending PC with SAD, The result showed that the compressive, split tensile and flexural strengths of NSCs increased as the curing age increases for both reference mix and SAD blended mix. Addition of SAD in the studied specimen lead to decrease in compressive, split tensile and flexural strengths as the SAD contents increased. It is, therefore, suggested that blend of Portland cement (PC) with SAD content within 10% will be beneficial in the production of normal strength concrete for the structural purpose by the construction industry, while also limiting the impact of the aluminum waste on the environment.

Furthermore, they proved that the water absorption of the reference normal strength concrete mix (SNSC0) as determined on the 28-day was observed to be low compare to samples containing secondary aluminum dross (SAD). This implies that secondary aluminum dross (SAD) addition resulted in higher water absorption with increases for higher substitution of secondary aluminum dross (SAD) content.

Elseknidy, Salmiaton and Shafizah (2020) carried out investigation on mechanical properties of concrete incorporating aluminum dross, fly ash, and quarry dust. They aimed to accomplish was a minimum compressive strength of 30 MPa (M30) with water cement ratio 0.45 at the age of 28 days. This study proposed to partially replace cement with aluminum dross and fly ash, and partially replace natural sand with quarry dust. Aluminum dross, cement, sand, and quarry dust were used in a variety of proportions with a constant percentage of fly ash for the design of nine concrete mixtures. Aluminum dross was replaced by 5, 10, 15, and 20% of the cement mass. At first, the optimum replacement of aluminum dross without using quarry dust was determined at a constant percentage of fly ash-15% based on the strength results. Later, by introducing the optimum substitution of aluminum dross with cement and fly ash, the quarry dust was partially replaced at 10, 20, 30, and 40% of river sand to determine the overall optimum mix. The mechanical and durability characteristics of the concrete using the three mixtures were analyzed. It has been observed that the mechanical and durability characteristics of a concrete mixture incorporating a fly ash-15%, aluminum dross-10%, and quarry dust-20% are better than that of standard concrete. Production of concrete using industrial waste can minimize infrastructure construction costs and reduce environmental impacts.

Reddy and Neeraja (2016) have shown that Mechanical and durability aspects of concrete incorporating secondary aluminum slag. By varied percentage of secondary aluminum slag at

0%, 5%, 10%, and 25% replacement cement. The result showed that the compressive strength, split tensile strength, and flexural strength decrease with increasing aluminum dross content. As the replacement percentage of aluminum dross is increased, more entrapped air occurs and this causes a negative effect on strength. They observed that up to 15% replacement of cement by secondary aluminum dross, the responses are comparable with the conventional concrete. However, at 30% replacement level, concrete cubes were broken.

B (2018) has studied the effect of aluminum dross on properties of concrete with SDA at 5% and 10% for compressive strength. It was mix proportion of M50, cubes of size 15cm x 15cm x 15cm are casted and compressive strength tests are taken on casted cubes of concrete in average of 3 cubes for single result of test. The result showed that the SDA concrete has lesser density than conventional concrete, so it can be used in high raised structures. Up to replacement of 5% of aluminum dross by weight of cement, it shows good properties.

2.9. Treatment of Raw Aluminum Dross

Elseknidy *et al* (2020) they noted that the raw aluminum slag mortar produced showed a noticeable increase in volume. Thus, the use of aluminum slag without prior washing is impractical. So the aluminum dross used was introduced into container containing distilled water; the solid-to-liquid ratio was maintained at 1:6. The mixture of aluminum dross and distilled water was stirred at room temperature for 30 min to remove alkaline and inorganic salts from the aluminum dross sample. Un-dissolved aluminum dross is removed by vacuum filtration and then dried in an oven at 100 ◦C for 12 hrs.

The chemical composition of the treated aluminum dross is shown in table

Table2.3 Chemical composition of aluminium dross

Property	Aluminum Dross (%)
Alumina (Al_2O_3)	19.96
Lime(C_aO)	18.09
Iron oxide (Fe_2O_3)	0.41
Magnesium oxide (M_gO)	0.52
Silica (SiO_2)	57.81

2.10 Water:-

Water is an integral part of construction. If the water quality is not maintained, the buildings get damaged easily.

Water is important in every step of construction. It plays a major role in cement concrete production and governs the strength, workability and curing of the concrete.

Mandar M.Joshi (2019) found that the mixing and curing should be clean and free from injurious quantities of alkalis, acid, oils, salt, sugar, organic materials, vegetable growth and other substances that may be deleterious to bricks, stone, concrete or steel. Potable water is generally considered satisfactory for mixing. The pH value of water should be not less than 6. They conclude that water fit for human consumption is generally acceptable for mixing mortar or concrete and curing work.

Ansari and Ameen (2020) examined that, water which is acceptable for drinking purpose is suitable for making the concrete. The main harmful substance in water for concrete is salt which is present in sea water. The salts present in sea water reduce the strength of concrete, but sometimes it has to be used when there is no alternative. Sea water contains up to 3.5% salt and has tendency to decrease the strength 10% - 20% of the concrete. There is more chance of causes of dampness in building.

Potable water is generally safe ,water not fit for drinking may also be satisfactorily used in making concrete.as a rule ,any water with a PH (degree of acidity) of 6.0 to 8.0 which does not taste saline or brackish is suitable for use ,but a dark colour or a smell do not necessary mean that deleterious substances are present(Neville and Brooks, 2010).

Past researchers in the world didn’t investigate with incorporation of aluminum waste and corn cob ash as a partial replacement for cement. But the researchers did investigated as admixture, as partial replacement for cement separately (individually).So this study is fully differentiate with other previous researches.

CHAPTER THREE

MATERIALS AND RESEARCH METHODOLOGY

3.1. Research Design

In order to achieve the required objectives, both qualitative and quantitative with comparative descriptive and experimental analysis type of the study were applied on the research. The qualitative explains the quality or nature of the materials with in theory while the quantitative shows the numerical amount of each materials used and furthermore the descriptive method is the way secondary aluminum dross and corn cob ash were extracted to made a concrete.

Comparative study is used to compare mechanical strength properties of concrete with partial replacement of cement by SAD - CCA and without replacement of cement by SAD-CCA.

An experimental study has been implemented to manipulate the independent variable and then justified and analyzed the effects of secondary aluminum dross and corn cob ash on workability and mechanical properties of concrete and to find optimum percentage value of SAD-CCA based on the experimental results. Finally, recommendation and conclusions was given based on the approaching experimental results and forwarded recommendation to mitigate the problem.

3.2. Study Variables

3.2.1. Dependent Variables

- Compressive strength of concrete
- Tensile strength of concrete
- Flexural strength of concrete
- Workability of concrete
- Initial and final setting time of secondary aluminum dross and corn cob ash cement

3.2.2. Independent Variables

- Percentage of secondary aluminum dross and corn cob ash

3.3. Data Requirement

The available test machines for the experimental analysis of the cubes, beams and cylinders samples are cones and universal testing machines were used for finding fresh and hardened concrete properties such as;

(i) Workability of fresh concrete
(ii) Compressive strength
(iii) Flexural strength
(iv) Split tensile strength
(v) Setting time

3.4. Sources of Data

The sources of data for this study were collected from both primary and secondary data sources.

3.4.1. Primary Data Sources

The primary data for this research were taken from the laboratory experiments. These experimental results were including workability, setting time, compressive strength, tensile strength, and flexural strength of concrete with and without partial replacement of secondary aluminum dross and corn cob ash as cement for 7 and 28 days of curing time.

3.4.2. Secondary Data Sources

The secondary data for this research were obtained from the works of literature which are related to this investigation (books, published articles, international journals, internets, magazine, and newspaper).

3.5. Population and Sampling Method

By considering the ingredients of concrete mix, two samples were selected, one with partial replacement of cement with SAD-CCA and other without partial replacement of cement with SAD-CCA what it called reference in the mix.

Then the total number of population was the number of cubes, cylinders and beams used as control and the number of cubes, cylinders and beams that was prepared from partial replacement of cement with SDA-CCA at different percentage by weight of cement for treated waste materials. Totally 72 concrete specimens were casted from which 24 specimens were used as control specimen. The test was taken at 7 and 28 days with minimum of three of sample for flexure test, split tensile test and compressive test and tested their mechanical properties of concrete.

Table3.1 Sample population

Total number of sample at 7 and 28 day				
Replacement of SDA-CCA Mixes	Cubes samples	Cylinder samples	Beam sample	Total number of sample
0%	6	6	6	18
4%	6	6	6	18
8%	6	6	6	18
12%	6	6	6	18

For this study, totally 24 samples of cubes, 24 samples of cylinders and 24 samples of beams were casted and their mechanical properties were tested. Hence the total number of sample for the study was 72 samples.

3.6. Data Collection Process

For this research, wasted aluminum dross and corn corncob (SDA-CCA) was used for partial replacement of cement in concrete mix. The shape of the dross is irregular, with a black color containing small pieces of aluminum.

Throughout the study, aluminum dross obtained from B and C Aluminum factory PLC in Addis Ababa and corn cob obtained from Gojeb Agricultural development Company in Jimma Zone were used as cement replacement.

Figure 3.2 Photos taken during the collection of aluminium dross from Addis Abeba

3.7. Data Presentation and Analysis

The data is quantitative. The data collected from experiment have been selected, processed, and analyzed. Then data were presented by tables, graphs, and charts.

3.8. Materials Used

Materials that have been used are cement, aggregate, water, secondary aluminum dross and corn cob ash with specification for convention concrete. In reference to this study, conventional concrete signifies the usual concrete which contains cement, water and aggregate as basic constituents.

3.8.1. Tests on Aggregates

Aggregates are material used as filler with cement paste in concrete. It is important to obtain right type and quality of aggregate to produce good quality of concrete.

3.8.1.1. Coarse aggregate

Crushed stone, gravel and broken brick are some of aggregate materials which is available as a coarse aggregate in production of concrete. The aggregate used in this experimental investigation was crushed stone with maximum diameter of 20 mm which was free from vegetable and dusts. Excess of fines in coarse aggregates were removed through the use of sieving with 4.75mm sieve diameter to satisfy the requirements of ASTM C33. The detail procedures for finding the aggregate properties was outlined in Appendix A. The following table shows summary of physical properties of coarse aggregate.

Table3.2 Physical properties of coarse aggregates

Aggregate	Apparent specific gravity	Bulk specific gravity(SSD)	Bulk specific gravity (oven dry)	Absorption Capacity (%)	Moisture content (%)	Unit weight (kg/m^3)
Coarse	2.91	2.86	2.84	0.91	0.7	1714

Measure the weight of aggregate By balance   dried saturated aggregate   record the weight of aggregate

Figure 3.3 Photos captured during coarse aggregate testing

3.8.1.2 Fine Aggregates

Fine aggregate can be naturally available or manufactured by crushing aggregate. In this study natural sand was used. This river sand collected from Chewaka River having maximum size of 4.75mm was used. Each physical properties of fine aggregate required for the mix design as per the specification had done in the laboratory. The detail procedure and result were outlined in Appendix A. The following table shows summary of physical properties of aggregate.

Table3.3 Physical properties of fine aggregates

Aggregate	Apparent specific gravity	Bulk specific gravity(SSD)	Bulk specific gravity (oven dry)	Absorption Capacity (%)	Moisture content (%)	Unit weight (kg/m^3)
Fine	2.8	2.76	2.74	0.8	0.4	1604

Washing of Sand   Weight of pycnometer+sample+water   measuring weight of sand

Figure 3.4 Determination of physical property of fine aggregate.

3.9. Cement

Cement is a binding material in the concrete. Some function of cement is:

- Binding the aggregate
- Provide the strength for concrete
- Fill up the void existing in concrete

Portland pozzolana cement (PPC) [Dangote product cement with grade of 32.5R] was used throughout experimental analysis.

3.10. Water

Water is very important component in the concrete production. It hydrates the cement and make concrete workable .Generally water is satisfactory for drinking is also for use in concrete. In this study potable water suitable for human consumption, fresh, clean, free from organic impurities and salt have employed throughout the experiment.

3.11. Aluminum Dross

Throughout the study, aluminum dross obtained from B and C aluminum factory PLC in Addis Ababa. The shapes of the dross are irregular with black color and containing small pieces of aluminum.

3.11.1. The Process of Preparing Secondary Aluminum Dross for Use

(i) Collecting secondary aluminum dross (waste) from B and **C** aluminum PLC factory in Addis Ababa.

(ii) Sieved the secondary aluminum dross using 90 µm sizes to remove aggregate and made a powder by obey standard specification such as IS 4031.

(iii) Thus, the use of aluminum slag/dross without prior washing is impractical. The aluminum dross was filled into a container containing distilled water and stirred at room temperature for 30 minutes to remove alkaline and inorganic salts from the aluminum dross sample. Undissolved aluminum dross is removed by vacuum filtration and then dried in an oven at $105^{o}C \pm 5^{o}C$ for 12 hrs. The washing procedure was based on the literature of (Elseknidy, Salmiaton and Shafizah, 2020).

A Collection of dross from factory

B sieved the dross using 90 µm

C washed for 30min

D Filtration of dross

E dried dross after oven dry exit

Figure 3.5 Photos shows the steps of SAD preparation

Table3.4 Chemical composition of secondary aluminium dross

Property	Aluminum Dross (%)
Alumina (Al_2O_3)	19.96
Silica (SiO_2)	57.81
Iron oxide (Fe_2O_3)	0.41
Magnesium oxide (MgO)	0.52
Lime(CaO)	18.09

3.12. Corn Cob Ash

The corn cob used for this study was obtained in dry form from Gojeb agricultural development company which is located 100 km from Jimma town.

3.12.2The Process of Preparing corn cob ash for Use

(i) Collected the corn cob in dry form from Gojeb Agricultural Development Company in Jimma zone.

(ii) The corn cob was sundried for one week and later grinded manually into smaller size to enhance adequate combustion.

(iii) Finally, the cobs were then burnt at furnace of Jimma Institute of Technology, school of civil and Environmental Engineering highway laboratory in to ash at maximum temperature 650^{o}C. The burnt ash was then sieved through standard sieve of 90µm.The CCA resulting from combustion was used in experiment. The combustion procedure was based on the literature of (Adebisi *et al.*, 2019). And also found that X - ray fluorescence machine was employed in the analysis of the ash to know the chemical element and oxide composition of CCA as shown in table 3.5.

Corn cob Adjusted furnace temperature adjusted temperature

D

Combustion of Corn Cob

E

Sample of Corn Cob Ash

Figure 3.6 Combustion of corn cob using furnaces

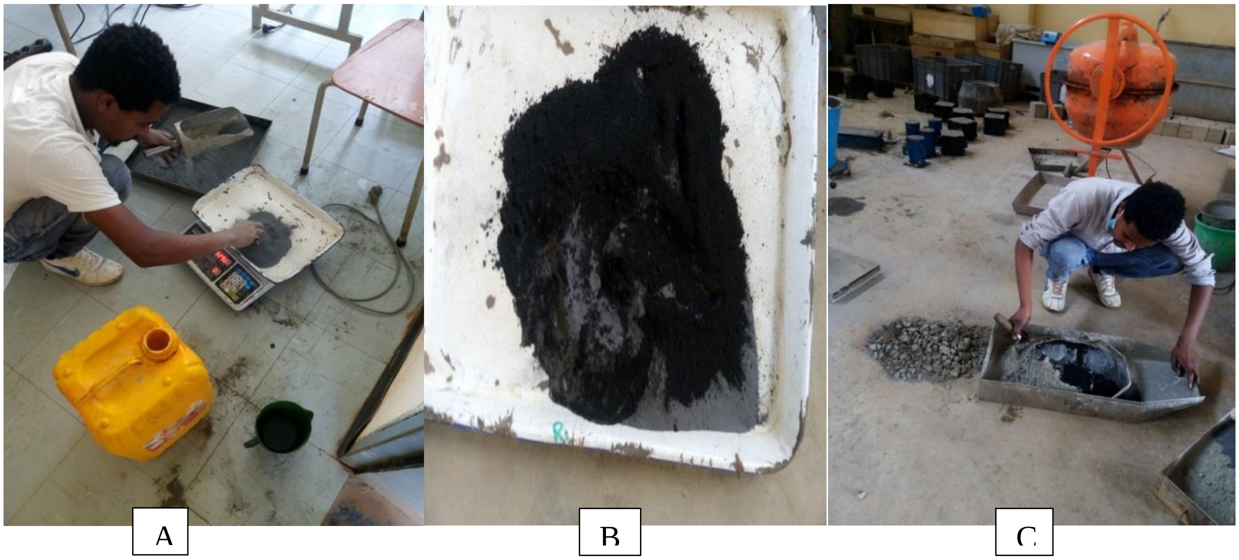
Table3.5 The chemical composition of Corn Cob ash

Constituents	Percentage Composition of CCA
Aluminum Oxide (Al_2O_3)	17.9
Silicon dioxide (SiO_2)	62.2
Potassium Oxide (K_2O_3)	2.61
Calcium Oxide (CaO)	2.96
Manganese Oxide(Mn_2O_3)	1.69
Iron Oxide (Fe_2O_3)	9.13
Copper Oxide (CuO)	0.22
Titanium Oxide (TiO_2)	0.49
Potassium Oxide (K_2O_3)	2.13

3.13. Mixing Procedure of Aluminum Dross and Corn Cob Ash with Cement

First prepared the material and measured the weight of aluminum dross and corn cob ash using balance based on mixing design. Then mixed aluminum dross and corn cob ash with optimum percentage first and rub the hybrid powder slightly till it get homogenous mix in dry form.

Thereafter, those mixed material were added with measured weight of cement and mixed by trowel. The following figure shows mixing of SAD, CCA and Cement.



Measuring Weight of Ash | Mixing Of SAD and CCA | Mixing Of SDA, CCA and Cement

Figure 3.7 mixing procedures of secondary aluminium dross corn cob ash and cement

3.14. Concrete Mix Design and Specimen Preparations

3.14.1. Mix Design

Concrete mix design involves a process of preparation in which a mix of ingredient creates the required strength and durability for concrete structure.

This study was done for C-25 grade concrete with mix design as per ACI procedures. The control mix has ratio of 1:1.91:2.999(cement: fine aggregate: coarse aggregate) which was adapted for this work with a constant water-cement ratio 0.52. It was making mixes containing SAD-CCA; the amounts of ash were calculated as 4%, 8% and 12% by weight proportion of cement in concrete. The Mix design procedures (steps) as per ACI code have mentioned as follows.

Step 1: The desired strength is 25MPa

Step 2: Choice of the slump. The expected slump for workability selected as between 25mm-100mm

Step 3: Choice of nominal maximum aggregate size. The coarse aggregate used for this study has nominal maximum size of 20mm.

Step 4: The concrete is non-air entrained since the structure is not exposed to sever weather as per ACI code for 20 mm aggregate size the total density of water is 185kg/m^3

Step 5: Selection of water cement ratio. The water cement ratio was required for non-air retained concrete of 25MPa compressive strength

- From strength point of view the estimated water-cement ratio is 0.62
- From the Exposure condition the estimated water to cement ratio is 0.5

Taking the minimum of the two values, the adopted water cement ratio to be used for the mix design is 0.5

Step 6: Determination of cement content. From the above developed information in step 4 and 5, the required cement content equal to estimated mixing water (step4) divided by water cement ratio (step5)

Cement $=\frac{185}{0.5}=370\text{kg/m}^3$

Step 7: Determination of coarse aggregate content, the quantity of coarse aggregate is estimated from bulk volume of dry rodded gravel. From ACI table 11.4 for maximum size of 20 mm coarse aggregate and fineness modulus of sand 2.8, the dry rodded bulk volume of coarse aggregate is 0.64per unit volume of concrete

The quantity of coarse aggregates is

$0.64\times1714=1096.96\text{kg}$

The SSD mass of aggregate become $=1096.96\times\left(1+\frac{0.91}{100}\right)=1106.94\text{kg}$

Step 8: Determination of volume of fine aggregate.in volume method, the absolute volume of mixes ingredients per unit cubic meter volume of concrete on volume basis is.

Cement $=\frac{\text{weight of cement}}{\text{specific gravity}}=\frac{370}{2.9\times100}=127586.207\text{cm}^3=0.12759\text{m}^3$

Water $=\frac{185}{1*1000}$=185000cm^3=0.185m^3

Coarse aggregate=$\frac{1096.96}{2.86*1000}$=378262.069cm^3=0.3783

Air (2%) $=\frac{2}{100}$=0.02

Total volume without sand=0.12759+0.185+0.3783+0.02=710900cm3=0.7109m^3

Therefore, absolute volume of fine aggregate =1-(0.12759+0.185+0.3783+0.02)= 289151.72cm^3=0.2892m^3

Absolute weight of fine aggregate=0.2892×2.76×10^3=798.058759kg/m^3

Therefore, the mass of ingredients per cubic meter of concrete on dry weight basis is:

Cement = 370 kg

Water = 185 kg

Coarse Aggregate = 1096.96kg and Sand (fine aggregate) = 798.059kg

Step 8: Filed adjustment for moisture in the aggregate. Hence the aggregate will be neither surface saturated (SSD) nor oven dry (OD) in the field, it must be adjust the aggregate weights for the amounts of water contained in the aggregate. Then absorbed water does not become parts of the mix water, only surface water need to be considered.

Fine aggregate has surface moisture of 0.4%.

Weight of fine aggregates=705.85kg/m^3

Coarse aggregate absorbs 0.91% of water.

Weight of coarse aggregates=1106.94kg/m^3

Adjust the amount of water based on moisture content

The required mixing water=(185-798.059)×(0.004-0.0091)-1096.96(0.007-0.008)=191.763kg/m^3

Table- final design mix proportion

Ingredients	Cement	sand	gravel	Water

quantity				
(kg/m^3)	370	705.8522	1106.94234	191.76318
Ratio	1	1.91	2.99	0.52
One bag Cement,Kg	50	95.38543	149.586802	25.913943

Step 9: secondary aluminum dross and corn cob ash mix design for each percent.

Concrete without secondary aluminum dross and corn cob ash (SDA-CCA) was used as control mix whereas ,3%SAD+1%CCA,6%SAD+2%SAD and 9%SAD+3%CCA were prepared to investigate the effect of secondary aluminum dross and corn cob ash as a partial replacement for cement by weight in concrete production.

Table3.6 Proportions of cement and secondary aluminium dross for 0%, 4%, 8% and 12%

Replacement In percent [%]	Dangote PPC with 32.5R Grade cement [kg]	Secondary aluminum dross[kg]	Corn cob ash[kg]
0	33.86	0	0
3%SAD+1%CCA	32.51	1.02	0.3386
6%SAD+2CCA	31.15	2.03	0.68
9SAD+3CCA	29.80	3.05	1.01

3.14.2. Mixing, Casting and Curing of Samples

First measured the weight of coarse aggregate, fine aggregate, cement ,secondary aluminum dross and corn cob ash based on mix design and mixed secondary aluminum dross and corn cob ash first then ,added with cement. Before adding the ingredients of concrete in to the mixer, interior parts of the mixer was cleaned by potable water and mixed the aggregate homogenously for a moment in concrete mixer. This was followed by the addition of cement and around one third of total mixing water by estimation. After some minute of mixing, the remaining mixing water was added. Finally mixing is ceased after all mix when homogenous mixture has obtained.

Before casting all the cubic molds, cylinder molds and beam molds were cleaned and internal parts of molds were oiled properly. Clean and oiled mold for each category was filled with concrete in three layers and tamped 25 times each layer with the tamping rod for compaction. The specimens were left in the steel molds for 24hrs. After 24 hours the specimens were remove from the molds and kept in the curing tank with potable water. The specimens were fully immersed in potable water for 7 and 28days. After the completion of curing all the specimens were tested.

A) Compacting using metal roads B) curing tank

Figure 3.8 shows casing and curing of samples

3.15. Experimental Program on cement

This test was conducted to determine the effects of replacing parts of Portland pozzolan cement with secondary aluminum dross and corn cob ash on consistency and setting time of blended cement. The Portland pozzolan cement tested first on its consistency and setting time and taken as a control, thereafter secondary aluminum dross and corn cob ash with cement was done. Finally compared the result of control mix and partial replacements of secondary aluminum dross and corn cob ash for cement and clarified its initial and final setting time.

3.16. Normal Consistency Test

For the determination of the initial setting time, final setting time and neat cement past of a standard consistence has to be used therefore, it is necessary to determine for any given cement the water content which will produce a paste of standard consistence. Consistence is determined by the Vicat apparatus, which measures the depth of penetration of 10mm diameter plunger under its own weight. When the depth penetration reaches a certain value, the water content required gives the standard consistence of between 26 and 33 expressed as percentage by mass of dry cement.

In this experiment the normal consistency test for control and blended cement were conducted for different mixes. The test has showed change in water requirement of paste due to replacement of cement by secondary aluminum dross and a corn cob ash as per ASTMC187 test procedure.

Figure 3.9 Procedure of consistency of cement and blended cement

3.17. Setting Time

Setting refers to a change from a fluid to a rigid state. General speaking, it is used to describe the stiffening of the cement paste. the initial setting time of the paste was determined by the duration of 25mm penetration of vicat needle into the paste in 30 seconds after it was released while the final setting time was determined by measuring the time related to zero penetration of the needle into past. According to ASTM 150, initial time of setting not less than 45 minutes and final time of setting not more than 375 minutes however the procedure was followed by (ASTMC191-82., 2004)ASTMC191-82.

3.18. Test Conducted On Concrete

The main tests conducted on this research are basically divided into two. These are tests performed on fresh concrete used to test workability of concrete and tests done on hardened concrete which include compressive strength test, flexural strength test and split tensile strength test.

3.18.1 Test on Fresh Concrete

Fresh concrete is defined as concrete at the state when it is components are fully mixed but its strength has not yet developed. The properties of fresh concrete directly influence the handling, placing and consolidation, as well as the properties of hardened concrete. Workability of concrete mix is the relative ease with which concrete can be placed, compacted and finished without separation or segregation of the individuals of materials.

It is used for two reasons:-

- ❖ If the concrete mixture is too dry it will be difficult to handle and placed it in the right potion
- ❖ If the concrete mixture is too wet coarse aggregate settle at the bottom of concrete mass and as the result concrete become non uniform composition.

Hence to check the workability of fresh concrete for this study were used two methods namely slump test and compaction factor test.

3.18.1.1 Slump Test

The slump test is widely used to measure the workability of fresh concrete. It measures the consistency of specifically prepared fresh concrete bach. The test was conducted according to ASTMC143 specification using slump cone. Standard slump cone 300mm high with a bottom diameter of 200mm and 100mm upper diameter was used. The mold was cleaned and freed from any surface moisture and then the concrete have been placed in three layers. Each layer was tamped 25 times by standard tamping rod (16mm diameter, 600mm length). Immediately after filling, the cone was slowly lifted. After cone was lifted vertically upwards, so as not disturb the fresh concrete and the slump was measured using a rod and a ruler. The slump measured was the vertical distance between the top of the mold and the top surface of the specimen.

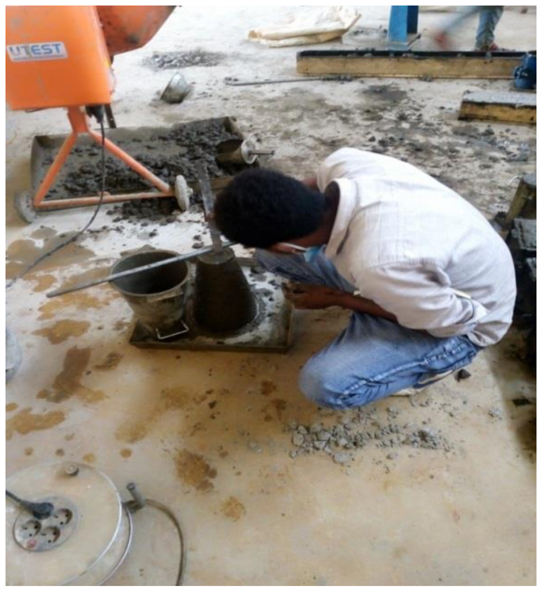


Figure3.10 Slump test

3.18.1.2 Compaction Factor Test

Compaction factor test is an alternative way of measuring workability of concrete and it is more precise than slump test and particularly useful for concrete mixes of low workability.

The test has performed in the following steps/procedures

Steps 1: Cleaned the internal part of the molds

Step 2: The samples of concrete have been placed gently in the upper hopper using the hand scoop.

Step 3: Opened the trap door of hopper then, concrete falls into the lower hoper, the concrete sticking to the sides of upper hopper pushed down ward by steel road.

Step 4: Immediately after the concrete has come to rest, the cylinder should be uncovered and trap door of the lower hopper was opened then the concrete allowed fall into the cylinder.

Step 5: Excess of concrete above the level of top of cylinder was cut off by holding a trowel.

Step 6: Weigh the cylinder with concrete. This weight is known as weight of partially compacted concrete (W1)

Step 6: Empty the cylinder and refill it in three layers and has compacted each layer till 100 Percent compaction is achieved.

Step 7: Leveled the top surface of the cylinder

Step 8: Wipe off and cleaned the outside surface of the cylinder and weigh the cylinder with fully compacted concrete.(the weight is called as the weight of fully compacted(W2)

Step 8: Determined the weight of empty cylinder

Step 9: Calculate the value of compaction factor using the following formula

$$Compaction\ Fator = \frac{\text{weight of partially compacted concrete}}{\text{weight of fully compacted concrete}}$$

A) Compaction factor test apparatus   B) fresh concrete added to the compaction test apparatus

Figure 3.11 Compaction test

3.19. Tests on Hardened Concrete

3.19.1 Compressive strength

Compressive strength can be defined as the capacity of concrete to withstand loads before failure. It has high strength in compression and weak in tension.

Specimens for the testing compressive strength of concrete were prepared by filling 150mm×150mm×150mm dimension cubical steel molds. The mix was containing partial replacement of cement with SAD-CCA by percentage of 0%, 4%, 8% and 12% by weight proportion. After 24 hours the specimens were removed from the molds and placed in curing thanks containing clean water. Three identical samples were prepared from each percentage partial replacement of cement with SAD-CCA powder and without replacement and their compressive strength determined after 7 and 28 days of curing using an automatic compression testing machines which has a capacity of 2000KN. The load was applied through the testing machines by gradually increasing rate of loading until failure occurs. The average compressive strength of three identical cubes was used to determine the compressive strength of each concrete mix. Comparison was done for each cube specimen containing partial replacements of cement by SAD-CCA with that of control specimen.

The compressive strength was calculated from the formula:

$$Compressive\ stress(\sigma) = \frac{peak\ load}{cross\ sectional\ area\ of\ th\ cube\ specimen} = \frac{P}{b \times d}$$

Where P=Peak Load

b=d= Width of the Specimen

A) Cleaned the crushing machines B) cubes on machines C) UTM displayed machines

Figure 3.12 Compressive strength tests machines using under UTM and the displayed result.

The strain corresponding point of compressive stress was determined by using displacement gauge which was attached on the compressive strength test machines before applying the load to the cubes specimen. During compression test the strain gauge was fitted to the compression testing machine so as to take the reading for strain stress diagram. The deformation (Δh) of specimens was recorded gradually from the gauge with respect to each load increment and strain was calculated by dividing deformation to the height of the cube specimen (h). The stress was caused due to applied compressive loading to the cube during the testing and it varied with respective gauge reading. From the result of compressive strength test, the stress strain diagram was analyzed and comparison was done for each partial replacement of cement by SAD-CCA with control specimen. The detail stress strain results obtained for all the samples at each curing day for different mix percentages are listed in Appendix B.

$$\varepsilon=\frac{\Delta h}{h}$$

Where

ε-is the corresponding strain

Δh- is the change in the depth of cube at different loading read from the gauge.

h- The original depth of the cube which is 150mm for this research.

3.19.2 Split Tensile Strength Test

Concrete is not expected to resist the direct tension because of its low tensile strength and brittle in nature. However determination of tensile strength is necessary to determine the load at which the concrete members may crack. The test was conducted as per ASTM-496-90 specification for split tensile strength. The samples were casted using steel cylindrical molds with the dimensions of 100mm diameter and 200mm length. After 24 hours the samples have removed from the molds and placed in curing tank for 7 and 28 days of curing period. The standard cylindrical concrete specimen was placed horizontally between the loading surfaces of the compression testing machine. The compression load has applied uniformly along the length of cylinder and the failure load recorded. A strip wood have placed between the specimen and the loading surfaces to ensure uniform distribution of the applied and preventing high magnitude of loads at the points of application. The failure of the cylinder was along the vertical diameter with respect to placed position during test. The average split tensile strength of three identical cylinders has used to determine the tensile strength of each concrete mix. Based on the result, comparisons have been made for each partial replacement of cement by SAD-CCA with control.

The splitting tensile strength of the specimen has calculated as follows:-

$$f_{ct} = \frac{2p}{\pi L d}$$

Where, f_{ct}=splitting tensile strength

L=length of the cylinder specimen

d=diameter of cylindrical specimen

p=maximum applied load by testing machine

A) Placing the sample in the machines B) cylinder sample in machines C) displayed machines

Figure 3.13 Split tensile strength SAD-CCA concrete under displayed UTM machine

3.19.3. Flexural Strength Test

Flexural strength is the ability of a beam to resist failure in bending. It is measure of an unreinforced concrete beam or slab to resist failure in bending .The test has been carried out as per ASTMC78 standard specification requirement. Hence the flexural test beams with standard dimension of 100mm*100mm*500mm molds size has been used. The concrete mix contains partial replacement of cement with incorporation of SAD-CCA at 0%, 4%, 8% and 12% by weight of cement. However, in the laboratory room was not enough flexural mold, so wooden formwork have fixed with equal dimension of steel mold (100×100×500) and used for casting the beam. The molds have been filled by plain concrete considering 0% SAD-CCA replacement as control specimens and others for the same dimension of molds have been filled by concrete which has mixed with partial replacement of cement with SAD-CCA at 4%, 8% and 12% by weight. After 24hours the specimens have been removed from molds and placed in curing tank. This test has been done on 7and 28 days of curing period. The beam has been placed horizontally on the supports of flexural testing machines and load applied to the beam by gradually increasing rate until failure occurs. Two points loading has been used for the purpose of allowing the uniform distribution of bending moment between the loading nodes. Finally comparisons and conclusion have been made based on the laboratory results.

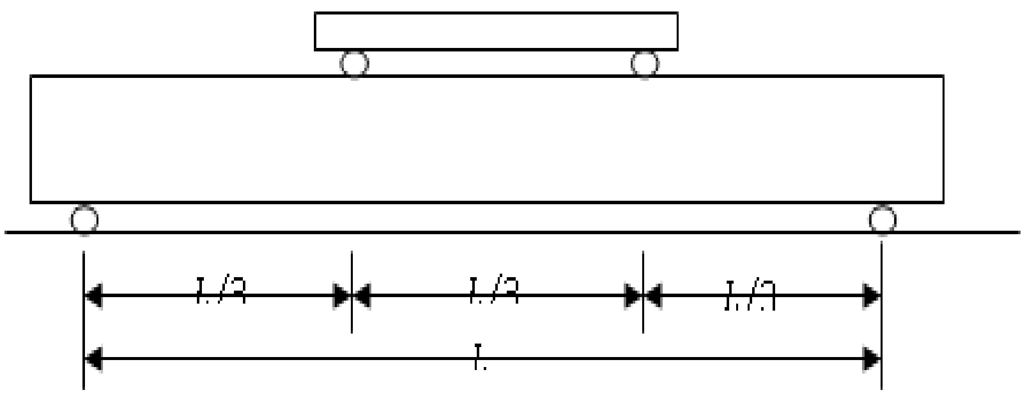


Figure 3.14 Two points loading of beam specimen

$$R= \frac{PL}{bd\hat{}2}$$

Where

R= modulus of rupture (MPa)

P=maximum applied load indicated by testing machines (kN)

L=span length (cm)

d =average depth of specimen at the fracture (cm)

b=average width of specimen at the fracture (cm)

Figure 3.15 Flexural strength tests

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Sieve Analysis

The sieve analysis determines the gradation (the distribution of aggregate particles, by size within a given sample) in order to determine compliance with production control requirements and verification specification.

Sieve analysis was done to determine the fineness modulus of aggregates and the relative amounts of particle size distribution of particle in the aggregate using sieve series of square or round openings starting from the large at the top or lager size. The sieve have arranged in descending order of size from top to bottom.

The coarse aggregate sieve analysis have been done for coarse aggregates passing sieve size of 37.5mm and retained on sieve size of 4.75mm according to ASTM sieve size. Accordingly the upper and lower bound limit for coarse aggregate particle size distribution are shown below in Table 4.1.

Table4.1 Sieve analysis for coarse aggregate

Sieve Size [mm]	Mass of samples		Wt. Retained [g]	% retained	Cumulative %retained	Cumulative %passing	Specification %passing		Remark
	trial 1	trial 2					ASTM Min	ASTM Max	ok
37.5	0	0	0	0	0	100	100	100	ok
28	501.6	491	496.3	9.926	9.926	90.074	90	100	ok
19	2228	2230	2228.8	44.576	54.502	45.498	40	85	ok
12.5	1419	1429	1423.8	28.476	82.978	17.022	10	40	ok
9.5	621	623	622	12.44	95.418	4.582	0	15	ok
4.75	225.6	224	224.6	4.492	99.91	0.09	0	5	ok
Pan	4.8	4.2	4.5	0.09	100	0	0	0	ok

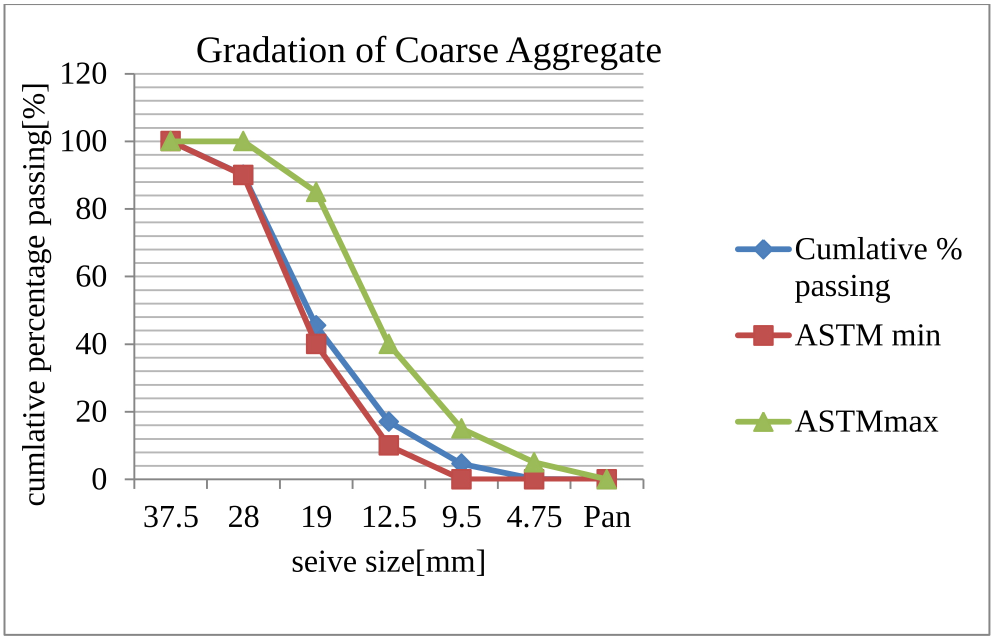


Figure 4.1 Particle size distribution curves for coarse aggregate

For sieve analysis of fine aggregate, the fine aggregate used in this study passed the 9.5mm and almost passed 4.75mm sieve size which fulfills the standard requirements according to ASTM standard. The fineness module is between 2.3 and 3.1. According to ASTM33 that means it was in range between ASTM lower and upper limit. The cumulative percentage passes and retain were within the intervals as shown in table 4.2 below.

Table4.2 Sieve analysis for fine aggregate

Sieve `Size(mm)	Mass retained(gm)			% Retained	%Cumulative retained	% Passing	ASTM C-33 Limits (%)		Remark
	Trial 1	Trial 2	Avg.				lower	upper	
9.5	0	0	0.0	0.00	0	100	100	100	ok
4.75	82	78	80.0	4.00	4	96	95	100	ok
2.36	146	150	148.0	7.40	11	89	80	100	ok
1.18	301	305	303.0	15.15	27	73	50	85	ok
0.60	551	556	553.4	27.67	54	46	25	60	ok
0.30	620	628	624.1	31.20	85	15	10	30	ok
0.15	244	243	243.4	12.17	98	2	2	10	ok
pan	56	40	48.1	2.40	100	0	_	_	_

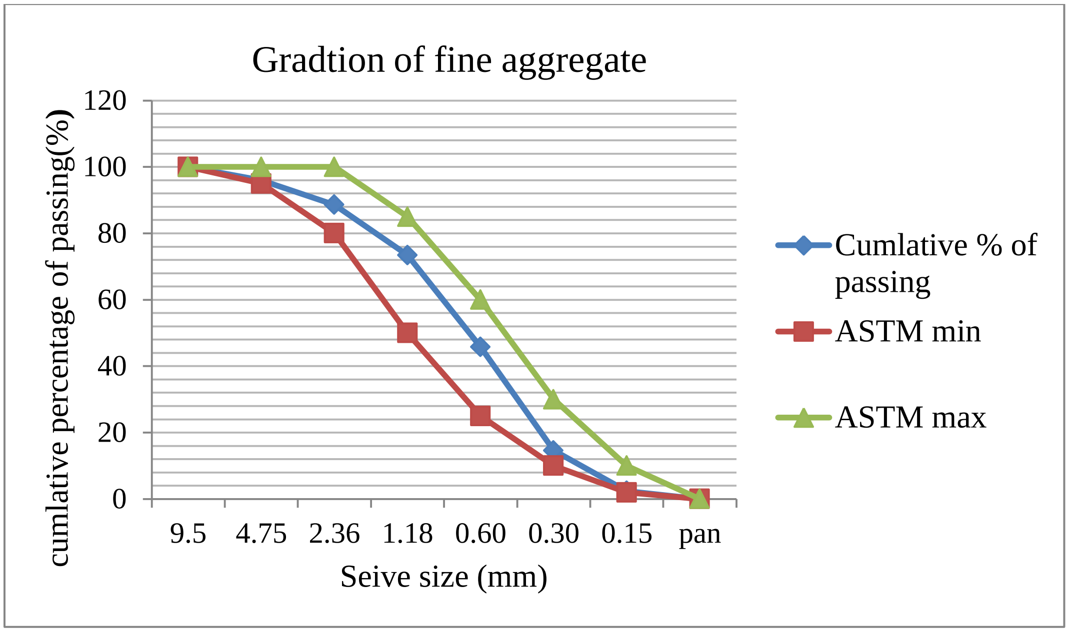


Figure 4.2 Particle size distribution curves for fine aggregate

4.2 Setting time

The Ethiopian standard limits the initial setting time of Portland cement not to be less than 60minutes and the final setting time not to exceed 10hrs. ASTM150 on the other hand, limits setting time of hydraulic cement to be between 45 to 375 minutes. The water added to the cement is 85% of water that gives a paste of standard consistence.

The initial setting time is the duration of cement paste related to 25mm penetration of the Vicat needle into the paste in 30 seconds after it is released while the final setting time is that related to zero penetration of the Vicat needle into the paste.

Table4. 3 Initial and final setting times of cement with and without SAD-CCA

Setting Time(min)		
Mixed Code	Initial(min)	Final(min)
Control	112	302
3%SAD +1%CCA	121	288
6%SAD +2%CCA	133	272
9%SAD +3%CCA	144	260

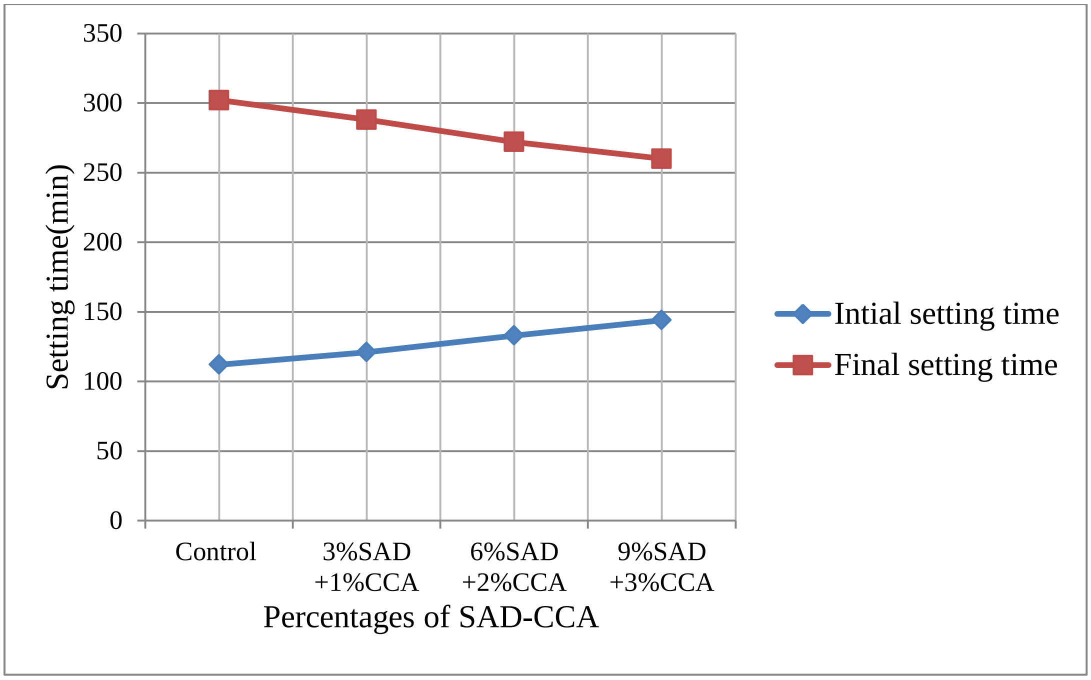


Figure4.3 Variation of initial and final setting times with and without percentages of SAD-CCA

From the result it can be noted that the initial setting was increased with the increase of percentage of hybrid waste and final setting time is decrease with the increase of percentages of dross. The reason for shortening and extend the setting time is the nano particles of secondary aluminium dross have higher surface area. This nano particle absorbs significant amounts of liquid. It needs more water for consistency and when added to cement reduces the pozzolanic reaction.

So, this indicates that SAD-CCA can be used as a retarder and thus it is good materials for hot weather concreting because of this in hot weather concreting the water present in the conventional concrete evaporate at faster rate, thereby accelerating the initial and final setting time. That means SAD-CCA gives enough time for casting, transporting and placing the concrete in hot weather condition and large construction projects.

4.3 Tests on Fresh Concrete

4.3.1 Workability of Concrete

The phenomena for fresh concrete can be laid, compacted and enough workable for desire purpose is described by workability of fresh concrete. Workable concrete means the concrete which can be placed and can be compacted easily without any segregation. The workability of concrete is controlled by the amount of water in concrete. In order to assess the effect of replacement of cement with hybrid of two waste on workability of fresh concrete, slump test and compaction test have been conducted for each of concrete mixes in accordance of ASTM.

According to ACI 1211-81

Table4.4 Slump and compaction factor recommendation for use according to ACI

Degree of workability	Slump(mm)	Compacting factor	Use for which concrete is suitable
Very low	0-25	0.78	Roads vibrated by power operated machines
low	25-50	0.85	Lightly reinforced section and roads vibrated by hand operated machines
medium	25-100	0.92	Normal reinforced concrete manually compacted and heavily reinforced section with vibration.
high	100-175	0.95	For section with congested reinforcement and not suitable for vibration.

Table4.5 Slumps and compaction factor test result containing SAD-CCA

percentage of replacement	Partially compacted mass(MP)	Fully compacted mass	Compaction factor	slump(mm)
0%	13.98	14.944	0.94208	27
3%SAD +1%CCA	13.678	14.868	0.92194	26.5
6%SAD +2%CCA	12.305	14.955	0.8228	17
9%SAD +3%CCA	11.56	14.83	0.7795	15

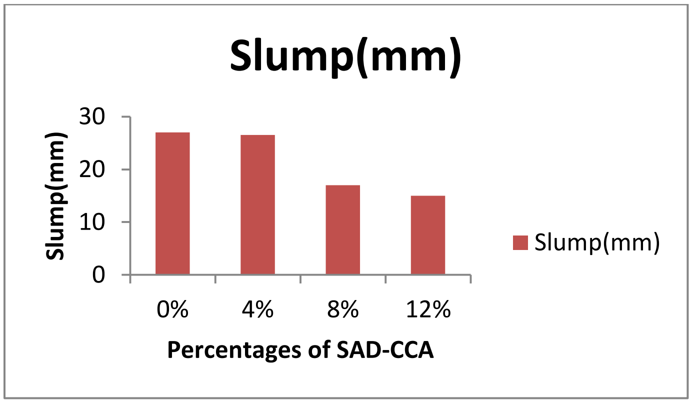


Figure 4.4 Slump for workability of fresh concrete with addition of SAD-CCA

From test result it has observed that the replacing of more SAD-CCA in concrete decrease the value of workability and compaction factor of fresh concrete from the result of slump test maximum workability obtained from 4% SAD-CCA next to control. The results of workability test on concrete with and without SAD-CCA represented in figure 4.4 .it has observed that the more SAD-CCA waste content increase the drier of concrete, this may because SAD-CCA is a high water absorption capacity. However, in accordance to ACI the slump value between 25-50 and compaction factor between 0.92-0.95 it can be used as normal reinforced concrete manually compacted and heavily reinforced section with vibration for control mix and 4% SAD-CCA mix replacement and for other left mix the slump value and compaction factor is below 25mm and 0.85 respectively. Hence accordance with ACI code it can be used for Roads Vibrated by Power operated machines.

4.4 Test on hardened concrete

4.4.1 Compressive strength test

One of the important properties of the hardened concrete is its strength which represents its ability to resist compression loads. The compressive strength of the concrete is considered to be the most important and is often taken as an index of the overall quality of concrete. The compressive strength of concrete is the compression load which causes the failure of specimen per unit cross section area of the specimen over which the load is applied.

In this study the effects of partial replacement of SAD-CCA for cement on concrete compressive strength characteristics has been studied and compared with control specimen. The replacement percentages were 4%, 8%, and 12% by weight of cement to compare the compressive strength of partially replaced concrete with the control concrete. All cube specimens had the dimension of 150mm×150mm×150mm. The results of compressive strength of the cubes tested at the age of 7 day and 28 day are shown in the table 4.6. At each age a minimum of three specimens were tested to ensure the accuracy of test results.

The detailed result of compressive strength for 7 and 28 day are tabulated under appendix B with stress and strain value.

Table4.6 Compressive loads and the corresponding compressive strength of cube with SAD-CCA

7 days compressive strength test result						
	load(KN)					
% of SAD-CCA	Sample 1	sample2	sample3	Average peak load(KN)	Compressive Strength (Map)	Variation From Control in (%)
0	377.34	356.32	366.73	366.797	16.30	0
4%	408.64	441.05	368.61	406.1	18.04	10.69
8%	345.60	347.63	354.6	340.827	15.52	-4.80
12%	314.1	317.7	306.72	312.84	13.90	-14.72

28 days compressive strength test result						
	load(KN)					
% of SAD-CCA	Sample 1	sample2	sample3	Average compressive load	Compressive strength (Mpa)	Variation from control (%)
0	566.73	622.48	596.71	595.30667	26.46	0
4%	689.26	610.62	651.38	650.42	29.01	9.63
8%	541.13	550.13	558.45	549.90333	24.94	-5.74
12%	489.4	517.95	501.3	502.88333	22.35	-15.53

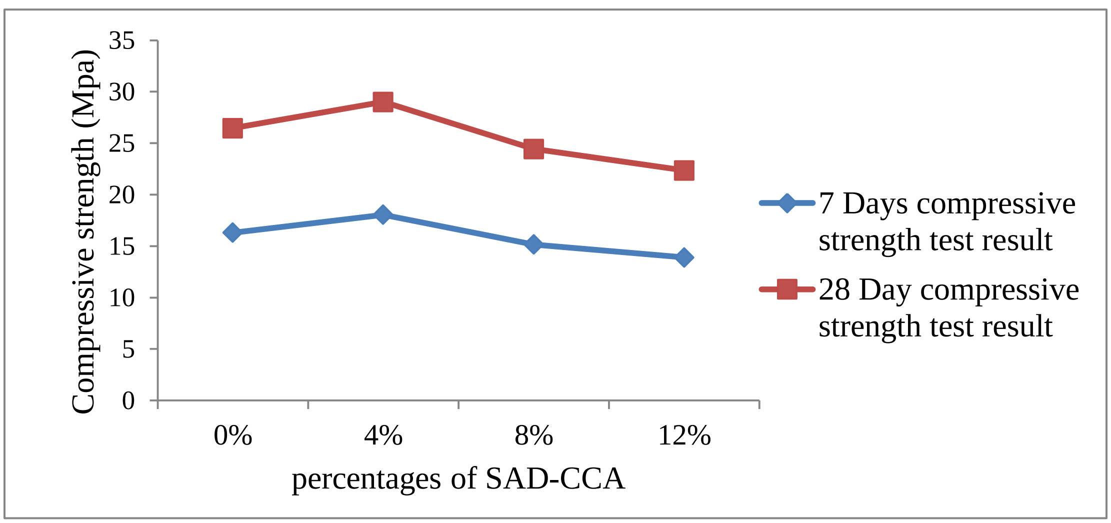


Figure 4.5 Comparison of compressive strength for different percentage of SAD-CCA replacement.

It has been observed from the test result as the age of curing increase the compressive strength of concrete also increase and the cube specimen tested for 7 and 28 days with different percentage of SAD-CCA waste shows a variation in compressive strength when compared with the control specimen. At early age of concrete test the 7 day of strength, the increments of compressive strength is 10.69% for 4% replacement compared with control. However, the reduction in compressive strength of 4.80% and 14.72% has observed for 8% and 12% replacement respectively.

At the ages of 28 days concrete test the increment of compressive strength is 9.63% for 4% replacement. The reduction compressive strength of 5.74% and 15.53% observed for 8% and 12% respectively. It has been also observed from test results, at later age of compressive strength test the 28 day strength satisfactory for C-25 compressive strength as it is greater than 99% of 25Mpa for 8% replacement.

In general the maximum result of compressive strength was found at 4% (3%SAD+1%CCA) shows an enhancement by 10.69% and 9.63% from the control at 7days and 28 days respectively. This shows that the combinations of SAD and CCA have relatively higher compressive strength and for the mix 8% and 12% SAD-CCA partially replaced cement the compressive strength goes on decreasing as compared to control. The reason for reduction strength of concrete for 8% and 12 % is due to more air contents in the mix for lager replacements. The air content in concrete was increased when SAD-CCA replacement rate also increased.

4.4.2 Stress -Strain Relation of Cubes with SAD-CCA

In this study the stress- strain characteristics was analyzed for 0%, 4%, 8% and 12% partial replacement of cement by SAD-CCA waste. The strain of compressive stress was determined by using displacement gauge which was attached on the compressive strength test machine before applying the load to the cube specimen. The deformation (Δh) of specimens have been recorded from the gauge with respect to each load increment and strain have calculated by dividing deformation to the height of the cube specimen (h). The stress was calculated using the load which has taken fit with corresponding gauge reading change in the compressive testing machine during the test under go. The uniaxial stress is given by:-

$$\sigma = \frac{P}{A}$$

Where; σ=stress with respective load (MPa).

P=Applied load (kN)

A=area of cube (mm^2)

The strain was also calculated for the change in height of cube obtained from the gauge reading during the load was applied to the cube divided by the original length of the sample.

$$\varepsilon = \frac{\Delta h}{h}$$ Where: - ε =strain for each change in length

Δh=change in height of cube

h=original height of cube

In this study, to draw the stress- strain curves from the experimental result of cube test were used. The stress- strain curves for each SAD-CCA with corresponding percentage contents have summarized in the following figures collecting all samples that give stress- strain curves. The details of all results and values computed for stress-strain relation is tabulated in appendix B.

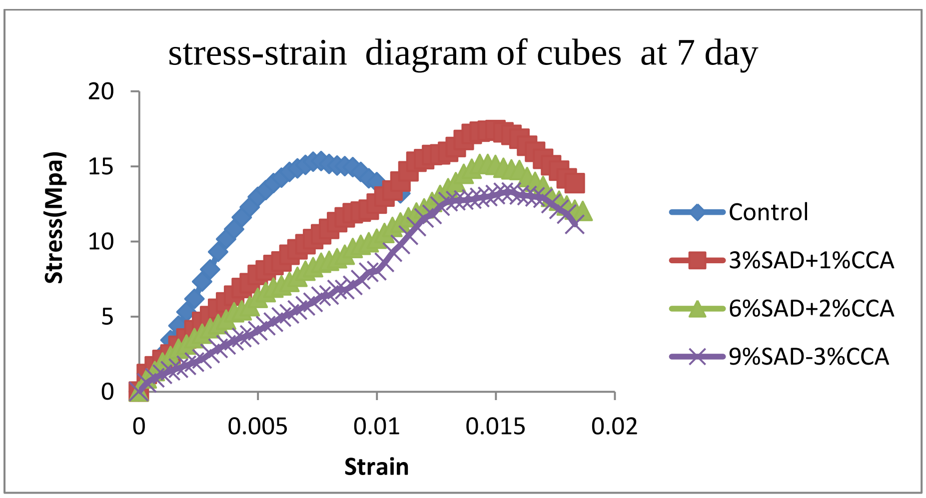


Figure 4.6: The stress strain response of concrete cubes made with and without SAD-CCA waste at ages of 7 days

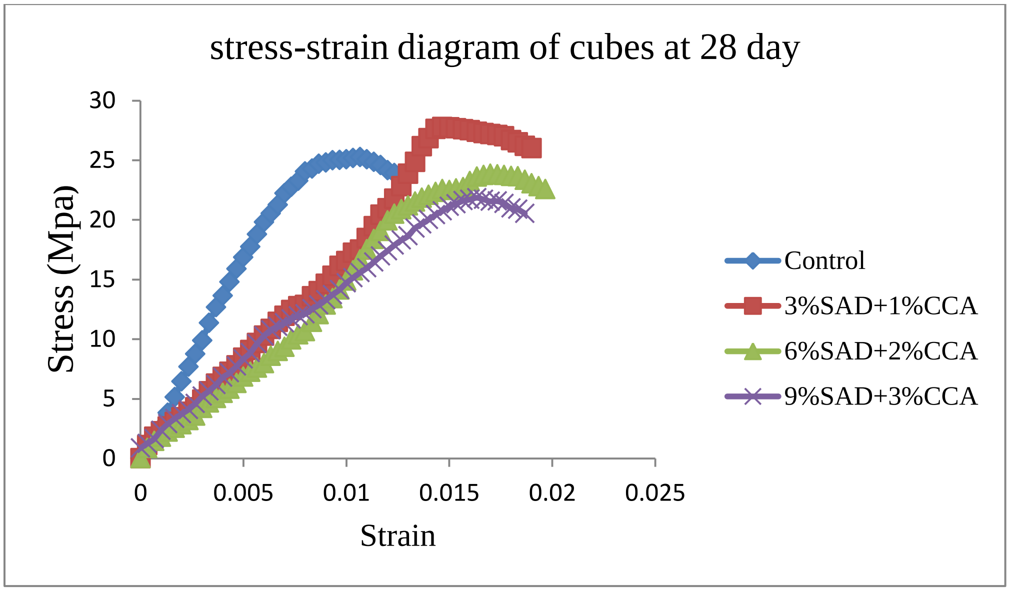


Figure 4.7 The stress strain response of concrete cubes made with and without SAD-CCA waste at ages of 28 days

From stress- strain curves result, it observed that for concrete mix with SAD-CCA at 4% higher compressive strength than control.

In general from the stress-strain curve it observed that for all mix with SAD-CCA concrete shows relatively ductile compared with control mix.

4.4.3. Split Tensile Strength Test

Concrete is not expected to resist direct tension because of its low tensile strength and brittle nature. Tensile strength is property of concrete which describe tensile crack of concrete due to tensile applied loading. Split tensile strength of concrete is lower when compared to its compressive strength. Due to difficulty in applying uniaxial tension to a concrete specimen the tensile strength of concrete can be determined by indirect test method called a split tensile test and it has used in this study for determining tensile properties of concrete specimens. In this study the effects of partial replacement of hybrid of SAD-CCA for cement at percentages of 4%, 8% and 12% on concrete split tensile strength studied and compared with control concrete. The split tensile strength test results of cylinders at 7and 28 days are shown in table 4.8 and 4.9 respectively.

Table4.7 Split tensile load and the corresponding tensile strength of cylinder at7day

	load(KN)					
% of SAD-CCA	Sample 1	sample2	sample3	Average peak load	Split tensile strength(Map)	Variation from control (%)
0	61.56	64.31	63.15	63.0067	2.01	
4%	95.43	107.83	101.79	101.683	3.24	61.19
8%	69.87	69.26	65.03	68.0533	2.17	7.77
12%	47.25	49.56	46.75	47.8533	1.52	-24.22

Table4.8 Split tensile load and the corresponding tensile strength of cylinder at28day

	load(KN)					
% of SAD-CCA	Sample 1	sample2	sample3	Average peak load	Split tensile strength(Map)	Variation from control (%)
0	120.62	72.36	96.91		3.08	
4%	105.84	141.3	132.26	126.467	4.02	30.52
8%	82.67	91.18	127.23	100.36	3.19	3.72
12%	62.45	66.5	73.45	67.4667	2.15	-30.28

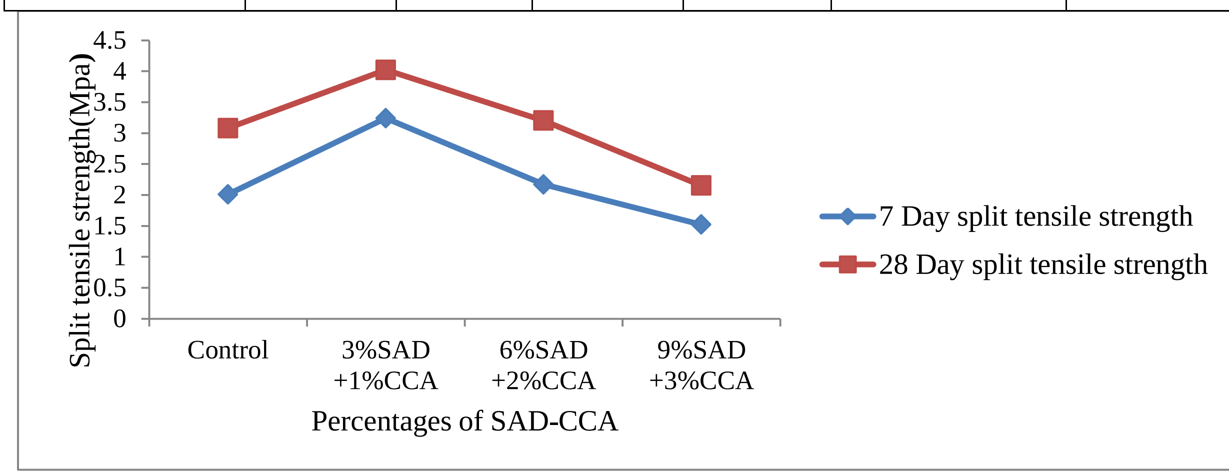


Figure 4.8 Comparison of split tensile strength for different percentage of SAD-CCA

From the observed result, it is evident that at 7day curing age splitting tensile strength values for 4% and 8% of SAD-CCA replaced concrete specimens were increased by 61.19% and 7.77% respectively compared with control mix. However, for 12%SAD-CCAmix the result indicates a decrease by 24.22% when compared with control strength.

Similarly, at the 28 day curing age splitting tensile strength values for 4% and 8% SAD-CCA replaced concrete specimens were increased by 30.52% and 3.72% respectively when compared with control strength. The maximum tensile strength was observed when the percentages of hybrid mix was 4% because the improved performance may be associated with the ductility property and the lower strength observed when the percentages of hybrid mix reaches 12%.

Thus, the split tensile strength of the concrete mixes affected in terms of tensile strength with addition of the hybrid mix as a partial replacement of cement in concrete production at 7 and 28 days of curing ages.

4.4.4 Flexural Strength Test

Flexural test evaluates the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beam to withstand failure in bending. The results of flexural test on concrete expressed as a modulus of rupture which represents as (MR) in MPa. The average flexural stresses were calculated from average rupture load. The average flexural strength test result for 7 and 28 days are shown in table 4.10 and 4.11 respectively.

Table4.9 Flexural load and corresponding flexural strength of beam at7day

7th Day Flexural Test Result						
	Load (KN)				Flexural strength (MPa)	
% of SAD -CCA	Sample 1	sample2	sample 3	average peak load	MR= $\frac{PL}{bd^2}$	Variation from control (%)
0%	14.9175	15.13125	14.985	15.01125	4.50	0
4%	18.9675	18.86	17.55	18.46	5.54	22.97
8%	15.75	14.74875	15.986	15.50	4.65	3.22
12%	12.67	11.5	12.78	12.3166667	3.70	-17.95

Table4.10 Flexural load and corresponding flexural strength of beam at 28 day

28th Day Flexural Test Result						
	load (kN)				flexural strength(MPa)	
% of SAD - CCA	Sample 1	Sample 2	Sample 3	average peak load	MR= $\frac{PL}{bd^2}$	Variation from control (%)
0%	21.10	21.20	22.01	21.45	6.44	0
4%	25.1	25.8	26	25.56	7.668	19.14
8%	22.30	21.24	22	21.96	6.59	2.37
12%	18.30	17.30	17.02	17.53	5.23	-18.30

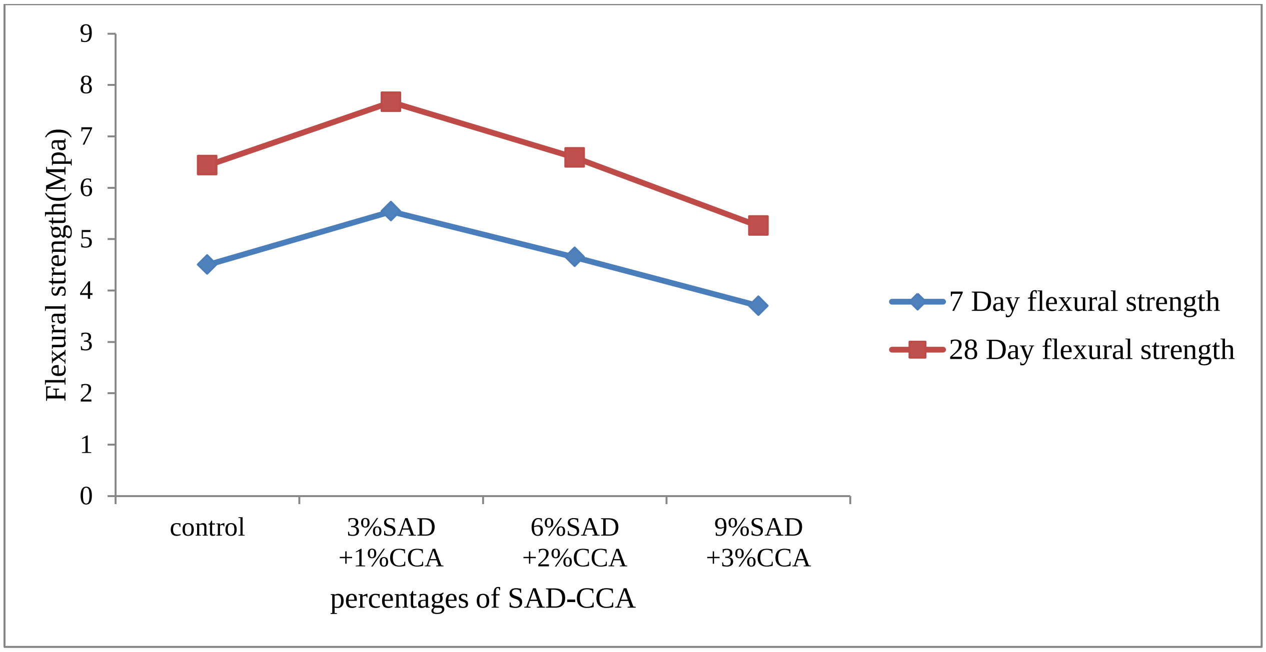


Figure 4.9 Shows comparison of flexural strength for different percentages of SAD-CCA

From the result, were clearly observed that the performance of beam tested with hybrid of secondary aluminum dross and corn cob ash as a partial replacement of cement in concrete shows good performance compared with the control. The flexural strength of concrete mix increased by 22.97% and 3.22% for 7 day with the partial replacement of SAD-CCA at 4% and 8% respectively whereas for 12% replacement rate decreased by 17.95%.

Similarly, at the replacement of 4%, and 8% by weight of cement the flexural strength increased by 19.14% and 2.37% respectively at 28 days of curing age and decreased by 18.30 for 12% replacement.

In general, the flexural strength of concrete increased as the ages of curing increased for all mix and the flexural strength of hybrid secondary aluminum dross and corn cob ash concrete show decrement for 9%SAD and 3% CCA addition at 7 and 28 days. It conclude that the addition of hybrid secondary aluminum dross and corn cob ash on concrete are effective in flexural load resistance for 4% and 8% mix compared with reference mix.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The present study was carried out on concrete incorporated with two wastes, namely secondary aluminum dross and corn cob ash for possible utilization in construction sector. Hybrid of secondary aluminum dross and corn cob ash has been replaced by cement in various percentages. The study is aimed at studying of the properties of fresh and hardened of concrete with partial replacement of cement by secondary aluminum dross and corn cob ash. According to experimental result, the main observations from the study are presented below.

- The workability of concrete slightly decrease with increasing aluminum dross and corn cob ash content, which means hybrid of aluminum dross and corn cob ash needed more water to make a concrete mixture more workable compared with control.
- Aluminum dross and corn cob ash blended concrete retards the initial setting time and accelerate the final setting time due to its higher surface area of aluminum dross.
- It is good materials for hot weather concreting. Because hot weather increase the hydration of cement resulting in faster setting of concrete which denotes the reduce availability of time for placing and finishing of concrete that means delay in setting of concrete observed.
- Strength of concrete rises with curing age and declines as percentage replacement of aluminum dross and corn cob ash increase for all mix.
- For an optimum workability and mechanical strength of concrete to be attained, a 4% replacement of cement with hybrid of secondary aluminum dross and corn cob ash is recommended.
- Compressive strength of concrete increase up to 9.63% for 4% replacement of cement.
- Split tensile strength of concrete increase up to 30.52% for 4% replacement of cement.
- Flexural strength of concrete increase up to 19.14% for 4% replacement of cement.
- It was conclude that the use of combination of SAD-CCA as a partial replacement for cement in concrete particularly in plain concrete up to 4% SAD-CCA replacement is

improved the compressive, tensile and flexural strength as well as it can be minimized cost of cement and environmental pollution.

5.2. RECOMMENDATION

- Concrete with hybrid of secondary aluminum dross and corn cob ash is recommended for hot weather condition and larger construction area because hybrid of secondary aluminum dross acts as retarder.
- The user should follow optimum percentage of secondary aluminum dross and corn cob ash which is 4% replacement rate.

Based on work conducted as part of this program the following recommendations for future work are reported.

- Experimental research is required to know peak maximum strength of concrete with secondary aluminum dross and corn cob ash up to 8% percentage of replacement by varied percentage of replacement rate and check its structural behavior with reinforced bar.
- Checking the workability and mechanical strength by varying water cement ratio and different grade of concrete.
- The reaction between hybrid of secondary aluminum dross, corn cob ash and Portland pozzolan cement when mixed with water shall be checked using advanced technology scanning electron microscopy (SEM).

REFERENCE

Abate, T. et al. (2015) 'Factors that transformed maize productivity in Ethiopia Factors that transformed maize productivity in Ethiopia', open access at Springerlink.com, (July). doi: 10.1007/s12571-015-0488-z.

Abu-lebdeh, T. and Agricultural, N. C. (2016) 'Investigating Effects of Introduction of Corncob Ash Into Portland Cements Concrete: Mechanical and Thermal Properties Investigating Effects of Introduction of Corncob Ash Into Portland Cements Concrete: Mechanical and Thermal Properties', American Journal of Engineering and Applied Sciences 7 (1): 137-148, 2014, (April). doi: 10.3844/ajeassp.2014.137.148.

Adebisi, O. et al. (2019) 'Suitability of Corn Cob Ash as Partial Replacement for Cement in Concrete', International Journal of Scientific & Engineering Research, 10(10), pp. 1344–1348.

Ahmed, M., Mallick, J. and Abul Hasan, M. (2016) 'A study of factors affecting the flexural tensile strength of concrete', Journal of King Saud University - Engineering Sciences, 28(2), pp. 147–156. doi: 10.1016/j.jksues.2014.04.001.

Ansari, M. A. and Ameen, S. (2020) 'MAJOR INGREDIENTS AND RAW MATERIALS OF ORDINARY CONCRETE', 07(June), pp. 2789–2795.

ASTMC191-82. (2004) 'Time of Setting of Hydraulic Cement by Vicat Needle 1', American Association State Highway and Transportation Officials Standard AASHTO No.: T131, i.

B, G. R. (2018) 'Review Paper on Effect of Aluminium Dross on Properties of Concrete', IJRTI, 3(2014), pp. 69–70.

Bird, T. (1984) 'Aluminium Production Costs.', (March), p. 2012.

Demand, A. (2005) 'Aluminium: □peci', pp. 1–13.

Dinku, A. (2005) 'ScholarWorks at WMU The Need for Standardization of Aggregates for Concrete Production in Ethiopian Construction Industry'.

Elseknidy, M. H. et al. (2020) 'A study on mechanical properties of concrete incorporating aluminum dross, fly ash, and quarry dust', Sustainability (Switzerland), 12(21), pp. 1–13. doi: 10.3390/su12219230.

Elseknidy, M. H., Salmiaton, A. and Shafizah, I. N. (2020) 'A Study on Mechanical Properties of Concrete Incorporating Aluminum Dross , Fly Ash , and Quarry Dust', MDPI, pp. 1–13.

Feng, H. et al. (2020) 'The investigation of optimizing leaching efficiency of al in secondary aluminum dross via pretreatment operations', Processes, 8(10), pp. 1–13. doi: 10.3390/pr8101269.

FISSAC (2016) 'Inventory of raw materials, waste, and energy flows in industrial sectors (metallurgic, ceramic, glass, chemical, and natural stone) considered in a dynamic scenario - exective summary', Fostering Industrial Symbiosis for A Sustainable Resource Intensive Industry Across The Extended Construction Value Chain Inventory.

Kamau, J. et al. (2016) 'Suitability of corncob ash as a supplementary cementitious material', International Journal of Materials Science and Engineering, 4(4), pp. 215–228. doi: 10.17706/ijmse.2016.4.4.215-228.

Mandar M.Joshi, D. S. K. D. (2019) 'QUALITY OF WATER FOR CONSTRUCTION-EFFECTS AND LIMITS', Journal of Emerging Technologies and Innovative Research (JETIR), 6(4), pp. 277–284. doi: 10.1097/00010694-197204000-00007.

Mujedu, K. A., Adebara, S. A. and Lamidi, I. O. (2014) 'The Use of Corn Cob Ash and Saw Dust Ash as Cement Replacement in The Use of Corn Cob Ash and Saw Dust Ash as Cement Replacement in Concrete Works', The International Journal Of Engineering And Science (IJES), (February).

Nduka, D. O. et al. (2020) 'Mechanical and Water Absorption Properties of Normal Strength Concrete (NSC) Containing Secondary Aluminum Dross (SAD)', International Journal of Engineering Research in Africa, 47, pp. 1–13.

Neville, A. M. and Brooks, J. J. (2010) CONCRETE TECHNOLOGY. Harlow, England • London • New York • Bosto.

Olafusi, O. S. et al. (2016) 'Flexural Performance of Self-Compacting Concrete Containing Corn-Cob Ash', (April). doi: 10.15224/978-1-63248-093-4-20.

Owolabi T.A. (2015) 'Effect Of Corncob Ash As Partial Substitute For Cement In Concrete', New York Science Journal, 151(11), pp. 10–17.

P Suwanmaneechot, T. N. P. J. (2015) 'Improvement , characterization and use of waste corn cob ash in cement-based materials Improvement , characterization and use of waste corn cob ash in cement-based materials', IOP Conference Series: Materials Science and Engineering. doi: 10.1088/1757-899X/103/1/012023.

Patel, M. et al. (2020) 'Experimental Study of Corn Cob Ash Concrete', IJIRT, 6(11), pp. 110–112.

Ramaswamy, P., Gomes, S. A. and Ravichander, N. P. (2019) 'Utilization of aluminum dross: Refractories from industrial waste', IOP Conference Series: Materials Science and Engineering, 577(1). doi: 10.1088/1757-899X/577/1/012101.

Rathod, R. R., Suryawanshi, N. T. and Memade, P. D. (2014) 'Evaluation of the properties of Red Mud Concrete Evaluation of the properties of Red Mud Concrete', (October).

Reddy, M. S. and Neeraja, D. (2016) 'Mechanical and durability aspects of concrete incorporating secondary aluminium slag', Resource-Efficient Technologies, 2(4), pp. 225–232. doi: 10.1016/j.reffit.2016.10.012.

S, O. O. and A, O. F. (2012) 'Strength Properties of Corn Cob Ash Concrete', Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS), 3(2), pp. 297–301.

Schiel, C. (2020) 'Background informal technical document on techniques to reduce emissions from aluminium production TFTEI informal background technical document Background informal technical document on techniques to reduce emission from aluminium production', (December).

Wayase, M. K. et al. (2018) 'An Experimental Study on Partial Replacement of Cement By Aluminium Dross In Concrete', Journal of Advances and Scholarly Researches in Allied

Education, 8(04), pp. 153–158. doi: 10.29070/15/56804.

APPENDICES

A-Tests on Aggregates

The physical properties of aggregates tests were carried out as per ASTM specification.

TableA-1 Standard test method for fine and coarse aggregate

Tests	Standards
Sieve analysis of fine and coarse aggregate	ASTM C136, C33
Unit weight of fine and coarse of aggregate	ASTM C29
Specific gravity and absorption of fine and coarse aggregate	ASTM C127,128
Moisture content of fine and coarse aggregate	ASTM C566
Silt content of fine aggregate	ASTM C117

A-1 Tests on Fine Aggregates

Sand Sieve Analysis

Sieve analysis is conducted to determine particle size distribution in a sample of aggregates.

Apparatus: sieve Apparatus: - the apparatus consists of eight different types of sieve i.e. 9.5mm, 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm, 0.15 mm and pan sieve for fine aggregates, electric shaker and weighing balance.

Procedure:-

1. 2000g of sand was measured from the sample which was proposed to use for study.
2. The sieves were arranged in descending order of size from top to bottom.
3. The measured sample of sand was put on the top part of sieve and shake for 10 minutes.
4. After 10-15 minutes the shaker was stopped. Then record the weight of retained samples of sand particles on each sieve size by using balance.
5. The percentage of weight retained on each sieve and cumulative percentage retained was calculated.
6. The percentage weigh which has passed through each sieve was calculated.
7. Lastly determine the fineness modulus of sand.

Table A-2.particle size distribution and fineness modules of sand.

Sieve Size (mm)	Mass Retained(gm)			% Retained	%cumulative retained	% Passing	ASTM C-33 Limits (%)		Remark
	Trial 1	Trial 2	Avg.				lower	upper	
9.5	0	0	0.0	0.00	0	100	100	100	ok
4.75	82	78	80.0	4.00	4	96	95	100	ok
2.36	146	150	148.0	7.40	11	89	80	100	ok
1.18	301	305	303.0	15.15	27	73	50	85	ok
0.60	551	556	553.4	27.67	54	46	25	60	ok
0.30	620	628	624.1	31.20	85	15	10	30	ok
0.15	244	243	243.4	12.17	98	2	2	10	ok
pan	56	40	48.1	2.40	100	0	_	_	_

Fineness modulus is defined as sum of the cumulative percentage of sand retained in the designated sieves divided by 100.

Fineness Modulus (FM) $=\frac{279}{100}$=2.79

Moisture Content of Sand

The procedure for the determination of moisture contents of sand:-

1. 500g sand was measured (A)
2. The measured samples of sand allowed to drying in oven for 24hours.
3. After 24hrs, the sample removed from oven dry and its weight measured and recorded as dry weight(B)
4. Lastly determinations of moisture content in sand have done as the following

   %moisture content=$\frac{A-B}{B} \times 100$

Where; A=weight of original sample

B= weight of oven dry samples (g)

Table A-3 Percentage Moisture Content of Sand

S.No	Description	Sample	
		1	2
1	Weight of original sample ,A,(Kg)	0.5	0.5
2	Oven dried mass ,B,(Kg)	0.4980	0.4976
3	Moisture content in %=((A-B)/B)*100	0.4	0.5
Average			0.4

Specific Gravity and Water Absorption of Sand

Apparatus: 500g of sample sand, water, pycnometer bottle and weighing balance.

Procedures:-

1. 500g sand was put in pycnometer and filled with water to the calibration capacity.
2. Rolling and agitating the pycnometer to eliminate air bubble has processed.
3. The total weight of the pycnometer, sample, and water together measured(C).
4. The total weight of the pycnometer and water t Was measured(B)
5. The sand was removed from the pycnometer, allowed to dry at oven a temperature of $(105 \pm 5)^{o}$C for 24hrs.
6. After removed of sand from oven cooled in air at room temperature and has measured the weight oven dried sand (A).
7. Finally determined the specific gravity and water absorption of sand.

Table A-4, Specific gravity and water absorption of sand.

Description	Sample No		
	Trial1	Trial2	Mean
Weight of saturated & surface dry sand (gm)	500	500	-
Weight of pycnometer+sample+water (C) (gm)	1869	1867	-
Weight of pycnometer+water (B) (gm)	1549	1549	-
Weight of oven dry sand (A) (gm)	495	497	-
Bulk specific gravity=A/(B+500-C)	2.75	2.73	2.74
Bulk specific gravity (sat.sur.dry basis)=500/(B+500-C)	2.778	2.747	2.76
Apparent specific gravity=A/(B+A-C)	2.829	2.777	2.80
Absorption capacity(%)=((500-A)/A)*100	1.0	0.6	0.81

Unit Weight of Sand

Unit weight is the ratio of weight to volume of given graded sand. Laboratory procedures have done to determine unit weight of sand used for this study in laboratory. The overall procedures includes filling into three layers by cylindrical metal and tamp 25 times for each layer have done.

The cylindrical metal used has constant volume. Finally the net weights of sand measurement have recorded.

Unit weight $=\frac{M}{V}$

Where

M=mass of sand

V=Volume of cylindrical metal

Table A-5 unit weight of sand (fine aggregate)

Sn.No	Description	trial 1	trial 2	Mean
1	Mass of cylinder +sample(Kg)	9.09	9.05	-
2	mass of cylinder(Kg)	1.052	1.052	-
3	Mass of sample(Kg)	8.038	7.998	-
4	Volume of measuring cylinder (m^3)	0.005	0.005	-
5	Unit weight(Kg/m^3)	1607.6	1599.6	1603.6

Average unit weight=1603.6Kg/m^3

Silt Content of Sand:-

Silt is unnecessary part of sand. If there is too much silt, the aggregate will have less adhesive property with cement resulting in weaker bond strength.as per Ethiopian standard code ,if the silt content is greater than 6%,it must be rejected that sand. The test method applied to determine the silt content is the laboratory method. The genera procedures includes, measuring 1Kg sand from the sample and then washing the sand was done up to clean water observed and then put on oven dry for 24hrs. After 24hrs values of silt content in sand have determined and test results are given below.

Table A-6 silt content of sand

S.No	Description	Sample	
		1	2
1	Air dried mass(g),M1	1000.0	1000.0
2	Oven dried mass(g),M2	960.3	982.0
3	Silt content in %=((M1-M2)/M1)*100	4.0	1.8
	Average		**2.9%**

Average value of silt content in sand is less than 6%

A-2 Tests on Coarse Aggregates

Specific Gravity and Absorption Test:-

Specific gravity of an aggregate is a measure of strength or quality of materials. The specific gravity of substance is the ratio between the weight of substance and that of the same volume of water. Water absorption is strength of materials.

Its objective was to determine specific gravity and water absorption capacity of coarse aggregate.
Apparatus:-hot air oven, weighing balance, tray, sample containers and wire basket.
Procedure:-

1. Samples of 2Kg of coarse aggregate have taken
2. Placing in a wire basket and immersing the basket with the sample in distilled water have done. The basket with samples was completely immersed in water for a period of 24hrs.
3. After 24hrs weighing the basket with samples in water (Wa). Then returning the basket in water and weighing in water (Wb) and weighing the aggregates which is surface dried with cloth (MSSD) has done.
4. Then placing the aggregate in an oven at a temperature of $110^{o}C \pm 5^{0}C$ for 24hrs
5. Then , after 24hrs, the sample removed from the oven, cooled in the air tight container and measured its weight(MD)

Where

Mw= weight of the saturated aggregate in water (wa- wb)

Wb =weight of basket in water

MSSD=saturated surface dry mass of coarse aggregate

MD=oven dried mass of coarse aggregate

Average Apparent specific gravity= $\frac{MD}{MD-MW}$

Average Bulk specific gravity (oven dry basis) = $\frac{MD}{MSSD-MW}$

Bulk specific gravity (saturated surface dry basis) = $\frac{MSSD}{MSSD-MW}$

% Water Absorption= $\frac{(\mathrm{MSSD-MD})}{MD} \times 100$

Table A-7 Specific gravity and absorption capacity of coarse aggregate

	Coarse aggregate (gravel)			Average
S.NO	Description	Trial1	Trial2	
1	M_W=Weight in water of saturated aggregate (Kg)	1.302	1.305	
2	M_{SSD}=Weight in air of saturated surface dry(Kg)	2.002	2.005	
3	M_D=Weight in air of oven dried aggregate(Kg)	1.985	1.986	
4	Bulk Specific gravity of (saturated surface dry basis)	2.860	2.864	2.86
5	Absorption capacity (%)	0.86	0.96	0.91%
6	Bulk specific gravity (oven dry basis)	2.835714	2.837143	2.84
7	Average Apparent specific gravity	2.906296	2.9163	2.91

Sieve Analysis Test:-

This section discuss about the gradation of coarse aggregate by round opening sieve and thereafter determine the fineness of modulus of coarse aggregate.

Procedure:-

1. A sample of 5kg coarse aggregate has taken (measured).
2. The sieves were arranged in descending order of size from the top to bottom.
3. The measured samples of coarse aggregate were put on the top part of sieve and shake using mechanical sieve shaker for 10-15 minutes and finally weight the material retained on each sieve size.
4. Then, cumulative percentage retained was calculated. Thereafter, the percentage weight which has passed through each sieve was calculated
5. Finally the fineness modulus of coarse aggregate calculated.

Table A-8 particle size distribution of coarse aggregates

Sieve Size[mm]	mass of samples		Wt. Retained[g]	% retained	Cumulative %retained	%passing	Specification %passing	
	trial 1	trial 2					Min	Max
37.5	0	0	0	0	0	100	100	100

28	501.6	491	496.3	9.926	9.926	90.074	90	100
19	2228	2229.6	2228.8	44.576	54.502	45.498	40	85
12.5	1419	1428.6	1423.8	28.476	82.978	17.022	10	40
9.5	621	623	622	12.44	95.418	4.582	0	15
4.75	225.6	223.6	224.6	4.492	99.91	0.09	0	5
Pan	4.8	4.2	4.5	0.09	100	0	0	0

Moisture Content of Coarse Aggregate:-

Under this investigation, determine the moisture content of the fine aggregates 2kg sample is taken and dried in the oven for 24 hours with a temperature of 110^{o}C+5^{o}C. Then the sample is removed from the oven and allowed to cool for some minutes and finally the mass is measured. The result is given below.

Table A-9 percentage moisture contents of coarse aggregates.

S.No	Description		Sample
		1	2
1	Weight of original sample ,A (Kg)	2.0	2.0
2	Weight of oven dried sample B ,(Kg)	1.986	1.987
3	Moisture content(%)=(A-B/A)*100	0.7%	0.7%
	Average		0.7%

Unit Weight of Coarse Aggregate:-

Unit weight is the ratio of sample weight to its volume occupied by the sample.

Apparatus: Balance, cylinder and metal rod for tamping.

The unit weight of coarse aggregate was determined using the following procure.

1. The aggregate has filled on three layers and each level of layers has compacted with steel rod 25 times.
2. Then level the surface aggregate at the top of cylinder using the rod and measure the weight of the aggregate inside the container.
3. calculate the unit weight of coarse aggregate

   Unit weight =$\frac{M}{V}$

   M = mass of Aggregate

   V = volume of cylindrical metal

   Mass of sample = (mass of sample + mass of cylinder) - Mass of cylinder

Table A-10 unit weight of coarse aggregate

SN.NO	Description	trial 1	trial 2	Mean
1	Mass of cylinder +sample(Kg)	18.813	18.83	
2	mass of cylinder(Kg)	1.677	1.677	
3	Mass of sample(Kg)	17.136	17.153	
4	Volume of measuring cylinder (m^3)	0.01	0.01	
5	Unit weight(Kg/m^3)	1713.6	1715.3	1714.45

Avg. unit weight=1714.45 Kg/m

B. Fineness of Cement

Procedure to determine the fineness of cement and secondary aluminum dross and corn cob ash

1. Collected sample of cement and rub by hand
2. Taken 100gm of cement sample and note its weight as W1
3. Drop 100gm of cement in 90 μm sieve and closed it with lid.
4. Then, shake the sieve with hands for 15 minutes.
5. After that take weight the retained cement on the 90μm sieve as W2.
6. Finally, calculated the fineness of cement using the following formula

$$\text{Fineness}= \left(\frac{W2}{W1}\right) \times 100$$

The following table shows fineness of cement value

Table B-1 Fineness of cement value

Number of trial	Weight of Cement samples(W1)	Weight cement sample Retained on 90μm Sieve(W2)	Fineness of Cement (%) $=\frac{w2}{w1} \times 100$
1	100	3.05	3.05
2	100	2.76	2.76
Average			2.905

The standard value of fineness of cement should have fineness less than 10% or fineness of cement should not be more than 10% as per IS 4031 recommendations.

So, the fineness of cement was found 2.905%. This shows the fineness of the cement was within the restriction. Therefore the Dangote PPC used for the investigation satisfies the requirement. Since the secondary aluminum dross and corn cob ash powder only passing 90µm sieve size were used it means that the residual retained on 90µm was zero. This also shows the fineness of secondary aluminum dross and corn cob ash powder satisfies the requirement.

C. Price of Cement, SAD and CC

Table C-1 Price of cement, SAD and CCA

S.No	Type of materials	Cost in Birr
1	Cement (100kg)	750 birr
2	SAD(100kg)	0.00 birr
3	CC in quintal	15 birr

According to transportation of the SAD and cement cost from source, there is no cost variation between cement and SAD because both SAD and cement obtained from adiss abebe. There is no cement company in Jimma but there is cement apportion store in the market. In addition to this this study is not limited to Jimma area, but it is applicable throughout over all part of Ethiopia and other world country where the materials are available.

D. Stress- strain relationship on specimens for cubes.

Table D-1 stress-strain diagram for cube at age of 28 day

0% Mix Compressive Strength @28day									
ΔH	Load(KN)			Area	Strain	Stress(Mpa)			
	1	2	3	mm^2		1	2	3	Avg.
0	0	0	0	22500	0	0	0	0	0
0.05	23	22	21	22500	0.00033	1.02222	0.97778	0.93333	0.97778
0.1	44	37	24	22500	0.00067	1.95555556	1.64444	1.06667	1.55556
0.15	88	53	34	22500	0.001	3.91111111	2.35556	1.51111	2.59259
0.2	128	76	54	22500	0.00133	5.68888889	3.37778	2.4	3.82222
0.25	174	105	67	22500	0.00167	7.73333333	4.66667	2.97778	5.12593

0.3	205	137	93	22500	0.002	9.11111111	6.08889	4.13333	6.44444
0.35	237	153	128	22500	0.00233	10.5333333	6.8	5.68889	7.67407
0.4	268	171	152	22500	0.00267	11.9111111	7.6	6.75556	8.75556
0.45	292	194	182	22500	0.003	12.9777778	8.62222	8.08889	9.8963
0.5	320	237	210	22500	0.00333	14.2222222	10.5333	9.33333	11.363
0.55	347	275	233	22500	0.00367	15.4222222	12.2222	10.3556	12.6667
0.6	371	299	251	22500	0.004	16.4888889	13.2889	11.1556	13.6444
0.65	399	325	274	22500	0.00433	17.7333333	14.4444	12.1778	14.7852
0.7	423	356	294	22500	0.00467	18.8	15.8222	13.0667	15.8963
0.75	445	378	315	22500	0.005	19.7777778	16.8	14	16.8593
0.8	467	396	334	22500	0.00533	20.7555556	17.6	14.8444	17.7333
0.85	489	423	357	22500	0.00567	21.7333333	18.8	15.8667	18.8
0.9	514	449	374	22500	0.006	22.8444444	19.9556	16.6222	19.8074
0.95	527	474	385	22500	0.00633	23.4222222	21.0667	17.1111	20.5333
1	542	495	398	22500	0.00667	24.0888889	22	17.6889	21.2593
1.05	553	523	424	22500	0.007	24.5777778	23.2444	18.8444	22.2222
1.1	563	537	437	22500	0.00733	25.0222222	23.8667	19.4222	22.7704
1.15	566.73	560	445	22500	0.00767	25.188	24.8889	19.7778	23.2849
1.2	565	582	477	22500	0.008	25.1111111	25.8667	21.2	24.0593
1.25	556	598	486	22500	0.00833	24.7111111	26.5778	21.6	24.2963
1.3	544	612	511	22500	0.00867	24.1777778	27.2	22.7111	24.6963
1.35	530	620	524	22500	0.009	23.5555556	27.5556	23.2889	24.8
1.4	525	622.48	539	22500	0.00933	23.3333333	27.6658	23.9556	24.9849
1.45	518	621	549	22500	0.00967	23.0222222	27.6	24.4	25.0074
1.5	514	617	561	22500	0.01	22.8444444	27.4222	24.9333	25.0667
1.55	511	610	578	22500	0.01033	22.7111111	27.1111	25.6889	25.1704
1.6	508	602	594	22500	0.01067	22.5777778	26.7556	26.4	25.2444
1.65	505	591	596.71	22500	0.011	22.4444444	26.2667	26.5204	25.0772
1.7	501	584	593	22500	0.01133	22.2666667	25.9556	26.3556	24.8593
1.75	495	572	592	22500	0.01167	22	25.4222	26.3111	24.5778
1.8	480	560	590	22500	0.012	21.3333333	24.8889	26.2222	24.1481
1.85	475	555	584	22500	0.01233	21.1111111	24.6667	25.9556	23.9111

Table D-2 stress-strain diagram for cube at age of 28 day

4% Mix Compressive Strength Test Result @28th Day									
ΔH	Load(KN)			Area	Strain	Stress(Mpa)			Avg.
	1	2	3	mm^2		1	2	3	
0	0	0	0	22500	0	0	0	0	0

0.05	24	29	23	22500	0.00033	1.06667	1.28889	1.02222	1.12593
0.1	51	34	37	22500	0.00067	2.26667	1.51111	1.64444	1.80741
0.15	61	44	48	22500	0.001	2.71111	1.95556	2.13333	2.26667
0.2	68	56	57	22500	0.00133	3.02222	2.48889	2.53333	2.68148
0.25	78	63	64	22500	0.00167	3.46667	2.8	2.84444	3.03704
0.3	90	69	73	22500	0.002	4	3.06667	3.24444	3.43704
0.35	100	78	85	22500	0.00233	4.44444	3.46667	3.77778	3.8963
0.4	109	86	94	22500	0.00267	4.84444	3.82222	4.17778	4.28148
0.45	129	101	103	22500	0.003	5.73333	4.48889	4.57778	4.93333
0.5	151	108	121	22500	0.00333	6.71111	4.8	5.37778	5.62963
0.55	163	118	142	22500	0.00367	7.24444	5.24444	6.31111	6.26667
0.6	176	130	154	22500	0.004	7.82222	5.77778	6.84444	6.81481
0.65	188	137	165	22500	0.00433	8.35556	6.08889	7.33333	7.25926
0.7	202	147	177	22500	0.00467	8.97778	6.53333	7.86667	7.79259
0.75	222	157	190	22500	0.005	9.86667	6.97778	8.44444	8.42963
0.8	239	165	209	22500	0.00533	10.6222	7.33333	9.28889	9.08148
0.85	254	174	225	22500	0.00567	11.2889	7.73333	10	9.67407
0.9	273	182	239	22500	0.006	12.1333	8.08889	10.6222	10.2815
0.95	285	191	257	22500	0.00633	12.6667	8.48889	11.4222	10.8593
1	300	204	269	22500	0.00667	13.3333	9.06667	11.9556	11.4519
1.05	309	216	282	22500	0.007	13.7333	9.6	12.5333	11.9556
1.1	327	220	292	22500	0.00733	14.5333	9.77778	12.9778	12.4296
1.15	329	224	308	22500	0.00767	14.6222	9.95556	13.6889	12.7556
1.2	334	224	310	22500	0.008	14.8444	9.95556	13.7778	12.8593
1.25	378	224	315	22500	0.00833	16.8	9.95556	14	13.5852
1.3	393	238	315	22500	0.00867	17.4667	10.5778	14	14.0148
1.35	400	253	335	22500	0.009	17.7778	11.2444	14.8889	14.637
1.4	402	275	356	22500	0.00933	17.8667	12.2222	15.8222	15.3037
1.45	420	290	379	22500	0.00967	18.6667	12.8889	16.8444	16.1333
1.5	420	305	392	22500	0.01	18.6667	13.5556	17.4222	16.5481
1.55	441	327	395	22500	0.01033	19.6	14.5333	17.5556	17.2296
1.6	443	344	395	22500	0.01067	19.6889	15.2889	17.5556	17.5111
1.65	470	361	416	22500	0.011	20.8889	16.0444	18.4889	18.4741
1.7	502	384	428	22500	0.01133	22.3111	17.0667	19.0222	19.4667
1.75	536	400	443	22500	0.01167	23.8222	17.7778	19.6889	20.4296
1.8	537	403	476	22500	0.012	23.8667	17.9111	21.1556	20.9778
1.85	546	432	492	22500	0.01233	24.2667	19.2	21.8667	21.7778
1.9	575	457	508	22500	0.01267	25.5556	20.3111	22.5778	22.8148
1.95	588	481	542	22500	0.013	26.1333	21.3778	24.0889	23.8667

2	607	501	570	22500	0.01333	26.9778	22.2667	25.3333	24.8593
2.05	642	521	604	22500	0.01367	28.5333	23.1556	26.8444	26.1778
2.1	661	528	623	22500	0.014	29.3778	23.4667	27.6889	26.8444
2.15	685	533	646	22500	0.01433	30.4444	23.6889	28.7111	27.6148
2.2	689.26	535	651.38	22500	0.01467	30.6338	23.7778	28.9502	27.7873
2.25	681	548	645	22500	0.015	30.2667	24.3556	28.6667	27.763
2.3	676	567	624	22500	0.01533	30.0444	25.2	27.7333	27.6593
2.35	672	576	615	22500	0.01567	29.8667	25.6	27.3333	27.6
2.4	665	584	608	22500	0.016	29.5556	25.9556	27.0222	27.5111
2.45	661	588	599	22500	0.01633	29.3778	26.1333	26.6222	27.3778
2.5	652	595	593	22500	0.01667	28.9778	26.4444	26.3556	27.2593
2.55	647	598	590	22500	0.017	28.7556	26.5778	26.2222	27.1852
2.6	641	602	586	22500	0.01733	28.4889	26.7556	26.0444	27.0963
2.65	636	602	585	22500	0.01767	28.2667	26.7556	26	27.0074
2.7	630	590	580	22500	0.018	28	26.2222	25.7778	26.6667
2.75	628	583	577	22500	0.01833	27.9111	25.9111	25.6444	26.4889
2.8	626	575	568	22500	0.01867	27.8222	25.5556	25.2444	26.2074
2.85	618	573	565	22500	0.019	27.4667	25.4667	25.1111	26.0148

Table D-3 stress-strain diagram for cube at age of 28 day

8% Mix Compressive Strength Test Result @28th Day									
ΔH	Load(KN)			Area					Avg.
	1	2	3	mm^2		Stress(Mpa)			
					Strain	1	2	3	
0	0	0	0	22500	0	0	0	0	0
0.05	17	25	17	22500	0.00033	0.75556	1.1111111	0.755556	0.87407
0.1	35	29	35	22500	0.00067	1.55556	1.2888889	1.555556	1.46667
0.15	44	37	42	22500	0.001	1.95556	1.6444444	1.866667	1.82222
0.2	56	48	47	22500	0.00133	2.48889	2.1333333	2.088889	2.23704
0.25	65	54	54	22500	0.00167	2.88889	2.4	2.4	2.56296
0.3	72	58	63	22500	0.002	3.2	2.5777778	2.8	2.85926
0.35	79	67	70	22500	0.00233	3.51111	2.9777778	3.111111	3.2
0.4	93	73	76	22500	0.00267	4.13333	3.2444444	3.377778	3.58519
0.45	109	86	90	22500	0.003	4.84444	3.8222222	4	4.22222
0.5	118	92	106	22500	0.00333	5.24444	4.0888889	4.711111	4.68148
0.55	127	100	114	22500	0.00367	5.64444	4.4444444	5.066667	5.05185
0.6	136	111	123	22500	0.004	6.04444	4.9333333	5.466667	5.48148
0.65	146	117	131	22500	0.00433	6.48889	5.2	5.822222	5.83704
0.7	161	125	140	22500	0.00467	7.15556	5.5555556	6.222222	6.31111

0.75	173	134	155	22500	0.005	7.68889	5.9555556	6.888889	6.84444
0.8	184	140	165	22500	0.00533	8.17778	6.2222222	7.333333	7.24444
0.85	198	149	167	22500	0.00567	8.8	6.6222222	7.422222	7.61481
0.9	207	155	177	22500	0.006	9.2	6.8888889	7.866667	7.98519
0.95	217	163	200	22500	0.00633	9.64444	7.2444444	8.888889	8.59259
1	224	174	210	22500	0.00667	9.95556	7.7333333	9.333333	9.00741
1.05	238	176	217	22500	0.007	10.5778	7.8222222	9.644444	9.34815
1.1	258	184	230	22500	0.00733	11.4667	8.1777778	10.22222	9.95556
1.15	278	194	230	22500	0.00767	12.3556	8.6222222	10.22222	10.4
1.2	291	195	234	22500	0.008	12.9333	8.6666667	10.4	10.6667
1.25	304	203	265	22500	0.00833	13.5111	9.0222222	11.77778	11.437
1.3	320	216	280	22500	0.00867	14.2222	9.6	12.44444	12.0889
1.35	341	235	294	22500	0.009	15.1556	10.444444	13.06667	12.8889
1.4	366	247	294	22500	0.00933	16.2667	10.977778	13.06667	13.437
1.45	391	260	304	22500	0.00967	17.3778	11.555556	13.51111	14.1481
1.5	417	279	309	22500	0.01	18.5333	12.4	13.73333	14.8889
1.55	440	294	330	22500	0.01033	19.5556	13.066667	14.66667	15.763
1.6	465	308	353	22500	0.01067	20.6667	13.688889	15.68889	16.6815
1.65	479	327	377	22500	0.011	21.2889	14.533333	16.75556	17.5259
1.7	497	342	403	22500	0.01133	22.0889	15.2	17.91111	18.4
1.75	517	344	425	22500	0.01167	22.9778	15.288889	18.88889	19.0519
1.8	529	369	449	22500	0.012	23.5111	16.4	19.95556	19.9556
1.85	537	390	457	22500	0.01233	23.8667	17.333333	20.31111	20.5037
1.9	538	413	458	22500	0.01267	23.9111	18.355556	20.35556	20.8741
1.95	540	428	463	22500	0.013	24	19.022222	20.57778	21.2
2	543	445	465	22500	0.01333	24.1333	19.777778	20.66667	21.5259
2.05	556	454	465	22500	0.01367	24.7111	20.177778	20.66667	21.8519
2.1	567	455	469	22500	0.014	25.2	20.222222	20.84444	22.0889
2.15	573	457	478	22500	0.01433	25.4667	20.311111	21.24444	22.3407
2.2	574.88	468	480	22500	0.01467	25.5502	20.8	21.33333	22.5612
2.25	565	472	481	22500	0.015	25.1111	20.977778	21.37778	22.4889
2.3	559	487	481	22500	0.01533	24.8444	21.644444	21.37778	22.6222
2.35	546	497	492	22500	0.01567	24.2667	22.088889	21.86667	22.7407
2.4	539	518	512	22500	0.016	23.9556	23.022222	22.75556	23.2444
2.45	534	536	524	22500	0.01633	23.7333	23.822222	23.28889	23.6148
2.5	527	541	536	22500	0.01667	23.4222	24.044444	23.82222	23.763
2.55	523	546	542	22500	0.017	23.2444	24.266667	24.08889	23.8667
2.6	513	548	546	22500	0.01733	22.8	24.355556	24.26667	23.8074
2.65	504	549	551	22500	0.01767	22.4	24.4	24.48889	23.763

2.7	492	550.13	556	22500	0.018	21.8667	24.450222	24.71111	23.676
2.75	489	548	558.45	22500	0.01833	21.7333	24.355556	24.82	23.6363
2.8	486	537	554	22500	0.01867	21.6	23.866667	24.62222	23.363
2.85	481	532	543	22500	0.019	21.3778	23.644444	24.13333	23.0519
2.9	479	523	538	22500	0.01933	21.2889	23.244444	23.91111	22.8148
2.95	476	519	529	22500	0.01967	21.1556	23.066667	23.51111	22.5778

Table D-4 stress-strain diagram for cube at age of 28 day

12% mix compressive strength test result @28day

ΔH	Load(KN)			Area	Strain	Stress(Mpa)			Avg.
	1	2	3			1	2	3	
0	0	0	0	22500	0	0	0	0	0
0.05	18	19	22	22500	0.00033	0.8	0.84444	0.97778	0.87407
0.1	27	23	35	22500	0.00067	1.2	1.02222	1.55556	1.25926
0.15	34	28	49	22500	0.001	1.51111	1.24444	2.17778	1.64444
0.2	44	31	84	22500	0.00133	1.95556	1.37778	3.73333	2.35556
0.25	57	35	104	22500	0.00167	2.53333	1.55556	4.62222	2.9037
0.3	63	46	116	22500	0.002	2.8	2.04444	5.15556	3.33333
0.35	67	51	134	22500	0.00233	2.97778	2.26667	5.95556	3.73333
0.4	77	55	145	22500	0.00267	3.42222	2.44444	6.44444	4.1037
0.45	86	62	163	22500	0.003	3.82222	2.75556	7.24444	4.60741
0.5	98	67	187	22500	0.00333	4.35556	2.97778	8.31111	5.21481
0.55	105	73	204	22500	0.00367	4.66667	3.24444	9.06667	5.65926
0.6	117	82	218	22500	0.004	5.2	3.64444	9.68889	6.17778
0.65	128	94	237	22500	0.00433	5.68889	4.17778	10.5333	6.8
0.7	132	103	249	22500	0.00467	5.86667	4.57778	11.0667	7.17037
0.75	143	114	265	22500	0.005	6.35556	5.06667	11.7778	7.73333
0.8	153	135	275	22500	0.00533	6.8	6	12.2222	8.34074
0.85	167	145	286	22500	0.00567	7.42222	6.44444	12.7111	8.85926
0.9	175	172	303	22500	0.006	7.77778	7.64444	13.4667	9.62963
0.95	186	197	310	22500	0.00633	8.26667	8.75556	13.7778	10.2667
1	191	223	313	22500	0.00667	8.48889	9.91111	13.9111	10.7704
1.05	199	234	314	22500	0.007	8.84444	10.4	13.9556	11.0667
1.1	204	243	319	22500	0.00733	9.06667	10.8	14.1778	11.3481
1.15	209	254	326	22500	0.00767	9.28889	11.2889	14.4889	11.6889
1.2	212	256	339	22500	0.008	9.42222	11.3778	15.0667	11.9556
1.25	215	258	345	22500	0.00833	9.55556	11.4667	15.3333	12.1185
1.3	219	269	359	22500	0.00867	9.73333	11.9556	15.9556	12.5481

1.35	231	274	363	22500	0.009	10.2667	12.1778	16.1333	12.8593
1.4	239	282	376	22500	0.00933	10.6222	12.5333	16.7111	13.2889
1.45	245	293	389	22500	0.00967	10.8889	13.0222	17.2889	13.7333
1.5	257	302	396	22500	0.01	11.4222	13.4222	17.6	14.1481
1.55	268	320	405	22500	0.01033	11.9111	14.2222	18	14.7111
1.6	279	332	412	22500	0.01067	12.4	14.7556	18.3111	15.1556
1.65	292	341	419	22500	0.011	12.9778	15.1556	18.6222	15.5852
1.7	305	345	428	22500	0.01133	13.5556	15.3333	19.0222	15.9704
1.75	318	355	438	22500	0.01167	14.1333	15.7778	19.4667	16.4593
1.8	332	364	449	22500	0.012	14.7556	16.1778	19.9556	16.963
1.85	346	376	453	22500	0.01233	15.3778	16.7111	20.1333	17.4074
1.9	359	389	459	22500	0.01267	15.9556	17.2889	20.4	17.8815
1.95	376	392	467	22500	0.013	16.7111	17.4222	20.7556	18.2963
2	387	397	475	22500	0.01333	17.2	17.6444	21.1111	18.6519
2.05	401	415	487	22500	0.01367	17.8222	18.4444	21.6444	19.3037
2.1	419	417	491	22500	0.014	18.6222	18.5333	21.8222	19.6593
2.15	432	425	495	22500	0.01433	19.2	18.8889	22	20.0296
2.2	446	435	498	22500	0.01467	19.8222	19.3333	22.1333	20.4296
2.25	453	449	499	22500	0.015	20.1333	19.9556	22.1778	20.7556
2.3	463	461	501.3	22500	0.01533	20.5778	20.4889	22.28	21.1156
2.35	469	474	498	22500	0.01567	20.8444	21.0667	22.1333	21.3481
2.4	475	495	488	22500	0.016	21.1111	22	21.6889	21.6
2.45	482	497	486	22500	0.01633	21.4222	22.0889	21.6	21.7037
2.5	489.4	501	485	22500	0.01667	21.7511	22.2667	21.5556	21.8578
2.55	480	506	480	22500	0.017	21.3333	22.4889	21.3333	21.7185
2.6	476	507	472	22500	0.01733	21.1556	22.5333	20.9778	21.5556
2.65	472	515	469	22500	0.01767	20.9778	22.8889	20.8444	21.5704
2.7	467	517.95	458	22500	0.018	20.7556	23.02	20.3556	21.377
2.75	461	505	451	22500	0.01833	20.4889	22.4444	20.0444	20.9926
2.8	459	500	450	22500	0.01867	20.4	22.2222	20	20.8741
2.85	450	495	442	22500	0.019	20	22	19.6444	20.5481

E-Sample photo captured during laboratory work